Nutritional Discordance

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# Introduction

Women and girls are commonly assumed to be at greater risk of food insecurity (e.g., UN Women 2012). Earlier research examined whether women consume a lower percentage of their required daily caloric intake (e.g., Haddad and Kanbur (1990); Berhman and Deolaliker (1990); Pitt et al. (1990); Haddad et al. (1995)), but, as Marcoux (2002) summarized, “evidence of pro-male biases in food consumption is scarce” (p. 275).

In recent years, this claim has been reconsidered, and more recent findings suggest that there is meaningful nutritional inequality within households. Much of the earlier research used caloric intake measures. Recent research has focused on richer nutritional intake and outcome measures, such as dietary diversity (Mangyo (2008); Villa et al. (2011); Rahman (2013)), nutrient adequacy (Coates 2017 and Coates 2018), and body mass index (Sahn 2009; D’Souza and Tandon 2018). This resurgent interest in understanding intra-household nutrition reflects the recognition that calories are just one measure of nutritional status.

The new studies that measure differences in nutritional status within households, which we refer to as nutritional discordance, use both a wide variety of methods and a wide variety of nutritional measures. Researchers have to make a series of choices about how to measure discordance, and there is little-to-no consensus on current best practice. For example, some approaches ignore activity intensity of each individual. Individuals working in higher-intensity occupations may have greater caloric requirements compared to those who do not. If men are expending a greater proportion of energy in high-intensity activities than women, failing to account for energy expenditure can make results appear more inequitable than they truly are. The nutrient-reference tables used in low-income country studies also differ. In some cases, USDA reference tables are used, even though the foods’ nutrients may vary (e.g., banana in the US is different than banana in Uganda). As a result of this variation, we know little from current studies about whether findings of nutritional discordance are sensitive to the choice of method or measure. We intend to disentangle how the choice of method and choice of nutritional measure impact findings for a single country: Bangladesh.

This research has two aims. First, we make a methodological intervention to learn the extent to which measurement choice influences findings of nutritional discordance. This can help us to determine when and where relying on unitary models of households is appropriate. Brown et al. (2017) argue there is “substantial intrahousehold inequality” in sub-Saharan Africa, where being an undernourished woman is poorly correlated with poverty status. Lentz et al. (2019) show that women eat last and least and consume fewer high-quality quality foods than other household members in rural South Asia. These and other studies raise questions about the continued reliance on unitary household models for food, agriculture and nutrition research. An important step is to identify how sensitive results that are discordant are to the choice of method.

Second, based on our findings, we aim to provide guidance on best practices for measurement. A better understanding of nutritional discordance is critical for food, agriculture, nutrition, gender, and social protection policy. For example, while efforts to link agriculture-to-nutrition remain widespread, achieving improved nutrition remains challenging (see Kadiyala et al. 2014). Similarly, an expanding interest on women’s empowerment (e.g., Pratley 2016) raises questions of when and how gender inequality manifests itself within households. A clearer understanding of how to measure such effects, and when it is useful to do so can help researchers and practitioners recognize when household bargaining matters and how to design program interventions better achieve desired impacts.

Our comparisons across key methodological decisions include:

1. Nutritional measures: we will estimate discordance for both calorie and nutrient intake, using 24 hour individual dietary recall data, household food expenditure data, Household Dietary Diversity Scores, and body mass index using anthropometric measurements.
2. Approaches to computing nutrient intake: we will compare several assumptions used to compute individual measures and to convert household level measures to individual measures:
   1. Per capita (PC) and Adult Equivalent (AE): We look at the method of distributing calories or nutrients from household level to individuals and then compare those allocations to actual nutrient intake.
   2. Food composition tables: We use food composition tables from Bangladesh and India, with additional data from the USDA food database.
3. Calorie and Nutrient Benchmarks:
   1. Methodology: We look at the source and methodology for benchmarks such as Estimated Average Requirement (EAR), Recommended Daily Allowance (RDA), and BMI tables.
   2. Geography: We consider the importance of regional compared to international nutrient benchmarks using USDA, FAO, and Indian reference tables.
   3. Parameters: We evaluate the effects of using age compared to age group, and including activity level, gender, height, weight, and pregnancy or lactation status affect frequency and level of nutritional discordance.
4. Multiple approaches to compute discordance: We consider various methods of computing discordance, such as Kuznets curves, log deviation of inequality, and differences in deviations from minimal required intakes.

We are now computing multiple nutritional measures. We will then compute correlations across the multiple nutritional measures. We will test the sensitivity of the nutrient intake results to the various approaches and parameter choices. By identifying relationships between measures, approaches, and parameters, we can make recommendations for best practices for measuring nutritional inequality, given data and temporal limitations.

