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World Food Programme

EUROPEAN COMMISSION

Humanitarian Aid

ODAN

.:: EMERGENCY NEEDS ASSESSMENT SERVICE

Diet Diversity Study

Friedman School of Nutrition Science and Policy
Tufts University, Boston

STRENGTHENING EMERGENCY NEEDS ASSESSMENT CAPACITY (SENAC)

NOVEMBER 2007

DIET DIVERSITY STUDY

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November, 2007

This study was prepared under the umbrella of the "Strengthening Emergency Needs Assessment Capacity" (SENAC) project. The SENAC project aims to reinforce WFP's capacity to assess humanitarian needs in the food sector during emergencies and the immediate aftermath through accurate and impartial needs assessments.

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This document has been produced with the financial assistance of the European Union. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

Acknowledgements

This report was supported by a grant from the World Food Program. We would like to acknowledge the helpful comments and suggestions from Agnes Dhur, Simon Renk, Joyce Luma, Peter Horjus, and Jan Delbaere of the World Food Program in Rome. We received very able assistance from Ankur Patel, Kyungjae Kang, and Akoto Osei in data analysis. We gratefully acknowledge the sources of the data used in this report. The data sets for Ghana and Ethiopia were obtained from the International Food Policy Research Institute; the Afghanistan data set was obtained from the World Food Program with permission of the Government of Afghanistan, and the Bangladesh data set was collected by researchers at Tufts with the support of the Food and Nutrition Technical Assistance Project of the Academy for Educational Development with funding from the US Agency for International Development. The Darfur data set was obtained from the World Food Program. We appreciate the opportunity to make use of these data.

Diet Diversity Study

Executive Summary

Adequate human nutrition involves regular intake of a wide range of nutrients, some of which must be consumed on a frequent basis, even if in small quantities. As such, dietary diversity (DD), typically measured in the form of a count of food groups or food group frequency, has been suggested as a proxy indicator for nutrient adequacy. Recently, the potential for measures of diet diversity to help identify food insecure households has received growing attention from operational agencies. This interest is founded on the observed relationship between income and diet diversification and is fuelled by the ease and low-cost of collecting and using dietary diversity indices. Nevertheless, a dietary diversity measure that is operationally relevant in diverse contexts remains an un-met programmatic need, particularly in settings of acute food insecurity requiring humanitarian intervention where the relationships between dietary diversity and income may be confounded.

The aims of this study were to: 1) compare various DD indicators to determine the best proxy for caloric adequacy; 2) assess which method for classifying households using their dietary diversity characteristics best predicts caloric insufficiency; 3) determine whether households in different contexts with the same dietary diversity profile have the same caloric intake; 4) determine the extent to which the same DD measure and cut-offs could be used in different locations; 5) assess the effects of certain characteristics of acute food insecure settings, such as wild food consumption and food aid receipts on the interpretation of measures of dietary diversity in very food constrained populations; and 6) to examine the implications of the above for emergency needs assessment data collection.[1]

To test the relationship of dietary diversity measures to caloric indicators, data from four surveys were used: the Bangladesh Food Insecurity and Validation Study (FIMVS); the Accra Urban Food and Nutrition Security Study (AUFNS); the Ethiopia Rural Household Survey (ERHS); and the Afghanistan National Risk and Vulnerability Assessment (NRVA). Since none of these surveys were conducted in specifically emergency-affected areas, data were also analyzed from the Darfur Emergency Food Security Assessment (EFSA). Though the latter did not include

[1] The aim of the study originally commissioned by WFP/SENAC was to test the operationalization of dietary diversity measures as proxy indicators of household food insecurity in emergency-affected populations. Part-way through the study process, WFP called for a reorientation in the objectives, which involved assessing dietary diversity as an indicator of caloric adequacy, specifically, rather than as an indicator of food security more broadly. These study aims reflect this modification.

measures of caloric intake, this data set was nevertheless useful for testing the relationships between dietary diversity and other food security indicators in an acutely food insecure context, for examining the impact of wild foods and food aid on dietary diversity, and for assessing the constraints of displacement, and specifically camp-based displacement, on dietary diversity.

In order to evaluate and compare various dietary diversity indicators, bivariate correlations were examined both among the candidate indicators and between each indicator and the caloric adequacy benchmark. Individual OLS regression models for each of the candidate DD indicators in each data set were tested and logistic regression models for each indicator and data set tested the degree to which different levels of the candidate DD indicators increased the likelihood of a shortfall in a consumption threshold. To explore the feasibility of applying the same cut-off (not just the same approach) across data sets, contingency table analysis was used to compare the classification of households above and below a cut-off on the candidate measure to households above and below a critical level of a benchmark, examining the sensitivity, specificity and predictive value of each indicator. Five dietary diversity indicators were tested: Food Group Score (using standardized groupings from the DHS surveys), Nutrient Groups Score, Calorie-Dense Food Groups Score, Unique Foods Score, and Calorie Dense Unique Foods Score. The Darfur data were assessed according to WFP's own dietary diversity measure.

A clear relationship between caloric adequacy and dietary diversity was shown across all the data sets with the partial exception of Ethiopia. The Ethiopia data were not collected in such a way as to enable accurate calculation of caloric intake, so many of the results of the analysis of data from Ethiopia are unreliable. While the statistical relationships were the same across the other data sets, the specifics varied considerably: both dietary diversity and caloric intake were significantly higher in Accra and Afghanistan than in Bangladesh. All of the dietary diversity indicators are highly correlated, and most correlate reasonably well with caloric adequacy. The correlations were the highest for the Unique Foods and the DHS Food Groups indicators. The Nutrient Groups and Calorie-Dense Food Groups indicators had fewer categories, and tended to have scores mostly in the higher ranges, meaning that these might be good indicators of extreme stress, but are not particularly suited for measuring small changes in status over time. All measures correlated well with a battery other food security indicators. All indicators were significantly associated with caloric adequacy in regression analysis, with DHS Food Groups and Unique Foods explaining the most variance.

The sensitivity and specificity analysis to test for appropriate cut-offs in scores of dietary diversity measures showed very different results for different locations, and no clearly adequate cut-off (ie. a cut off that did not include a significant number of false positives and false negatives) for dietary diversity scores was identified. This was true not only for a universally applicable cut-off across data sets, but also within even a single data set. Again, the DHS Food Groups indicator did the best job of maximizing specificity and sensitivity.

The results confirm that measures of dietary diversity do reflect the adequacy and quality of diet at the household level. After controlling for confounders in a multivariate analysis, all DD indicators showed very significant positive relationships with calorie consumption in all four countries. However, all the data sets used to analyze caloric adequacy were drawn from settings that were not currently affected by an acute emergency. The extent to which dietary diversity may have a different meaning in emergencies cannot be inferred from these results. All the constructed measures of diet diversity were closely correlated with each other. Nonetheless, each one may have a somewhat different interpretation. Indicators with more groups are more sensitive to minor changes; those with fewer groups, reflecting very basic, generic diet patterns, are likely to be better indicators of extreme stress. Results were inconsistent regarding which indicator showed the greatest predictive ability or the most robust correlation with calorie consumption. Analysis of DD indicators in Darfur suggested that the incorporation of such aspects of emergency settings as the consumption of wild or 'famine' foods, and the effect of food aid receipt on diversity merit further exploration. The relationship with caloric intake could not be investigated.

Based on sensitivity and specificity analysis, it proved impossible to find a universal cut-off in any of the indicators tested that would consistently identify a set proportion of households falling below a chosen level of calorie consumption. The variability of results suggests that relying on a single indicator to proxy dietary adequacy will likely result in the misclassification of households for diagnostic or targeting purposes. These results indicate that for assessment and targeting purposes, more than one proxy indicator should be used.

Further study and primary data collection to quantify calorie intake directly (not through proxies), along with other measures of dietary diversity and household food security, is strongly recommended in order to assess the usefulness of the dietary diversity indicator in access-constrained, emergency settings.

We can briefly summarize our conclusions as follows.

- These results confirm that dietary diversity measures show a consistent association with dietary adequacy and caloric intake.
    - We did not find clear superiority of one indicator over another; all are closely correlated
    - Because of diverse contexts and the strong desire of households to diversify at very low levels of caloric intake, universal cut off values are unlikely to be found
    - Very aggregated (e.g. five food group) measures may discriminate in severely deprived more than in less deprived populations
- This relationship has not been tested in emergency or crisis settings; such research is badly needed
    - The role and significance of 'famine foods' needs to be explored further
    - The effect of food aid on DD indicators needs to be explored
- Assessing the use of DD indicators as a proxy for diet adequacy requires information on both variables
    - Food expenditures or provisioning are poor proxies for consumption; detailed consumption data are needed
    - DD indicators constructed from detailed consumption data may be different from indicators collected from general questions specifically to construct DD scores.
- The promising potential for using DD as one in a set of indicators of household food security and diet quality justifies further research on the issue.

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Friedman School of Nutrition Science and Policy,
Tufts University, Boston.
November 21, 2007

1. Introduction

The World Health Organization has suggested that at least 20, perhaps as many as 30, biologically distinct variants of foods should be consumed each week for a healthy diet (WHO/FAO 2003). This is because adequate human nutrition involves regular intake of a wide range of nutrients, some of which are manufactured in the human body but many of which are not, and therefore have to be consumed on a frequent basis even if in small quantities.[2] This essential underpinning of nutrition science has led to the creation of various measures of dietary diversity that correlate with identified risk factors linked to a range of health-related outcomes, including premature mortality (Kant et al. 1993; Seymour et al. 2003), chronic and acute diseases (Schneider et al. 2000; Menotti et al. 2004; Schulze and Hoffmann 2007), and compromised growth (Arimond and Ruel 2004; Cordeiro 2007)—all mediated through, or at least interacting with, macro-, and micronutrient deficiencies. Building on epidemiologic studies validating such approaches to analysing diet-disease interactions (see Newby et al. 2003; Neuhouser et al. 2003; Newby and Tucker 2004), the potential for measures of diet diversity to help identify risk factors related to *household* food insecurity, as opposed to *individual* wellbeing, has received growing attention from operational agencies.

A measure of the risk of dietary inadequacy that is simple to collect and easy to interpret remains an un-met programmatic priority in the context of humanitarian action. One of the agreed principles of Good Humanitarian Donorship is rigorous and transparent methods of emergency needs assessment (DI 2006). The work of ODAN at WFP, the introduction of a Needs Analysis Framework and Matrix by OCHA, and the continued multi-partner development of an Integrated Food Security and Humanitarian Phase Classification are all part of a broad attempt to harmonize measurement tools and indicators for universal use in emergency settings (Walker and Pepper 2007). It is widely believed that an indicator of diversity in household consumption patterns can serve to enhance needs assessment approaches.

[2] Of course sound nutrition is not only about foods consumed; it also depends on a balance between nutrient intake and requirements, consumption in relation to energy expenditure, a interactions with non-food factors, including clean water, disease burden/health care, caring practices, etc.

Diet quality has long been referred to in UN manuals dealing with emergency management. For example, UNHCR's 1982 handbook for field operations states that "essential vitamin and mineral requirements must be met: a varied diet is the best means of doing so" (p.102).[3] The multi-agency manual on management of nutrition in major emergencies from 2000 similarly notes that a diet that is diversified is key to good nutrition and that, "if evaluation of dietary intake indicates specific deficiencies," then rations should be tailored to deal with identified problems; the food basket composition should be varied; and the provision of appropriate combinations of nutrient-rich and micronutrient-fortified foods should be ensured (WHO 2000, p.15) Similarly, in its guidelines for fieldworkers dealing with emergency assessments, Save the Children (UK) argues that "you need to be able to answer the following questions in order to assess the impact of food security on nutrition in the affected population:…What is the overall quality of the diet of different population groups? Is there access to foods of high dietary quality?" (SCF 2004, p. 23)

It is important to emphasize the term "access" in the latter quote because interest in the operational applications of dietary diversity indicators has grown not only because of perceived ease of collection (compared with detailed household expenditure or consumption surveys), but also because diversity is thought to be a less distal proxy for the *access* dimension of food security than other commonly used measures. For example, FAO's (2005) reference guide on 'nutrition indicators for development' specifies the use of food diversity (number of food groups consumed) and food variety (number of foods consumed) as proxies for the 'food access' domain of widely-held food security conceptual frameworks.

WFP also sees the potential for 'household dietary diversity' to proxy food access and availability, as part of a suite of indicators focused on consumption behaviour (WFP 2005). Aiga and Dhur (2006) state that WFP combines information on food consumption in terms of three separate but related elements: i) dietary diversity, (number of unique food items consumed during the previous seven days); ii) food consumption frequency (number of days during which each food item was consumed over the previous week); and iii) the primary source of each food. This recently-developed approach recognizes diet quality, separate from dietary 'adequacy' (volume of consumption, or adequate calorie intake), and links these to information on sources of food which allows for attention to entitlement issues, and to issues relating to personal and social acceptability of food procurement methods, reliance on transfers, and other potentially

[3] Even earlier, a 1966 WHO manual on nutrition assessment stated that "it is obviously important to have as much detailed knowledge as possible of the foods actually eaten in the community, both for assessing nutritional status and for discovering the dietary etiological factors that may be amenable to correction." (p.114)

unacceptable means of food provisioning.[4] The underlying concept is that *appropriately constructed* indices of diversity in patterns of consumption reflect overall food adequacy at the household level, nutrient adequacy across members of the household, as well as an ability to avoid dietary monotony that may be associated with poor diet quality, and that such indicators offer an understanding of household food access that is related to, but different from, conventional measures of child nutritional status or mortality (Dhur 2007).

However, the key is to determine what "*appropriately constructed*" means for WFP's beneficiaries—people who are food insecure, often nutritionally compromised, usually facing high mortality risks in a very wide range of settings, not only in the context of chronic poverty but also in emergencies where food systems are constrained if not facing total collapse. This study was commissioned as part of a wider process that has sought to determine if measures of diet diversity can indeed be constructed to determine levels of dietary inadequacy in populations at risk of nutritional compromise—particularly in the context of acute food insecurity.

[4] Attention to quality of diet is reflected in recent statements such as: "WFP has seen no evidence of starvation in Kandahar city, although there are many people who have inadequate diets both in terms of the amount of food available to them, and in diet diversity." (Reliefweb, report on food insecurity in Afghanistan, May 30, 2007)

2. Study Aims

The aim of the study originally commissioned by WFP/SENAC was to test the operationalization of dietary diversity measures as proxy indicators of household food insecurity in emergency-affected populations. Part-way through the study process, WFP called for a reorientation in the objectives, which involved assessing dietary diversity as an indicator of caloric adequacy, specifically, rather than as an indicator of food security more broadly. This shift in focus affected which secondary data sets were suitable for analysis and introduced limitations related other subsidiary questions of interest to both WFP and TUFTS. This final report responds to this refocusing by WFP. The revised objectives are presented here, followed by a brief discussion of the questions that cannot be answered within the limitations imposed by the new study aims.

The main objective of this study is to provide guidance on operationalizing dietary diversity (DD) indicators in the assessment of household caloric adequacy. (As noted, this represents a change from the original objective to explore such indicators as measures of household food insecurity in emergency situations.)

The aims are the following.

1) Compare various DD indicators (constructed from food groups and/or individual food items) to determine which is the closest proxy for deficiencies in household caloric adequacy
2) Assess which method for classifying households using their dietary diversity characteristics best predicts caloric insufficiency.
3) Determine the extent to which households in widely different contexts with the same dietary diversity profile also have the same caloric intake. To what extent can the same DD measure and cut-offs be used in different locations.
4) Assess the potential confounding effects of issues like wild food consumption, distress food consumption, and food aid receipts, on the interpretation of measures of dietary diversity in very food constrained populations.[5]
5) Examine the implications of the above for the collection of baseline and emergency needs assessment data.

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[5] This set of questions was de-emphasized after a refocusing of the study objectives by WFP which limited the data that we could use to chronically food insecure populations rather than crisis-affected ones, However, this small set of questions pertaining specifically to emergencies will be explored in a single data set collected from Darfur in 2005.

WFP was hopeful that it would be possible to examine these objectives in both emergency and non-emergency contexts. However, our ability to meet these two priorities in combination was severely limited by the lack of calorie data in emergency data sets. Because of these data limitations, and based on discussion with WFP, we were required to prioritize those data sets that offered scope to calculate a caloric adequacy benchmark for validation purposes, even though all of these data sets originated from non-emergency situations. Other sub-questions related to operationalizing DD were not examined here due to the data limitations imposed by restricting the data sets to those with caloric adequacy information:

a. What is the most appropriate reference period?
b. Should the actual number of times a food was consumed be counted, or is it adequate to capture the number of days that a food was consumed?
c. Should individual level dietary information be included, or just household level?
d. Does applying weights based on frequency of consumption improve predictive ability of the DD indicator?
e. How well does the current WFP approach to classifying households based on DD information predict caloric sufficiency?
f. How important are seasonal variations, and how can we account for them?

None of the available data sets (that were selected because they yielded caloric consumption information) included a variable reference period; none included information at the individual level, and none included information on the same households in different seasons. Only a single data set, the NRVA 2005 data from Afghanistan, included information on frequency of food/food group consumption that would have enabled a validation of the WFP approach to classifying households based on their dietary diversity. However, the frequency data were found to be inconsistent with the food consumption data for nearly 50% of households, and these inconsistencies were not randomly distributed throughout the sample (see Appendix A for a more complete description of the inconsistencies). As such, Tufts and WFP agreed that the results of the frequency questions in the NRVA data were not sufficiently reliable to use in testing the WFP dietary diversity approach.

We recommend WFP consider undertaking data collection to make it possible to address these very important questions in an appropriate population; in our conclusions we briefly summarize the types of information that would be needed for such a study.

3. Background and Review of Relevant Literature

Diversity in diet carries the implication not only of 'sufficiency' (in nutrient terms), but also of avoiding monotony. Dietary choice was seen to be important as early as the late 19th century, when first attempts were made to determine national poverty lines—drawn up (as still today) using the cost of a *basket* of foods considered to be essential to meet minimum dietary needs (Dixon and Macarov 1998). From the earliest days of poverty measurement, adequacy was never considered solely in terms of a single food that would meet most energy requirements. This is because, as pointed out by Behrman and Deolalikar (1989) in their analysis of data from 47 developing countries, "as food budgets increase from very low levels, there is a very pronounced increase in the demand for food variety. [Food] variety *per se* is valued so that people purchase increased food variety as their incomes increase, even though that may not alter their calorie intakes."

The challenge has been to determine how much diversity is minimally sufficient—or, to put it the other way, below what point can we universally determine there to be a dietary adequacy problem? Behrman and Deolalikar (1989) noted that this is not easy to establish since it depends on, a) demand factors (e.g. nutrition knowledge, taste and preferences), and b) supply factors (e.g. availability of foods to choose from, relative prices, research and transaction costs), and both are relevant at even the lowest levels of consumption--that is, even at very low incomes, poor households are concerned not only with obtaining calories at the lowest cost, but with moving away from monotony as fast as they can. This means that diversity is a relevant concept even when calorie requirements have not yet been met, and this makes the determination of absolute cut-off points for measures of dietary diversity difficult.[6]

Of course in times of crisis, typically characterized by a collapse of purchasing power coupled with constrained food supply, diversity is squeezed in the search for minimum calories. This results in dietary adaptations that lie at the core of most household coping strategies. These go beyond reduced consumption to include substitution towards nutritionally inferior (and less desired) commodities, trade-offs in the allocation of food within households (some family members receiving less food or specific nutrients than they need), compromised quality of foods (consumption of otherwise marginally edible stocks), and increased consumption of foods strange to the normal diet, including uncultivated or so-called 'famine' foods that may in fact be harmful

[6] Behrman and Deolalikar (1989) point to additional methodological difficulties that are well laid out in Patil and Tallie (1982).

to the consumer (Wiesman et al. 2006; Webb et al. 2006).[7] Each of these consumption adaptations has implications for dietary adequacy measured in terms of 'quality' (diversity, nutrient density, nutrient adequacy, etc), not just quantity.

The scientific literature on measures of dietary diversity (hereafter referred to as DD) has mushroomed recently. Most of this literature continues to be supportive of an important general conclusion: measures of DD (be they counts of unique foods, food frequency measures, or indices constructed around food groups) are typically robustly correlated with outcome measures of human wellbeing, including socioeconomic status, child nutritional status, energy consumption, and some aspects of micronutrient status (Hoddinott and Yohannes 2002; Arimond and Ruel 2004; Wiesman et al. 2006; Savy 2006). One example of a study that measured diet diversity not against nutritional outcomes but explicitly against indicators of household food security was Gittleson et al. (1998), which found in Nepal that, "caste status and socio-economic status were more associated with frequency of consumption of the different food groups than the food security scales" constructed around current food stores and the flow of 20 key foods 'into and out of the household' during the preceding 12 months (p. 215).

That said, there is little consistency in the way that indicators are constructed or what they are measured against (i.e. what they proxy for). Most DD indicators are similar in that they are commonly constructed as a score. DD scores tend to consist of a simple or weighted sum of either of *individual* food items or *groupings* of items consumed in a given recall period. The 'score' approach generates a relative measure; that is, it only determines whether one household ranks higher or lower than others in the same sample, not how well a household fares relative to an absolute standard. Continuous scores are usually *ordinal* rather than using *intervals.* Whereas ordinal scores tell us that a household with a higher score has more dietary diversity than households with a lower score, interval level scales suggest (more usefully), that a household with a score of 8 has double the degree of dietary diversity as a household with a score of 4. One example of this approach is the work in Mali of Torheim et al. (2004) who tested two simple scores: one based on the number of unique foods consumed (a food variety score for individual consumers), and the other based on the number of food groups consumed (a dietary diversity score). They found both scores to be positively correlated with total energy intake, with

[7] In this sense, 'diversity' is not axiomatically desirable in all cases since it could be linked to higher consumption of potentially deleterious foods, such as the drought-resistant grain *Lathyrus sativus* (see Getahun et. al. 2003), or (in urban settings) with unhealthy foods (van Dam 2005). As Arimond and Ruel (2004, p. 2585) put it, "depending on local diet patterns, high diversity scores may be more or less nutritionally meaningful."

coefficients of 0.38 and 0.29, respectively. Another example is provided by work in Vietnam by Olgle et al. (2001), who divided their sample into those with a high food variety score (≥15) *and* a high diet diversity score (≥8), and those below those score levels. They too found that women with high scores had significantly higher mean energy intakes than those with lower scores.

The problem is that the content of such scores has limited consistency across studies. For example, the number of food groups used (which derive from choices about how to group foods together or separately), and the number of potential individual 'unique' foods, differ widely. Behrman and Deolalikar (1989) used 9 food groups in their 47 country study--separating fish from meat, combining milk, cheese and eggs in one group, combining fruits and vegetables, combining sugar with spices and salt, but separating out 'coffee, tea and cocoa' from other 'beverages'. While Torheim et al. (2004), also created 9 food groups for work in Mali, these groups were quite different in composition: cereals, legumes, oil/sugar, fruit, vegetables, meat, milk, fish, eggs, and green leaves. By comparison, Kant and Graubard (1999) used only 5 groups: namely, fruit, vegetables, grain, dairy, and meat; and in Iran, Mirmiran et al. (2004) used a score based on 5 groups (bread-grains, vegetables, fruits, meats, and dairy foods), but divided into 23 sub-groups-- the bread-grain group broken down into 7 categories (refined bread, biscuits, macaroni, whole bread, corn flakes, rice, refined meal), the fruit group divided into only 2 subgroups (fruit and fruit juice, berries and citrus), vegetables into 7, and so on. The only commonality across these studies was significant correlations among diversity scores and various nutrition outcomes. This commonality should not be downplayed, however, since it suggests that the associations between diversity scores and nutrition outcomes are robust to their construction – an important observation for a study attempting to identify the 'ideal' DD index.

The aggregation of foods/food groups in an index, while useful to some extent, obscures potentially important details regarding *which* foods are lacking from the diet and how often they were or were not consumed. In Malawi, children with kwashiorkor were found to have a similar diet diversity score as those with marasmus—although it is widely thought that kwashiorkor is linked to a diet low in micronutrients and antioxidants as well as protein (Ndekha et al. 2006; Lin et al. 2007). In other words, it is not easy to discern from a continuous measure which elements of 'diversity' are doing what. Furthermore, including frequency weights into scoring systems can exacerbate the problem since two different dimensions are folded into a single total, which hampers interpretation.[8] However, adding the number (frequency) of servings of foods consumed does bring any score closer to actual consumption patterns. In Iran, Azadbakht et al. (2005) found that while energy intake was a strong predictor of the mean probability of adequacy in models controlled for age, body mass index, education level and job status (R^2=0.48), adding the number of servings from each of the food group to the models significantly improved the model fit (R^2=0.55).

Categories within groups also matter; that is, it has been argued that within a single food group it is important to consume more than one item (such as wheat, sorghum *and* rice within the rubric of cereals), rather than only one of them (Kennedy et al. 2005). And while not consuming vegetables is a known health risk, it has also been shown that an increase in the *number* of different 'vegetables' consumed can lower cancer risk—again suggesting that within category differences may matter (Slattery et al. 1997). Similarly, Proudhon (2002, p.66) has argued that "it is essential that protein intake be diversified in order to compensate for [the fact that] foods from animal sources generally offer a more satisfactory amino acid profile than foods from vegetable sources."

Nutrient density is another feature of many scoring systems that seek to interpret the 'value' of the diversity, beyond diversity's sake. For example, the Consortium for Southern Africa Food Security Emergency (C-SAFE) activity has used a score based on the nutrient density of multiple foods, leading to a maximum possible score of 48 (the higher the score the more nutritionally dense the diet).[9] Similarly, researchers in Zambia weighted their food groups according to density, such that consumption of foods from a nutrient-rich meats group received 4 points, while the cereals group received only 2 points (FHANIS/CSO 1998). Indeed, Hoenicke et al. (2006) go so far as to suggest that micronutrient deficiencies in the Philippines are "caused by low quantities of micronutrient-rich foods [more] than by a low diversification in the meals. Dietary diversity measured in the number of different food items consumed does not differ significantly between poor and non-poor, nor between micronutrient-deficient and non-deficient households." This view is supported by Pathak et al. (2004) who found in India that consumption of foods "rich in micronutrients (pulses, vegetables, fruits, nuts and oil seeds, animal foods) was infrequent [and

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[8] Consider a score with just 2 food groups and frequency options ranging from 1-4 days. A household scoring a "4" may be consuming one food group on four days or two food groups on two days each.

[9] A consortium of international NGOs led by CARE, CRS and World Vision implementing food security programming in Southern Africa

therefore that] low frequency of consumption of food groups rich in micronutrients" was a key factor in deficiencies.

It is in part because of such concerns that some researchers specify the nutrient-specific outcomes of specific interest, and tie those to the foods most likely to deliver the required nutrients. For example, Newby et al. (2003) constructed an index to measure diet quality on a risk gradient specific to diet-related chronic disease. For this index they used 8 'food' groups that are in fact a mix of foods and individual nutrients (total fat, saturated fat, cholesterol, fruit and vegetables, grains and legumes, protein, sodium, and calcium). These were summed into a composite diet quality score ranging from 0 to 16, and the authors found that the index is strongly related with high fiber and vitamin C intakes. Also in this domain, Rose and Tschirley (2000) devised a Mozambique Diet Quality Index, with a range from 0 to 10 representing a sum of component scores for individual nutrients--2 points each for iron, vitamin A, energy, protein, plus 2 points for the mean level of adequacy for 7 other nutrients. And Pedro et al. (1996), who focused on dietary inadequacy of Vitamin A intake, categorized foods as being high, moderate or low providers of vitamin A based on the retinol content of typical portion sizes, and found significant correlations between intake scores and biochemical markers of nutrient status among pre-school children.

Of course, school children have different absolute requirements than adults, and men have different requirements than women, and some researchers have sought to specify relationships between food groups and nutrient outcomes or diseases not only for the general population, but also for specific sub-populations of consumers. Kennedy et al. (2007), for instance, assessed whether a diet diversity score based on a simple count of food groups consumed, combined with a quantity measure (a 10-g minimum intake for each food group), can indicate micronutrient intake in non breast-fed Filipino children of 24 to 71 months old. They found that while the *average* diet consisted of 4 to 5 food groups, the best cut-off points for achieving 50 and 75% probability of adequate micronutrient intake (thereby maximizing sensitivity and specificity) were 5 and 6 food groups, respectively—for pre-school children only. Similarly, in Malawi, Gibson et al. (2003) calculated a food diversity score aimed at assessing micronutrient status in *only stunted* children ages 30 to 90 months, while Sullivan et al. (2006) used a diversity score to assess micronutrient sufficiency among severely malnourished children aged 1 to 5 years. At the other end of the age spectrum, Bernstein et al. (2002) used a dietary variety score ranging from 23 to 48 (with a specific fruit and vegetable variety score from 5 to 20) applied to the consumption of frail, elderly nursing home residents. Again, higher variety was associated with better markers of nutrition.

A second type of DD measure classifies households and facilitates judgment about their absolute dietary adequacy or well-being.[10] For example, Kennedy et al. (1995) developed a Healthy Eating Index using a score based on the degree to which respondents self-reported consumption in line with dietary guidelines (as well as validating against biochemical markers of nutrient adequacy). Similarly, Mirmirian et al. (2006) found that a constructed dietary diversity score in Iran was a useful indicator of *adequacy achieved* across 14 nutrients. But again there is a wide range of approaches used. Sometimes the reference or benchmark is defined as the a 'normal' diet for the population (when seeking to determine relative changes in patterns), while others refer to national or international standards set for adequate intake (AI), recommended daily allowances (RDA), or specific levels of micronutrient requirements (see Devaney et al. 2007 and Bondia-Pons et al. 2007).

An additional element is consideration of <u>balance among foods</u>, often measured in absolute terms against food pyramid recommendations on servings by food group. Using a Diet Quality Index to assess diet quality across countries (at the national level), Kim et al. (2003) also focus not only on food variety and adequacy, but also on overall dietary balance, as do Arimond and Ruel (2004) in their focus on "balance between plant foods and animal-source foods". Schneider et al. (2000) constructed a 'mini nutritional assessment' as a prognostic tool in hospitals that combines questions about food items and frequency, such as whether or not an individual consumes, "at least one serving of dairy products per day; two or more servings of beans or eggs per week; two or more servings of fruits or vegetables per day", and so on.

In some cases, 'balance' is defined in terms of first meeting minimum requirements in terms of energy or some other nutrient (a conditional term), and then adding diversity above that. According to Allen (2006), for instance, "dietary diversity is an especially important determinant of micronutrient intakes when animal source food intake is low." Her contention is that when animal source food consumption is high, several other conditions of 'balance' in the diet will have already been met, and hence a diversity score is only useful at certain levels of deficient consumption. Tarini et al. (1999) similarly argue that while dietary scores can be useful, "the diversity of food eaten may be a better determinant of growth status if energy intake is close to meeting dietary requirements."

[10] This method has so far mostly been used in richer countries, although WFP has adopted this approach in its VAM Household Food Security Profile Thematic Guidelines (2005).

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Operational organizations are interested in such issues, which relate to important elements of categorical indicators, for several reasons--not least because they allow for estimates of the prevalence of a particular problem. However, categorical indicators are not always more useful than a continuous score. Coates et al. (2003) found that a continuous household food insecurity score could detect more subtle changes in household food insecurity than three broad categories. The reason is that a greater magnitude of change was required for a household to shift from one entire category to the next, than to shift more subtly along the scale. Furthermore, a continuous DD score is well-suited for monitoring changes in DD over time. With a baseline, the increase or decrease in number of food groups consumed can be reported and, with a known relationship to other indicators of interest, the information can be used to predict corresponding improvements or deteriorations in dietary adequacy or other measures of household well-being.

Categories are typically created by applying cut-offs to an existing score (e.g. households with a score >5 may be considered to have sufficient dietary diversity). In the literature, these score cut-offs are sometimes arbitrary (subjectively defined), sometimes derived by splitting the score into statistical terciles, and other times arrived at using a systematic process of sensitivity/specificity analysis or ROC curves that compare the proxy indicator to some gold standard. When there is no clear gold standard, as in the case of household food insecurity measurement, 'expert judgement' or 'consensus' is relied on instead (see FANTA, 2006; Ohls et al. 1997).

The ultimate goal of food insecurity measurement is the identification of a score and categorical indicator that can validly measure food insecurity in any context, and therefore facilitate comparisons not only across time and space but also across geographic and cultural context. Much of the literature that seeks to construct and validate diversity scores begins with the *a priori* assumption that all diets are local and that any DD score is not likely to be generalizeable. For example, Lorenzana and Sanjur (1999) created their index only using 12 foods identified as being 'important in the local diet'. Indeed, both Ruel (2004) and Wiesman et al. (2006) suggest that since individual foods can be highly context-specific, food groups need to be carefully defined for each population based on their specific local diet: "cut-off points to define varying levels of diversity have to be defined in the context where they are used, taking into account local food systems and dietary patterns" (Ruel 2004, p. 3924).

However, there remains a hope that, while so-called 'process' indicators may be context specific (such as ability to make charcoal, to migrate, or to sell land), a diet diversity measure, based on common *physiological* underpinning, still has the potential be comparable across contexts. Coates et al (2006) recognized that there is a commonality to the experience of household food insecurity that appears to transcend cultural settings and experiences, since it relates (at a deeper level) to consuming or not consuming sufficient food to survive and thrive. Analysis across multiple data sets resulted in a set of generic questions that tap into this 'universality' and allow for construction of continuous and categorical indicators from 9 core questions. Similarly, the Coping Strategies Index developed by Maxwell and colleagues (Maxwell 2007) has been tested across many settings and has shown to be strongly associated with food insecurity benchmarks regardless of context. The question now is, can the same be said of indicators of diet diversity that link directly to consumption patterns, but also relate to differing degrees of household vulnerability to food insecurity?

We must acknowledge, however, that construction of dietary diversity indicators may not always represent the simple, fast, cheap alternative to other diagnostic approaches. Some studies have questioned the power of food frequency questionnaires to assess critical aspects of consumption behavior and resultant nutrient intakes—not because such approaches are not valid, but because the methods adopted in getting information from consumers will have a significant impact on the results obtained (Shaefer et. al. 2000). For example, Persson et al. (2001) conducted a study in Indonesia of the reliability of dietary intake methods using 24 hour recalls. They found that a single dietary report had relatively poor predictive power for actual consumption; two or three repeated recalls gave good results for macronutrient intake, but at least six replicates were needed to get reasonable data on micronutrient consumption. Longer recall periods may improve representativeness of the usual diet, but often at a cost in accuracy of recall. Similarly, a recent report from the US Department of Agriculture was based on a critical assessment of methods used in dietary surveys (Devaney et. al. 2007). The authors found that errors in dietary recall data—either underreporting or over-reporting of intakes—led to reported inadequacies in food intakes. And Tur et al. (2005) found that an international diet quality index was not always useful in identifying dietary inadequacies, "due to methodological factors and cultural biases." None of this invalidates DD measures, but these studies do remind us of the need for caution in the interpretation of any indicator, and for methodological rigor in collecting the data on which it is to be based.

Testing the relationship of dietary diversity to caloric or nutrient adequacy or household food security is a significant challenge. As van Dam (2005) put it, "the methodology to study dietary patterns is still developing, [and it is not yet clear] what methods will be most useful for addressing confounding factors, formulating new hypotheses on the link between diet and disease, and providing information for…interventions” (p.574). A valid assessment across contexts requires data that are collected using standardized instruments in different (ideally food insecure) locations. For instance, the Demographic and Health Surveys recently began to use a standard set of 15 food groups when collecting information on dietary patterns in their multi-topic surveys, and FANTA has recently published a guide advocating the use of those same food groups for measuring household food insecurity (Coates et al. 2006). This study is not so much concerned with taking a single, ‘standardized’ score or index and validating it for use in emergency contexts, but rather tackling two underlying, first-order objectives: 1) to identify an optimal (valid, predictive) construction, and 2) to ensure it is suitable for use within *and* across multiple food insecure contexts.

4. Methods

4.1 Analytical Strategy

The first aim of the study was to evaluate which of various continuous DD indicators (ie. in the form of an index) were most closely associated with the benchmark variable, household daily caloric intake per adult equivalent. The investigators were interested not only in associations within a particular data set, but also in the extent to which these associations were similar *across* data sets, in order to judge the universality of dietary diversity patterns as predictors of calorie intake.

The variable 'household caloric adequacy per adult equivalent' was computed from each data set (see section 4.4, below, for more detail) along with candidate DD indicators. These candidate indicators were standardized to the extent possible across each of the four data sets analyzed for this part of the study (See section 4.5 for a description of these indicators). In order to assess which of these candidate indicators did the best job of predicting caloric adequacy, first bivariate correlations (Spearman r for non-parametric distributions) were examined both among the candidate indicators and between each indicator and the caloric adequacy benchmark. The direction and magnitude of these correlations were also compared across data sets. Next, individual OLS regression models for each of the candidate DD indicators in each data set were tested, predicting household kcal per ae from the DD indicator and controlling for common confounders like household size and geographic (urban/rural) location. Next, logistic regression models for each indicator and data set tested the degree to which different levels of the candidate DD indicators increased the likelihood of a shortfall in a consumption threshold (defined as consuming at least 1800 kcals/ae, specified as a yes/no dummy variable).

A second key goal of the study was to determine whether households could be classified on the basis of their dietary diversity patterns in order to draw conclusions about the sufficiency of their caloric intake. Another goal was to explore the feasibility of applying the same cut-off (not just the same approach) across data sets, in order to make comparisons from one place to another about the households' or populations' status.

One way of doing this is to conduct a contingency table analysis comparing the classification of households above and below a cut-off on the candidate measure to households above and below a critical level of a benchmark (in this case, caloric adequacy using the 1800-calorie benchmark). There are three primary concepts of interest here: the 'sensitivity' of the indicator – the proportion of households with insufficient caloric consumption detected as such by the candidate indicator; the 'specificity' of the indicator – the proportion of households with sufficient calories detected as such by the candidate indicator; and the 'predictive value' – the proportion of households with insufficient caloric intake among all households with insufficient intake detected by the candidate indicator. The extent of misclassification is also of interest. Because contingency table analysis can be quite sensitive to the specific cut-offs chosen for the candidate index (Chung et al, 1997), in this study, the sensitivity and specificity were computed by consecutively evaluating each value on the index as a potential cut-off, using the same benchmark cut-off (did not meet 1800 kcals) throughout. This approach was chosen as an easier-to-communicate alternative to estimating receiver-operator curves (ROC), that look at the classification of one variable against another along a continuum of cut-off values, assessing the optimal relative sensitivity and specificity of one against another. In this study the sensitivity and specificity of different cut-off values were assessed against the benchmark in order to determine at which value the sensitivity and specificity were maximized. These results were then compared across data sets to see how similarly/differently the same cut-offs performed in different contexts.

An additional categorization approach was tested as an alternative to drawing cut-offs based on an index. This approach is similar to the one currently used by WFP to classify households by dietary pattern, but the WFP approach incorporates a measure of frequency of consumption over a reference week along with a simple measure of whether or not the food was consumed. None of the four data sets we used contained both kcal data AND information on the frequency of individual food consumption – this frequency information would be needed to replicate the WFP method, and the kcal data would be needed to validate it. In our approach, we constructed diet patterns based on consumption of each of five nutrient groups: carbohydrates, fruits/vegetables (non-animal micronutrient sources), fats/oils, animal protein sources, and vegetable protein sources. All patterns of nutrient group consumption adhered to by households in the sample were described using a simple pattern analysis: each of five nutrient groups were coded with a 1 if the nutrient was consumed, zero otherwise. These 5 variables were combined in a string to produce a summary of the consumption pattern for each household. We considered this approach to be more straightforward to interpret than the cluster analysis used by WFP, and we would recommend it for future work of this type. Once the various patterns were identified, the next step was to determine which of the patterns best predicted caloric consumption (in)adequacy by examining the percentage of households exhibiting each pattern that exceeded the caloric thresholds 1800 and 1600 kcals. As with all other analyses, these were performed for each data set so that comparisons in local (and universal) categorization approaches could be made.

The third objective of the study was to conduct a limited analysis of an emergency data set to assess basic issues related to the performance of DD indicators in contexts of acute food insecurity (despite the lack of calorie availability data). Recall that the original intention of the study was to examine issues related to dietary diversity measurement in emergency contexts and the relationships between dietary diversity and food insecurity indicators. After WFP decided to refocus away from food insecurity indicators more broadly to HH kcal adequacy specifically, it was necessary to identify data sets that would enable the calculation of HH kcals/ae. Because no data from an emergency context could be identified that had HH kcal/ae information, no emergency-affected/acutely food insecure populations were included in the earlier analyses described above. Despite the lack of the calorie benchmark in the emergency data, Tufts investigators felt it was worthwhile to conduct some basic assessment of issues in the performance of DD indicators in contexts of acute food insecurity.

Therefore, the following questions were tested using data collected from Darfur in 2005:

1) What is strength of the correlation of DD indicators – constructed both with and without wild/distress foods - with other food security benchmarks?
2) How does wild food consumption relate to the consumption of other types of foods? How well does it serve as a proxy for food insecurity?
3) How well does the WFP method of categorizing households by DD predict household food security?
4) To what extent do households that received food aid and those that live in camps for internally displaced persons (IDPs) have higher dietary diversity than those that do not?

Cross-tabulations and bivariate correlations were performed to assess the role of wild foods in the dietary diversity score, to examine the association among different dietary diversity indices and proxy indicators of food insecurity, and to assess the extent to which various dietary adequacy classifications also classify households as food insecure.

Multivariate linear regression analysis using ordinary least squares (OLS) was used to identify predictors of dietary diversity and, in particular, to determine whether and how food aid receipts and household displacement status (ie. camp resident or IDP non-camp resident) affects dietary diversity. A Breusch-Pagan test identified heteroskedasticity in all regression models, so each model was re-estimated using robust standard errors.

Two separate models were used to identify predictors of dietary diversity amongst all households. The first used a dietary diversity score that represented the average number of foods consumed per day (including the collapsed cereals category and excluding wild foods) as the dependent variable. The second model used a score which reflected the number of food items the household consumed per week. This indicator maintained each cereal category separately and included wild foods. Both of these models included IDP household status as a binary variable (1=IDP household living in a camp or IDP household living in a community; 0=resident household).

Two additional models were estimated to more closely analyze the effects of different variables on dietary diversity amongst only IDP households. The same outcome variables and independent variables were included in the model with one exception: IDP household status was used as a binary variable with 1=IDP households living in a camp and 0= IDP households living in a community.

It was expected that the set of analyses from this portion of the study, though not exhaustive, would be most useful for assisting WFP to determine which issues are most important in field-testing and validating an 'ideal' DD indicator for application in emergency contexts.

4.2 Selection of Data Sets

In order to enable the assessment of different DD predictors of caloric adequacy, data sets were evaluated according to the following criteria:

1) Data sets analyzed in the study were selected if they offered the means to calculate a) the benchmark, in this case household caloric intake per ae, AND b) various candidate DD indicators believed to be possible proxies for the benchmark.
2) Data sets also needed to contain information on other covariates, including urban/rural location, socio-economic status, land holdings, and household size and dependency ratio that could be constructed comparably from one data set to the next.

None of the EFSA or CSFVA data sets reviewed offered the means to calculate household caloric adequacy. For this reason, other available data sets were evaluated for the study, including a number of data sets owned by Tufts, several publicly available data sets on the IFPRI website, and LSMS data from the World Bank.

Based on these criteria, data sets from the following countries were selected for further evaluation: South Africa, Ghana, Afghanistan, Burundi, Malawi, Bangladesh, and Ethiopia. After a preliminary evaluation suggested that these data sets were suitable, work began to construct the benchmark, caloric adequacy. However, part way into the task, three of the data sets (S. Africa, Burundi, Malawi) had to be dropped after investigators encountered obstacles that impeded the calculation of the calorie variables. These obstacles included: data in an overly aggregated form that made it impossible to apply to a nutrient database for conversion from quantity consumed to calories, data collected as part of very simplified food expenditure modules that were not detailed enough to be accurate/complete, and food expenditure modules that collected information on purchased quantity using units (eg. finger, can) that could not be converted to weights and therefore not to calories. We were left with four data sets for the calculation of DD indicators and their relationship to calorie consumption: Afghanistan, Bangladesh, Ethiopia, and Ghana, as well as a data set containing different information collected in Darfur. A description of these data sets follows.

4.3 Description of data sets

Five data sets were used in the analysis for this report. This section offers a brief description of the characteristics of these data sets.

The Bangladesh Food Insecurity Measurement and Validation Study (FIMVS) was a three-year FANTA-funded research initiative intended to develop and test a process for adapting the US household food insecurity scale to developing countries. During the third survey round analyzed for this study, experienced male and female enumerators administered a detailed questionnaire to 565 of the 600 households that had participated in the prior survey rounds (35 households were lost to follow-up). The original sample was drawn from the north, center, and south regions of the country. The subdistricts (upazilas) from which the villages and households were chosen were classified primarily as 'highly food insecure' by the WFP/VAM Bangladesh mapping exercise. Implemented in February 2003, the third survey round included information on individual and household characteristics including demographics, anthropometry, morbidity/mortality, income sources, water, agricultural production, food and non-food expenditures, assets, nutrition knowledge, and household's experience with and perceptions of food insecurity. Dietary data from the survey was in the form of a 24-hour recall of individual food consumption by the female respondent in charge of meal preparation. Individual recalls were aggregated to construct an estimate for the household. In addition, enumerators provided a household food security rating of each household based on their observations.

The Accra Urban Food and Nutrition Security Study (AUFNS)[11]. This dataset was collected among households in the urban area of Accra in Ghana between January and April 1997. A total of 559 households in 16 enumeration areas in the Greater Accra Metropolitan Area were selected on the basis of including at least one child under the age of 36 months. Data were collected by the International Food Policy Research Institute (IFPRI) in collaboration with the Noguchi Memorial Institute for Medical Research at the University of Ghana, Legon. The data set includes information on household livelihoods, income and employment status; household food consumption (including detailed information on street food consumption) based on a seven-day recall; household food and non-food expenditures, assets; care practices; and the nutritional and health status of women and children. Topics in the community survey included market prices, street foods, quality of services, and NGO activity. Data for the present study were drawn from the modules on food consumption and expenditure, household demographics and coping strategies. Information about household food expenditure and consumption was based on a seven-day recall, which included detailed individual accounts of street food consumption.

The Ethiopia Rural Household Survey (ERHS)[12]. This dataset was collected from households in selected rural communities in Ethiopia in four rounds (1989, 1994, 1995 and 1997). Initially conducted in seven Peasant Associations (PAs) located in Amhara, Oromiya and the Southern regions, the last three rounds included 15 villages in various parts of the country, including the central and northern highlands, enset-growing areas in the south, and sorghum growing areas in drier parts of the country. The sample was 450 households for the first round, 1477 for the latter rounds. The nine additional communities were selected to account for the diversity in the farming

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[11] The data from the Ethiopia Rural Household Survey (ERHS) have been made available by the Economics Department, Addis Ababa University, the Centre for the Study of African Economies, University of Oxford and the International Food Policy Research Institute. Funding for data collection was provided by the Economic and Social Research Council (ESRC), the Swedish International Development Agency (SIDA) and the United States Agency for International Development (USAID); the preparation of the public release version of these data was supported, in part, by the World Bank. AAU, CSAE, IFPRI, ESRC, SIDA, USAID and the World Bank are not responsible for any errors in these data or for their use or interpretation.

[12] The data from the Accra Urban Food and Nutrition Security Study (AUFNS) have been made available by the Nutrition Unit of the Noguchi Memorial Institute for Medical Research at the University of Ghana, Legon, and the International Food Policy Research Institute. Funding for data collection was provided by the World Health Organization and the Rockefeller Foundation. IFPRI and the University of Ghana are not responsible for any errors in these data or for their use or interpretation.

systems in the country, including the grain-plough areas of the Northern and Central highlands, the enset-growing areas and the sorghum-hoe areas. One pastoralist area in Southern Ethiopia that was included in the 1989 round had to be dropped from subsequent rounds because of conflict in the area. Food consumption data were collected based on summing all purchases in the past seven days, and adding food consumed in the last seven days that was obtained from own production or draw-down of household stocks, or received as pay or gifts. Purchases, of course, might have been intended for a longer period than the week of the purchase. Given how the first part of the question was asked, respondents might have misunderstood the second and third parts and reported food received in the past seven days, even if it was not consumed during that period. The calorie intake data from this survey are somewhat suspect, therefore.

The data for the ERHS were collected by the International Food Policy Research Institute (IFPRI) in collaboration with Addis Ababa University and the University of Oxford. The data set includes information on household demographics, livelihood assets and knowledge, food consumption and expenditure, health, women's time allocation, and community level data on services and marketing. Data for the present study were drawn from the demographics and food consumption modules of the fourth round data set.

The Afghanistan National Risk and Vulnerability Assessment (NRVA) was carried out in 2005 with the aim to "to gather information to update and guide policy-making decisions in development programmes and to improve the efficacy of sectoral interventions" (Ministry of Rehabilitation and Development and the Central Statistics Office, 2007). The NRVA was a nationally representative survey, reaching 30,822 households in 34 provinces spread across Kuchi, rural, and urban areas. Dietary data for the survey was captured with an instrument that asked the person in the household primarily responsible for food preparation to report the quantity of 64 different foods consumed by the household during the previous seven days. The authors report that the amounts of food reported were only estimated, not weighed directly. Enumerators were instructed to question respondents if they reported grain and fat/oil consumption suggesting total consumption below 2100 calories per person per day; this instruction may have resulted in overestimation of calorie consumption, since low-end consumption might have been rejected. This information was used for both dietary diversity and caloric intake analysis.

Household survey data for the second part of the study were analyzed from the 2005 Darfur Emergency Food Security and Nutrition Assessment (EFSNA). The assessment was conducted jointly by the World Food Programme (WFP), the United Nations Children's Fund (UNICEF), the Food and Agriculture Organization of the United Nations (FAO) and the Government of Sudan (GoS) from 26 August to 14 October, 2005. The 2005 exercise was a follow-up to a baseline assessment which was conducted in September, 2004. The 2005 dataset was chosen for this particular study because it was more comprehensive and collected more detailed information on food security than the 2004 survey. Furthermore, by 2005, WFP had scaled-up its food aid program, and the 2005 survey collected more data specific to food aid receipt, so this data set offered the possibility of testing the effect of food aid on dietary diversity. The sample was designed to be representative of "crisis-affected" populations (as classified by OCHA in August 2005) across the three Darfur states. Populations in the sample include 'community residents', internally displaced persons living in camps, and IDPs living outside of an official camp situation. A multi-stage cluster sampling technique was used to select 30 clusters of 30 households for each state, and the total number of households surveyed was 2,090. Survey respondents were an adult male or female, usually brother or sister of the household head.

In this survey, a household was defined as, "A group of people who routinely ate out of the same pot, *and* [author emphasis] slept in the same structure or family compound (or physical location)". The WFP (2005b) report notes that individuals qualifying as household members under this definition were not necessarily relatives and may have lived (but not slept) in a different physical environment. Available dietary data from this survey include a dietary diversity module asking respondents to recall the frequency of their consumption of 12 different foods and food groups over a period of 7 days. This module includes information on the primary source of food consumed in each of these groups. Additional questions asked separately about the number of meals that adults and children consumed in the previous day.

Table 1 summarizes the characteristics of each study data set.

4.4 Calculation of Caloric Intake per Adult Equivalent

Due to differences among the data sets in how the dietary information was recorded, each of the four data sets used for the bulk of the study required slightly different approaches and assumptions for the construction a caloric adequacy variable. In the sections that follow, we summarize the approaches and assumptions for each data set.

4.4.1 Bangladesh: Bangladesh Food Insecurity Measurement and Validation Study (FIMVS)

Calorie consumption was derived from a 24-hour recall administered to the female head of household or main food preparer, who estimated amounts prepared at home, and the portions for each member or guest consuming the meal. Quantities of foods as consumed were converted to calories using appropriate food composition data bases.

First each individual household member's caloric needs were estimated based on age, gender, and physiologic status (pregnancy/lactation). Rather than using the body weight of individual, the Bangladesh population's average weight is taken[13]. Medium body frame and medium level of activity was assumed. For women who were identified as pregnant or lactating, an allowance for the extra calorie needs (e.g. 285 kcal for pregnant women) was added. For the children between 6 months and less than ten years old, the child's age and gender were used to determine the calorie requirement. The children less than 6 month old are excluded from the analysis since there is no information on their breast milk consumption or food allocation. Each individual's calorie requirement was divided by caloric requirement of an adult male with average weight and moderate physical activity level, age between 30 to 60 years old, considered to be 1.0 adult equivalent. The following is an example of how the adult equivalent size of household.

In this data set, information was collected on guests in the household. The presence of guest requires special treatment. Guests often did not share all three meals in the households. In this case, adding the caloric n the calorie availability per adult equivalent per day. Therefore the presence of guests was considered meal by meal. In most cultures, calories consumed at daily meal are not equal to each other (e.g. breakfast can be lighter than the lunch and perhaps lunch is lighter than dinner). In the data from Bangladesh we found that 30%, 35%, and 35% of total caloric intake were taken at breakfast, lunch and dinner respectively by using household heads'

[13]The average weight per each age and gender group is taken from "Measuring household food consumption: a technical guide", (Swindale and Ohri-Vachaspati 2004).

meal pattern[14]. The weight of each meal's calorie was factored in the calculation for the guest's caloric need. For instance, a 30 year old male guest who was present for breakfast and lunch is considered as .65 adult equivalent.

4.4.2 Ghana: The Accra Urban Food and Nutrition Security Study (AUFNS).

The caloric adequacy variable was constructed from a food expenditure and consumption module that took into consideration food purchase, home production, food gifts, remittances of food into and out of the household, and changes in food stocks over a seven day period. Given the complexity of food preference, this module was extensive, and covered a vast array of street foods that had to be collected on an individual by individual basis, not a household basis. In total, street foods accounted for about 1/3 of total consumption. A variety of common measures were used to estimate quantities of food, which were then converted into weights, and each item was given a caloric value per 100 grams using a locally applicable nutrient database. Food consumption at the household level was then divided by the number of adult equivalent units in the household to get an estimate at the ae level. This estimate included in the calculation of calories per adult equivalent guests and the number of days out of the past seven that such guests consumed food in the household. Street food consumption by individuals was aggregated into the household total.

One issue in the Ghana data set was that mixed dishes could not be disaggregated into their component ingredients, so that such items were categorized according to the ingredient that was presumed to provide the greatest proportion of calories.

4.4.3 Ethiopia: The Ethiopia Rural Household Survey (ERHS).

The caloric adequacy variable was derived from a food expenditure questionnaire that asked households to recall, over the previous 7 days, whether they had purchased any of 34 common foods for consumption or consumed these foods from their own stock or from food received as pay or gifts. The questionnaire collected a) the quantity of foods purchased, b) quantity of foods consumed from household stock, and c) foods received and consumed from gifts, in-kind wages, or barter. A few prepared dishes were also included. Because the amounts of foods were recorded using local units (eg. chinet, dawla), a conversion file, included with the IFPRI data set, was applied to convert the local unit amount of each of the different food items into kilograms. Next, the amount consumed for each food item was converted to calories using a nutrient

[14] The male household head who had breakfast, lunch, and dinner was selected. The average contribution of breakfast to the calorie was .30. that of lunch and dinner was .35.

database obtained from the Ethiopian Health and Nutrition and Research Institute (EHNRI)[15] that adjusted appropriately for edible portion, supplemented with the FAO Infoods data base for Africa when necessary. The calories for each food item were summed to obtain a total household value. Once total calories consumed by the household was calculated, this figure was adjusted by the age/sex composition of the household using adult equivalent (AE) conversions based on calorie requirements by age/sex category listed in WHO/FAO (1985).

Though the process sounds simple enough, there were several challenges with this data set in deriving calories from a module that was designed primarily to calculate food expenditures. The calorie estimates derived from these data were high and extremely variable and did not behave as expected. There are several possible explanations for these results. For instance, this type of module does not include information on guests (or day laborers) who may have eaten with household members. Additional food is typically purchased to feed guests, but we had no way to count these additional individuals in the per capita or per ae calculations. This of course inflated the number of calories actually eaten by household members. Second, the structure of this module was difficult for respondents to understand, in that it asked about purchases in two different ways – in the second way, it did not specify clearly that the interest was in purchases that were *consumed in the previous 7 days*. Given the wording of the questions, it is probable that respondents were reporting food that entered the household, not what they actually ate during the previous week. In other words, bulk purchases that were intended to feed the family over time were lumped together with smaller purchases that were actually consumed by the family within the 7 day recall period. In order to account for these lumpier expenditures, reported items weighing more than 25 kgs were dropped from the analysis. In the final calculation, the distribution of consumption was truncated at kcals per AE higher than 8000 and lower than 500, meaning that households with totals in this range were excluded as biologically implausible outliers. These same cut-offs were used in all four data sets.

4.4.4 Afghanistan: Afghanistan National Risk and Vulnerability Assessment (NRVA).

The NRVA report (Johnecheck and Holland 2005) describes computation of caloric intake as follows. "Caloric intake was estimated by converting consumed weights by the caloric values listed in the FAO's Food Composition Tables for the Near East. Caloric figures were adjusted by using standardized amounts to account for partial wastage and refuse (labeled as the 'as

[15] Food Composition Table for Use in Ethiopia, Part IV. A Research Project Sponsored Jointly by the Ethiopian Health and Nutrition Research Institute (EHNRI) and the Food and Agriculture Organization of the United Nations (FAO), 1995-1997.

purchased' caloric equivalents in the FAO's table). These figures were then adjusted by age and sex composition of the household in order to calculate household caloric sex and age adjusted daily per capita intake levels. Adjustment was made for guests by taking the average adult equivalent value for a person in the sample, and adjusting for the number of times a guest ate in the household in the past week. The mean consumption level estimated using this method was very close to the mean reported in the NVRA report. Because the food was not weighed during the assessment, the data only provided rough caloric estimates for the household and are not adequate for calculating the dietary intake of other nutrients"

These data were collected immediately following a record harvest. In addition, instructions on the survey instrument stated that households should report a minimum amount of food consumed (estimated in a table by household size and composition) in order for the reports to be plausible. We believe, therefore, that the calories are overestimated, as enumerators were required to report a minimum amount of consumption per household before submitting their completed surveys.

4.5 Calculation of Candidate Dietary Diversity Indicators

An often underestimated challenge in the construction and testing of DD indicators is to ensure that the choice of comparator benchmark (for validation purposes) is driven by a clear sense of *what* is being measured (is it energy adequacy, all-nutrient adequacy, 'household food security', socioeconomic status?), and *why* (how will the measure be used?). In this study, WFP was interested in testing dietary diversity primarily as a short-cut to assessing nutrient adequacy. Nutrient adequacy represents both 'sufficiency' (calories) and 'quality' (macro and micronutrients) dimensions of household food insecurity. Though nutrient adequacy was of primary interest, other nutrient intakes aside from calories were considered by WFP to be too difficult to estimate accurately from available data. As a result, the decision was taken to limit the benchmark variable to 'caloric adequacy' only. This decision has obvious implications for the approach taken to select data and to construct candidate proxy indicators of dietary diversity – in essence, candidate dietary diversity indicators were constructed that were thought to best predict calories (eg. using only calorie dense food groups); therefore other constructions that might better predict dietary *quality* were not tested.

Five candidate dietary diversity indicators were constructed for testing for the first part of the study. The first indicator, Unique Foods, was constructed by creating an index from all food items that had been reported as consumed. All items were equally weighted and then summed. Because the different data sets asked about different numbers of food items, the total possible score for this indicator varied by data set. Though the scores of the Unique Foods indicator are not directly comparable across these data sets, the associations between Unique Foods and household kilocalories per ae are. The second candidate dietary diversity indicator was 'DHS Food Groups', an equally weighted index of those food groups out of the 12 standard DHS groups from which at least one food item was consumed. Table 2a lists the food groups that comprised the DHS Food Group index. In assigning foods to food groups, often the choice of which of the DHS groups the food belonged to was obvious. However, at times the food items were actually listed not individually but as prepared or processed foods with more than one ingredient. In such cases, foods were assigned to the group based on their primary ingredient (that is, the ingredient providing the bulk of the calories). The third indicator was Nutrient Groups, an index of consumption of key nutrient groups, comprised of a possible five categories – carbohydrates, fat, non-animal sources of micronutrients (i.e. fruits and vegetables), animal protein, and non-animal protein (vegetables, e.g. pulses). We felt that this index stood the best chance of having universal properties, given that it was the most generic of the five. Two other indicators were calculated that we thought might best approximate calories. Calorie Dense Food Groups is an index of only those DHS food groups consumed that were particularly calorie dense. These food groups are shown in Table 2a: cereals, roots/tubers, fats/oils, sugar/honey, pulses/nuts, and animal foods (meat, eggs, dairy, etc). . Calorie Dense Unique Foods follows the same logic, but is the sum of all unique foods drawn from these calorie dense groups.