# Methodology

Researchers face multiple decisions points when computing nutritional discordance. From the initial selection of data to the final inequality measure, choices are made which can influence research outcomes. Figures 1 and 2 map the pathways of those decisions, for research starting with household level survey data and individual level survey data, respectively.

**Survey Data:**

In Figure 1, the first step is to distinguish two different data sources: household expenditure and consumption surveys (HCES) which report household recall of purchases of food and non-food items and consumption over a set time period, often 7 days, and household food diaries, which typically track food intake over a 24 hour period. Comparison of the two survey approaches have found that they are comparable in their collection of relevant consumption data. (Fiedler, et. al. (2012)) Household budget surveys, Living Standard Measurement Studies, Comprehensive Food Security Assessment Surveys are all examples of HCES. Factors that can affect the quality of the results of a HCES include the length of time covered by the survey, the types of categories or options provided to the enumerators, the likelihood of food consumed away from home, and the level of literacy and urbanization of the household. (Fiedler, et. al. (2012)) In sum, these surveys are widespread, but not without error. The type of analysis can affect the need for survey depth: food security assessment make require less specific information about food type or quality than assessments of household food preferences or malnutrition. The latter also may be agnostic to choice of food source and encourage the use of consumption rather than expenditure data. HCES are less costly and easier to collect that individual-level survey data but provide limited information on individual consumption behavior or food availability. (Murphy, et. al. (2012), Fiedler, et. al. (2012), Sununtnasuk and Fiedler (2017))

Figure 2 demonstrates the pathway beginning from individual level survey data, which can be in the form of consumption diaries or recalls, or observed food weight records (OFWR.) Considered the gold standard for individual consumption data: OFWR capture video or photo of food consumed and allow the researcher to determine the quantity and quality of the food, while their cost makes them difficult to implement at scale. (Fiedler, et. al. (2012), Lividini, et. al. (2013)) Individual consumption diaries or recall surveys often ask the respondent to identify consumption over a 24 hour period. This short time frame can miss day -to-day variation in consumption patterns or preferences that can only be seen with a longer survey period. (Murphy, et. al. (2012))

A final source of data would be anthropometric surveys measuring individual heights or weights, or biomarkers serum to measure nutrient status. The cost of administering these tests and the training necessary to implement them are non-negligible. (Murphy, et. al. (2012))

**Food Composition Tables:**

In order to convert the food items reported in the dietary data sets into energy and nutrient values, food composition tables must be used. The food composition tables determine the nutrient content of foods through chemical analysis. (xxx) The U.S. Department of Agriculture provides a comprehensive database FoodData Central which contains data on food and nutrients for both items prepared at home or away from home. This database has been used extensively for non-US based research. (Bermudez, et. al. (2012), Lividni, et. al. (2013)) However, the quality and nutritional profile of foods can vary both across and within countries. For research in non-US countries, it may be preferred to use regional food composition tables, which may provide greater accuracy in nutrient content and contain the local names of items to increase likelihood of identification. (Behrman (1998), Sununtnasuk et. al. (2017), Coates (2018), D’Souza and Tandon (2019). A combination of food composition tables may be required to identify all items, as well as standardization of food sizes and quantities, which is the approach we followed. Adjustments are also made for bioavailability of nutrients and cooking retention factors. (Coates (2017), Karageorgou, et. al. (2018))

The uniqueness of the BIHS dataset is that it provides information on individual consumption of food and therefore nutrients. First, we use the module of “recipes” which report type and quantity of ingredients used to create each meals for a household over a 24-hour period. The cooked weight of the meal is reported. Once the first data set has been converted into nutrients, a second data is required to allocate the nutrients to household members. The second module lists each meal served in the 24 hour period, and the quantity of the meal that was consumed by each household member. Meals taken away from home and portions of meals consumed by guests, pets, or discarded are reported in this data set, and can be adjusted for accordingly. Using this data set, individuals can be assigned portions of the nutrients for each recipe, as the relative portion of the cooked quantity he or she consumed relative to the total cooked quantity of the recipe. This is summed over individuals to provide the 24 hours total of calories and micro and macro nutrients consumed by each member of the household, titled “Reported Individual Nutrient Consumption.” Children under 2 years old were eliminated from the data set, as it was unknown the quantity and frequency of breast-feeding, and relative share of nutrients to consumed food. The results of converting food consumption data into nutrients is represented in figures 1 and 2 by the respectively, blue and orange diamonds for “Reported Household (Individual) Consumption of the Nutrient.”