4.5.1 Darfur Dietary Diversity Indicators

To assess food consumption and dietary diversity, the Darfur survey asked respondents to report the number of days in the past week the household consumed particular foods/food groups[16] from a list of twelve items. Table 2b summarizes the variable names, definitions, and constructions of the dietary diversity indicators created and tested from these data. It should be noted that all indicators weighted each of the foods/food groups equally. The first indicator (DDavg) was an average of the number of food items consumed per day. The score for this indicator was calculated by summing the number of days of consumption of each food and dividing by 7. The maximum score possible was 12, if foods from all 12 groups were consumed every day. There was a potential issue with the 'wild food' group being included in this indicator, since the consumption of wild foods could inflate dietary diversity but be negatively associated with nutritional adequacy. Therefore, a second indicator (DDavg_nowild) was developed that was

[16] List of 12 foods/food groups: sorghum, millet, other cereals, groundnuts/legumes, meat/chicken/bush meat, cooking oil/fats, vegetables, fruits, milk/yogurt/cheese, sugar, eggs, wild foods.

identical to the first without the information on wild foods. Because sorghum, millet, and other cereals were individually listed, but most other foods were listed by group, there was concern that the first two indicators would overestimate the household's true dietary diversity. Therefore, a third indicator (AvgDD2) was calculated by collapsing the sorghum, millet, and other cereal categories and calculating the average number of days per week that any one of the three items was consumed. Then, this value for the new comprehensive cereal group was added to the sum of the number of days the other listed food items (excluding wild foods) were consumed and divided by seven. The maximum score possible for this third indicator was 9.

Though the third indicator was used in the majority of analyses, three additional and more conventional indicators were included for comparison. The variable, 'Allfdssumwk' was an average number of different food items consumed *at all* per week was calculated by summing the number of all foods/food groups that the household reported consuming at least once per week. If a household had consumed all listed foods at least once in the past week, they would have achieved a maximum score of twelve. This same indicator was slightly recalculated to exclude the wild foods group and was renamed 'Allfdssumwk_nowild'.

An average number of different food *groups* consumed per week (allfdgrpwk) was also calculated by collapsing listed food items into five food groups[17] and summing the number of food groups the household reported consuming at least once per week. If the household consumed all five food groups in the past week, they would have achieved a score of five.

4.5.2 Darfur Dietary Adequacy Categories

In addition to dietary diversity scores, households were classified based on their dietary adequacy as proxied by collapsing food groups from the survey into their primary nutrient source. Because the survey did not collect a detailed diet history at the individual level, nor did it collect information on quantity or frequency (per day) of consumption, it was not possible to assess nutritional intake and make comparisons with established caloric and nutrient standards. In WFP's 2004 Emergency Food Security and Nutrition Assessment (EFSNA) in Darfur, 'minimum' consumption was defined as daily consumption of one source of carbohydrate (i.e. sorghum, millet or wheat), one source of protein (pulses, egg, meat/poultry), one source of fat (oil, or cooking fat) and sugar (considering the social importance of coffee and tea).

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[17] 5 food groups: cereals (includes sorghum, millet, 'other' cereals), protein (includes groundnuts/legumes, meat/chicken/bush meat, eggs, milk/yogurt/cheese), fat (includes oil), fruits and vegetables, and sugar. Sugar was included as a separate category because that is how the WFP EFSNA defined it.

This analysis employed the same definitions, with one exception: milk, yogurt, and cheese were included as sources of protein. However, because the WFP classification system does not account for the importance of micronutrient intake from fruit and vegetable sources, a second indictor was defined as daily intake of at least one source of carbohydrate, one source of protein, one source of fat and one fruit or vegetable. A similar, but less strict indicator was also developed, which defined minimum consumption as daily intake of at least one source of carbohydrate, one source of protein and one source of fat, but consumption of fruits or vegetables was only necessary three or more times per week. Both of these indicators excluded sugar in its definition of minimum consumption. A more simplistic indicator that defined minimum consumption as daily intake of at least one source of carbohydrate, one source of protein, and one fat was also included.

4.6 Limitations

The analysis was severely constrained by four main factors: a) a paucity of rigorous empirical survey data on food consumption from true emergency settings, b) a complete lack of dietary data that could be used to calculate household caloric adequacy in any of these emergency data sets, c) a shortage of dietary intake data (rather than merely expenditure data), even in non-emergency settings, and d) in any survey that did have dietary intake data, there was a lack of accompanying food frequency information with which to calculate frequency weights for the construction of potentially useful dietary diversity indicators. A wide number of surveys were considered for this analysis, most of which had to be discarded for one or both of these reasons.

This last data limitation prevented the construction and validation of DD indicators using the current WFP method for classifying households according to their dietary diversity patterns, since the WFP method uses information on the frequency of food/nutrient group consumption over the previous week in order to perform this classification. The 'WFP method' was replicated using the Darfur data and tested with various other indicators of food insecurity aside from caloric adequacy.

5. Results

Analysis of the usefulness of Dietary Diversity as an indicator of caloric adequacy depends on having accurate assessment of household caloric consumption. The data from Bangladesh were based on 24-hour recall of quantified consumption data; the data from Ghana were based on a seven-day recall of household consumption, as were the Afghanistan data. Information on calories in Ethiopia was imputed from seven-day recall of purchases and of consumption from own production/stocks and gifts/pay. Concerns about the accuracy of these methods are discussed above. Furthermore, the samples are quite different as well. The Ghana data were collected from an urban sample, not selected to be low income or vulnerable, while the other data sets are entirely or almost all rural (see Table 3) and biased toward low income. None, however, was an emergency or crisis-affected population at the time of their respective surveys. The differences in geographic context and in data collection method should inform any interpretation of the results presented here.

5.1 The Sample

Table 3 shows the characteristics of the samples from the four countries, demonstrating clearly how different they are in many respects. Average household size ranges from 5 members to 5.9. In Ghana, only households with children under 36 months were included. In the Bangladesh sample, 43.7% of households had children under five; this proportion was somewhat lower for Ethiopia and Afghanistan. Female headship is rare in Bangladesh (5.4% of households) and Afghanistan (1.75%), but not uncommon in Ethiopia (24%) and Ghana (35%). The Ghana sample was 100% urban (all living in the capital city of Accra); the Bangladesh sample was almost entirely (93.7%) rural, and the Afghanistan and Ethiopia samples were drawn from rural areas, in Afghanistan representing about 80% of the population. Land ownership is about zero in the urban Ghana sample; it is very high (94%) in Ethiopia, and more balanced for Afghanistan (39% of households have some productive land) and Bangladesh (56%). For those that do have productive land, the amount of land varies widely among the three countries: about six acres in Ethiopia and Afghanistan, but only .8 acres in Bangladesh. Note also that the sample size for Afghanistan, over 29,000 households, is widely divergent from the other three studies (about 1,000 for Ethiopia; about 550 for Bangladesh and Ghana). The large sample size means that some results will be statistically significant even if they are small in functional terms.

5.2 Measures of Dietary Diversity

The measures of Dietary Diversity were described earlier. They are: DHS Food Groups; Nutrient Groups; Calorie Dense Groups; and Unique Foods and Calorie Dense Unique Foods.

5.3 Dietary patterns

In Ghana and Bangladesh, 100% of households consumed a cereal grain; close to 100% consumed some oil or fat, and almost all consumed some vegetables or fruits. Within these similarities, there are notable differences. Within the carbohydrate group, diversity was much higher in Ghana than in Bangladesh. Ghanaians consumed 13 different foods in the carbohydrate group: eight different cereals, and four different roots and tubers, compared with only one of each type in Bangladesh. The number of households consuming roots/tubers and sugars was lower in Bangladesh as well. The same pattern is repeated in the protein group: in the Ghana sample, the median number of different protein foods consumed was seven, compared with two in Bangladesh, and pulses, meat, fish, milk, and eggs were all consumed by a much lower fraction of Bangladeshi households than of Ghanaian ones. In Bangladesh, all households consumed some vegetables, but only 16 percent consumed any fruits, while over 90% of Ghanaian households consumed both fruits and vegetables.

Virtually all households in the Afghanistan and Ethiopia samples consumed cereal grains, but far more Afghan households consumed roots, tubers and sugars than was the case in Ethiopia. This means that diversity within the carbohydrate groups was higher in Afghanistan than in Ethiopia. A much lower proportion of households in Ethiopia consumed any major protein source: 59%, compared with over 90% in Afghanistan. Most households in Afghanistan consumed animal source protein: meat, or milk, while fewer than half the households in Ethiopia consumed milk, and fewer than one in five consumed meat. (Fish was not a significant food in either country.) Close to 90% of households in both countries consumed vegetables, on average two different types; but almost half of Afghan households consumed fruits, while under 15% of Ethiopian households did. Table 4 shows these results in detail.

All measures of diet diversity show the same pattern across countries, with Ghana the highest, followed by Bangladesh, Afghanistan, and then Ethiopia. Ghana shows a higher number of unique foods within each food group than any of the other country samples. Compared to the other three countries, Ghana has a very diverse diet. In addition, the high level of diversity in Ghana no doubt reflects the urban location and the fact that the sample was not selected to be low income. Given this higher diversity in unique foods, it is not surprising that the Ghanaian sample showed higher dietary diversity by all the measures tested (Table 5). On average, they consumed 10.4 food groups out of 12, compared with seven for Bangladesh, 6.7 for Afghanistan, and 4.6 for Ethiopia; and 33.5 unique foods, compared with only 13.7 in Bangladesh, 11.3 for Afghanistan, and 8.5 for Ethiopia. When we consider Nutrient Groups, we might expect the numbers to be much more similar, and this is largely the case: number of Nutrient Groups is 4.9 for Ghana, 4.1 for Bangladesh, and 4.2 for Afghanistan, but only 2.8 for Ethiopia. Although dietary variety within categories is much higher in Ghana, diets in three of the four countries tend to contain the major nutrient sources – carbohydrates, fruits/vegetables, a source of fat, and a protein source (animal or vegetable). Ethiopia is the exception, with lower variety than the other countries at the level of Food Groups, Nutrient Groups, and Unique Foods.

Table 5 shows the degree to which these measures are associated with greater caloric adequacy. These results show a consistent pattern, with higher scores on any indicator associated with higher categories of caloric intake, in all but the Ethiopian data. These differences are significant except for Nutrient Groups, where, as we noted before, the differences among countries are small, and the differences in Nutrient Group score among calorie intake categories are also small. This may mean that this indicator of number of aggregated food groups discriminates less well than the other indicators, in particular number of food groups out of 12 (DHS Groups), or number of unique foods. Because households apparently preserve their basic dietary pattern (as reflected in Nutrient Group score) even at lower levels of calorie intake, we may speculate that a shortfall in this indicator may be an indicator of severe distress not observed in our samples. In the Ethiopian sample, none of the DD indicators constructed on the basis of food groups was significantly different by category of caloric intake; only the measures based on unique foods showed a consistent and significant relationship with level of caloric intake per adult equivalent. Recall, though, we question the validity of the calorie data from Ethiopia.

While the patterns are the same, the proportion of the population falling into each category of calorie intake is markedly different among the four countries. The average caloric intake per adult-equivalent in Bangladesh is 1601 (median 1407), while in Ghana, the mean is 2606 (median 2331); the figures are 3037 (median 2893) for Afghanistan and mean 2350 (median 1907) for Ethiopia. We find the figures for Afghanistan unreasonably high given the context in the country, despite the fact that these data were collected immediately after a very good harvest. The figures for Ethiopia are more plausible, but as we will see, they are highly variable and often inconsistent. As discussed above, the way consumption data were collected in the Ethiopian survey resulted in unreliable estimation of weekly intake; the method for Afghanistan had a serious risk of overestimating consumption.

Only 32 percent of the Bangladeshi households consume at least 1800 kcals/adult equivalent (ae), while 73 percent of those from Ghana do. These figures are plausible, given the differing populations from which the data were drawn. The figures for consuming at least 1800 kcals/ae are 92% for Afghanistan, and 53% for Ethiopia. Despite the fact that recommended caloric intake for an adult-equivalent is similar in these populations, falling below 1800 kcals per day represents relatively severe hardship in Accra, while it is the norm for the Bangladesh households in this sample. It is unclear how to interpret the figures for Afghanistan and Ethiopia, given our uncertainty about the reliability of the calorie figures.

Table 6a-c presents these results in more detail, broken down by individual score on three indicators: DHS Groups, Nutrient Groups, and Calorie Dense Food Groups.

5.3.1 DHS Food Groups

In the Bangladesh sample, not a single household consumed fewer than four food groups, and only 2.4 percent consumed as few as four. Most people consumed between five and nine food groups. The relationship between number of food groups and percent consuming 1800 kcals/ae or more is consistent: the percentage rises from 5.7% for those consuming only five, steadily to 53% for those consuming foods from nine food groups. Above nine, almost no one is in the lower calorie categories – but fewer than five percent of households consumed foods from ten or more groups. In Ghana, the picture is similar at the low end: fewer than three percent of households reported consuming foods from five or fewer groups (none consumed a single food group), and these households are almost universally in the lower calorie categories. Far more of the Ghana households consumed a wider variety of foods. Almost 30% consumed foods from all twelve groups, and another 28% consumed foods from 11 of the 12. Less than a quarter of the sample consumed fewer than ten food groups. Still, there is a consistent relationship between this indicator and the likelihood of consuming 1800 kcals/ae: the percent of households in this higher consumption category is 20% for those consuming 8 groups, rising to 82% for those consuming 11 or 12, a very marked relationship.

Fewer than six percent of households in Afghanistan consumed three or fewer food groups, and fewer than three percent consumed ten or more. The relationship between number of food groups and the likelihood of consuming at least 1800 calories is consistent, rising from 55% of those consuming only one group (less than half of one percent), to 96% of those consuming ten, and 100% of those consuming eleven groups. Only at the level of six food groups or above does the proportion of household achieving 1800 calories reach the population average of 92%. The picture is somewhat different for Ethiopia. Less than one percent of the sample consumed nine or more food groups, but six percent reported consuming only two. Most consumed between three and six. No consistent pattern emerges between number of food groups and the likelihood of consuming more than 1800 calories: the figure is about 52% for every group except the lowest and highest; for both of these, one third of the small number of households in the category, reported being in the highest calorie category. Again, the relationships are quite consistent except for Ethiopia, where we question the calorie figures.

5.3.2 Nutrient Groups

Essentially no one in Bangladesh reported consuming only two nutrient groups: two households, both below 1600 calories. Between three and five nutrient groups, the percentage falling into the highest calorie intake category rises steadily from 14% for three to 50% for five. Fifty seven percent of households consumed food from four nutrient groups, but only 27% of this group is in the high consumption category; these figures are reversed for those consuming all five nutrient groups: 28% have this DD indicator score, but over 50% of them are in the highest consumption category. Only above four nutrient groups did more than half the households consume at least 1800 calories. In Ghana, only the top two scores are represented, and the percent of households in the highest calorie category rises from 63% to 75% as the DD score rises from 4 to 5.

Because of the large numbers in the Afghan sample, we find households representing all five DD scores. The percent of households consuming 1800 calories or more rises systematically from 59% for the lowest score to 95% for the highest. Among the Ethiopia households, the nutrient group indicator is a poor discriminator except for the highest score: 69% of households consuming from all five nutrient groups consumed 1800 calories or more, compared with about 50% for all the other groups.

5.3.3 Calorie Dense Food Groups

We see much the same pattern with the Calorie Dense Food Groups indicator. In Bangladesh, the percent of households in the highest calorie consumption group rises monotonically from 9.3% in the group consuming two, to 69% in the group consuming all six of the calorie dense food groups. In Ghana, the comparable figures are 33% for those consuming three groups (representing two percent of the sample), to 81% of those consuming six. In both cases, consuming more than four groups is a marker for more than half the households being in the highest group. In Afghanistan, over half the households consumed at least 1800 calories at every score level, but the relationship between this percentage and the DD score is consistent: 63% for the lowest score of 1, rising to 96% for the highest score of 6. Since 92% of households in this sample report consuming 1800 calories or more, the lower categories are an indicator of below average calorie consumption. Once again, the results for Ethiopia do not conform to the pattern: there is no consistent relationship between Calorie Dense Food Group score and percent of households consuming 1800 calories or more.

5.4 Pattern Analysis

We used the Nutrient Group indicator to create a set of descriptors for different dietary patterns among the sample households, based on whether they consumed anything from each of the five nutrient groups: carbohydrates, fruits/vegetables, fats, animal protein sources, and vegetable protein sources (see Table 2a for the composition of these groups). These results are shown in Table 7. In Bangladesh, the two commonest patterns were consuming all the nutrient groups (153 households, or 28%), and consuming all the groups except vegetable protein (288 households, or 52%). About five percent of households consumed all the groups except for animal protein, and about 14% consumed carbohydrates, fruits/vegetables, and fats, but no protein source. Not surprisingly, the groups that lacked one or both protein sources were more likely to be in the groups consuming less than 1800 calories per adult equivalent per day: 85% of those with no protein source, 67% of those with no animal protein, and 72% of those with no vegetable protein. Mean calorie consumption showed a similar consistent pattern: about 1260 for those with no protein source; about 1550 for those with only one of the protein sources, and 1922 for those consuming foods from all five groups. It does not appear that animal versus vegetable protein sources are an indicator of better or worse dietary circumstances in this sample. Among households consuming foods from all five nutrient groups, about half consumed below 1800 calories, and about half were at or above that level. Consuming all five nutrient groups is strongly associated with a higher likelihood of being in the higher calorie consumption category, since overall, only 32% of households consume more than 1800 calories/adult equivalent/day.

These results present a stark contrast with Ghana, where 88% of households consumed foods from all five nutrient groups, and about nine percent consumed all but a vegetable protein source, with insignificant numbers demonstrating any of the other patterns. These two patterns show a modest relationship with calorie intake: those consuming foods from all five groups consumed an average of 2667 calories, compared with 2437 for those lacking a vegetable protein source – too close to be considered different. Of those consuming from all five groups, 75% consumed at least 1800 calories, compared with 67% of those lacking a vegetable protein source. There is a suggestion in the data that perhaps consuming from all five nutrient groups implies higher calorie intake, but neither group showed calorie deficiency. Overall, 73% of households in the Accra sample consumed at least 1800 calories per adult equivalent per day. Since so few different patterns were represented in the Ghana sample, the Nutrient Group indicator is not very sensitive to different levels of calorie intake, although we may speculate that households consuming fewer than four groups (that is, entirely missing a major nutrient group source) might show more severely limited food adequacy.

In Afghanistan, the modal pattern is consumption from all five nutrient groups: 47% of households are in this category, and of these, 95% consume at least 1800 kcals per AE (Recall that overall, 92% of Afghan households reported consuming above this level.) The next commonest pattern is consumption of all foods except vegetable protein (27%); only 4% were missing only animal protein; in both these patterns, 92% of households, the average for the sample, consume at least 1800 kcals/ae. Of those missing both vegetable protein and fruits/vegetables, a relatively small number (4.4%), 89% consumed at least 1800 kcals/ae, Of those consuming only one or two Nutrient Groups, only 75% consumed at least 1800 calories/ae, and of the very small number consuming only cereals, 59% reached the 1800 kcal benchmark. These results suggest that, despite the apparently high caloric intake in this sample, considerably lower calorie consumption is associated with a very restricted number of Nutrient Groups in the diet.

In Ethiopia, the modal pattern, reported by 27% of households, was to consume only two Nutrient Groups: carbohydrates and fruits/vegetables. In this group, 56% of households consume at least 1800 kcals/ae, compared with 53% of the total sample. The second most common pattern (25% of households) was to consume cereals, fruits/vegetables, and animal protein, but no fat source or vegetable protein. In this group, 45% report consuming at least 1800 kcals/ae. Fewer than five percent of households reported consuming food from all five Nutrient Groups, and among these, 69% reported consuming at least 1800 kcals/ae, suggesting a positive relationship between Nutrient Groups and calorie consumption. But, as mentioned earlier, we consider the calorie intake information from Ethiopia to be unreliable.

5.5 Relationships among the Indicators

We would expect that the five candidate indicators would be closely related to each other, and this indeed is the case. All the indicators show fairly high and very significant correlations in both countries. Table 8-1a -d shows the correlations among the five indicators for each of the four countries. The correlations among indicators in Bangladesh range from .86 (between Calorie Dense Foods and Calorie Dense Groups), to .46 - .51 for Nutrient Groups with Unique Foods, Calorie Dense Groups, and Unique Dense Foods. The correlation of Food Groups with Unique Foods is .79 in Bangladesh. For Ghana, the range is similar, from .9 to a low of .33, but more of the correlations are on the lower side. The weakest correlations in the Bangladesh data are between Nutrient Groups and Unique Calorie-dense Foods, and between Nutrient Groups and Unique Foods, and the strongest are between Unique Calorie-dense Foods and Calorie-dense Food Groups. The pattern is somewhat different in Ghana, where the correlations between Food Groups and Nutrient Groups and between Nutrient Groups and Unique Foods and Unique Calorie-dense foods are much weaker. The Nutrient Groups indicator in particular shows lower correlations with all the other DD indicators. The correlation between food groups and Unique Foods is .68. In both the Afghan and Ethiopian data sets, correlations among the five indicators are consistently quite high: the lowest is .68, and the highest is .88 for Afghanistan, and they fall between .67 and .85 for Ethiopia. The correlation between Food Groups and Unique Foods is .88 in Afghanistan and .83 in Ethiopia.

These relationships suggest that all the indicators do measure aspects of the same underlying phenomenon of dietary diversity, and they capture much of the same information. It is fairly consistent that the Nutrient Groups indicator shows somewhat lower correlations with the other indicators. The key question, though, is how well these indicators relate to the outcome of interest, calorie consumption per adult equivalent.

5.6 Relationship of DD Indicators to Calorie Intake

Table 9 shows the correlation of each DD indicator with household caloric intake per capita in each country. Graphs 1-4 (a-e) show the distribution of caloric intake according to each DD indicator for each country, with the best fitted regression line for the relationship.

For all the countries except Ethiopia, all the correlations of the DD indicators with calorie consumption are positive and highly significant, although they are consistently lower than the correlations among the indicators themselves. In Bangladesh, they range between .3 and .39, and between .16 and .41 in Ghana. In Afghanistan, the correlations range from .22 to .35.

Correlations are somewhat lower for Nutrient Groups (Afganistan) or Calorie Dense Groups (Bangladesh, Ghana), than for the DD indicators that have a wider range of variation (DHS Food Groups, and the two measures incorporating unique foods.) It may be that households preserve a broad dietary pattern to include at least some food from most of the major food groups, under normal circumstances. Recall that none of these populations was in a crisis or emergency situation.

The strongest correlations with calorie intake are for DHS Food Groups, Unique Foods, and Calorie-dense Food Groups in Bangladesh, and with Unique Foods, DHS Food Groups, and Unique Calorie-dense Foods in Ghana. In Afghanistan, the highest correlations are with Unique Foods and Unique Calorie Dense Foods. There is no consistent pattern as to which indicator shows the highest correlation with calorie intake. For Bangladesh, all the indicators except Nutrient Groups have very similar correlations, .37 to .39. In Ghana, the highest is with DHS Food Groups, while in Afghanistan the highest is with Calorie-dense Unique Foods.

The correlations of the DD indicators with calorie intake in Ethiopia raise serious questions (as discussed before) about the validity of the calorie intake indicator. All but one of the DD indicators show correlations that are very low and not significantly different from zero. We find this result implausible. The Ethiopia questionnaire was ill-suited to capturing dietary intake, and, in light of the consistent results for the other three countries, calls into question the calorie intake measure rather than the value of the DD indicators.

The accompanying graphs demonstrate that, with the exception of Ethiopia, there is a consistent positive relationship between each measure of DD and household calorie intake per adult equivalent, though the relationship is somewhat tempered by the very wide variability in calorie intake at each level of the indicators.

These results demonstrate that, except for Ethiopia, the DD indicators do behave as would be expected for measures of diet quality or adequacy.

5.7 Relationship of Indicators to Other Household Characteristics

Table 8-2a-d shows the bivariate nonparametric correlations between the various DD indicators and key household characteristics. All the indicators show the expected positive, significant relationships with food expenditure per capita and negative relationships with food share of total expenditure. Female headship is consistently negatively associated with all the indicators of dietary diversity in Bangladesh (where female headship is an indicator of hardship), but not significantly related to any of the indicators except DHS Food Groups in Ghana. In Ghana, we were able to calculate a Coping Strategies Index (CSI) score. The higher the score, the greater the level of coping – hence a greater level of food insecurity and an expected negative correlation with dietary diversity. All the diversity indicators show the expected negative relationship with the CSI, with the exception of Nutrient Groups (where it is not different from zero) – once again indicating that the Nutrient Groups indicator is perhaps less responsive to changes in a household's circumstances than the other indicators, within the normal (non-emergency) range. In fact, Nutrient Groups generally show somewhat lower correlations with household characteristics (food expenditure, food share of expenditure) than the other DD indicators. Bangladesh was the only sample for which we had a direct measure of food insecurity (the female enumerator's judgment of whether the household was food secure or not). Being food secure showed a consistent, highly significant correlation with dietary diversity by every measure; the range of values was .37-.39 except for nutrient groups, where the correlation was .30, still highly significant.

In Ghana, all the households were urban. In Bangladesh, about five percent of the sample was classified as urban, but urban location showed no significant relationships with any of the indicators (or any other household characteristic). Owning productive land, though, was positively and significantly related to all the dietary diversity indicators in Bangladesh, though the correlations were not high (.10 to .16).

In Afghanistan, household size is consistently positively correlated with diet diversity, as is food expenditure per capita. Owning productive land shows a consistent, highly significant, though low *negative* correlation with all the DD indicators (recall the large sample size allows even weak relationships to reach statistical significance); perhaps depending on home production results in lower market participation and thus a less varied diet. This relationship would be worth exploring further. Female headship is not significantly related to any of the DD indicators in the Afghanistan sample, despite the plausible expectation that female headship is a sign of food security risk.

We have seen that four of the five DD indicators showed no relationship with caloric intake in the Ethiopia sample. However, all the DD indicators showed very significant positive correlation with food expenditure per capita and with household size, and negative relationship with female headship.

5.8 Indicators as Predictors of Calorie Intake

We tested the strength of each indicator as a predictor of calorie intake per adult equivalent using multiple regression, first with calories as a continuous variable, and then using logistic regression to predict whether a household fell at or above, or below the cut-off of 1800 calories per adult equivalent.

In both the Bangladesh and Ghana samples, all the indicators were very significantly associated with calories consumed ($p<.000$ for all indicators), after adjusting for a few easily observed household characteristics (Table 10a-e). Table 11 shows the results of the multivariate OLS regression of all four countries. In both Bangladesh and Ghana, the percent of variance explained (adjusted R-squared) was highest for Number of Unique Foods, and lowest for Nutrient Groups. There is a striking difference between the two countries in the explanatory power of all the DD indicators. In the Bangladesh sample, the adjusted R-square values range from .35 to .53, and the standardized coefficients show an effect of about half a standard deviation. In the Ghana sample, the adjusted R-square values are much lower, between .10 and .23. These differences may reflect the fact that the Ghana sample was not selected to be low income; it represents an urban population with a relatively high level of calorie intake, in a culture in which diet tends to be quite varied. In the mostly rural, mostly low-income Bangladesh sample, with quite low levels of calorie intake overall, and with a greater range of dietary diversity scores, the DD indicators do a better job of predicting calorie consumption.

In the logistic regression results, once again all the DD indicators are significant and positive predictors of a household consuming at least 1800 kcals/ae/day. In all cases, the measures of goodness of fit were higher for the Bangladesh sample, and the percent correctly predicted was slightly higher for Bangladesh than for Ghana. In Bangladesh, consuming one more food group raised the probability of consuming at least 1800 calories by 2.3 times; consuming one more Nutrient Group multiplied by almost five times the probability of reaching that level. In the case of Ghana, consuming one more food group raised the chance of consuming 1800 calories or more by 1.5 times, and consuming one more nutrient group multiplied the chances by 1.4 times. Because the range of number of unique foods was much greater, the odds ratios for a one-unit change were (of course) smaller: only 1.1 for Ghana (though still significant), and 1.6 for Bangladesh. Table 12a-d shows these results, with one panel for each country.

In the Bangladesh sample, adjusting for confounders greatly improves the predictive ability of the odds ratios. Compared with the crude (unadjusted) odds ratios, the adjusted odds ratios are larger in value, and the percent of cases correctly predicted rises noticeably – most dramatically in the case of the DHS food groups. In contrast, in Ghana the odds ratios for the DD indicators as predictors of consuming 1800 calories or more do not change at all after adjusting for confounders, and the predictions do not improve. For Bangladesh, the percent correctly predicted by the adjusted odds ratio is considerably better than would be achieved by guessing (all are at or above 80%); for Ghana, the percentage correctly predicted is almost the same as the percent of households falling into the higher consumption category and does not represent much of an improvement.

In both the Afghanistan and Ethiopia samples, every DD indicator is a significant, positive predictor of household kcals/ae, after controlling for a few household characteristics in an OLS multiple regression. In the Afghan results, adjusted R-square for the regressions ranged from .10 for Nutrient Groups to .19 for Calorie Dense Unique Foods. This is consistent with the simple bivariate correlations – highest for calorie dense unique foods and lowest for nutrient or calorie dense nutrient groups. Both regressions using unique foods (unique and calorie dense unique) have higher R-square values than those using groups, presumably because there is a wider variation to begin with in these. The effect of a unit change in the DD score on kcals/ae is substantial, ranging from .3 of a standard deviation for DHS food groups to around .4 of a standard deviation for the unique food indicators.

Given the very low, non-significant correlations of the DD indicators with calorie consumption in the Ethiopia data, it is perhaps unexpected that we find all the indicators are consistent, statistically significant, positive predictors of household calorie intake, after controlling for household size, female headship, land ownership, and dependency ratio. The explanatory power of the regressions (adjusted R-square) ranges from .17 to .31. The greatest explanatory power is provided by the number of unique calorie dense foods consumed; all the others are similar, between .18 and .21. The measured size of the effect of a unit change in the DD indicator is smaller in Ethiopia than in Afghanistan: for the food group indicators, the effect ranges from .09 to .14 of a standard deviation, while the unique food indicators show effects of .2 of a SD for unique foods, and .38 of a SD for unique calorie dense foods. Controlling for possible confounders greatly improves the predictive power of the DD indicators for Ethiopia; nonetheless, these results must be treated with caution, given our concerns about the calorie consumption data.

Based on the logistic regressions, all the odds ratios for the DD indicators in the Afghanistan sample are positive and highly significant, increasing the likelihood of consuming more than 1800 kcals/ae by a factor of 1.2 to 2. The percent of cases correctly predicted is about 92% for all the indicators; given that 92% of households report consuming above this level, the result is not better than simply guessing "yes" for every household. Once again, controlling for confounders results in DD indicators that show significant and positive odds ratios, with the exception of the DHS Food Groups. An increase in the number of DHS Groups does not significantly increase calorie intake; the other indicators have odds ratios ranging from 1.1 to 1.6. The percent of cases correctly predicted is about 65% for all the indicators; this is better than random guessing, since only 53% of households report consuming more than 1800 kcals/ae. After controlling for confounders, the odds ratios become statistically significant, and slightly larger in absolute terms than the crude odds ratios. The predictive power, though, is not improved: the percent correctly predicted remains at about 92%.

Adjusting for confounders in the logistic regression, the DD indicators that measure individual foods, and the indicator for Calorie Dense Groups reach statistical significance in the Ethiopia data. Compared with the crude odds ratios, the model fit is improved. The crude odds ratios explain almost none of the variance, though, which means that it is the other household characteristics, not the DD indicators, that are contributing to any explanatory power. Once again, though, we have concerns about the validity of the calorie information for Ethiopia.

5.9 Sensitivity and Specificity

We tested the indicators to see whether we could identify the best cut-off for each indicator to define the group at most risk of consuming less than 1800 calories per adult equivalent per day. We did this by estimating the sensitivity and specificity of each indicator at every possible level. These results are shown in Table 15a-c.

These tables show five different parameters that measure how well a particular indicator identifies those with insufficient (below 1800) calorie intake. Sensitivity (Se) gives the proportion of all those with insufficient consumption who would be identified by that cut-off value. Specificity (Sp) gives the proportion of those who are correctly identified as having sufficient (1800 or over) calorie intake. The inverse, or one minus the specificity proportion, is the proportion of those with sufficient calories who are identified incorrectly as having insufficient calorie intake. The next two columns identify the percent of "true positives" (households correctly identified as having insufficient calorie intake) among all those identified as "positive" (P+) on the DD indicator, and the percent of "true negatives" (households correctly identified as having sufficient calories) among all those identified as negative, or having sufficient calories (P-). Finally, the last column shows the percent of all cases correctly identified.

Ideally, one would want a high value for both sensitivity and specificity: to capture a high proportion of those at risk for low calorie intake, while correctly excluding a high proportion of those who are not at risk. The only one of the DD indicators that comes close to achieving this is the DHS Food Group score. Table 15b shows that for Ghana, a cut-off of 11 or fewer food groups will capture 63% of those who have low calorie consumption, and only 36% of those who ought not to be included in this group, but only 39% of those identified as low consumers actually are in the lower consumption category. For Bangladesh, the two best cut-off points are at eight or seven food groups. At eight, 75% of those at risk of insufficient consumption are captured, but 47% of those not at risk are also incorrectly included in that group. At seven, only 53% of those with low calorie consumption are captured, but the 'false positive' rate is reduced to 26%, and 81% of those identified as at risk in fact consume less than 1800 calories. For Afghanistan, a cut off value of seven DHS food groups correctly identifies 62% of those at risk of insufficient calorie intake (recall this is only 8% of the sample), but incorrectly captures 39% of the much larger number of households consuming 1800 calories or more. Of those identified as at-risk, only 12% are actually consuming insufficient calories. Looking at Ethiopia, even with our concern for the validity of the calorie data, the best cut-off value is at five food groups, and this captures under half of those with insufficient calories, while including half of those in the higher consumption category. Given that about 50% of households reach the 1800 calorie benchmark, this is not much better than simply assigning everyone to one group. Given the very different consumption patterns among these samples, it is unrealistic to hope that the same number of food groups might be used in all three settings as an indicator of calorie insufficiency.

The DHS Food Group indicator does better than either of the other indicators considered here. For the Nutrient Group indicator, there is no value for the Ghana sample that achieves anywhere close to even 50% of sensitivity and specificity; in fact, the best sensitivity level is a poor 19%, and that is only for households consuming fewer than all five groups. For Bangladesh, the same cut-off value of five performs fairly well, capturing 80% of those with low consumption, and excluding 56% of those whose consumption is high; 75% of those identified as having low consumption actually consume less than 1800 calories, compared with a population probability of 68%. For Afghanistan, a cut-off value of five correctly identifies 73% of low consumers and excludes just about half of those consuming more than 1800 calories, but only 11% of households identified as low consumers actually are. Furthermore, a cut-off value at the very top of the distribution may not be very useful as a mechanism for targeting food assistance.

The pattern is similar for Calorie Dense Food Groups. Only in Bangladesh is it possible to find a cut-off value – four groups – that captures more than half of the low consumers while excluding more than half of the high consumers. At this level, 83% of those counted as low consumers actually are. The best cut-off value for Ghana is at six. By selecting households that consume fewer than the maximum of six food groups, 69% of low consumers are captured, and 51% of high consumers are excluded. Still, this is a relatively high value, and even so, only 34% of those identified as low consumers really are. In Afghanistan, a cut off value of five shows a sensitivity of 59% and a specificity of 65%, but still, because of the small number of low consumers, only 13% of those identified as low consumers really are.

We conclude that DHS Food Groups may be better at discriminating among levels of calorie consumption than the other more aggregated food group indicators. We were unable to conduct a comparable analysis of the two indicators based on unique foods because there were simply too many to do a sensitivity/specificity analysis for every possible level. In any case, the range is quite different from one country sample to another, making it very unlikely that a common cut off value could be used for all countries.

5.10 Darfur Results: Household Demographics and Dietary Patterns

Table 16 shows key household demographics. The geographic distribution was relatively even across the three states: approximately 38% of households residing in North Darfur, 30% in South Darfur and 32% in West Darfur. Fifty-nine percent of households were considered to be internally displaced[18], and 41% were residents[19]. Of the internally displaced households, approximately two-thirds lived in camps and one-third lived in resident communities. Two-thirds of all households were headed by males, and one-third of households were female-headed. In terms of economic status and sources of income, quite a range of sources of income was observed. The most commonly reported primary source of household income was wage/skilled labor or salaried work, followed by sale of cereal, agriculture, livestock or animal products. The mean monthly household expenditure on food, including cash and credit purchases, was 9606

[18] An Internally Displaced Person (IDP) was defined as a person who was not residing in their usual place of residence and who was displaced for more than 30 months.
[19] A resident was defined as a person who reported to be living in their usual place of residence.

dinars (48 USD). The total monthly household expenditure, including cash and credit purchases for food and non-food items, was 14,918 dinars (74 USD). Therefore, food purchases accounted for approximately 64% of all household expenditure. Just over half of all households reported owning at least one large animal and approximately half of all households reported cultivating any agricultural land in the past year.

Table 17 summarizes the type and frequency of foods/food groups consumed, as reported in the dietary diversity module and, in Darfur, the proportion of those HHs consuming a food group that received it in the form of food aid. Cereals were consumed on more than three days by nearly all households. That cereals consumption is so high is not surprising given its role as major staple in nearly all cultures and the fact that 78.6% of households that consumed cereals received it as food aid. What is more interesting is the fact that, in Darfur, a slightly higher percentage of households reported eating meat than pulses, and 60.2% ate meat at least 3 days while only 29.1% ate pulses with that frequency. Not only is this unexpected given that meat is not typically included in a food ration, but almost everywhere meat is a more luxurious and expensive source of protein than pulses or groundnuts. It is possible that portions of the pulses in the food aid rations were being sold or traded for the preferred food (meat), and those Darfur households receiving the ration were able to access meat because of this additional entitlement. Importantly, it is not possible to tell from these data alone whether a food is *not* eaten because it cannot be afforded (signalling hardship) or isn't available (supply constraint) or whether it is simply not part of a customary diet. Conversely, a food may be accessible due to external support (food aid) and the possibility for substitution, and its consumption does not necessarily signal sustainable dietary well-being, if food aid were withdrawn.

Another useful observation revealed in this table is the high prevalence of sugar consumption relative to the consumption of other, potentially more nutrient dense food sources like fruits. Again, the fact that sugar was commonly part of the food ration in Darfur (for use in tea) underscores the difficulty in drawing conclusions about the security of the diet (i.e., what happens if the ration is withdrawn) and in comparing the meaning of food group consumption from one place to the next without additional context. Sugar is treated as its own food group because of its importance in the Darfur context; about half of households consuming it received it as food aid; but sugar is not nutrient dense, and, as an additional 'food group' might not be a marker of dietary adequacy. In a cultural context where sugar is so important, its presence might well be an indicator of SES or food security, but this is probably not applicable to many other settings.

5.11 Wild Foods Consumption in Dietary Diversity Indices and as a Stand-alone Marker of Food Insecurity

Table 18 presents the results of bivariate correlations among the frequency of wild food consumption and other consumption variables, including individual food groups and diet diversity indices. Based on the significant and negative correlations of wild foods with every consumption variable except sorghum, it is clear that wild foods are an 'inferior' food group (in terms of preference, not necessarily nutrition) that is consumed as an alternative to other types of foods. This result suggests that wild foods should not be included in any dietary diversity index where a higher score represents a preferred dietary practice. This represents a conundrum in the design of a diversity index. It is possible that wild foods are providing a vital source of nutrition, maintaining households that would otherwise severely lack nutrients at a consumption threshold on par with other better of households. But consumption of such foods nonetheless may represent for the consuming households severe supply or access constraints to food security, and inclusion of wild foods in an additive fashion might incorrectly suggest a higher food security status. Unfortunately, this possibility cannot be tested within these data.

Given that wild food consumption appears to increase when preferences are curtailed, and given that income/expenditures represent a primary means of exercising preferences, it is possible that the consumption of wild foods may signify a severe shortage of purchasing power. If this is true, then this indicator on its own may be sufficiently discriminating to be used for the basis of targeting of a food aid response. Table 19 presents the results of a cross-tabulation of wild food consumption (consumed at all in the past week – yes or no) with displacement status, camp residency and per capita expenditure (total and food only). Contrary to the hypothesis, and despite the negative bivariate correlations referred to earlier, Table 19 shows that the proportion of people consuming wild foods is fairly similar across all categories, with a slightly higher proportion of the middle expenditure tercile consuming wild foods.

Table 19 also presents the cross-tabulation of wild food consumption with displacement status. A similar hypothesis would suggest that displaced people would be more reliant on wild foods, and the camp-bound IDPs would have less ability to access wild foods, since it is quite possible that wild food availability and freedom to access it play a role in whether or not it is consumed when necessary. Table 19 shows similar results for the relationship between wild food consumption and displacement status. The table suggests that those who consume wild foods are hardly any less likely to reside in a camp setting and are no more likely to be IDPs than not. Overall, Table 19 suggests that the consumption of wild foods, on its own, is not a sufficient marker of hardship to be useful for targeting purposes, since other factors like access interact to determine whether this behavior is reported or not.

5.12 Darfur Dietary Diversity Index Correlations with Food Security Proxies

Table 20 presents the results of the examination of the association among various candidate dietary diversity indices. The purpose of this portion of the analysis was to assess which indicator is most strongly associated with various food insecurity proxies. This analysis is similar to one done in other sections of this study, except that the candidate indicators from this data set are different in some potentially useful ways – that is, this data set offers the ability to examine indicators that are weighted by frequency of consumption over a week, which other work (SENAC 2006) has suggested to have better capability in predicting nutrient adequacy. All the DD indicators tested correlate robustly with the alternative measures of food security. The best single DD indicator is the average number of foods consumed per day (AVGDD2) which correlates significantly with all the food security variables except for proportion of household budget spent on food, for which the correlation is the opposite of what would be expected. (It may be that the bivariate correlation is masking the effect of other household characteristics that increase food expenditures at a given level of income.) The same indicator with wild foods removed (DDAVG_nowild) is the second best indicator. None of the indicators correlated particularly well with the proportion of households budgets spent on food, though all correlated strongly with per capita expenditure on food.

5.13 Dietary Adequacy Classifications and Food Security Categorization

Table 21 presents the classification of households into the 4 dietary adequacy groups described in the methods section. When the 2004 WFP definition was used 23.6% of households were classified as achieving minimum consumption. When the more rigorous definition of dietary adequacy was employed, which excluded intake of sugar and included daily intake of fruits or vegetables, this proportion fell to a mere 3.6%. When this definition was relaxed to require consumption of fruits or vegetables at least three times per week 20% of households achieved minimum consumption. Twenty-six percent of households met the basic consumption definition of daily consumption of at least one source of carbohydrate, one source of protein and one source of fat.

Household membership in each one of these groups was cross-tabulated with two proximate indicators of insecure food access –food expenditure per capita and the percentage of total expenditures devoted to food spending – in order to determine whether these classifications are useful in predicting the household's food security status.

The results suggest that, indeed, those households that achieve the minimum consumption of each of these adequacy groups are more likely to also have the highest per capita food expenditure and spend the smallest portion of their budget on food, although the results are somewhat mixed on the latter point. Though there is a clear trend, these dietary adequacy indicators are not perfect proxies. This table suggests that greater food spending does not guarantee 'healthy' food consumption patterns, and that the route from food access ('potential consumption') to dietary diversity ('actual consumption') is likely to be mediated by important forces like preferences, knowledge, and culture. With regard to using these adequacy indicators to target households or to signal the need for a response, further exploration is warranted, since based on this preliminary analysis it appears that a large percentage of households would be misclassified based simply on DD indicators.

5.14 Regression Models Predicting Dietary Diversity in Darfur Households

The final step in this analysis of the Darfur dietary diversity data was to model the predictors of dietary diversity in order to ascertain, among other things, whether households receiving food aid reflect higher dietary diversity (as we expect), and whether camp-residing or non-camp IDP households have higher dietary diversity.

The results of multivariate linear regression analysis to predict dietary diversity in all households are illustrated in Table 22. The first model included the average number of food groups consumed per day (with cereal groups collapsed and wild foods excluded) as the dependent variable, while model two used the number of different unique foods consumed by the household per week as the dependent variable. Both models were found to be highly significant. Twenty-four percent, and 26% of the variation in dietary diversity was explained by the independent variables included in models one and two, respectively.

The cultivation of agricultural land was found to be negatively associated with dietary diversity in the first model and had no significant effect in the second model. Recall we found a similar result for Ethiopia in the calorie adequacy analyses. The negative association is somewhat surprising, as one may expect that household food production and consequently household food availability and consumption would be greater amongst households that are able to cultivate land. However, this variable reflects land cultivated over the past year and may not necessarily identify effects on recent consumption. Also, households depending on their own production may be more likely to limit consumption to those items they can produce themselves. Another possibility is that members of households who are not cultivating land may be more likely to be employed in the formal sector and may have a higher, more reliable source of income which would allow them to purchase a greater variety of foods; in any case, they may be more reliant on the market, which provides a more varied food supply. Households receiving food aid in the past two months had a dietary diversity score that was 0.262 and 0.230 points greater than households who did not receive food aid, in models one and two, respectively. Not surprisingly, number of meals consumed by adults per day was positively associated with dietary diversity in both models. As the number of adult meals consumed per day increased by one, the number of foods consumed per day increased by 0.226 and the number of different foods consumed by the household increased by 0.34 per week. Of course, the direction of causality in this relationship is dual: higher access to a diverse diet translates into more meals consumed. Though the household's food expenditure did not have an effect on either dietary diversity score, the household's total expenditure was significantly and positively associated with both outcome variables. As to be expected, experiencing a recent shock and the number of consumption-related coping strategies employed in the past 30 days were both negatively associated with dietary diversity. As the household employed one additional coping strategy, the number of foods consumed per day decreased by 0.09, and the number of foods consumed per week fell by 0.77, all else equal. Ownership of a large animal did not have an effect on dietary diversity in either model. While the sex of the household head did not have an effect in the first model, female headship had a negative effect on the household's dietary diversity in the second model. Household size did not appear to have an effect; however, the household's geography did. Households living in West Darfur and South Darfur both had higher dietary diversity scores than households living in North Darfur.

The effects of independent variables on dietary diversity amongst IDP households are presented in Table 23. Again, both models are highly significant. Model three accounted for 23% of the variance in daily dietary diversity and model four accounted for 28% of the variance in weekly dietary diversity. Contrary to models one and two, cultivation of agricultural land did not have an effect on the number of different foods consumed per day when the analysis was limited to IDPs, but did have a significantly positive effect on the number of different foods consumed by the household per week. IDP households cultivating land consumed nearly half a food item more per week compared with IDP households not cultivating any land, all else equal. Whether the IDP household lived in a community or camp did not have an effect in model three, but did have a positive effect on the number of different foods consumed per week. IDP households living in camps consumed fewer different foods per week than IDP households living in communities. As in models one and two, total household expenditure also strongly and positively associated with dietary diversity. The experience of a recent shock had a negative effect on daily dietary diversity, but did not have an effect on weekly dietary diversity. This results suggests the usefulness of having frequency information: households may struggle to preserve an acceptable dietary pattern by reducing the frequency rather than cutting a particular food or food group from the diet completely. Conversely, the number of consumption-related coping strategies employed in the past thirty days had a negative effect on weekly dietary diversity, but did not have a significant effect on daily dietary diversity. Both models three and four show a negative effect of female headship on dietary diversity. Household size did not have a significant effect in model three (daily DD), but did have a small, but significant negative effect on weekly dietary diversity in model four. As in models one and two, residence in the West or the South was associated with improved dietary diversity in comparison to residence in the North.

6. Conclusions and Recommendations

Our results are consistent with the growing literature suggesting that measures of dietary diversity are an accurate reflection of the adequacy and quality of diet at the household level. Even despite the fact that the datasets used in this study a) were not designed to answer the analytical questions at hand, and b) generally had less-than-ideal measures of caloric intake, consistent evidence was found that all the measures of DD show a positive correlation with household measures of caloric intake per adult equivalent. This was reflected in bivariate correlations between every indicator and calorie consumption (except in Ethiopia). After controlling for confounders in a multivariate analysis, all DD indicators showed very significant positive relationships with calorie consumption in all four countries.

However, all the data sets used to analyze caloric adequacy were drawn from settings that were not currently affected by an acute emergency. The households sampled were certainly drawn from countries often facing covariate shocks (such as armed conflict, drought, and flood), but the consumption patterns assessed were not, at the point of survey, currently shocked. To the extent that dietary diversity may have a different meaning in emergencies, we cannot extrapolate from these results to apply them to extreme situations. In particular, we might consider famine situations, where households might rely on a diverse group of "famine foods" that are markers not for adequacy but for food stress; in settings where people are dependent on food aid rations, it might happen that a relatively diverse group of foods is provided so that diversity would not necessarily proxy for adequacy in the same way that it would in a free living population.

All the constructed measures of diet diversity were closely related to each other. Nonetheless, each one may have a somewhat different interpretation. Clearly, the number of DHS food groups shows more variation (with a range of 1-12) than the other aggregated food group indicators (with ranges of 1-5 or 1-6), and so may be more sensitive to change. The number of unique foods is more variable still, and from our limited data it seems that greater variability within a food group, as well as variability of groups, is a positive indicator of dietary adequacy. There were not consistent results as to which indicator showed the greatest predictive ability or the most robust correlation with calorie consumption, although the regressions with number of unique or calorie-dense unique foods tended to have higher correlations and explanatory power (model fit) than those using food groups, presumably because the greater variation made them more sensitive. Fine-tuning of a particular indicator is probably less productive than improving data collection methods and expanding our knowledge base with respect to the application of these measures in diverse, particular emergency contexts. This suggests that using a consistent set of food groups for the construction of a DD indicator would be more valuable than trying to develop different categories for different locations and situations. The treatment of wild or 'famine' foods in construction of a DD measures bears further exploration, given the somewhat inconsistent relationship of this diet component with indicators of food security and hardship.

The Nutrient Groups indicator, which gave one point for consuming foods from each of only five groups – carbohydrates, fruits/vegetables, fats/oils/ animal protein and vegetable protein – was generally less sensitive to change than the other indicators. Regression parameters were consistently lower for this indicator as compared with the others. This is undoubtedly due to the fact that there is less variability in this indicator than in any of the others. These data suggest that most households will consume foods representing at least four of these groups (possibly choosing one of the two protein sources) if they can. There was universally a systematic relationship between consuming fewer Nutrient Groups and having a smaller proportion of households consuming at least 1800 calories per adult equivalent. Even in the Afghanistan data, where 92% of households consumed at that level or above, a low Nutrient Group score indicates a lower probability of being in the highest consumption category. The very fact that consumption patterns with respect to nutrient groups are resistant to change might possibly make it a suitable indicator of serious deprivation: with the inability to access foods from all five nutrient categories suggesting relatively severe food stress. We could not observe this in the data sets we used, where the lower scores on this indicator were not well represented. This measure of variety is no doubt useful as an indicator of diet quality as well as caloric sufficiency: absence of any major plant source of micronutrients, or of any animal protein source, or of a grain/pulse combination, probably suggests a lack of balance as well as a lack of quantity.

Thus the Nutrient Group indicator is probably useful to identify the presence of a severe problem, but probably not the most suitable indicator to measure change over time. One of the indicators that has greater range – DHS Food Groups, or Unique Foods, for instance – would be a more suitable measure for assessing whether and how the food adequacy situation is changing over time, whether in response to an intervention, or as a result of changes in the environmental context. The DHS Food Groups indicator would promote greater comparative analysis across contexts, since it is more standard measure. It may capture local variation less well than the Unique Foods indicator, since cultures and contexts vary in how many different individual foods are available for consumption.

These data sets were not comparable in a variety of ways. The Ghana sample was urban and representative of the entire city (i.e. included all income groups). The Bangladesh sample was mostly rural and selected to be low income, and both Afghanistan and Ethiopia were entirely rural. The distribution of scores for all the DD indicators was quite different from country to country. As measured, the calorie consumption levels also varied a great deal. For example, 92% of Afghan households, and 73% of Ghanaian ones consumed at least 1800 kcals/ae, while only 32% of Bangladesh households fell into that category. This inevitably means that the prediction of the consumption category into which a household falls is unreliable. Note also that the data collection methods for Ethiopia were not designed for estimation of calorie intake.

In part because of this wide variability, it proved impossible to find a universal cut-off in any of the indicators tested that would consistently identify a set proportion of households falling below a chosen level of calorie consumption.

The evidence is strong that dietary diversity varies systematically with calorie consumption level. Based on our sensitivity and specificity analysis, we would not recommend using a DD indicator as a diagnostic tool for individual households, but it might well be useful for identifying high-risk situations when a certain proportion of households are predicted to fall below a given DD indicator score. In general, both sensitivity and specificity were below the levels one would hope for in a diagnostic tool. Sensitivity/specificity analysis suggested that the DHS Food Groups indicator was probably more useful than the more aggregated groups, simply because in these populations, acceptable levels of sensitivity were not achieved until quite high levels of the more aggregated group scores, and so would not allow for much discrimination. Though the data constraints did not allow for a direct assessment of how well the WFP method for calculating and categorizing dietary diversity serves as a proxy for caloric adequacy, once the data do become available this method should be used to assess the sensitivity and specificity of the cut-offs that WFP currently uses. WFP should also consider applying this method for determining appropriate cut-offs in other types of indicators, such as the coping strategies index and the household food insecurity access scale.

The constraint we faced in analyzing dietary diversity as an indicator of caloric sufficiency was that no data sets were drawn from current emergency or crisis-affected populations containing required information on calorie consumption (at the level of detail needed to make judgments on nutrient adequacy). Even in the data sets we used, in all but one, calories were not estimated based on quantitative 24-hour recalls but on purchases or other more aggregated recall methods.

The data available from an actual emergency (Darfur) confirm the basic relationship between dietary diversity indicators and other indicators of food access, but could not test the relationship with dietary intake.

The variability of results in this study would also suggest that relying on a single indicator (or related group of indicators as this study has done) to proxy dietary adequacy will likely result in the misclassification of households with regard to their food security status. Based on these results, there is little doubt that dietary diversity indicators do capture the element of dietary quality, and to some extent dietary adequacy. However, other measures can capture other elements of dietary adequacy – as well as other elements of the complex notion of food security – and thus our recommendation would be that for assessment and targeting purposes, more than one proxy indicator should be included in WFP's analytical toolbox, and more than one should be used in assessments (as per the current practice). Again, the results from the one emergency case we analyzed (Darfur) confirm this conclusion.

We have addressed the study aims to the extent possible with the available data. A comparison of the various indicators does not immediately suggest one indicator that is clearly superior to the others. DHS Food Groups may be more sensitive to change than the other grouped indicators; we have speculated that Nutrient Groups may be more resistant to change and perhaps an indicator of greater deprivation. We find that these households, drawn from widely different contexts, were not really comparable in terms of their caloric intake, and no universal cut-off appears to be appropriate for all groups. Lacking any information on frequency, we were unable to assess the implications of including such information to weight DD indicators in assessing household caloric adequacy. In the Darfur data, incorporating frequency did alter some conclusions compared with a simply knowing if a food was consumed at all in the past week. Because measures of DD do reflect differing levels of caloric intake, information on DD would be useful as a baseline indicator, against which to compare changes over time.

Working with these data sets suggested several methodological issues to consider in implementing future consumption studies. Certainly, if the goal is to be able to assess caloric intake, consumption data must be collected in terms of foods consumed, not commodities purchased. Data collected for the purpose of estimating expenditures is a poor proxy for actual consumption, since any day or week's purchases may be intended to last for a longer period of time, and households may consume food that was purchased previously. Further, consumption data should include information on individual ingredients and their quantities in cooked, multiingredient dishes. This is important for calorie estimation, but also for measuring dietary diversity, as a single "food" may actually contain ingredients representing multiple food groups. Reporting these foods in terms of only the major ingredient will understate dietary variety.

Constructing DD indices from consumption data collected as detailed 24-hour or 7-day diet recalls may be misleading, and we cannot draw firm conclusions about the usefulness of DD indicators as a time-saving strategy without comparing detailed consumption information with data collected in terms of food groups. We know that food groups may mask variation in calorie and nutrient content of individual items (this is particularly true for the "miscellaneous" category), and it remains to be verified if food group information alone is sufficient to proxy for detailed consumption information. Similarly, we know that simply increasing numbers may not universally be a proxy for improved diet quality: simply 'adding more' (in terms of food groups) does not inherently suggest a better diet unless certain minimum needs are met first.

We strongly recommend that WFP undertake to quantify calorie intake, along with other measures of dietary diversity and household food security, in order to assess the usefulness of the dietary diversity indicator in truly access-constrained, emergency settings. A study that tracked dietary diversity along with food access and consumption through the course of an emergency could not only test dietary diversity indicators against other indicators that could potentially strengthen conclusions about the usefulness of the DD measures, it could also address other questions that available data would not permit this study to address, including the following.

Absolute values in indicators compared to variations from a baseline

Whether "famine foods" and food aid significantly alter the observed relationship of dietary diversity to caloric adequacy;

How closely these indicators pick up changes in access to adequate food over the course of an emergency (and hence in relation to both shocks and interventions);

To date, no study has considered 24-hour recalls on dietary intake in an emergency, in part because of resource constraints, but also because the analysis takes too long to be useful for emergency assessment purposes. But the investment in such an effort would be amply repaid by possibly being able to develop practical, time- and cost-saving measures for assessing diets of affected populations by testing various of these against dietary intake in actual emergencies. Given the promising results from the present study, which indeed confirmed the systematic relationship between DD measures and caloric intake, as well as some of the other indicators briefly observed in this study, such an investment would be highly worthwhile.

We can briefly summarize our conclusions as follows.

- These results confirm that dietary diversity measures show a consistent association with dietary adequacy and caloric intake.
    - We did not find clear superiority of one indicator over another; all are closely correlated
    - Because of diverse contexts and the strong desire of households to diversify at very low levels of caloric intake, universal cut off values are unlikely to be found
    - Very aggregated (e.g. five food group) measures may discriminate in severely deprived more than in less deprived populations
- This relationship has not been tested in emergency or crisis settings; such research is badly needed
    - The role and significance of 'famine foods' needs to be explored further
    - The effect of food aid on DD indicators needs to be explored
- Assessing the use of DD indicators as a proxy for diet adequacy requires information on both variables
    - Food expenditures or provisioning are poor proxies for consumption; detailed consumption data are needed
    - DD indicators constructed from detailed consumption data may be different from indicators collected from general questions specifically to construct DD scores.
- The promising potential for using DD as one in a set of indicators of household food security justifies further research on the issue.