**Adult Equivalents:**

When consumption data is only available at the household level, various methods are used to assign shares to individuals to allocate nutrient consumption. The easiest would be the “per capita approach” which allocates nutrients equally among all members of a household. However, this approach assumes that all household members consume the nutrient equally and misses out on household variation due to the different needs of children vs adults, for example. (Karageorgou, et. al. (2018)) A second approach assumes that the share of the nutrient allocated to the individual is proportion to individual nutrient requirements. First, the individual’s nutrient requirements must be identified using the nutrient reference standards. The individual’s “Adult Equivalent” (AE) is expressed as a ratio, relative to the nutrient requirement for a base individual, typically a 18-30 year old male with moderate physical activity level. The AE is divided by the sum of all adult equivalents in the household to determine the individual’s allocative share of household composition. While this can be done for nutrients individually, the AE generated by the relative share of kilocalories is typically used. Coates (2017) calculated nutrient-specific adult equivalents and found that the differences were not significant when compared to using the AE value derived from energy consumption to identify shares for all nutrients. Total household nutrient consumption is then multiplied by the individual share to yield the individuals “allocated consumption” of the nutrient.

**Nutrient References:**

The largest variation in metrics can be seen in the choice of reference standards for nutrient requirements, and the choices made in determining the appropriate reference standard for the group or individual. There have been proposals to harmonize nutrient standards across countries and methodologies. (Allen, et. al. 2019)

The Institutes of Medicine (IOM), a joint US-Canadian effort, published the *Dietary Reference Intakes* (DRI) in 2006, covering energy, carbohydrate, fiber, fat, fatty acid, cholesterol, protein, and amino acid requirements.[[1]](#footnote-1) These are considered the gold standard by nutritionists, and have subsequent updates have covered other nutrients such as Calcium and Vitamin D in 2006 and Sodium and Potassium in 2011. The IOM guidelines are the only option for micronutrients and provide the most comprehensive guidance for macronutrients. The U.S. also posts dietary guidelines, and the 2015-2020 U.S, Dietary Guidelines have been used, although infrequently. (Brown, et. al. (2019))

Given that the DRIs were developed for and by US and Canada, there is a reasonable concern over the applicability of these standards to global populations. However, there is no alternative as comprehensive with the respect to the range of nutrients, or as validated by the scientific community. The World Health Organization (WHO) and U.N. Food and Agriculture Organization (FAO) published energy requirements (FAO 2004) and recommendations for nutrient intakes (RNIs) for protein (2002), energy (2005), carbohydrates (2007), and fats and fatty acids (2010). These recommendations do not provide EARs and are not seen as validated by the nutrition community. The WHO guidelines are a valuable resource for weight and height assessments and targets for global populations. (Schenider and Hertforth (2020), Allen, et. al. (2019)) The WHO/FAO requirements are generally used for energy requirements, complementary to IOM standards for micronutrients (Bermudez. et. al. (2012), Lividni , et. .al. (2013), Sununtnasuk, et.al. (2017), Coates (2017))

The diversity in the weights, heights, and nutritional characteristics of different populations begs the need for regional requirements, which exist in selected countries. The National Institute of Nutrition published Dietary Recommendations for Indians in 2011, which provided RDAs for protein, fat, calcium, and iron and energy requirements based on an average weight and height for sex, age, and life stage groups.

**Physical Activity**

Active individuals require more nutrients than sedentary. The delineation of individuals by physical activity level can affect the individual nutrient requirements and likelihood of an individual being identified as inadequate. All three sets of nutrient standards mentioned adjust energy and often nutrient requirements based on classification of physical activity level. The DRIs provide 4 categories: sedentary, low active, moderately active, and high active and adjust energy requirements based on a multiplier for each category. The WHO/FAO requirements provide ranges of multipliers for adjusting energy requirements within low, moderate, and heavy categories. The NIN requirements are provided for each category, without provision of the underlying calculation. Some papers classify all individuals as moderate (Karageorgou, et. al. (2018), Coates(2017, 2018), D’Souza and Tandon (2019)), while others allocate activity category between “light”, “moderate”, and “active” based on occupation category, as we have done in the appendix. We relied on recommendations from Steeves et. al. (2015), who used accelerometry data collected in 2003-2004 from over 1000 adults in the United States, to allocate individuals into three groups based on occupation. For WHO/FAO analysis, we selected the lowest point in the range provided, consistent with prior research using the BIHS data set. (Sununtnask and Fiedler (2017)).

**Life stage**

Nutrient requirements do not increase monotonically with respect to age. Children, pregnant, and lactating women have different nutrient requirement and require adjustments to calculations. The IOM, WHO/FAO, and India nutrient standards all provide recommendations specific to life stage group. However, it is not always possible to identify from survey data whether an infant is fully or partially breastfeeding, or how far along a woman is in her pregnancy. One option is to eliminate all children under 2 years of age, and pregnant and lactating women. (D’Souza and Tandon (2019), Brown, et.al. (2019)) Another is to estimate pregnancy and lactation status within a 3-6-month window and assign the average requirements for that window. (Sununtnask and Fiedler (2017)We assumed lactating women were the average of the additional requirements for full and partially lactating women and eliminated all children under the age of 2. Furthermore, the choice of nutrient matters: the requirements and methods of measuring inadequacy for iron differ from most other nutrients.

**Reference Heights and Weights**

The India energy and nutrient requirements are provided for a reference height and weight by age, sex, physical activity, and life stage group, for a set reference height and weight that is given. The IOM energy recommendations (and any nutrients that are a percentage of energy requirements) rely on incorporation of a weight, height, age, physical activity level for a given sex and life stage group. The WHO/FAO energy requirements rely on a weight and physical activity for a give age, sex, life stage group. Thus for IOM and WHO/FAO calculations, the choice of weight, height, and age can have a significant impact on energy needs.

Often, the calculation is made for the entire age, sex life stage group using the reference height and weight determined by the reference standard, resulting in the same energy requirement for the entire group. Another approach is to create individual specific requirements by using the individual’s current weight and height. The EER is “the average dietary energy intake that is predicted to maintain energy balance in a healthy adult of a defined age, gender, weight, height, and level of physical activity consistent with good health.” (IOM (2006)) Therefore, using group-based reference heights and weights, half of the individuals in the group should maintain their health with the group energy intake. However, this level might be unrealistic if a population is currently below the reference height or weight for their age, sex, life stage group, and even more so if applying US/Canada based standards to global populations. Using the individual-specific requirement allows for the maintenance of the health status of that individual, but if his or her weight or height is below or above the standard, the energy requirement might not be appropriate for maintaining health, if the individual would not have been considered “healthy” by nutritional standards. Additionally, it may be unrealistic to aggregate the individual-specific measure of inadequacy and infer statistics about the prevalence of inadequacy at a population level.

While IOM, WHO/FAO, and India all provide reference weights and heights for age, sex, life stage groups, the gold standard recognized by nutritionists are the WHO child growth standards. These standards were developed in 2006 using measurements collected globally, using measurements for children under 5 and then extrapolation of references for children 5-19 years old. The CDC recommends their use in the United States for children under 5. (WHO, (2006))

**Nutrient Standards**

The DRIs identify a variety of measures for nutrient intake: Estimate Average Requirements (EAR), Recommended Dietary Allowances (RDA), Adequate Intakes (AI), and Tolerable Upper Intake Levels (UL) as well as Estimated Energy Requirements (EER.) For each macro and micronutrient, there is a recommended metric for measuring nutrient adequacy at a population level and at an individual level. The definitions of these metrics are included below:

In general, the standards set forth differ by whether the standards will be used to determine the prevalence of inadequacy compared to making dietary recommendations, and whether the inadequacy or recommendations are being made at an individual or population level. For assessing the nutrient inadequacy of an individual, the DRIs recommend using EAR, EER, RDA, AI, UL. RDAs are not recommending for assessing the adequacy of intake for a group, as 97-98% of the population should meet the RDA requirement. For planning diets to meet nutrient requirements, the DRIs recommend using RDA, AI, and UL for individuals, and EAR, EER, AI, and UL for groups.

* **Estimated Average Requirement (EAR):** The average daily nutrient intake level that is estimated to meet the requirements of half of the healthy individuals in a particular life stage and gender group. It is actually a median. Although it can also be used to examine the probability that usual intake is inadequate for individuals (in conjunction with information on the variability of requirements), it is not meant to be used as a goal for daily intake by individuals.
* **Recommended Daily Allowance (RDA):** The average daily nutrient intake level that is estimated to meet the requirement of nearly all (97-98 %) of the healthy individuals in a particular life stage and gender group. It is the EAR + 2SD. The RDA thus exceeds the requirements of nearly all members of the group. It can be used as a guide for daily intake by individuals. Because it falls above the requirements of most people, intakes below the RDA cannot be assessed as being inadequate. Usual intake at the RDA should have a low probability of inadequacy.
* **Adequate Intake (AI):** The recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate; used when an RDA cannot be determined.
* **Tolerable Upper Limit (UL):** The highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.
* **Acceptable Macronutrient Distribution Range (AMDR):** The range of intakes of an energy source that is associated with a reduced risk of chronic disease yet can provide adequate amounts of essential nutrients. The AMDR is expressed as a percentage of total energy intake. The key feature of each AMDR is that it has a lower and upper boundary. Intakes that fall below or above this range increase the potential for an elevated risk of chronic diseases and raise the risk of inadequate consumption of essential nutrients.
* **Requirement distribution** is the variability in a requirement across individuals. Intake distribution is the reported variability in nutrient intake within an individual.