Tables

Table 1: Key Characteristics of Study Data Sets

	Data set	Survey year	Sample (HHs)	Recall period	HH or individual	Food groups?	Unique Foods	Wild Foods?	Food Source?	Source of HH Kcal Adequacy Indicator	Other Dietary Data
1	Ethiopia	1997	1477	7 days	Household	Yes	Yes	No	Yes	Food consumption and expenditure	• Meals per day in past week • Bulk cereal purchase in past 4 months
2	Ghana	1997	559	7 days	Household	No	Yes	Not sure	Yes	Food consumption and expenditure	• "Street foods," • Consumption coping strategies
3	Afghanistan	2003	31412	7 days	Household	No	Yes	Yes	No	7-day food recall	• Food group recall- past 4 months
4	Bangladesh	2003	600	1 day	Household	No	Yes	Yes	Yes	24-hour recall	• Individual 24 hour recalls • Consumption coping strategies
5	Darfur	2005	2090	7 days	Household	Yes	No	No	Yes	7-day food group frequency recall	• Times adults ate previous day, • Times children < 15 ate prev. day

Table 2: Description of Candidate Dietary Diversity Indicators

No	Variable Name	Description	Food Groups/Food items	Construction	Weighting
1.	DHS Groups (DHSgrps)	Index of DHS food groups consumed	All DHS food groups	∑ (all food groups consumed at all)	Each food group is equally weighted
2.	Calorie Dense Food Groups (DenseDHS)	Index of calorie dense DHS food groups	Roots/Tubers, Cereals, legumes, animal source foods, oils, and sugars	∑ (all calories dense DHS food groups consumed at all)	Each food group is equally weighted
3.	Nutrient group (Nutgrps)	Index of consumption of key nutrient groups	Carbs; Animal protein; non-animal protein; fat; non-animal sources of micronutrients (see Table 3a)	∑ (all nutrient groups consumed at all)	Each nutrient group is equally weighted
4.	Unique Foods (Uniquefs)	Index of individual food items consumed	All foods in a food consumption module	∑ (all foods consumed at all)	Each food is equally weighted
5.	Calorie Dense Unique Foods (Dense unique)	Index of individual food items consumed from calorie dense food groups	All foods in the calorie dense DHS food groups	∑ (all foods in the calorie dense food groups consumed at all)	Each food is equally weighted

Table 2a: Mapping of DHS Food Groups to Major Nutrient Groups Based on Primary Nutrient Contribution

	DHS Food Group	Nutrient Group Assignment	Calorie-dense Group
1	Cereals	Carbohydrates	yes
2	Root and tubers	Carbohydrates	yes
3	Vegetables	Non-animal micronutrient sources	no
4	Fruits	Non-animal micronutrient sources	no
5	Meat, poultry, offal	Animal Protein	yes, grouped with other animal source foods
6	Eggs	Animal Protein	yes, grouped with other animal source foods
7	Fish and seafood	Animal Protein	yes, grouped with other animal source foods
8	Pulses/legumes/nuts	Non-Animal Protein	yes
9	Milk and milk products	Animal Protein	yes, grouped with other animal source foods
10	Oil/fats	Fat	yes
11	Sugar/honey	Carbohydrates	yes
12	Miscellaneous	N/A	no

Table 2b: Definition and Construction of Darfur Candidate Dietary Diversity Indicators

Variable Name	Dietary Diversity Definition	Construction
DDavg	Mean # of Food Items Consumed per Day [1]	# of days of consumption of (sorghum + millet + other cereals + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs + wild foods) / 7
DDavg_nowild	Mean # of Food Items Consumed per Day, No Wild Foods[2]	# of days of consumption of (sorghum + millet + other cereals + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7
AVGDD2	Mean # of Food Items per Day (cereals collapsed)[3]	# of days of consumption of (cereal* + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7; *cereal = average # of days per week sorghum, millet, and/or cereals consumed
Allfdssumwk	Mean # of Different Foods Consumed per Week[4]	Reported from a list of 12 food items (sorghum, millet, other cereals, groundnuts/legumes, meat/chicken/bush meat, oil, vegetables, fruit, milk/yogurt/cheese, sugar, eggs, wild foods)
Allfdssumwk_nowild	Mean # of Different Foods Consumed per Week, No Wild Foods[5]	Reported from a list of 12 food items (sorghum, millet, other cereals, groundnuts/legumes, meat/chicken/bush meat, oil, vegetables, fruit, milk/yogurt/cheese, sugar, eggs)
Allfdgrpwk	Mean # of Food Groups Consumed per Week	Five food groups possible: cereals (incl. sorghum, millet, 'other' cereals), protein (incl. pulses, meat, eggs, milk/dairy), fat (incl. oil), fruits/vegetables, sugar

Table 3: Key Characteristics of Sample Households

	Bangladesh (N=551)		Ghana (N=548)		Afghanistan (N=29720)		Ethiopia (N=1081)	
Characteristic:	N	Value*	N	Value*	N	Value*	N	Value*
Household size	551	5[2]	548	5[3]	29720	5.9[2.9]	1081	5.4[3.6]
HH with at least 1 child <60 mo. (%)	551	43.70%	548	100%	16597	55.80%	715	66.10%
Dependency ratio[2]	551	.40[.61] [2a]	548	1[1] [2b]	29720	0.7[0.9]	1081	.7[.8]
Female headed household (%)	551	5.40%	548	34.90%	521	1.70%	258	23.80%
Urban (%)	551	93.50%	548	100%	29720	0%	1081	0%
Any productive land (%)	551	56.10%	548	3.10%	11518	38.70%	1007	93.10%
Productive land size (acres) [3]	309	.80[1.16]	17	.0007[.003]	11518	2.5[2]	1007	3.7[5.5]

Note:
*Values are percentages and median [interquartile range]
[2] Dependency ratio is calculated as # household members le 12/ household members gt 12
[2b] Dependency ratio for Ghana includes elders as dependents
[2a] Dependency ratio for Bangladesh based on members le 10 years and ge 60/members gt 10 and lt 60 years
[3] Households with no productive land are excluded from the average

Table 4: Frequency of HH Consumption of Food and Nutrient Groups

Food/Nutrient Groups	Bangladesh (N= 551)		Ghana (N= 548)		Afghanistan (N= 29720)		Ethiopia (N= 1081)	
	Consumed? (% yes)	# Foods eaten in each group (median)	Consumed? (% yes)	# Foods eaten in each group (median)	Consumed? (% yes)	# Foods eaten in each group (median)	Consumed? (% yes)	# Foods eaten in each group (median)
Carbohydrates	100	2	100	13	99.98	4	99.07	2
Cereals	100	1	100	8	99.64	2	97.32	2
Roots/tubers	82.9	1	99.1	4	79.71	1	20.54	1
Sugars	39.4	1	56.8	1	72.55	1	35.71	1
Protein	86	2	99.5	7	90.45	3	58.74	2
Pulses	33.4	1	90.3	2	56.44	1	20.81	1
Meat	14.3	1	82.7	2	71.08	1	17.67	1
Fish	64.4	1	88.7	2	0.59	1	-	-
Milk	30.7	1	69.9	1	59.36	2	42.65	1
Eggs	15.6	1	69	1	-	-	9.44	1
Fats	99.1	1	98	3	92.48	1	24.7	1
Oils	99.1	1	98	3	92.48	1	24.7	1
Non-animal Sources of Micronutrients	100	4	98.7	7	89.38	3	89.55	3
Vegetables	100	4	96.4	4	87.72	3	89.36	3
Fruits	15.8	1	90.5	3	45.79	1	13.97	1

Table 5: Mean (+/-SD) of Candidate DD Indices by Country and Kcal per Adult Equivalent (AE) Adequacy Group

#	Indicator Name	Bangladesh				Ghana				Afghanistan				Ethiopia			
		Total n=551	< 1600 Kcals n=330	1600-1800 Kcals n=45	> 1800 Kcals n= 176	Total n=548	< 1600 Kcals n=107	1600-1800 Kcals n=43	> 1800 Kcals n=398	Total n= 29720	< 1600 Kcals n= 1612	1600-1800 kcals n= 738	> 1800 kcals n= 27370	Total n= 1081	< 1600 kcals n=432	1600-1800 kcals n=73	> 1800 kcals n=576
1	DHSgrp	7 (1.5)	6.6_a (1.4)	7.0_a (1.4)	7.6 (1.4)	10.4 (1.7)	9.3 (2.2)	10.2_a (1.6)	10.7_a (1.3)	6.7 (1.8)	5.5 (2.1)	5.7 (2.0)	6.8 (1.8)	4.6 (1.6)	4.7_a (1.6)	4.3_a (1.5)	4.6_a (1.6)
2	Nutgrps	4.1 (.65)	4.0_a (.64)	4.1_a (.60)	4.4_a (.60)	4.9 (.45)	4.7 (.75)	4.9_a (.29)	4.9_a (.34)	4.2 (0.8)	3.6_a (1.1)	3.7_a (1.0)	4.2 (0.8)	2.8 (0.9)	2.8_a (0.9)	2.7_a (0.9)	2.8_a (0.9)
3	Dense DHS	3.7 (.93)	3.5_a (.85)	3.6_a (.91)	4.2 (.91)	5.3 (.80)	4.9 (.94)	5.2_a (.83)	5.4_a (.71)	4.7 (1.2)	3.9_a (1.4)	4.0_a (1.4)	4.7 (1.2)	2.1 (1.0)	2.1_a (1.0)	1.9_a (0.9)	2.2_a (1.0)
4	Uniquef	13.7 (3.7)	12.7 (3.2)	14.7_a (3.5)	15.4_a (3.8)	33.5 (9.0)	26.9 (8.6)	32.7_a (8.0)	35.3_a (8.4)	11.3 (4.6)	8.6_a (4.2)	8.9_a (4.3)	11.4 (4.5)	8.5 (3.4)	$8.3_{a,b}$ (3.5)	7.5_a (3.0)	8.8_b (3.4)
5	Dense Uniquef	4.6 (1.7)	4.2_a (1.5)	$4.7_{a,b}$ (1.6)	5.3_b (1.7)	19.6 (5.4)	16.1 (5.1)	19.7_a (5.5)	20.5_a (5.1)	6.9 (2.2)	5.3 (2.1)	5.6 (2.2)	7 (2.2)	3.2 (1.6)	2.8_a (1.4)	2.8_a (1.4)	3.6 (1.6)

Dense Unique and Dense DHS are based on calories dense food groups: cereals, roots/tubers, meat, pulses, fat and sugar. Means with common subscripts are NOT significantly different from each other within kcal per AE groups (Bonferroni post hoc)

Table 6a: Distribution of DHS Food Group Score by Kcal per AE Categories for Each Dataset

	Bangladesh %				Ghana %				Afghanistan %				Ethiopia %			
Index Score	Total n= 551	<1600 kcals n= 330	1600-1800 kcals n= 45	>1800 kcals n= 176	Total n= 548	<1600 kcals n= 107	1600-1800 kcals n= 43	>1800 kcals n= 398	Total n= 29720	<1600 kcals n= 1612	1600-1800 kcals n= 738	>1800 kcals n= 27370	Total n= 1,081	<1600 kcals n= 432	1600-1800 kcals n= 73	>1800 kcals n= 576
1	0	0	0	0	0	0	0	0	0.5	2.8	3.0	0.3	1.2	2.1	0	0.7
2	0	0	0	0	0.2	0.9	0	0	2.1	6.1	3.8	1.8	6.5	5.8	9.6	6.6
3	0	0	0	0	0.2	0.9	0	0	3.8	9.9	7.3	3.4	18.7	14.4	28.8	20.7
4	2.4	3.0	2.2	1.1	1.1	3.7	0	0.5	6.2	12.3	12.2	5.7	22.0	22.7	19.2	21.9
5	12.7	18.2	13.3	2.3	0.5	2.8	0	0	11.1	14.6	17.2	10.7	21.7	23.4	16.4	21.2
6	29.0	33.3	22.2	22.7	0.9	2.8	2.3	0.3	16.9	17.1	16.9	16.9	15.6	16.9	13.7	14.9
7	21.8	22.1	24.4	20.5	3.1	4.7	2.3	2.8	21.0	16.6	18.2	21.3	9.4	9.0	11.0	9.6
8	16.2	12.4	20.0	22.2	4.5	11.2	9.3	2.3	19.8	12.7	12.1	20.4	4.3	4.9	1.4	4.2
9	13.4	8.2	17.8	22.2	12.4	19.6	18.6	9.8	15.8	6.9	7.3	16.6	0.6	0.9	0	0.4
10	4.2	2.7	0	8.0	20.6	21.5	16.3	20.9	2.7	0.9	2.0	2.8	0	0	0	0
11	0.4	0	0	1.1	27.7	15.0	25.6	31.4	0.04	0	0	0.05	0	0	0	0
12	0	0	0	0	28.6	16.8	25.6	32.2	0	0	0	0	0	0	0	0
Median [IQR]	7.0 [2]	6.0 [1]	7.0 [2]	8.0 [3]	11.0 [2]	10.0 [3]	11.0 [3]	11.0 [2]	7.0 [2]	6.0 [3]	6.0 [3]	7.0 [2]	5.0 [3]	5.0 [2]	4.0 [3]	5.0 [3]

Table 6b: Distribution of Nutrient Food Group Scores by Kcal per AE Categories for Each Dataset
(possible score 1-5)

	Bangladesh %				Ghana %				Afghanistan %				Ethiopia %			
Index Score	Total n= 551	<1600 kcals n= 330	1600-1800 kcals n= 45	>1800 kcals n= 176	Total n= 548	<1600 kcals n= 107	1600-1800 kcals n= 43	>1800 kcals n= 398	Total n= 29,720	<1600 kcals n= 1,612	1600-1800 Kcals n= 738	>1800 kcals n= 27,370	Total n= 1,081	<1600 kcals n= 432	1600-1800 kcals n= 73	>1800 kcals n= 576
1	0	0	0	0	0.2	0.9	0	0	0.7	3.6	3.8	0.5	6.5	6.9	8.2	5.9
2	0.4	0.6	0	0	0.5	1.9	0	0.3	4.2	12.7	9.9	3.6	30.5	28.5	38.4	31.1
3	14.2	18.5	13.3	6.3	1.1	4.7	0	0.3	12.9	21.8	22.1	12.1	39.4	42.6	28.8	38.4
4	57.7	60.9	64.4	50.0	10.4	15.9	9.3	9.0	35.2	34.8	36.0	35.2	19.1	18.8	23.3	18.8
5	27.8	20.0	22.2	43.8	87.8	76.6	90.7	90.5	47.0	27.1	28.2	48.7	4.5	3.2	1.4	5.9
Median [IQR]	4.0 [1]	4.0 [0]	4.0 [0]	4.0 [1]	5.0 [0]	5.0 [0]	5.0 [0]	5.0 [0]	4.0 [1]	4.0 [2]	4.0 [2]	4.0 [1]	3.0 [1]	3.0 [1]	3.0 [1]	3.0 [1]

Table 6c: Distribution of Calorie Dense Group Score by Kcal per AE Categories for Each Dataset (possible score 0-6)

	Bangladesh %				Ghana %				Afghanistan %				Ethiopia %			
Index Score	Total n= 551	<1600 kcals n= 330	1600-1800 Kcals n= 45	>1800 kcals n= 176	Total n= 548	<1600 kcals n= 107	1600-1800 kcals n= 43	>1800 kcals n= 398	Total n= 29,720	<1600 kcals n= 1,612	1600-1800 Kcals n= 738	>1800 kcals n= 27,370	Total n= 1,081	<1600 kcals n= 432	1600-1800 kcals n= 73	>1800 kcals n= 576
0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.7	0	0
1	0	0	0	0	0	0	0	0	1.2	5.6	4.9	0.8	30.2	27.1	39.7	31.3
2	7.8	10.9	6.7	2.3	0.4	0.9	2.3	0	5.5	13.4	11.5	4.9	35.9	41.0	35.6	32.1
3	37.2	44.5	42.2	22.2	2.2	7.5	0	1.0	10.6	18.7	18.3	9.9	21.5	20.4	13.7	23.3
4	35.9	33.9	33.2	40.3	13.0	23.4	11.6	10.3	19.4	21.9	23.9	19.1	10.6	8.8	11.0	12.0
5	16.2	9.4	15.6	29.0	39.2	40.2	46.5	38.2	29.6	22.8	24.3	30.2	1.6	2.1	0	1.4
6	2.9	1.2	2.2	6.3	45.3	28.0	39.5	50.5	33.7	17.6	17.2	35.1	0	0	0	0
Median [IQR]	4.0 [1]	3.0 [1]	4.0 [1]	4.0 [1]	5.0 [1]	5.0 [2]	5.0 [1]	6.0 [1]	5.0 [2]	4.0 [2]	4.0 [2]	5.0 [2]	2.0 [2]	2.0 [2]	2.0 [1]	2.0 [2]

Table 7: Percentage of Households Meeting Various Caloric per AE Cut-offs with Different Nutrient Group Consumption Patterns

Nutrient Groups Consumption Pattern	Afghanistan			Ethiopia			Bangladesh			Ghana		
	Freq. (%)	Mean ± Std. dev Cal per adeq	% >1800 kcals	Freq. (%)	Mean ± Std. dev Cal per adeq	% >1800 kcals	Freq. (%)	Mean ± Std. dev Cal per adeq	% >1800 kcals	Freq. (%)	Mean ± Std. dev Cal per adeq	% >1800 kcals
	n= 29720		n= 27370	n= 1081		n= 576	n= 551		n= 176	n= 548		n= 398
Carbohydrates	0.7	2106.8±962.3	0.46	6.29	2255.5±1458.1	5.9	0	-	0	0.18	-	0
Non-animal Micronutrient source	0	-	0	0.19	-	0	0	-	0	0	-	0
Fats	0.007	-	0	0	-	0	0	-	0	0	-	0
Animal Protein	0	-	0	0	-	0	0	-	0	0	-	0
Non-Animal Protein Source	0	-	0	0	-	0	0	-	0	0	-	0
10110	4.5	3043.9±1187.2	4.35	0.37	-	0.17	0	-	0	0	-	0
11000	1.2	2094.9±866.6	0.84	26.92	2363.6±1536.0	28.13	0.36	-	0	0	-	0
11001	0.4	2492.5±983.0	0.33	5.92	3087.7±1760.3	8.33	0.18	-	0	0.18	-	0.25
11010	2.1	2396.2±1050.9	1.76	25.35	2040.5±1341.9	21.18	0.36	-	0	0.18	-	0
11011	2.2	2688.3±1081.5	2.04	7.59	2614.6±1442.1	9.03	0	-	0	0.91	1746.5±423.9	0.75
11100	5.3	2679.5±892.0	5.16	6.94	2707.4±1729.8	7.99	13.61	1259.3±622.3	6.25	0.18	-	0
11101	4.3	2785.9±848.3	4.34	1.39	3135.8±2036.1	2.08	5.44	1556.7±611.0	5.68	0.55	-	0
11110	26.8	2999.1±1023.1	26.83	9.99	2071.0±1571.4	7.64	52.27	1537.5±732.0	44.32	8.94	2437.1±1196.9	8.29
11111	47	3231.2±1050.1	48.71	4.53	2787.8±1765.7	5.9	27.77	1922.4±896.6	43.75	87.77	2667.1±1217.9	90.45

Note:

1. Cording for Nutrient Group

Carbohydrates	10000
Non-animal Micronutrient source	1000
Fats	100
Animal Protein	10
Non-Animal Protein Source	1

2. Mean ± Std. dev is reported only if the frequency is more than 4
3. Result is presented when at least one of frequency % is more than 4 %.

Table 8-1a: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Bangladesh (n=551, n varies for pairs between 485 and 551)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs
DHSgrps					
Nutgrps	0.65 ***				
DenseDHS	0.80 ***	0.57 ***			
Uniquefs	0.79 ***	0.51 ***	0.63 ***		
DenseUniquefs	0.75 ***	0.46 ***	0.86 ***	0.70 ***	

* p<.05; ** p<.01; ***p<.001

Table 8-1b: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Ghana (overall n=548, n varies for pairs between 542 and 548)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs
DHSgrps					
Nutgrps	0.38***				
DenseDHS	0.83 ***	0.46 ***			
Uniquefs	0.68 ***	0.32 ***	0.58 ***		
DenseUniquefs	0.52 ***	0.33 ***	0.53 ***	0.90 ***	

* p<.05; ** p<.01; ***p<.001

Table 8-1c: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Afghanistan (overall n=26135)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs
DHSgrps					
Nutgrps	0.78***				
DenseDHS	0.86***	0.81***			
Uniquefs	0.88***	0.68***	0.73***		
DenseUniquefs	0.80***	0.72***	0.84***	0.85***	

* p<.05; ** p<.01; ***p<.001

Table 8-1d: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Ethiopia (overall n=961)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs
DHSgrps					
Nutgrps	0.82***				
DenseDHS	0.85***	0.71***			
Uniquefs	0.83***	0.69***	0.67***		
DenseUniquefs	0.66***	0.59***	0.77***	0.72***	

p<.05; ** p<.01; ***p<.001

Table 8-2a: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Bangladesh (overall n=551, n varies for pairs between 485 and 551)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs	HH Caloric intake (per AE)	Food Exp p.c.	Food secure HH	Total expend. Per capita	% of total expend. On food	Female headed	Dependency ratio	Urban location
HH Caloric Intake (per AE)	0.39 ***	0.30 ***	0.38 ***	0.39 ***	0.37 ***								
Food Exp per capita	0.25 ***	0.16 ***	0.21 ***	0.25 ***	0.15 **	0.16 ***							
Food Secure	0.34 ***	0.23 ***	0.26 ***	0.37 ***	0.25***	0.15 **	0.35 ***						
Total Expend. Per capita	0.31 ***	0.19 ***	0.25 ***	0.32 ***	0.21 ***	0.20 ***	0.74 ***	0.43 ***					
% of total expend. on food	-0.16 ***	-0.07 ns	-0.13 **	-0.19 ***	-0.11 *	0.01 ns	-0.12 **	-0.30 ***	-0.24 ***				
Female headed	-0.12**	-0.10 *	-0.07 ns	-0.15 ***	-0.09 *	0.07 ns	-0.06 ns	-0.08 ns	-0.06 ns	0.08 ns			
Dependency ratio	-0.02 ns	-0.05 ns	-0.06 ns	-0.03 ns	-0.01 ns	-0.02 ns	-0.20 ***	-0.15 ***	-0.23 ***	0.16 ***	0.02 ns		
Urban	0.04 ns	0.06 ns	0.07 ns	0.02 ns	0.05 ns	0.08 ns	0.06 ns	0.02 ns	0.07 ns	0.04 ns	0.07 ns	-0.01 ns	
Has productive land	0.16 ***	0.10 *	0.15 ***	0.15 **	0.13 **	-0.08 ns	0.08 ns	0.39 ***	0.15 **	-0.34 ***	-0.10 *	-0.08 ns	0.05 ns

* p<.05; ** p<.01; ***p<.001

Table 8-2b: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Ghana (overall n=548, n varies for pairs between 542 and 548)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs	HH Caloric intake (per AE)	Food Exp per capita	CSI score	Total Expenditure per capita	% of total expend on food	Female headed
HH Caloric intake (per AE)	0.30 ***	0.16 ***	0.27 ***	0.41 ***	0.37 ***						
Food Exp p.c.	0.43 ***	0.12 **	0.37 ***	0.48 ***	0.40 ***	0.76 ***					
CSI score	-0.28 ***	-0.04 ns	-0.18 ***	-0.20 ***	-0.10 *	-0.10 *	-0.25 ***				
Tot expend. per capita	0.45 ***	0.12 **	0.36 ***	0.42 ***	0.31 ***	0.59 ***	0.83 ***	-0.35***			
% of tot expend on food	-0.14 **	-0.003 ns	-0.10 *	-0.04 ns	0.04 ns	0.12 **	0.05 ns	0.25 ***	-0.46 ***		
Female headed	-0.10*	-0.01 ns	-0.02 ns	-0.03 ns	0.03 ns	0.11 **	0.02 ns	0.26 ***	-0.12 **	0.27 ***	
Depend. Ratio	-0.12**	-0.01 ns	-0.08 ns	-0.06 ns	-0.02 ns	-0.10 *	-0.22 ***	0.22 ***	-0.26 ***	0.16 ***	0.22 ***

* p<.05; ** p<.01; ***p<.001
CSI – "Coping Strategies Index"

Table 8-2c: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Afghanistan (overall n=26135)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs	HH Caloric Intake (per AE)	Household size	Food Exp per capita	Has productive land	Female headed
HH Caloric Intake (per AE)	0.29***	0.22***	0.26***	0.33***	0.35***					
Household size	0.19***	0.16***	0.17***	0.20***	0.19***	-0.17***				
Food Exp per capita	0.12***	0.10***	0.12***	0.15***	0.15***	0.16***	-0.27***			
Has productive land	-0.02*	-0.04***	-0.05***	-0.03***	-0.02**	0.01ns	0.16***	-0.20***		
Female headed	-0.01ns	-0.01ns	-0.01ns	-0.002ns	-0.01ns	-0.01ns	-0.04***	0.04***	-0.04***	
Dependency ratio	-0.06***	-0.05***	-0.04***	-0.06***	-0.05***	0.15***	-0.12***	-0.03**	-0.03***	-0.01ns

* p<.05; ** p<.01; ***p<.001

Table 8-2d: Bivariate Spearman Associations among Candidate Dietary Diversity and Common Household Food Insecurity Indicators for Ethiopia (overall n=961)

	DHSgrps	Nutgrps	DenseDHS	Uniquefs	Dense Uniquefs	HH Caloric Intake (per AE)	Household size	Food Exp per capita	Has productive land	Female headed
HH Caloric Intake (per AE)	-0.04ns	0.02ns	0.03ns	0.08ns	0.29***					
Household size	0.24***	0.19***	0.19***	0.20***	0.14**	-0.41***				
Food Exp per capita	0.19***	0.17***	0.25***	0.19***	0.31***	0.36***	-0.19***			
Has productive land	0.11*	0.10ns	0.07ns	0.11ns	0.07ns	-0.16***	0.22***	-0.08ns		
Female headed	-0.20***	-0.13**	-0.12**	-0.19***	-0.09ns	0.04ns	-0.17***	0.03ns	-0.20***	
Dependency ratio	-0.002ns	-0.02ns	0.01ns	0.04ns	0.03ns	0.09ns	-0.10ns	0.07ns	-0.07ns	-0.09ns

* p<.05; ** p<.01; ***p<.001

Table 9: Spearman Bivariate Associations among Candidate Dietary Diversity Indicators and Household Caloric Intake per AE by Country

	Bangladesh (n=551)	Ghana (n=548)	Afghanistan (n=26135)	Ethiopia (n= 1081)
DHSgrps	.39 ***	.41 ***	.28 ***	-.04 ns
Nutgrps	.39 ***	.30 ***	.22 ***	.02 ns
DenseDHS	.30***	.16 ***	.26 ***	.03 ns
Uniquefs	.38***	.27 ***	.32 ***	.06 ns
DenseUniquefs	.37***	.37 ***	.35 ***	.27 ***

* p<.05; ** p<.01; ***p<.001

DHSgrps	Number of food groups (1-12)
Nutgrp	Number of nutrient groups (1-5)
DenseDHS	Number of nutrient dense food groups (1-6)
Uniquefs	Number of unique foods
DenseUniquef	Number of unique nutrient dense foods

Table 10a: Comparison by Country of OLS Multivariate Regressions Predicting HH Kcal Intake per AE: *DHS Food Groups*

	Bangladesh n= 545		Ghana n= 548		Afghanistan n= 26196		Ethiopia n= 972	
	β	P(t)	β	P(t)	β	P(t)	β	P(t)
DHS Food Groups	251.8	0.000	223.4	0.000	170.4	0.000	85.9	0.003
HH size	-172.7	0.000	-117.3	0.000	-83.7	0.000	-195.8	0.000
Head is female	171.6	0.126	391.6	0.000	-124.9	0.009	-11.8	0.915
Dependency ratio	-20.6	0.696	-107.7	0.087	161.3	0.000	66.7	0.312
Urban	112.5	0.253	NA	NA	NA	NA	NA	NA
Have productive land	4.1	0.935	NA	NA	131.8	0.000	-761.9	0.000
Model Adj. R^2	0.440		0.158		0.135		0.178	
F	72.285		26.7		820.8		43.14	
Sig. F	0.000		0.000		0.000		0.000	

Dependent variable: calorie available per one adult equivalent

Table 10b: Comparison by Country of OLS Multivariate Regressions Predicting HH Kcal Intake per AE: *Nutrient Groups*

	Bangladesh n= 545		Ghana n= 548		Afghanistan n= 26196		Ethiopia n= 972	
	β	P(t)	β	P(t)	β	P(t)	β	P(t)
Nutrient Groups	435.0	0.000	498.9	0.000	301.9	0.000	228.0	0.000
HH size	-167.2	0.000	-122.0	0.000	-77.9	0.000	-198.4	0.000
Head is female	129.4	0.285	351.5	0.001	-113.2	0.019	-11.5	0.916
Dependency ratio	-13.3	0.816	-141.4	0.030	157.5	0.000	71.0	0.278
Urban	158.2	0.137	NA	NA	NA	NA	NA	NA
Have productive land	54.3	0.324	NA	NA	129.9	0.000	-792.2	0.000
Model Adj. R^2	0.346		0.100		0.107		0.190	
F	48.946		16.267		630.02		46.54	
Sig. F	0.000		0.000		0.000		0.000	

Dependent variable: calorie available per one adult equivalent

Table 10c: Comparison by Country of OLS Multivariate Regressions Predicting HH Kcal Intake per AE: *Calorie Dense Food Groups*

	Bangladesh n= 545		Ghana n= 548		Afghanistan n= 26196		Ethiopia n= 972	
	β	P(t)	β	P(t)	β	P(t)	β	P(t)
Calorie Dense Food Groups	366.3	0.000	382.1	0.000	233.3	0.000	212.7	0.000
HH size	-160.8	0.000	-114.0	0.000	-80.8	0.000	-199.0	0.000
Head is female	106.5	0.354	345.0	0.001	-124.0	0.010	-14.2	0.897
Dependency ratio	8.3	0.879	-124.3	0.052	153.2	0.000	59.9	0.360
Urban	104.1	0.304	NA	NA	NA	NA	NA	NA
Have productive land	0.8	0.988	NA	NA	141.6	0.000	-762.4	0.000
Model Adj. R^2	0.409		0.129		0.120		0.191	
F	63.719		21.204		712.18		46.75	
Sig. F	0.000		0.000		0.000		0.000	

Dependent variable: calorie available per one adult equivalent

Table 10d: Comparison by Country of OLS Multivariate Regressions Predicting HH Kcal Intake per AE: *Unique Foods*

	Bangladesh n= 545		Ghana n= 548		Afghanistan n= 26196		Ethiopia n= 972	
	β	P(t)	β	P(t)	β	P(t)	β	P(t)
Unique Foods	123.7	0.000	54.7	0.000	82.9	0.000	90.6	0.000
HH size	-200.8	0.000	-132.6	0.000	-88.0	0.000	-204.7	0.000
Head is female	203.9	0.047	345.5	0.001	-152.2	0.001	48.6	0.655
Dependency ratio	-9.8	0.840	-91.2	0.131	166.7	0.000	46.2	0.475
Urban	64.7	0.473	NA	NA	NA	NA	NA	NA
Have productive land	3.8	0.936	NA	NA	135.0	0.000	-789.8	0.000
Model Adj. R^2	0.532		0.228		0.177		0.210	
F	104.270		41.307		1124.31		52.58	
Sig. F	0.000		0.000		0.000		0.000	

Dependent variable: calorie available per one adult equivalent

Table 10e: Comparison by Country of OLS Multivariate Regressions Predicting HH Kcal Intake per AE: *Calorie Dense Unique Foods*