* **Estimated Energy Requirement (EER):** Average dietary energy intake that is predicted to maintain energy balance in a healthy adult of a defined age, gender, weight, height, and level of physical activity consistent with good health. Includes adjustments for needs of children, pregnant and lactating women.

In general, EARs are the primary metric for measuring inadequacy of a micronutrient in a population, representing the “average daily intake level that is estimated to meet half the requirement of the healthy individuals in a particular life stage and gender group.” (IOM (2006)) The RDAs are two standard deviations above the median, so for all nutrients where an EAR is provided, an RDA is identifiable. When there is insufficient scientific evidence to establish an EAR/RDA, the Adequate Intake (AI) metric is used, which is “the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate.” To make recommendations for nutrient intake by individuals, RDAs and AIs should be used. (IOM (2005))

For all nutrients with EARs that are normally distributed, the IOM recommends using the cut-point method, which assumes that the proportion of individuals with intakes below the EAR is consistent with the proportion of individuals with inadequate intakes of the nutrient. The cut-point method assumes intakes and requirements independent, symmetrical (not true for iron), distribution of intakes more variables than distribution of requirements For nutrients that are not normally distributed, such as iron, the probability method must be used, which averages probabilities (from z-scores) across individuals to estimate the prevalence of inadequacy in a group. This approach assumes that intakes and requirements are independent.

**Nutrient Inadequacy:**

The general approach has been to apply the EAR cut-point method to either groups or individuals, despite it being a group level statistic. The application of EARs is also not without question: if the EAR requirements are defined as meeting the needs of half the population, then we would expect to see half of the individuals in each age/group strata to not meet the requirement. Applying the EAR cut-point method on an individual basis misses the intention of it being a population level standard. However, there is no better alternative, and assumptions are made to apply it.

The magnitude or intensity of energy and nutrient gaps is generally presented as the percentage below the requirement for the proportion of population with inadequate intake. (Sununtnasak & Fiedler (2017), D’Souza and Tandon (2019)).

Methodology by Nutrient (2 years and older):

|  |  |  |  |
| --- | --- | --- | --- |
|  | **IOM** | **WHO/FAO** | **India** |
| Energy | EER or BMI | TEE or BMI | RDA (kcal/day) |
| Protein | EAR/RDA, AMDR | RNI | RDA (g/day) |
| Carbohydrates | EAR/RDA, AMDR | n/a | n/a |
| Fat | AMDR | n/a | RDA (g/day) |
| Calcium | EAR |  | RDA (g/day) |
| Iron | EAR |  | RDA (g/day) |

*Energy*

The IOM defines the EER as above. The WHO/FAO approach to energy requirements for adults identifies a basal metabolic rate (BMR) which is the “minimum energy expenditure that is compatible with life.” It is a function of weight for each age sex group. The BMR is adjusted for pregnancy and lactation status and then multiplied by the Physical Activity Level (PAL) multiplier to obtain the Total Energy Expenditure (TEE), which is the “energy spent, on average, in a 24-hour period by an individual, or a group of individuals.” For children, the TEE calculation include weight for each age and sex group. The TEE is then adjusted to be 15% lower for sedentary children and 15% for active children. (WHO, 2001)

The assumption that intakes and requirements are independent is asserted to be false for energy: people feel hungry and so they eat more, reflecting accurate signaling and actions. But the assertion that for macro and micronutrients, intakes and requirements are independent is underwhelming. It assumes that there is no dietary knowledge or planning to consume fats, proteins, and carbohydrates with respect to requirements for those nutrients, either because there is no signal or because of a lack of knowledge.

Body Mass Index (BMI) is calculated as the individual weight in kilograms divided by the square of the individuals height in meters. The WHO defines healthy BMI within the 18.5-24.9 range. (WHO, xx)

*Protein*

The IOM provides an RDA of 0.8 grams/kilogram of bodyweight for adults, and EARs ranging from 0.87 to 0.66 for children to adults, respectively. WHO/FAO provide a recommended level of 0.66 g/kg for adults to 0.74 g/kg for children, as well as safe upper limits, akin to TUL. The NIN recommendations are provided by age and sex group. All three sets of recommendations make adjustments for pregnancy and lactation status.

*Fat*

The IOM provides an AI for lipid intake under one year, and an AMDR of 20-35% of energy intake for all others. (IOM, 2005)

*Carbohydrate*

The IOM sets an EAR for carbohydrates of 100 grams per day for all individuals over one year, with an additional 35 grams for pregnancy and an additional 60 grams during lactation. The AMDR for carbohydrates is 45-65% for adults. (IOM, 2005)

*Calcium*

*Iron*

Iron is a question of bioavailability, may want to avoid.

**Nutrient Inadequacy by Survey Data Type**

As described in figures 1 and 2, the type of survey data that is available will change the calculation of nutrient intake. For either measure, the prevalence of inadequacy can be calculated by comparing the individual reported or allocated consumption of the nutrient to the nutrient standard, to identify both the frequency and intensity of inadequacy.

**Nutrient Inequality**

Intrahousehold nutrient inequality can be measured in various ways:

* If individual level data is available (as with the BIHS), the reported individual nutrient consumption can be compared to the allocated individual nutrient consumption to test whether the household is allocating nutrients by need. (Sununtnasak and Fiedler (2017), D’Souza and Tandon (2019)) This can be done using percentages of inadequacy, log deviations, or difference in deviations, z-scores or other unit free measures (e.g. expressing allocated inadequacy as a percentage of reported inadequacy.) Concordance correlation measure are also used to compare the consistency between allocated and reported nutrient inadequacy.
* For household level data, the frequency or intensity of inadequacy for individuals can be compared within a household or across population groups. Coates (2017) compared inadequacies for boys relative to girls, and children relative to adults. This can be done using percentages or z-scores for intensity of inadequacy, or other unit-free measures. An approach used by Berti (2012) used the relative dietary adequacy ratios:

=The energy adequacy ratio of group i (average intake of group i/average energy requirement of group i)/ energy adequacy ratio of the group of adult males

* Kuznets curves to consider prevalence of inadequacy with respect to self-measure, or to household level variables (i.e. income.) (Sah and Younger (2010)

# Data

To compare across methodologies, we use the Bangladesh Integrated Household Survey (BIHS). BIHS is a rich, nationally representative survey collected in 2011-12 of over 21,000 individuals across more than 6500 households. Of these households, we excluded 1000 that were not considered representative as well as 12 additional polygamous households, resulting in a sample of 5491 households. Within those 5491 households, we identified 21,229 individuals who were 2 years of age and older, were present during the 6 months prior to the survey, and had meal data available. Individuals 2 and older were selected as nutrition requirements for breastfed children were beyond the scope of this paper.

# Summary Statistics

Table 1 presents descriptive statistics for 5491 households included in the BIHS sample and are weighted to be representative of the rural population of Bangladesh using weights provided by IFPRI. All household heads were and spouses were present for the six months prior to the survey. All household heads were male. Food purchases represented 57% of weekly household expenditures. Adults are defined as individuals 18 years old and over and represent more than half of all household members. The average household has a household dietary diversity score of 8.4, which means that the average household consumes between 8 and 12 of the following food categories on a weekly basis: cereals, roots and tubers, vegetables, fruits, meat (including poultry), eggs, seafood, pulses and legumes, milk and dairy products, sugar, fats, and miscellaneous items.

Statistics for household heads and spouses are included. Approximately 50% of either group can read or write and have no schooling. Secondary schooling is uncommon, and over half work in agriculture. The Body Mass Index is 20.24 for household heads and 20.85 for spouses, which is within the range of what is considered healthy by IOM, WHO/FAO, and NIN standards. Reported calorie consumption is approximately 2000 kcal on average for household heads, and 1700 kcal for spouses.

In Table 2, data on the reference heights, weights, and relative consumption shares are presented for the 22,129 individuals in the sample. Age-sex groups are presented, with the weighted average of the individuals in that group. “Sample” weight and height refers to the weighted average weight and height of individuals in the data set, while “Reference Standard” refers to the weighted average of weights and heights assigned to each individual by age, sex, and life stage group for each of the three standards (“India”, “WHO/FAO”, “IOM.”).

For weights, the weighted average weight for all age sex groups is lower than any of the reference standards. The reference standards for WHO/FAO and IOM are similar, and larger than the reference standards for India in all cases. For height, there is significant variation between the IOM and WHO/FAO standards for children under the age of 18. The discrepancy can be seen in Table 2, and can have a significant impact on the determination of energy requirements for the DRIs which include height in the formula, as well as for AMDR nutrient requirements that are calculated as a percentage of the energy requirement.