	Bangladesh n= 545		Ghana n= 548		Afghanistan n= 26196		Ethiopia n= 972	
	β	P(t)	β	P(t)	β	P(t)	β	P(t)
Calorie Dense Unique Foods	215.9	0.000	78.5	0.000	183.0	0.000	349.7	0.000
HH size	-171.0	0.000	-129.8	0.000	-90.8	0.000	-213.1	0.000
Head is female	121.9	0.282	296.6	0.004	-137.5	0.003	29.6	0.769
Dependency ratio	-29.3	0.585	-108.6	0.079	165.3	0.000	30.6	0.613
Urban	76.1	0.447	NA	NA	NA	NA	NA	NA
Have productive land	19.3	0.709	NA	NA	132.2	0.000	-782.4	0.000
Model Adj. R^2	0.425		0.187		0.198		0.309	
F	68.022		32.546		1295.35		87.96	
Sig. F	0.000		0.000		0.000		0.000	

Dependent variable: calorie available per one adult equivalent

Table 11: Regression Parameters for Five DD Indicators, Cross-Country Comparison

		Bangladesh n= 545	Ghana n= 548	Afghanistan n= 26196	Ethiopia n= 972
DHS groups	Coeff*	251.8***	223.4***	170.4***	85.9**
	Beta (stdized)	0.49	0.30	0.31	0.09
	R-square	0.44	0.16	0.14	0.18
Nutrient Groups	Coeff*	435.0***	498.9***	301.9***	228.0***
	Beta (stdized)	0.37	0.19	0.26	0.14
	R-square	0.35	0.10	0.11	0.19
Cal Dense Groups	Coeff*	366.3***	382.1***	233.3***	212.7***
	Beta (stdized)	0.45	0.25	0.28	0.15
	R-square	0.41	0.13	0.12	0.19
Unique Foods	Coeff*	123.7***	54.7***	82.9***	90.6***
	Beta (stdized)	0.60	0.40	0.37	0.21
	R-square	0.53	0.23	0.18	0.21
Unique dense foods	Coeff*	215.9***	78.5***	183.0***	349.7***
	Beta (stdized)	0.47	0.35	0.40	0.38
	R-square	0.43	0.19	0.20	0.31

Note:
Stars indicate significance of the coeff, * p<.05; ** p<.01; ***p<.001

Table 12a: Comparison by Candidate Dietary Diversity Indicator of Logistic Regressions Predicting HH Consumption of > 1800 Kcal per AE for Bangladesh (n = 551)

	DHS Food Groups	Nutrient Groups	Calorie Dense Food Groups	Unique Foods	Dense Unique Foods
	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI
DD indicator	2.4*** (2.0-2.8)	5.0*** (3.3-7.4)	3.8*** (2.8-5.2)	1.6*** (1.5-1.8)	2.1*** (1.7-2.4)
HH size	0.4*** (0.4-0.5)	0.4*** (0.4-0.5)	0.4*** (0.4-0.5)	0.3*** (0.3-0.4)	0.4*** (0.4-0.5)
Head is female	1.0 (0.4-2.7)	0.8 (0.3-2.1)	0.8 (0.3-2.1)	1.1 (0.4-3.2)	0.8 (0.3-2.1)
Dependency ratio	1.1 (0.7-1.8)	1.2 (0.7-1.8)	1.3 (0.8-2.1)	1.2 (0.8-2.1)	1.1 (0.7-1.8)
Urban area	1.5 (0.6-3.6)	1.7 (0.7-4.0)	1.5 (0.6-3.4)	1.2 (0.4-3.2)	1.3 (0.5-3.0)
Has productive land	1.0 (0.6-1.6)	1.3 (0.8-2.0)	1.0 (0.6-1.6)	1.0 (0.6-1.7)	1.1 (0.7-1.7)
Cox & Snell R Square	0.34	0.30	0.33	0.40	0.32
Nagelkerke R Square	0.48	0.42	0.47	0.57	0.45
Percentage predicted Correct	82.0	79.6	80.4	86.1	80.2
	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI
DD indicator	1.7*** (1.5-1.9)	2.6*** (1.9-3.6)	2.4*** (1.9-3.0)	1.2*** (1.2-1.3)	1.5*** (1.4-1.7)
Cox & Snell R Square	0.11	0.07	0.12	0.11	0.09
Nagelkerke R Square	0.15	0.10	0.17	0.16	0.13
Percentage predicted Correct	32.4	68.8	72.1	69.9	69.9

* p<.05; ** p<.01; ***p<.001

Table 12b: Comparison by Candidate Dietary Diversity Indicator of Logistic Regressions Predicting HH Consumption of > 1800 Kcal per AE for Ghana (n= 548)

	DHS Food Groups	Nutrient Groups	Calorie Dense Food Groups	Unique Foods	Dense Unique Foods
	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI
DD indicator	1.5*** (1.3-1.7)	2.4*** (1.6-3.7)	1.9*** (1.5-2.5)	1.1*** (1.1-1.1)	1.2*** (1.1-1.2)
HH size	0.9** (0.8-0.9)	0.9** (0.8-0.9)	0.9** (0.8-1.0)	0.8*** (0.8-0.9)	0.9*** (0.8-0.9)
Head is female	1.7* (1.1-2.6)	1.5 (1.0-2.3)	1.5 (0.9-2.3)	1.6 (1.0-2.5)	1.4 (0.9-2.2)
Dependency ratio	0.8 (0.6-1.1)	0.8 (0.6-1.0)	0.8 (0.6-1.0)	0.8 (0.6-1.1)	0.8 (0.6-1.1)
Cox & Snell R Square	0.11	0.06	0.08	0.15	0.11
Nagelkerke R Square	0.17	0.09	0.11	0.22	0.16
Percentage predicted Correct	75.5	74.3	73.5	74.3	74.1
	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI
DD indicator	1.5*** (1.3-1.7)	2.1*** (1.4-3.2)	1.9*** (1.5-2.4)	1.1*** (1.1-1.1)	1.1*** (1.1-1.2)
Cox & Snell R Square	0.08	0.03	0.05	0.11	0.08
Nagelkerke R Square	0.12	0.04	0.07	0.16	0.12
Percentage predicted Correct	73.5	73.7	73.7	75.2	73.4

* p<.05; ** p<.01; ***p<.001

Table 12c: Comparison by Candidate Dietary Diversity Indicator of Logistic Regressions Predicting HH Consumption of > 1800 Kcal per AE for Afghanistan (n=26196)

	DHS Food Groups	Nutrient Groups	Calorie Dense Food Groups	Unique Foods	Dense Unique Foods
	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI
DD indicator	1.4***(1.4-1.5)	2.0***(1.9-2.1)	1.7***(1.6-1.7)	1.2***(1.2-1.2)	1.6***(1.5-1.6)
HH size	0.9***(0.9-0.9)	0.9***(0.9-0.9)	0.9***(0.9-0.9)	0.9***(0.9-0.9)	0.9***(0.8-0.9)
Head is female	0.9(0.6-1.3)	0.9(0.6-1.3)	0.9(0.6-1.2)	0.9***(0.6-1.2)	0.9(0.6-1.2)
Dependency ratio	1.5***(1.3-1.6)	1.4***(1.3-1.6)	1.4***(1.3-1.5)	1.5***(1.3-1.6)	1.5***(1.4-1.6)
Has productive land	1.6***(1.4-1.7)	1.6***(1.4-1.7)	1.6***(1.4-1.7)	1.5***(1.4-1.7)	1.6***(1.4-1.7)
Cox & Snell R Square	0.04	0.04	0.04	0.05	1.00
Nagelkerke R Square	0.04	0.04	0.04	0.05	1.00
Percentage predicted Correct	92.4	92.4	92.4	92.4	92.4
	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI
DD indicator	1.4***(1.3-1.4)	1.8***(1.8-1.9)	1.6***(1.5-1.6)	1.2***(1.2-1.2)	1.5***(1.4-1.5)
Cox & Snell R Square	0.026	0.026	0.027	0.03	0.044
Nagelkerke R Square	0.026	0.026	0.027	0.03	0.044
Percentage predicted Correct	92.09	92.09	92.09	92.09	92.09

* p<.05; ** p<.01; ***p<.001

Table 12d: Comparison by Candidate Dietary Diversity Indicator of Logistic Regressions Predicting HH Consumption of > 1800 Kcal per AE for Ethiopia (n= 972)

	DHS Food Groups	Nutrient Groups	Calorie Dense Food Groups	Unique Foods	Dense Unique Foods
	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI	Adj. OR & CI
DD indicator	1.1(1.0-1.2)	1.3**(1.1-1.5)	1.2**(1.1-1.4)	1.1***(1.1-1.2)	1.6***(1.4-1.7)
HH size	0.8***(0.7-0.8)	0.8***(0.7-0.8)	0.8***(0.7-0.8)	0.8***(0.7-0.8)	0.7***(0.7-0.8)
Head is female	0.9(0.6-1.3)	0.9(0.6-1.3)	0.9(0.6-1.3)	1.0(0.7-1.4)	1.0(0.7-1.4)
Dependency ratio	1.2(1.0-1.4)	1.2(1.0-1.4)	1.2(1.0-1.4)	1.2(0.9-1.4)	1.1(0.9-1.4)
Has productive land	0.5*(0.3-1.0)	0.5*(0.3-0.9)	0.5*(0.3-1.0)	0.5*(0.3-0.9)	0.5*(0.2-0.9)
Cox & Snell R Square	0.11	0.12	0.12	0.13	0.20
Nagelkerke R Square	0.15	0.16	0.16	0.17	0.26
Percentage predicted Correct	64.5	64.7	64.9	65.7	69.0
	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI	Crude OR & CI
DD indicator	1.0(0.9-1.0)	1.1(0.9-1.2)	1.1(1.0-1.2)	1.0*(1.0-1.1)	1.4***(1.3-1.5)
Cox & Snell R Square	0.001	0.001	0.001	0.006	0.058
Nagelkerke R Square	0.001	0.001	0.001	0.006	0.058
Percentage predicted Correct	53.28	53.28	53.56	55.04	60.04

* p<.05; ** p<.01; ***p<.001

Table 13: Adjusted Odds Ratios for Five DD Indicators, Cross-Country Comparison

		Bangladesh n = 551	Ghana n =548	Afghanistan n = 26196	Ethiopia n = 972
DHS Food Groups	Adj OR ***	2.4*** (2.0-2.8)	1.5*** (1.3-1.7)	1.4***(1.4-1.5)	1.1(1-1.2)
	Pct correct	82	75.5	92.4	64.5
	CoxSnell	0.34	0.11	0.04	0.11
	Nagelkirke	0.48	0.165	0.04	0.15
Nutrient Groups	Adj OR ***	5.0*** (3.3-7.4)	2.4*** (1.6-3.7)	2.0***(1.9-2.1)	1.3**(1.1-1.5)
	Pct correct	79.6	74.3	92.4	64.7
	CoxSnell	0.30	0.06	0.04	0.12
	Nagelkirke	0.42	0.085	0.04	0.16
Calorie Dense Groups	Adj OR ***	3.8*** (2.8-5.2)	1.9*** (1.5-2.5)	1.7***(1.6-1.7)	1.2**(1.1-1.4)
	Pct correct	80.4	73.5	92.4	64.9
	CoxSnell	0.33	0.08	0.04	0.12
	Nagelkirke	0.47	0.11	0.04	0.16
Unique Foods	Adj OR ***	1.6*** (1.5-1.8)	1.1*** (1.1-1.1)	1.2***(1.2-1.2)	1.1***(1.1-1.2)
	Pct correct	86.1	74.3	92.4	65.7
	CoxSnell	0.40	0.15	0.05	0.13
	Nagelkirke	0.57	0.22	0.05	0.17
Calorie Dense Unique Foods	Adj OR ***	2.1*** (1.7-2.4)	1.2*** (1.1-1.2)	1.6***(1.5-1.6)	1.6***(1.4-1.7)
	Pct correct	80.2	74.1	92.4	69
	CoxSnell	0.32	0.11	1.00	0.20
	Nagelkirke	0.45	0.16	1.00	0.26

* p<.05; ** p<.01; ***p<.001

Table 14: Sensitivity and Specificity Analysis: Conceptual Summary

		Benchmark Indicator	
		+	-
Candidate Indicator	+	True positive (a)	False positive (b)
	-	False negative (c)	True negative (d)

From: Habicht et al. (1982).

Sensitivity (Se): [a/(a + c)]. proportion of true positives detected by candidate indicator

Specificity (Sp): [d/(b + d)]. proportion of true negatives detected by candidate indicator

Predictive value positive (PV+): [a/(a + b)]. proportion of true positives among all positives by candidate indicator
Most useful in 'ruling in' cases.

Predictive value Negative (PV-): [d/(c +d)]. proportion of true negatives among all negatives by candidate indicator
Most useful in 'ruling out' cases.

Table 15a: Sensitivity/Specificity Analysis Testing Nutrient Groups Index Thresholds against Households Consuming either < or ≥1800 Kcals per AE, by Country

	Afghanistan n = 29720							Ethiopia n = 1081							Bangladesh n = 551							Ghana n = 548						
	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co
ge 5	645	13333	0.73	0.49	0.11	0.95	51	15	34	0.97	0.06	0.47	0.69	48	76	77	0.80	0.44	0.75	0.50	68	121	360	0.19	0.90	0.43	0.75	71
lt 5	1705	14037						490	542						299	99						29	38					
ge 4	1472	22961	0.37	0.84	0.17	0.94	80	113	142	0.78	0.25	0.47	0.56	49	306	165	0.18	0.94	0.86	0.35	42	142	396	0.05	0.99	0.80	0.74	74
lt 4	878	4409						392	434						69	11						8	2					
ge 3	1987	26265	0.15	0.96	0.25	0.93	90	318	363	0.37	0.63	0.47	0.53	51	373	176	0.01	1.00	1.00	0.32	32	147	397	0.02	1.00	0.75	0.73	73
lt 3	363	1105						187	213						2	0						3	1					
ge 2	2264	27245	0.04	1.00	0.41	0.92	92	469	542	0.07	0.94	0.51	0.54	53	375	176	0.00	1.00	NA	0.32	32	149	398	0.01	1.00	NA	0.73	73
lt 2	86	125						36	34						0	0						1	0					

Table 15b: Sensitivity/Specificity Analysis Testing DHS Groups Index Thresholds against Households Consuming either < or ≥1800 Kcals per AE, by Country

	Afghanistan n = 29720							Ethiopia n = 1081							Bangladesh n = 551							Ghana n = 548						
	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co
ge12	0	0	1.00	0.00	0.08	na	8	0	0	1.00	0.00	0.47	na	47	0	0	1.00	0.00	0.68	na	68	29	128	0.81	0.32	0.31	0.82	45
lt12	2350	27370						505	576						375	176						121	270					
ge11	0	13	1.00	0.00	0.08	1.00	8	0	0	1.00	0.00	0.47	na	47	0	2	1.00	0.01	0.68	1.00	68	56	253	0.63	0.64	0.39	0.82	63
lt11	2350	27357						505	576						375	174						94	145					
ge10	30	786	0.99	0.03	0.08	0.96	10	0	0	1.00	0.00	0.47	na	47	9	16	0.98	0.09	0.70	0.64	69	86	336	0.43	0.84	0.51	0.80	73
lt10	2320	26584						505	576						366	160						64	62					
ge9	195	5327	0.92	0.19	0.09	0.96	25	4	2	0.99	0.00	0.47	0.33	47	44	55	0.88	0.31	0.73	0.56	70	115	375	0.23	0.94	0.60	0.77	75
lt9	2155	22043						501	574						331	121						35	23					
ge8	489	10913	0.79	0.40	0.10	0.96	43	26	26	0.95	0.05	0.47	0.50	47	94	94	0.75	0.53	0.77	0.50	68	131	384	0.13	0.96	0.58	0.75	74
lt8	1861	16457						479	550						281	82						19	14					
ge7	890	16748	0.62	0.61	0.12	0.95	61	73	81	0.86	0.14	0.47	0.53	47	178	130	0.53	0.74	0.81	0.42	59	137	395	0.09	0.99	0.81	0.74	74
lt7	1460	10622						432	495						197	46						13	3					
ge6	1290	21382	0.45	0.78	0.15	0.94	76	156	167	0.69	0.29	0.46	0.52	48	298	170	0.21	0.97	0.93	0.36	45	141	396	0.06	0.99	0.82	0.74	74
lt6	1060	5988						349	409						77	6						9	2					
ge5	1653	24317	0.30	0.89	0.19	0.94	84	269	289	0.47	0.50	0.45	0.52	49	364	174	0.03	0.99	0.85	0.32	34	144	396	0.04	0.99	0.75	0.73	73
lt5	697	3053						236	287						11	2						6	2					
ge4	1942	25876	0.17	0.95	0.21	0.93	88	381	415	0.25	0.72	0.44	0.52	50	375	176	0.00	1.00	na	0.32	32	148	398	0.01	1.00	1.00	0.73	73
lt4	408	1494						124	161						0	0						2	0					
ge3	2156	26792	0.08	0.98	0.25	0.93	91	464	534	0.08	0.93	0.49	0.54	53	375	176	0.00	1.00	na	0.32	32	149	398	0.01	1.00	1.00	0.73	73
lt3	194	578						41	42						0	0						1	0					
ge2	2283	27286	0.03	1.00	0.44	0.92	92	496	572	0.02	0.99	0.69	0.54	54	375	176	0.00	1.00	na	0.32	32	150	398	1.00	0.00	0.27	na	na
lt2	67	84						9	4						0	0						0	0					

Table 15c: Sensitivity/Specificity Analysis Testing Calorie Dense Group Thresholds against Households Consuming either < or ≥1800 Kcals per AE, by Country

	Afghanistan n = 29720							Ethiopia n = 1081						
	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co
ge 6	411	9608	0.83	0.35	0.10	0.96	39	0	0	1.00	0.00	0.47	na	47
lt 6	1939	17762						505	576					
ge 5	957	17864	0.59	0.65	0.13	0.95	65	9	8	0.98	0.01	0.47	0.47	47
lt 5	1393	9506						496	568					
ge 4	1486	23096	0.37	0.84	0.17	0.94	81	55	77	0.89	0.13	0.47	0.58	49
lt 4	864	4274						450	499					
ge 3	1923	25812	0.18	0.94	0.22	0.93	88	153	211	0.70	0.37	0.49	0.58	52
lt 3	427	1558						352	365					
ge 2	2224	27151	0.05	0.99	0.37	0.92	92	356	396	0.30	0.69	0.45	0.53	50
lt 2	126	219						149	180					

	Bangladesh n = 551							Ghana n = 548						
	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co	< 1800	≥ 1800	Se	Sp	PV +	PV-	% Co
ge 6	5	11	0.99	0.06	0.69	na	69	47	201	0.69	0.51	0.34	0.81	55
lt 6	370	165						103	197					
ge 5	43	62	0.89	0.35	0.74	0.59	72	110	353	0.27	0.89	0.47	0.76	72
lt 5	332	114						40	45					
ge 4	170	133	0.55	0.76	0.83	0.44	61	140	394	0.07	0.99	0.71	0.74	74
lt 4	205	43						10	4					
ge 3	336	172	0.10	0.98	0.91	0.34	38	148	398	0.01	1.00	1.00	0.73	73
lt 3	39	4						2	0					
ge 2	375	176	0.00	1.00	na	0.32	32	150	398	0.00	1.00	na	0.73	73
lt 2	0	0						0	0					

Table 16: Household Demographics

	N	%
State		
North	791	37.8
West	663	31.7
South	636	30.4
Type of Household		
Resident	809	41.4
IDP hh in camp	782	40.0
IDP hh in community	364	18.6
Household Headship		
Male-headed	1402	67.1
Female-headed	688	32.9
Main Source of Income		
Wage Labour, Skilled Labor, Salaried Work	822	39.4
Sale of Cereals, Ag, Livestock, Animal Prod.	407	19.5
Food Aid Sales	385	18.5
Firewood, Grass Sales	286	13.8
Petty Trade	69	3.3
Kinship, Begging, Borrowing	34	2.4
Remittances	33	1.6
Others	31	1.5
Monthly Household Expenditure (in dinars)		
Mean food expenditure ± SD	9606 ± 8733	
Mean total (food+non-food) expenditure ± SD	14918 ± 13447	
Animal Ownership		
Ownership of ≥1 Large Animal*	1128	54.0
Agricultural Production		
Cultivation of any agricultural land in past year	1063	50.9

Table 17: Frequency and Source (Food aid or Not) of Food Group Consumption

	Darfur 2005 (N=2090)		
Foods/Groups Consumed	At all? (%)	At least 3 days? (%)	Source was food aid?* (%)
Cereals	99.7	98.9	78.6
Pulses	64.6	29.1	65.7
Meat	68.2	60.2	0.3
Milk	37.5	16.7	0.0
Eggs	4.4	3.4	0.0
Sugar	92.2	6.9	46.2
Oil	95.1	6.2	65.3
Fruits	16.1	13.5	0.6
Vegetables	43.5	24.0	0.0
Wild Foods	25.7	18.3	0.0

Sources:
WFP Emergency Food Security and Nutrition Assessment in Darfur, Sudan, 2005;
*Of those that consumed this food group at all, % who cited any food aid as a source

Table 18: Bivariate Correlations among Frequency of Wild Food Consumption, Frequency of Consumption of Individual Food Groups, and Dietary Diversity Indices

Correlate	Wild Foods (Pearson r)
Millet	-.06*
Sorghum	.09***
Other Cereals	-.07**
Pulses	-.07**
Meat	-.04
Milk	-.06*
Eggs	-.03
Sugar	-.04*
Oil	-.02
Fruits	-.01
Vegetables	-.08***
AVDDD2[1]	-.10***
DDavg_nowild[2]	-.09***
Allfdssumwk_nowild[3]	-.07**
AllfdgrpWk_nowild[4]	-.10***

[1]# of days of consumption of (cereal* + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7; *cereal = average # of days per week sorghum, millet, and/or cereals consumed
[2]# of days of consumption of (sorghum + millet + other cereals + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7
[3] Reported from a list of 12 food items (sorghum, millet, other cereals, groundnuts/legumes, meat/chicken/bush meat, oil, vegetables, fruit, milk/yogurt/cheese, sugar, eggs)
[4]5 food groups possible: cereals (incl. sorghum, millet, 'other' cereals), protein (incl. pulses, meat, eggs, milk/dairy), fat (incl. oil), fruits/vegetables, sugar
* $p<.05$;
** $p<.01$;
*** $p<.001$

Table 19: Crosstabulation of Wild Food Consumption, Household Displacement Status (IDP or Camp), and Total Per Capita Monthly Expenditure Terciles

Consumed wild foods	IDP			Camp resident			Pc Expenditure Tercile				PcFood Expenditure Tercile			
	(N= 1955)			(N= 2090)			(N=2090)				(N= 2090)			
	Yes	No	Total	Yes	No	Total	Highest	Middle	Lowest	Total	Highest	Middle	Lowest	Total
Yes (% within wild food consu.)	321	197	518	197	340	537	164	200	173	537	166	198	173	537
	(62.0)	(38.0)	(100.0)	(36.7)	(63.3)	(100.0)	(30.5)	(37.2)	(32.2)	(100.0)	(30.9)	(36.9)	(32.2)	(100.0)
No (% within wild food consu.)	825	612	1437	585	968	1553	533	497	523	1553	532	504	517	1553
	(57.4)	(42.6)	(100.0)	(37.7)	(62.3)	(100.0)	(34.3)	(32.0)	(33.7)	(100.0)	(34.3)	(32.5)	(33.3)	(100.0)

Table 20: Bivariate Associations among Darfur Dietary Diversity Indicators and Common Food Insecurity Proxies

	DDAVG_nowild	AVGDD2	Allfdsumwk_nowld	allfdgrpwk
Consumption				
Adults consume lt 3 meals per day	-.25***	-.24***	-.26***	-.17***
Children consume lt 3 meals per day	-.23***	-.25***	-.22***	-.22***
Expenditure				
Monthly food exp. (p.c.)	.30***	.28***	.34***	.23***
Monthly total exp. (pc)	.35***	.34***	.39***	.26***
% spent on food†	-.04	-.06**	.03	.02
Assets				
Asset score	.36***	.32***	.42***	.26***
Livestock diversity	.12***	.10***	.12***	.05*
Coping status				
Number of coping strategies affirmed	-.22***	-.19***	-.17***	-.12***

* p<.05; ** p<.01; *** p<.001

Table 21: Crosstabulation of Nutrient Consumption Adequacy Groups with Food Expenditure p.c. and Percentage of Total Expenditure Spent on Food

Achieved minimum consumption of the following nutrient groups	Tertiles of Per Capita Food Expenditure (N= 1992)				Tertiles of Percentage of Expenditures Spent on Food (N= 2048)			
	Lowest	Middle	Highest	Total	Lowest	Middle	Highest	Total
1. Daily Intake of ≥ 1 cereal*, 1 protein†, 1 fat° & 1 fruit/veg	13 (17.8)	26 (35.6)	34 (46.6)	73 (100)	30 (41.1)	26 (35.6)	17 (23.3)	73 (100)
2. Daily Intake of ≥ 1 cereal*, 1 protein† and 1 fat° + fr/veg consumption ≥ 3 times per week	98 (23.9)	141 (34.4)	171 (41.7)	410 (100)	134 (32.8)	159 (38.9)	116 (28.4)	409 (100)
3. Daily Intake of ≥ 1 cereal*, 1 protein†, 1 fat° and sugar	115 (23.6)	165 (33.9)	207 (42.5)	487 (100)	199 (41.0)	168 (34.6)	118 (24.3)	485 (100)
4. Daily Intake of ≥ 1 cereal*, 1 protein† and 1 fat	156 (28.4)	178 (32.4)	216 (39.3)	550 (100)	227 (41.8)	184 (33.9)	132 (24.3)	543 (100)

* 'cereal' defined as millet, sorghum or other cereal
† 'protein' defined as pulse/legume/groundnut, animal meat, egg, milk
° 'fat' defined as oil

Table 22: Predictors of Dietary Diversity - OLS with Robust SE

Model Number	**1**	**2**
Dependent Variable	**AVGDD2[a]**	**Allfdsumwk[b]**
Independent Variables	**B (robust SE)**	**B (robust SE)**
Constant	-0.588 (0.271)*	-2.35 (0.427)**
Cultivate ag land (dummy)	-0.202 (0.054)**	0.053 (0.095)
IDP hh (dummy)	-0.127 (0.054)*	-0.197 (0.096)*
Food aid received in July or August (dummy)	0.262 (0.057)**	0.230 (0.101)**
# of adult meals/d	0.226 (0.040)**	0.340 (0.069)**
Log total food expenditure	-0.051 (0.057)	0.0156 (0.097)
Log total expenditure	0.485 (0.061)**	0.818 (0.099)**
Shock (dummy)	-0.218 (0.062)**	-0.233(0.102)*
# of consumption-related coping strategies in past 30 d	-0.092 (0.031)**	-0.77 (0.049)**
Large animal ownership (dummy)	0.081 (0.053)	0.036 (0.091)
Female headed household (dummy)	-0.028 (0.051)	-0.171 (0.085)*
Household size	-0.013 (0.009)	-0.029 (0.0154)
West	0.178 (0.057)**	0.662 (0.098)**
South	0.254 (0.058)**	0.728 (0.099)**
N	**1800**	**1800**
R Squared	**0.244**	**0.268**
Adjusted R Squared	**0.239**	**0.263**
F value	**44.38****	**50.34****

[a] # of days of consumption of (cereals + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7
[b] # of different foods consumed by the household at least once in the past week (list of 12 food items: sorghum, millet, other cereals, groundnuts/pulses, meat/chicken, cooking oil, vegetables, fruits, milk/yogurt, sugar, eggs, wild foods)
* p<0.05
**p<0.01

Table 23: Predictors of Dietary Diversity amongst IDPs – OLS with Robust SE

Model Number	**3**	**4**
Dependent Variable	**AVGDD2[a]**	**Allfdsumwk[b]**
Independent Variables	**B (robust SE)**	**B (robust SE)**
Constant	-0.443 (0.329)	-1.85 (0.503) **
Cultivate ag land (dummy)	0.031 (0.066)	0.426 (0.116)**
IDP camp (dummy)	0.0378 (0.0648)	-0.282 (0.114)*
Food aid received in July or August (dummy)	0.474 (0.075)**	0.686 (0.133)**
# of adult meals/d	0.220 (0.050)**	0.159 (0.081)
Log total food expenditure	-0.067 (0.069)	-0.074 (0.117)
Log total expenditure	0.452 (0.0742)**	0.853 (0.124)**
Shock (dummy)	-0.226 (0.084)**	-0.148 (0.127)
# of consumption-related coping strategies in past 30 d	-0.066 (0.040)	-0.193 (0.059)**
Large animal ownership (dummy)	-0.012 (0.062)	-0.019 (0.106)
Female headed household (dummy)	-0.130 (0.064)*	-0.274 (0.103)**
Household size	-0.0135 (0.012)	-0.042 (0.019)*
West	0.187 (0.075)*	0.586 (0.124)**
South	0.186 (0.085)*	0.735 (0.141)**
N	**1055**	**1055**
R Squared	**0.242**	**0.291**
Adjusted R Squared	**0.233**	**0.282**
F value	**25.59****	**32.80****

[a] # of days of consumption of (cereals + groundnuts/pulses + meat/chicken + cooking oil + vegetables + fruits + milk/yogurt + sugar + eggs) / 7
[b] # of different foods consumed by the household at least once in the past week (list of 12 food items: sorghum, millet, other cereals, groundnuts/pulses, meat/chicken, cooking oil, vegetables, fruits, milk/yogurt, sugar, eggs, wild foods)
* p<0.05
**p<0.01

Figures

Fig. 1 Calories per AE by DHS Food Groups Bangladesh

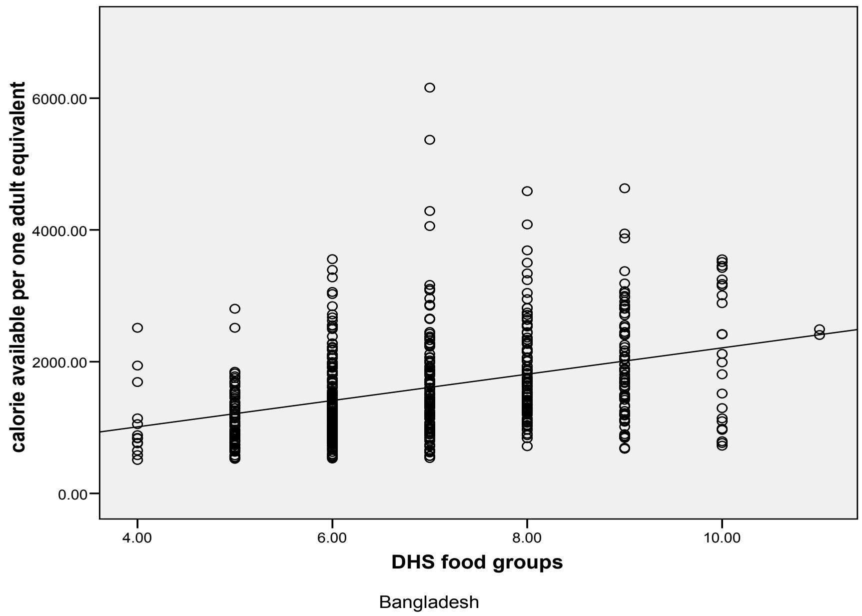


Fig. 2. Calories per AE by Nutrient Groups Bangladesh

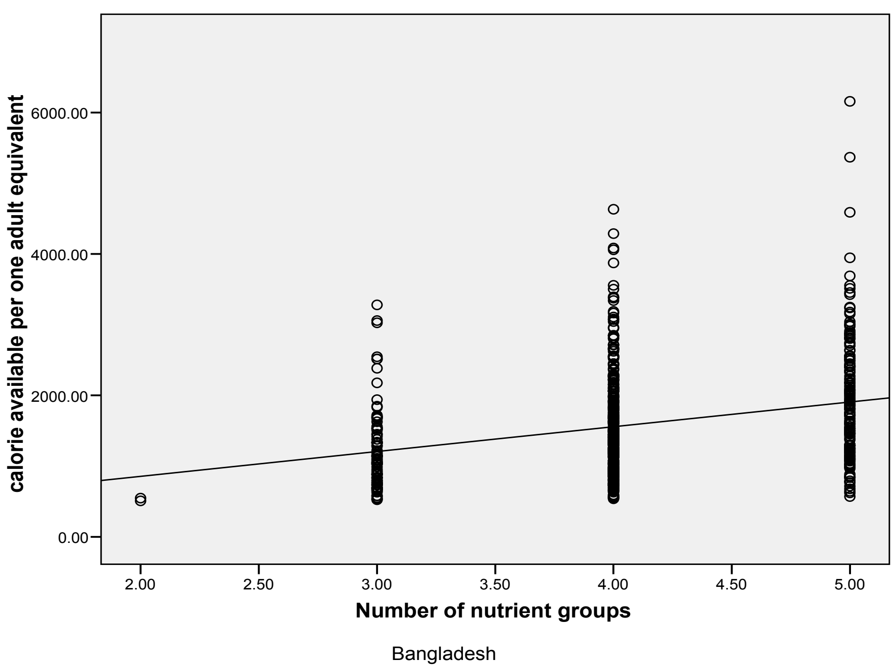


Fig 3. Calories per AE by Calorie Dense Food Groups Bangladesh

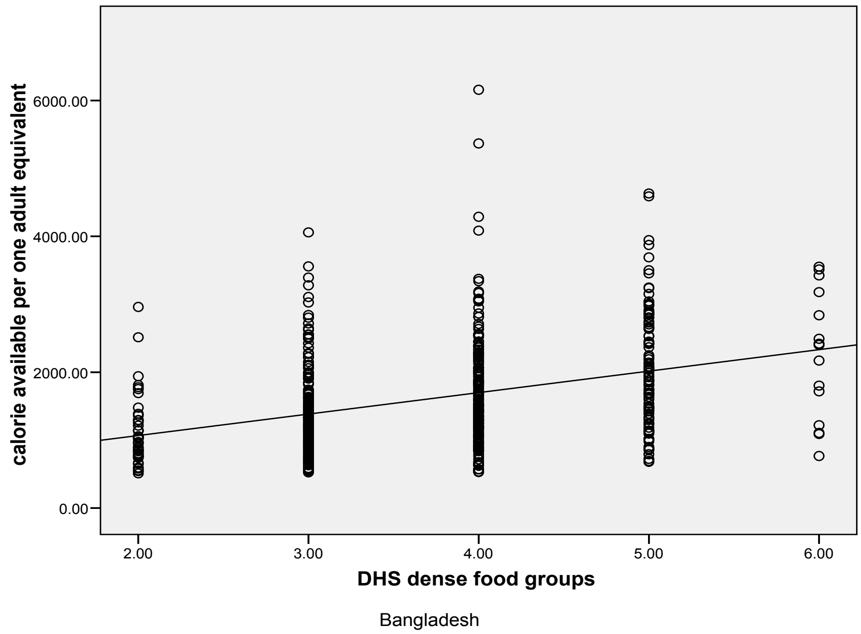


Fig. 4 Calories per AE by Unique Foods Bangladesh

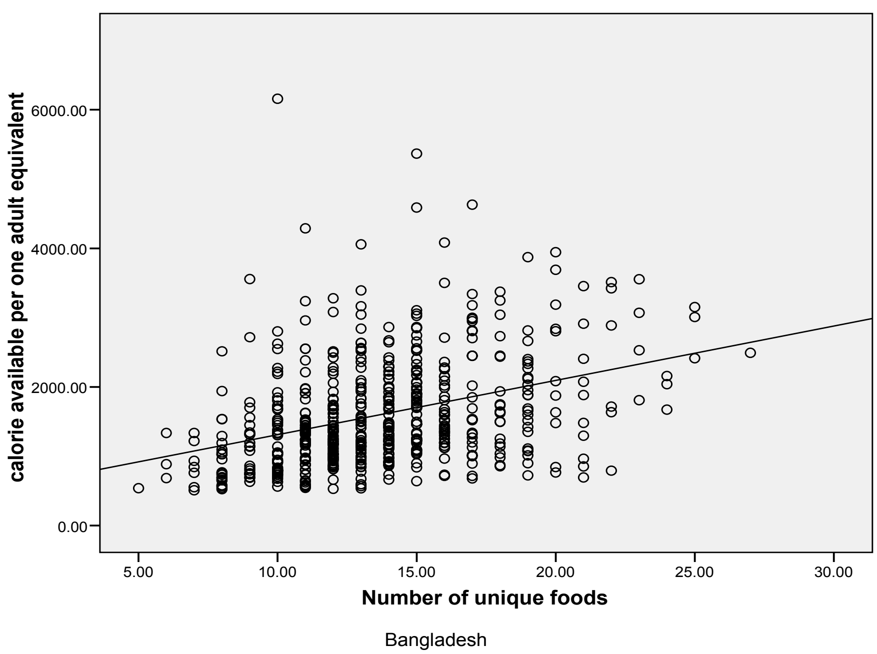


Fig. 5 Calories per AE by Calorie Dense Unique Foods Bangladesh

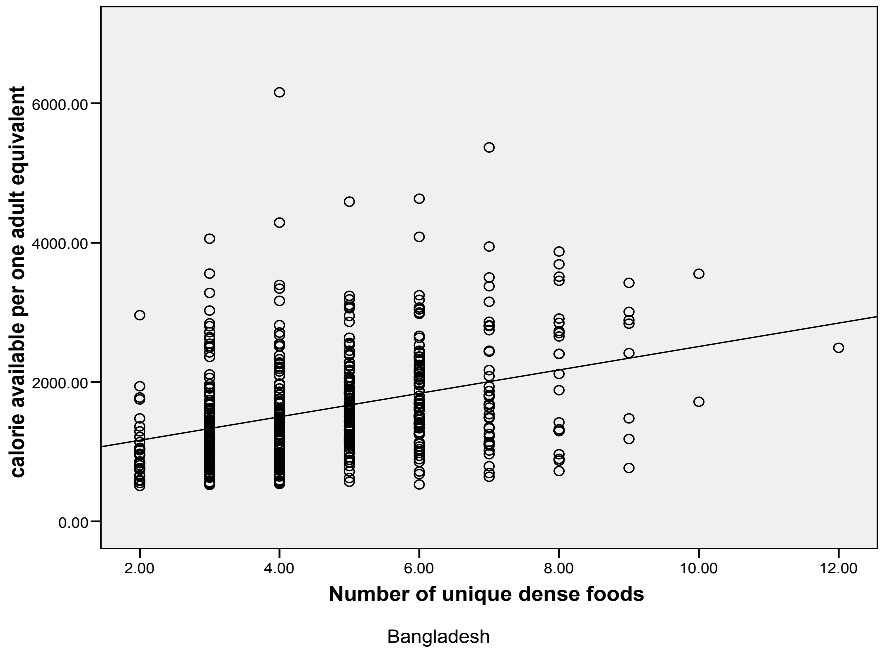


Fig. 6 Calories per AE by DHS Food Groups Ghana

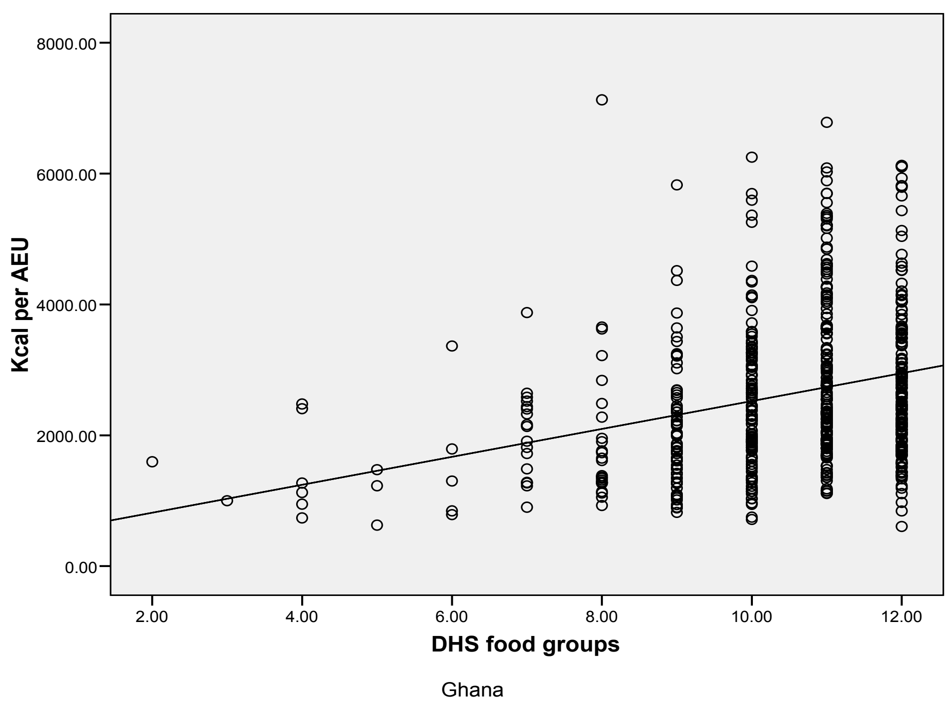


Fig. 7 Calories per AE by Nutrient Groups Ghana

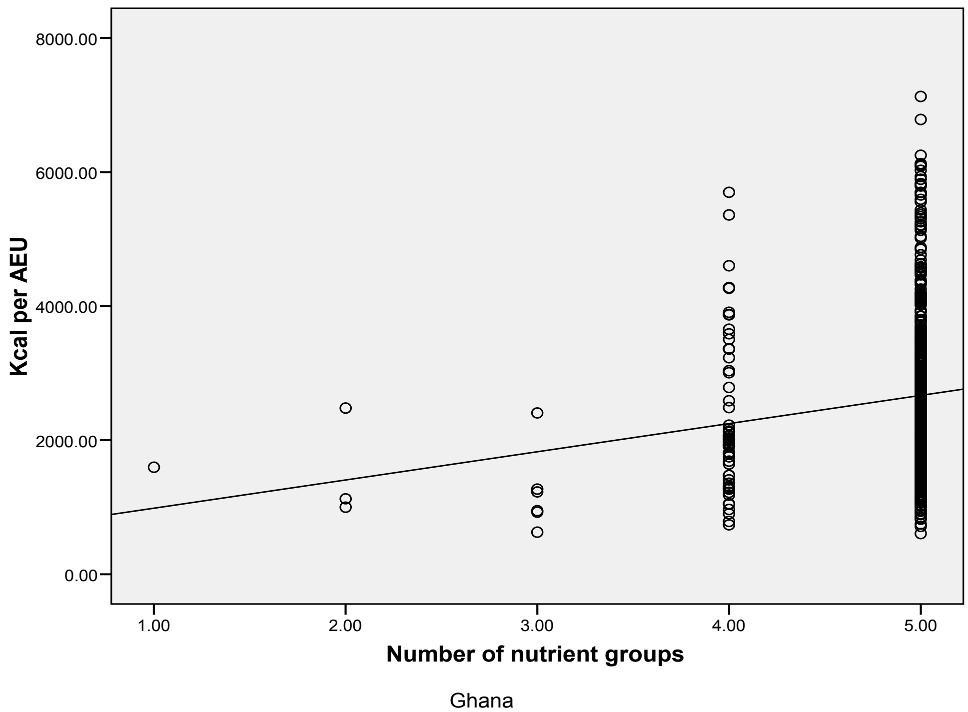


Fig. 8. Calories per AE by Calorie Dense Nutrient Groups Ghana

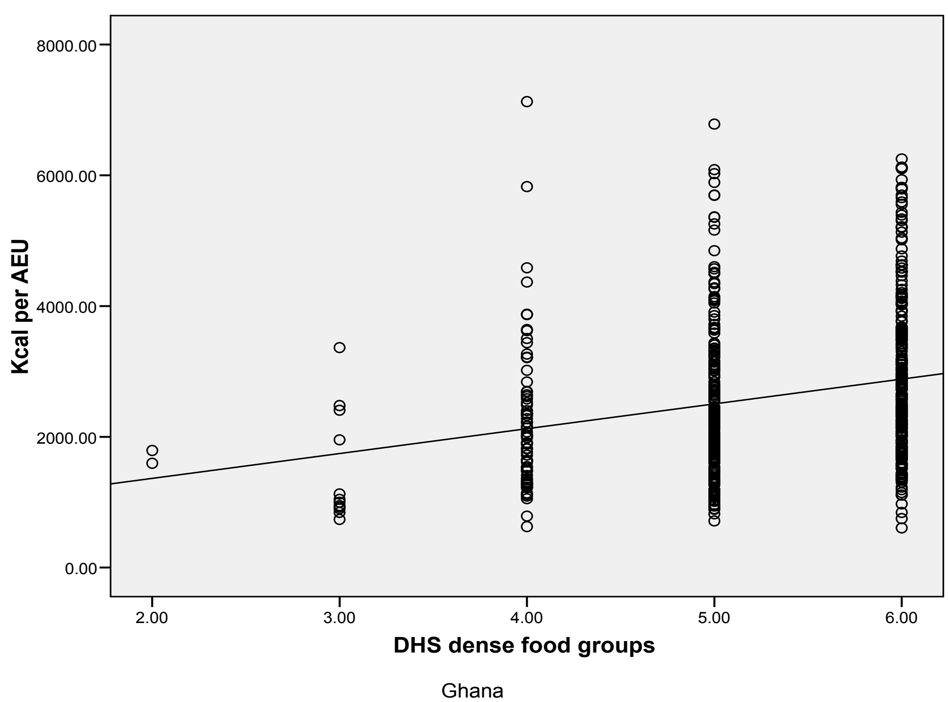


Fig 9. Calories per AE by Number of Unique Foods Ghana

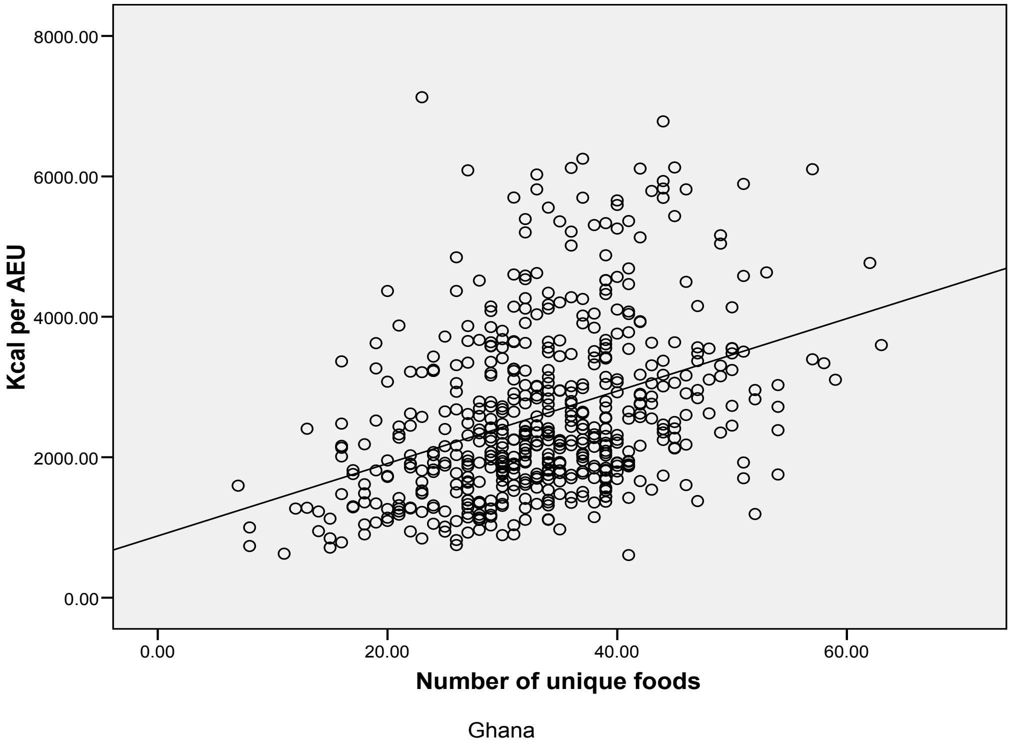


Fig. 10 Calories per AE by Number of Calorie Dense Unique Foods Ghana

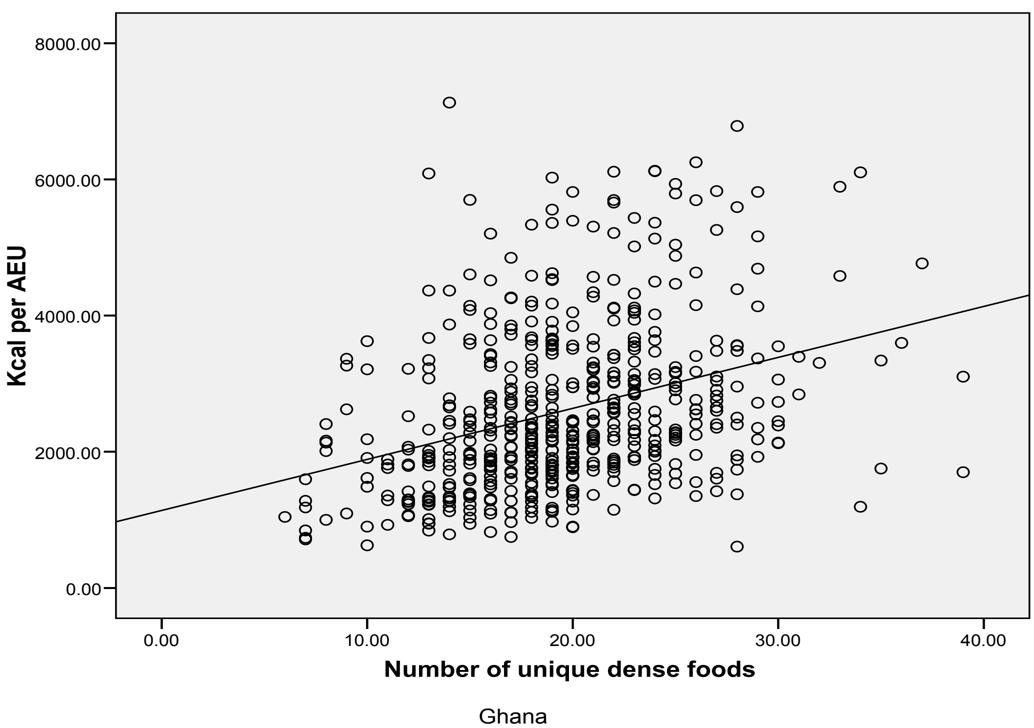


Fig. 11 Calories per AE by DHS Food Groups Afghanistan

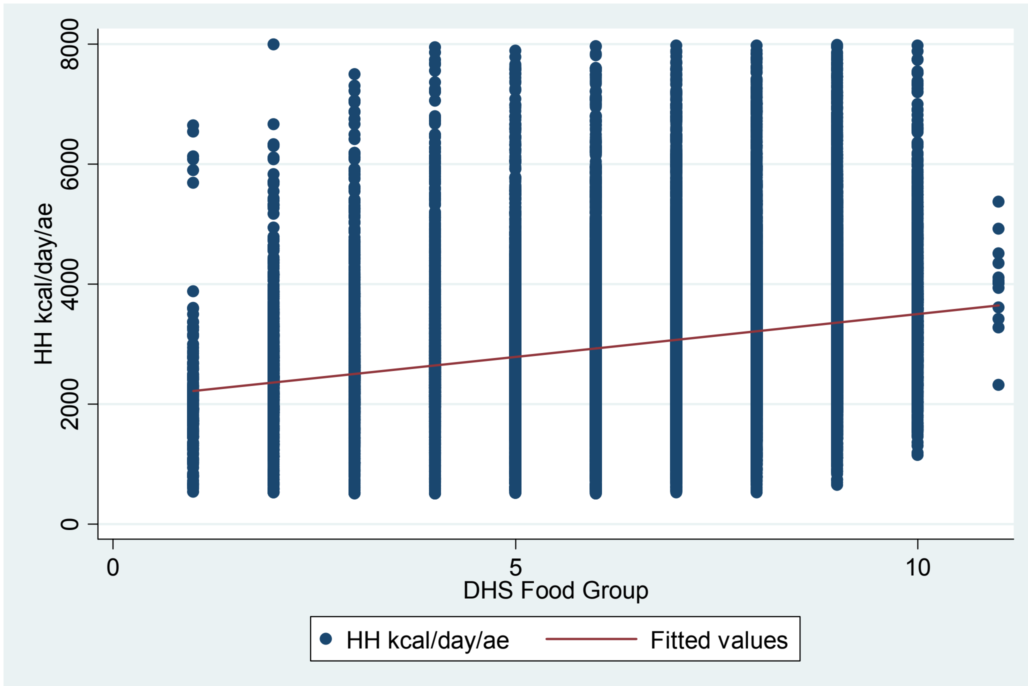


Fig 12. Calories per AE by Nutrient Groups Afghanistan

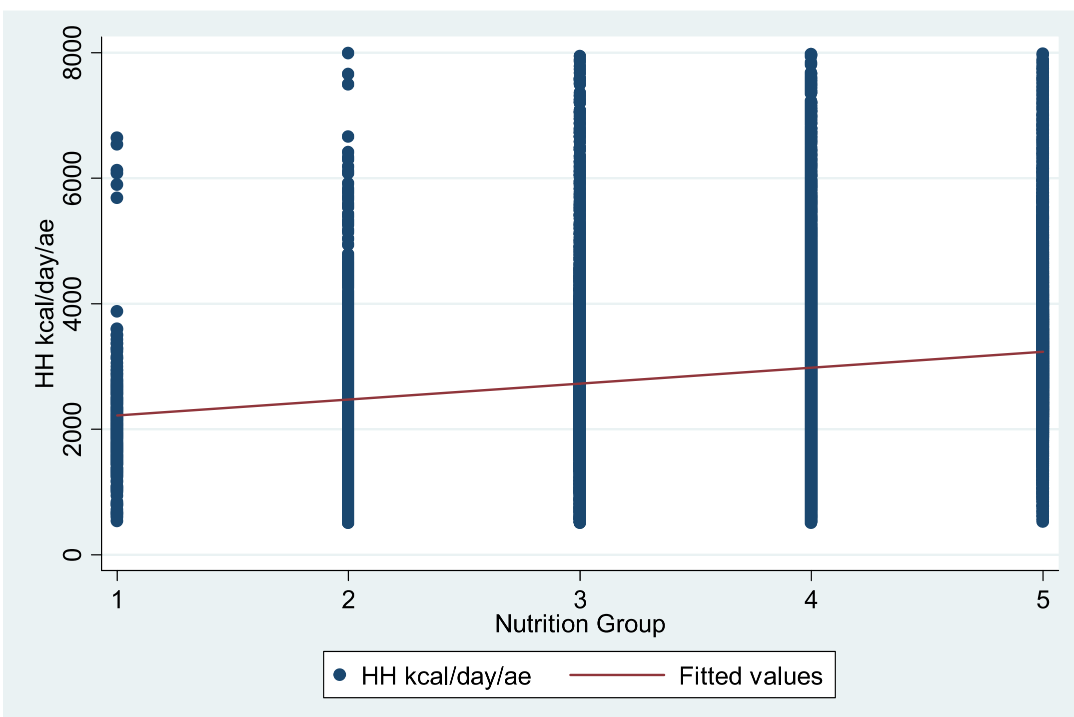


Fig 13 Calories per AE by Calorie Dense Food Groups Afghanistan

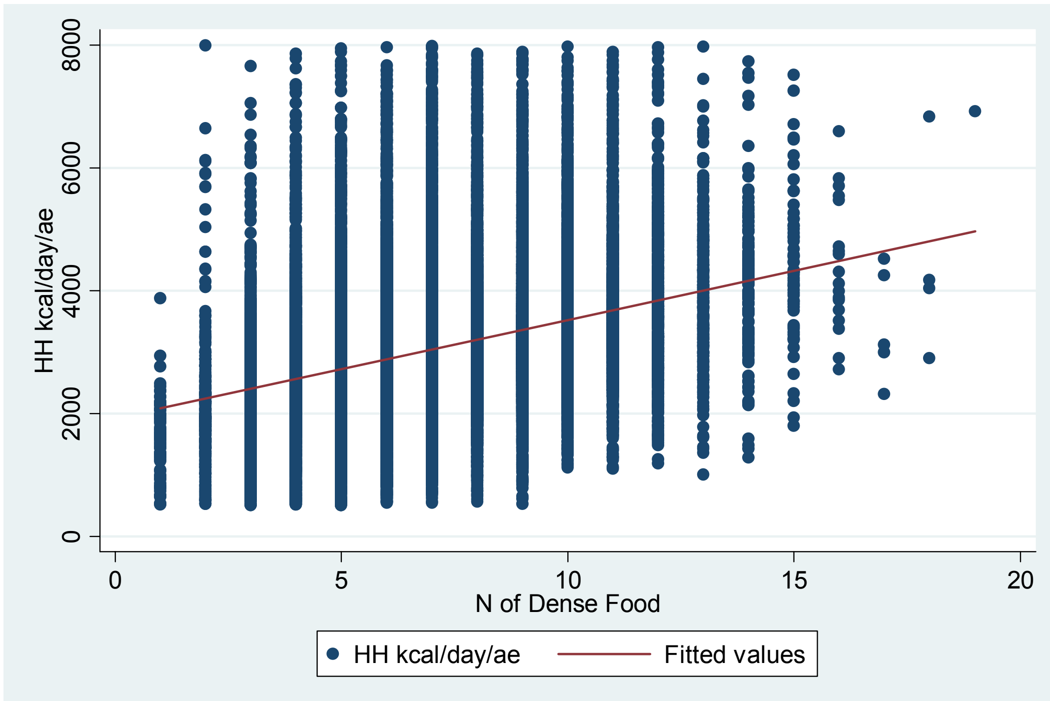


Fig 14 Calories per AE by Unique Foods Afghanistan

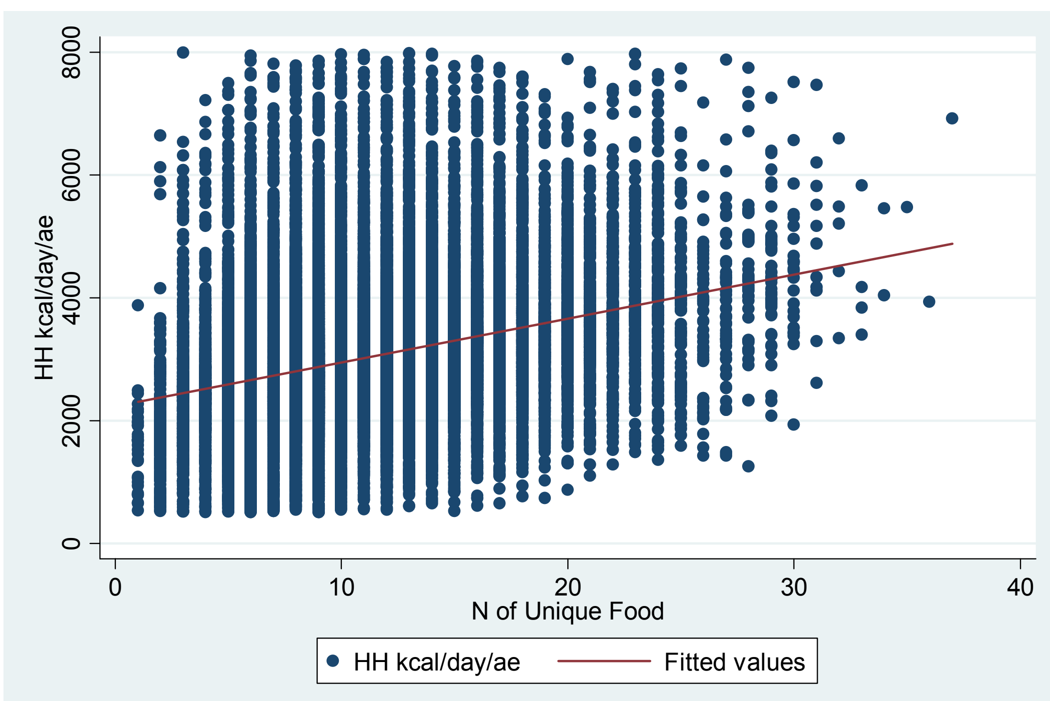


Fig. 15 Calories per AE by Calorie Dense Unique Foods Afghanistan

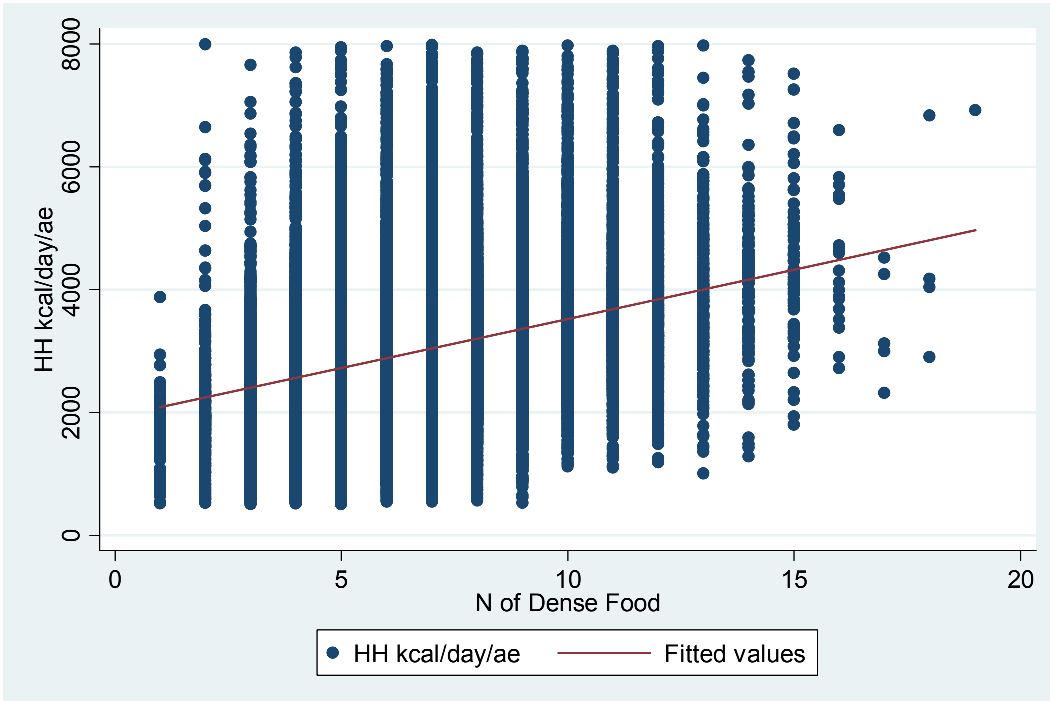


Fig. 16 Calories per AE by DHS Food Groups Ethiopia

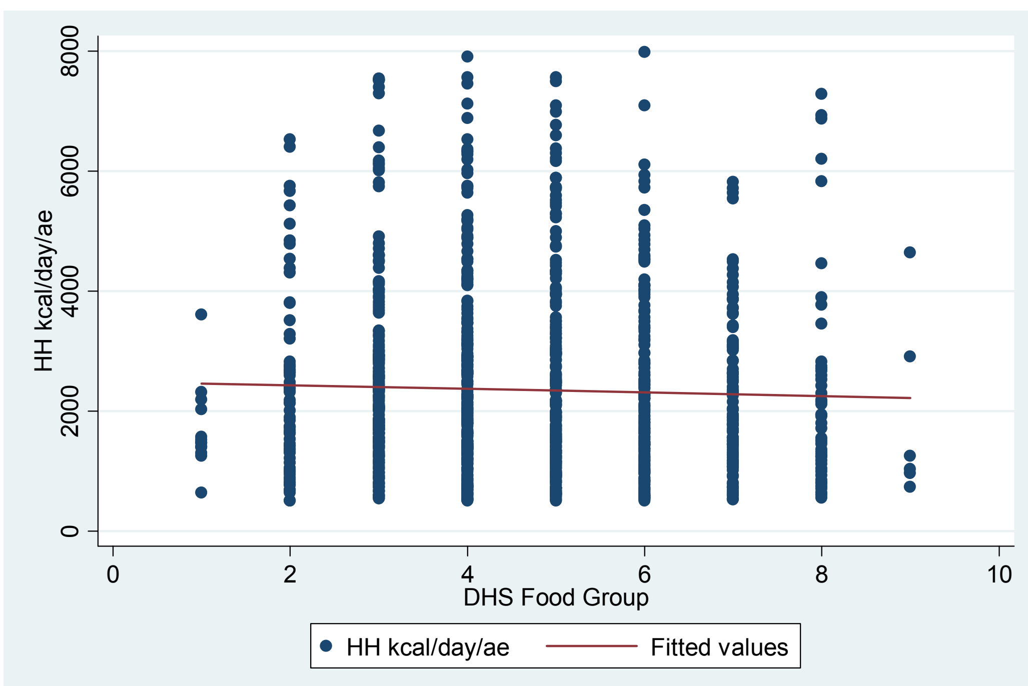


Fig 17 Calories per AE by Nutrient Groups Ethiopia

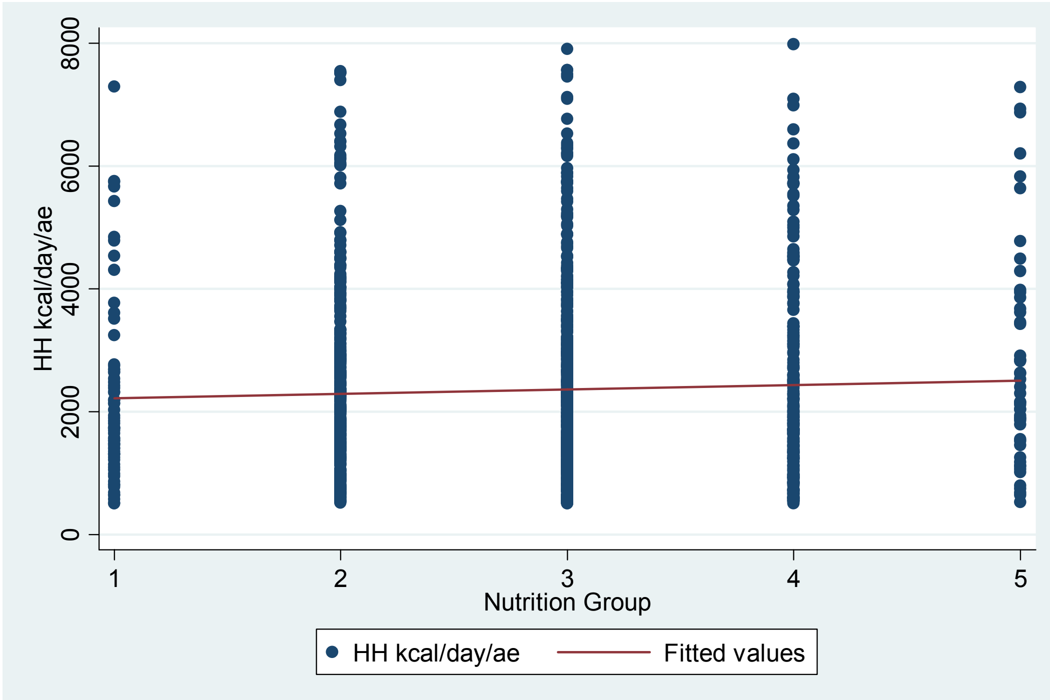


Fig 18 Calories per AE by Calorie Dense Food Groups Ethiopia

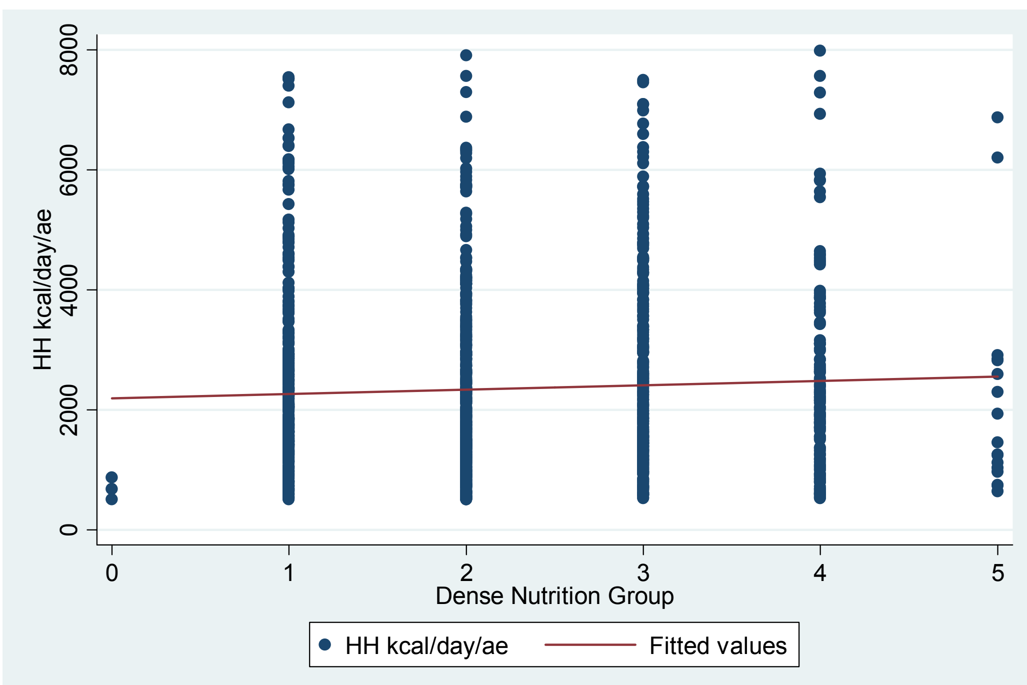


Fig 19 Calories per AE by Unique Foods Ethiopia

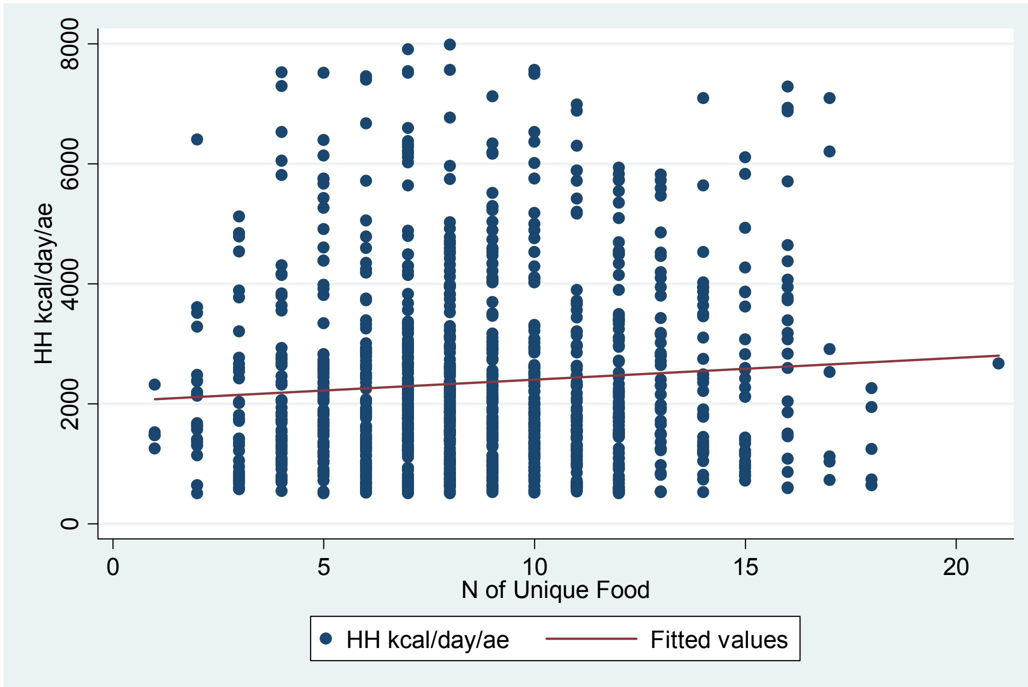
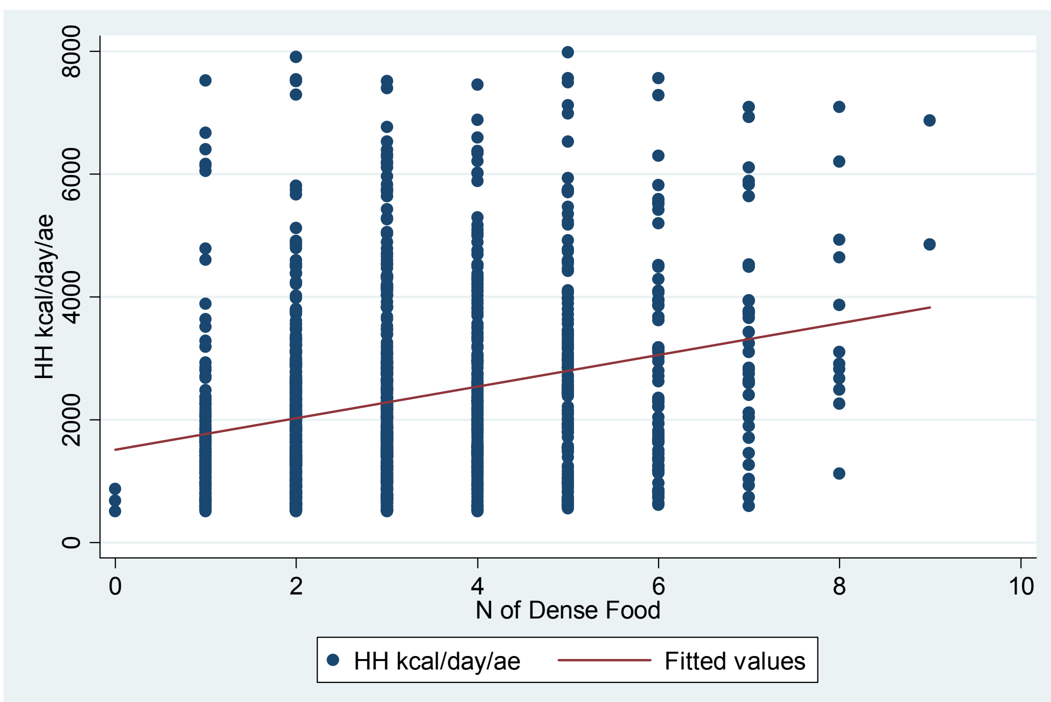


Fig 20 Calories per AGE by Calorie Dense Unique Foods Ethiopia



Appendix A: Summary of Inconsistencies detected in the Afghanistan National Risk and Vulnerability Assessment (2005) Data Set

The NRVA 2005 data from Afghanistan was the only data set available to Tufts that included information for calculating caloric adequacy *and* frequency of food/food group consumption. Both variables were needed for a validation of the WFP approach to classifying households based on their dietary diversity as a proxy for caloric intake.

In the NRVA 2005 data set, dietary data were captured with an instrument that asked the person in the household primarily responsible for food preparation to report the frequency, source, and quantity of consumption of 64 different foods during the previous seven days. From the data on quantity consumed of each food item, it was possible to calculate an estimate of household caloric availability per capita using methods described in the body of the report, and these estimates were used in many of the analyses comprising a portion of this report. The next step was to construct a dietary diversity indicator using the WFP method, which involves a consideration of the number of times a food/food group was consumed the previous week, for comparison to the household caloric adequacy information. At this point, it became apparent that response options for the frequency question were "1-7 days" - there did not seem to be an option for not consuming the food at all (0 days). In checking to see how this issue may have influenced the data, we created a variable for whether respondents reported eating more than 0 Kg of that item and cross-tabulated it by the number of days that they reported consuming it. Ideally, we would not find anyone that reported consuming an item on 1 or more days that also reported consuming 0 kg of that food item. However, a sampling of food items showed that there were several households that reported eating the item on at least one day but consuming 0 as the amount. For instance: Wheat: 524 hhs; Rice: 789 hhs; Beans: 1801 hhs; Chickpea: 1071 hhs; Egg: 656 hhs; Tomato: 632 hhs. There were also instances where zero days of consumption were recorded alongside a report of a non-zero quantity. These types of discrepancies were detected in nearly 50% of the sampled households, where a discrepancy in a single food item marked a household as “inconsistent”. In most cases where a household was ‘inconsistent’, there was not just a single discrepancy but rather multiple inconsistencies. These inconsistencies were not found in reference to minor, less important foods or foods like spices that were consumed in small quantities, they were also detected in the data for consumption of major staples.

The next step in the diagnostic process was to assess whether these “funny” households, or those households with inconsistencies, were randomly distributed throughout the sample. If they were, then the plan was to omit these households from the sample and run the analyses for the report on the remaining households. As such, households with and without inconsistencies were compared according to several characteristics. The results showed that these two groups were statistically different in terms of their mean household sizes, per capita food expenditure, and geographic location. Based on these results, Tufts felt that these particular variables in the data set were not reliable enough to use as the basis for assessing and validating the WFP method of classifying households according to their dietary diversity.

References

Aiga, H. and A. Dhur. 2006. *Measuring household food insecurity in emergencies: WFP's Household Food Consumption Approach*. Rome. Mimeo.

Allen, L. 2006. Causes of nutrition-related public health problems of preschool children: available diet. *J Pediatr Gastroenterol Nutr*. 43 (Suppl. 3): S8-12.

Azadbakht, L., P. Mirmiran and F. Azizi. 2005. Variety scores of food groups contribute to the specific nutrient adequacy in Tehranian men. *Europ. Jou. Clin.l Nutr*. 59: 1233–40.

Behrman, J. and A. Deolalikar. Is Variety the Spice of Life? Implications for Calorie Intake. 1989. *Review of Economics and Statistics*. :666-72.

Bernstein, M., M. Nelson, K. Tucker, J. Layne, E. Johnson, A. Nuernberger, C. Castaneda, J. Judge, D. Buchner, S. Fiatarone. 2002. Home-Based Nutrition Intervention to Increase Consumption of Fruits, Vegetables and Calcium-Rich Foods in Community Dwelling Elders. *Jou. Am. Dietetic Assoc*. 102:1421-7.

Bondia-Pons, I., L. Serra-Majem, A. Castellote, and M. López-Sabater. 2007. Compliance with the European and national nutritional objectives in a Mediterranean population. *Eur J Clin Nutr*. doi:10.1038/sj.ejcn.1602662

Clausen T., K. Charlton, K. Gobotswang, and G. Holmboe-Ottesen. 2005. Predictors of food variety and dietary diversity among older persons in Botswana. *Nutrition*. 21(1): 86-95.

Coates, J., A. Swindale and P. Bilinsky. 2006. *Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide (v. 2).* Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Cordeiro, L. 2007. *Household Food Security and the Nutritional Status of Rural Tanzanian Adolescents*. Doctoral Thesis. Friedman School of Nutrition Science and Policy, Tufts University. Boston, USA.

Christiaensen, L. R. Boisvert and J. Hoddinott. 2000. *Validating Operational Food Insecurity Indicators against a Dynamic Benchmark.* World Bank Policy Research Working Paper No. 2471. Washington, D.C.: World Bank

Van Dam, R. 2005. New approaches to the study of dietary patterns. *Brit. Jou. Nutr*. 93 : 573-4.

Devaney, B. M. Crepinsek, K. Fortson, and L. Quay. 2007. *Review of Dietary*

Reference Intakes for Selected Nutrients Challenges and Implications for Federal Food and Nutrition Policy. Contractor and Cooperator Report No. 28. Washington, D.C.: United States Department of Agriculture.

Dhur, A. 2007. *Strengthening Rapid Food and Nutrition Security Assessments*. Draft WFP/ODAN Guidance Note. Rome

DI (Development Initiatives). 2006. *Global Humanitarian Assistance 2006*. Evercreech, UK.

Dixon, J., and d. Macarov (eds). 1998. *Poverty*. London, UK: Routledge.

Drescher L., S. Thiele and G. Mensink. 2007. A new index to measure healthy food diversity better reflects a healthy diet than traditional measures. *Jou. Nutr.* 137 (3): 647-51.

FAO (Food and Agriculture Organization). 2005. *Nutrition Indicators for Development* Reference Guide produced by B. Maire and F. Delpeuch. Rome.

FAO/WHO (Food and Agriculture Organization/World Health Organization). 1992. *Nutrition: The Global Challenge*. Report for the International Conference on Nutrition, December 5-11, Rome, Italy.

FHANIS/CSO (Food, Health and Nutrition Information System/Central Statistical Office). 1998. *FHANIS Urban Report: Monitoring of the Household Food Security, Health, and Nutrition in Urban Areas*. Lusaka, Zambia: Central Statistical Office.

Getahun, H.., F. Lambein. M. Vanhoorne and P. Van der Stuft. 2003. Food-aid cereals to reduce neurolathryism related to grass-pea preparations during famine. *Lancet*. 362 (11): 1808-10.

Gibson, R., F. Yeudall, N. Drost, B.Mtitimuni and T. Cullinan. 2003. Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries Experiences of a Community-Based Dietary Intervention to Enhance Micronutrient Adequacy of Diets Low in Animal Source Foods and High in Phytate: A Case Study in Rural Malawian Children. *J. Nutr.* 133 (Suppl.): 3992S–9S.