The next set of columns in Table 2 present the Adult Equivalents (AE), which are the ratio of the individual’s energy requirements relative to those of an 18-30-year-old male with moderate activity: 3014.5 kcal for IOM standards, and 2886.1 kcal for WHO/FAO. For India, the adult equivalents are provided by the NIN and are within a narrower range that the AE determined through WHO/FAO or IOM requirements. “Reference (actual) Weight/Height” indicates that the energy requirements were calculated using the reference (actual) weight/height for the individual. These AE are used to determine the individual’s share of nutrients to be allocated from household nutrients available.

# Results

# Discussion

# Tables and Figures

Figure 1: **Map to measure energy/nutrient inadequacy for individuals and inequality using household survey data:**

**Food Composition Table**

* USDA Database
* Regional Survey
* Private data

Adjustments for bioavailability and retention factors

**Household Survey Data**

* Household Expenditure
* Household Recall Diary

Adjustments for lifestage and activity level

**Individual nutrient requirements**

* IOM (US/Canada)
* WHO/FAO
* Regional

START

**Adult Equivalents (AE)**

* Ratio of individual energy or nutrient requirements to requirements for base individual
* Pre-generated AE
* Per capita

Reported household consumption of the nutrient

Inadequacy Measure for Individual\_j

Individual\_i’s **share** is individual\_i’s AE divided by the sum of all household AE

Inadequacy Measure for Individual\_i for allocated nutrient consumption

Inadequacy Measure for Individual\_i for calculated nutrient consumption

Measure of inequality between individual\_i and individual\_j

Inequality Measure between individual\_i and individual\_j

Calculated individual consumption of the nutrient

END

Figure 2: **Map to measure energy/nutrient inadequacy for individuals and inequality staring with individual-level survey data:**

END

Measure of inequality between individual\_i and individual\_j

Inadequacy Measure for Individual\_j

Inadequacy Measure for Individual\_i for reported nutrient consumption

**Individual nutrient requirements**

* IOM (US/Canada)
* WHO/FAO
* Regional (India)

Reported individual consumption of the nutrient

Adjustments for bioavailability and retention factors

START

**Individual Survey Data**

* Individual Consumption Diary or Recall
* Observed Food Weight Record

Adjustments for lifestage and activity level

**Food Composition Table**

* USDA Database
* Regional Survey
* Private data

Reported individual consumption of the nutrient

Adjustments for bioavailability and retention factors

Table 1: Descriptive Statistics from 2011-2012 BIHS sample of 5491 rural households



Table 2: Comparison of Reference Standards (IOM, WHO/FAO, India)