Gittelsohn, J., S. Mookerji and G. Pelto. 1998. Operationalizing household food security in rural Nepal. *Food and Nutrition Bulletin*. 19 (3): 210-22.

Hatløy, A., L. Torheim and A. Oshaug. 1998. Food variety--a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *Eur J Clin Nutr*. 52 (12):891-8.

De Haen, H. 2002. *Lessons Learned* in Summary of Proceedings of the International Scientific Symposium on Measurement and Assessment of Food Deprivation and Undernutrition, June 26-28, 2002, Rome, Italy: Food and Agriculture Organization of the United Nations, pp. 69-74.

Hoenicke, M., O. Ecker, M. Qaim and K. Weinberger. 2006. *Vitamin A and iron consumption and the role of indigenous vegetables: a household level analysis in the Philippines*. Discussion Paper No. 03/2006. Institute of Agricultural Economics and Social Sciences in the Tropics and Subtropics. Stuttgart, Germany: University of Hohenheim.

Hoffman, K., M. Schulze, A. Schienkiewitz, U. Noethlings and H. Boeing. 2004. Application of a new statistical method to derive dietary patterns in nutritional epidemiology. *Am. Jou. Epidemiol*. 159: 935-44.

Kant, A., A. Schatzkin, T. Harris, R. Ziegler and G. Block. 1993. Dietary diversity and subsequent mortality in the First National Health and Nutrition Examination Survey Epidemiologic Folly-Up Study. *Am. Jou. Clin. Nutr*. 57:434-40.

Kennedy, G., M. Pedro, C. Seghieri, G. Nantel and I. Brouwer. 2007. Dietary Diversity Score Is a Useful Indicator of Micronutrient Intake in Non-Breast-Feeding Filipino Children. *Jou. Nutr*. 137:472-77.

Kennedy G., O. Islam, P. Eyzaguirre and S. Kennedy. 2005. Field testing of plant genetic diversity indicators for nutrition surveys: rice-based diet of rural Bangladesh as a model. *Jou Food Composition and Analysis*. 8 (4): 255-268.

Kim, S., P. Haines, A. Siega-Riz and B. Popkin. 2003. The Diet Quality Index-International (DQI-I) Provides an Effective Tool for Cross-National Comparison of Diet Quality as Illustrated by China and the United States. *J. Nutr*. 133: 3476-84.

Lin C., S. Boslaugh, H. Ciliberto, K. Maleta, P. Ashorn, A.Briend, and M. Manary. 2007. A prospective assessment of food and nutrient intake in a population of Malawian children at risk for kwashiorkor. *Jou. Pediatr Gastroenterol Nutr*. 44 (4): 487-93.

Maxwell, D., R. Caldwell and M. Langworthy. 2007. Comparing "Apples to Apples:" Are Universal Measures of Household Food Security Achievable? Working Paper. Feinstein International Center, Medford MA.

Menotti, A., G. Farchi, M. Massari, K. Freeman, and F. Seccareccia. 2004. An index to measure the association between dietary patterns and coronary heart disease risk factors: findings from two Italian studies. *Preventive Medicine*, 39 (4): 841-7.

Mirmiran, P., L. Azadbakht, and F. Azizi. 2006. Dietary Diversity within Food Groups: An Indicator of Specific Nutrient Adequacy in Tehranian Women. *Jou American College Nutrition*, 25 (4): 354-361

Mirmiran P., L. Azadbakht, A. Esmaillzadeh, and F. Azizi. 2004. Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets. *Asia Pac Jou. Clin Nutr*. 13 (1):56-60.

Ndekha, M., D. Maker C. Hotz and M. Manary. 2006. The quality of the diet in Malawian children with kwashiorkor and marasmus. *Maternal and Child Nutrition*. 2 (2): 114-22.

Neuhouser, M., R. Patterson, I. King, N. Horner and J. Lampe. 2003. Selected nutritional biomarkers predict diet quality. *Public Health Nutrition*. 6 (7): 703-9

Newby, P., F. Hu, E. Rimm, S. Smith-Warner, D. Feskanich, L. Sampson and W. Willett. 2003. Reproducibility and validity of the Diet Quality Index Revised as assessed by use of a food-frequency questionnaire. *Am. Jou. Clin. Nutr*. 78 (5): 941-9

Newby, P. and K. Tucker 2004. Empirically derived eating patterns using factor or cluster analysis: a review. *Nutr Rev*. 62 (5): 177-203.

Ogle, B., P. Hung, and H. Tuyet. 2001. Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety. *Asia Pac J Clin Nutr*. 10 (1):21–30.

Onyango, A. 2003. Dietary diversity, child nutreition and health in contemporary African communities. *Comp. Biochem. Physiol A Mol Integr Physiol*. 136: 61-9.

Pathak P., U. Kapil, S. Kapoor, R. Saxena, A. Kumar, N. Gupta, S. Dwivedi, R. Singh and P. Singh. 2004. Prevalence of multiple micronutrient deficiencies amongst pregnant women in a rural area of Haryana. *Indian J Pediatr*. 71 (11):1007-14.

Patil, G. and C. Taillie. 1982. Diversity as a Concept and Its Measurement. *Jou. Am. Stats. Assoc*. 77 (9): 548-61.

Pedro, R. L. Candelaria, F. Bacos, B. Ungson and E. Lanot. 1996. A simplified dietary assessment to identify groups at-risk for dietary vitamin A deficiency. *Asia Pacific J Clin Nutr*. 5 (3): 164-9.

Persson, V., A. Winkvist, T. Ninuk, S. Hartini, T. Greiner, M. Hakim and H. Stenlund. 2001. Variability in Nutrient Intakes among Pregnant Women in Indonesia:Implications for the Design of Epidemiological Studies Using the 24-h Recall Method. *Jou. Nutr*. 131: 325-30

Ponce, X., E. Ramirez and H. Delisle. 2006. A More Diversified Diet among Mexican

Men May Also Be More Atherogenic. *J. Nutr*. 136:2921-7.

Proudhon, C. 2002. *Assessment and Treatment of Malnutrition in Emergency Situations*. Paris, France: Action Contre la Faim.

Rose, D. and D. Tschirley. 2000. *A Simplified Method for Assessing Dietary Adequacy in Mozambique.* Ministry of Agriculture, Directorate of Economics. Research Paper Series No. 36. Republic of Mozambique. Mimeo.

Savy, M., Y. Martin-Prével, P. Traissac, S. Eymard-Duvernay and F. Delpeuch. 2006. Dietary Diversity Scores and Nutritional Status of Women Change during the Seasonal Food Shortage in Rural Burkina Faso. *Jou. Nutr*. 136: 2625-32.

SCF (Save the Children). 2004. *Emergency Nutrition Assessment*. London, UK.

Scheafer, D. J. Augusin. M. Schaefer, H. Rasmussen, J. Ordovas, G. Dallal and J. Dwyer. 2000. Lack of efficacy of a food-frequency questionnaire in assessing dietary macronutrient intakes in subjects consuming diets of known composition. *Am Jou. Clin. Nutr.* 71 (3): 746-51.

Schneider, S. And X. Hebuterne. 2000. Use of Nutritional Scores to Predict Clinical Outcomes in Chronic Diseases. *Nutr. Reviews*. 58 (2): 31-8.

Schulze M., and K. Hoffmann. 2007. Methodological approaches to study dietary patterns in relation to risk of coronary heart disease and stroke. *British Jou. Nutrition* 95 (5): 860-9.

Serra-Majem, L. et. al. 2003. Comparative analysis of nutrition data from national, household, and individual levels. *Jou. Epi. and Community Health* 57:74-80.

Seymour, J., E. Calle, E. Flagg, R. Coates, E. Ford and M. Thun. 2003. Diet Quality Index as a Predictor of Short-term Mortality. *Am J Epidemiol* 157:980-8.

Slattery M., T. Berry, J. Potter and B. Caan. 1997. Diet diversity, diet composition, and risk of colon cancer. *Cancer Causes Control.* 8 (6): 872-82.

Steyn N., J. Nel, G. Nantel, G. Kennedy and D. Labadarios. 2006. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutrition*: 9(5): 644–50.

Sullivan, J., N. MacDonald, D. Maker, C. Hotz, and M. Manary. 2006. The quality of the diet in Malawian children with kwashiorkor and marasmus. *Maternal & Child Nutr.* 2 (2): 114–22.

Swindale, A., Ohri-Vachaspati, P. 2005. *Measuring Household Food Consumption: A Technical Guide*. Washington DC: Academy for Educational Development, Food and Nutrition Technical Assistance.

Tarini, A., S. Bakari, and H. Delisle. 1999. The overall nutritional quality of the diet is reflected in the growth of Nigerian children. *Sante*. 9(1): 23-31.

Torheim, L., I. Barikmo, C. Parr, A. Hatløy, F. Ouattara and A. Oshaug. 2003. Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for Western Mali. *European Jou Clin Nutr*. 57 (10): 1283-91.

Tur, J., D. Romaguera, and A. Pons. 2005. The Diet Quality Index-International (DQI-I): is it a useful tool to evaluate the quality of the Mediterranean diet? *Brit Jou Nutr*. 93 (3):369-76.

UNHCR (United Nations High Commissioner for Refugees). 1982. *Handbook for Emergencies*. Geneva, Switzerland.

Walker, P. and K. Pepper. 2007. *Follow the Money: A review and analysis of the state of humanitarian funding*. Draft briefing paper for meeting on progress in good humanitarian donorship. Feinstein International Center, Friedman School, Tufts University.

Webb, P., J. Coates, E. Frongillo, B. Rogers, A. Swindale and P. Bilinsky. 2006. Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do. *Journal of Nutrition*. 136: S1404-08.

WFP (World Food Programme of the United Nations). 2005. *Emergency Food Security Assesssment Handbook*. Rome, Italy.

WHO (World Health Organization). 1966. *The Assessment of the Nutrition Status of the Community (with special reference to field surveys in developing regions of the world)*. Principal author, D. Jelliffe. Geneva, Switzerland.

1999. *Rapid Health Assessment Protocols for Emergencies*. Geneva, Switzerland.

2000. *The management of nutrition in major emergencies*. Geneva: WHO, International Federation of the Red Cross and Red Crescent Societies, World Food Programme and the United Nations High Commissioner for Refugees.

WHO/FAO (World Health Organization/ Food and Agriculture Organization). 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of a joint WHO/FAO expert consultation, Geneva, 28 January -- 1 February 2002. WHO technical Report Series No. 916. Geneva, Switzerland.