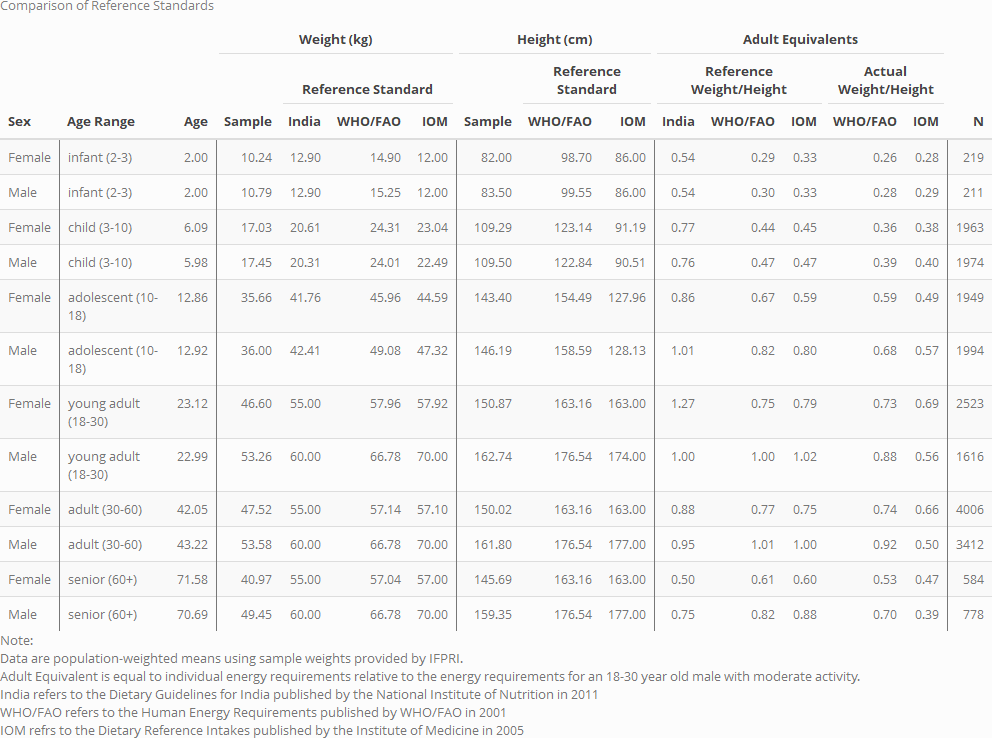


Table 3: Frequency and Intensity of Energy Inadequacy

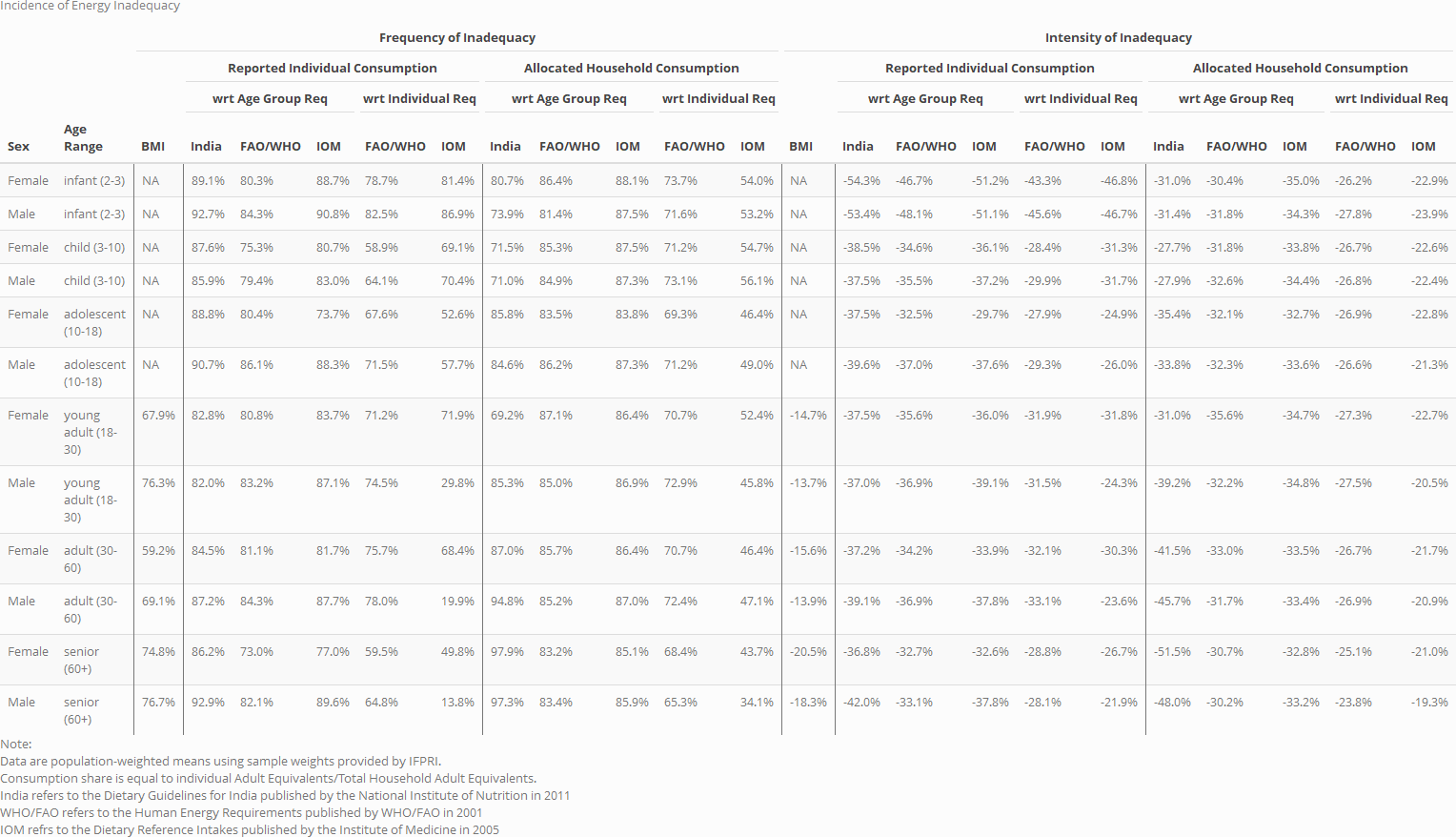


Table 4: Frequency and Intensity of Protein Inadequacy

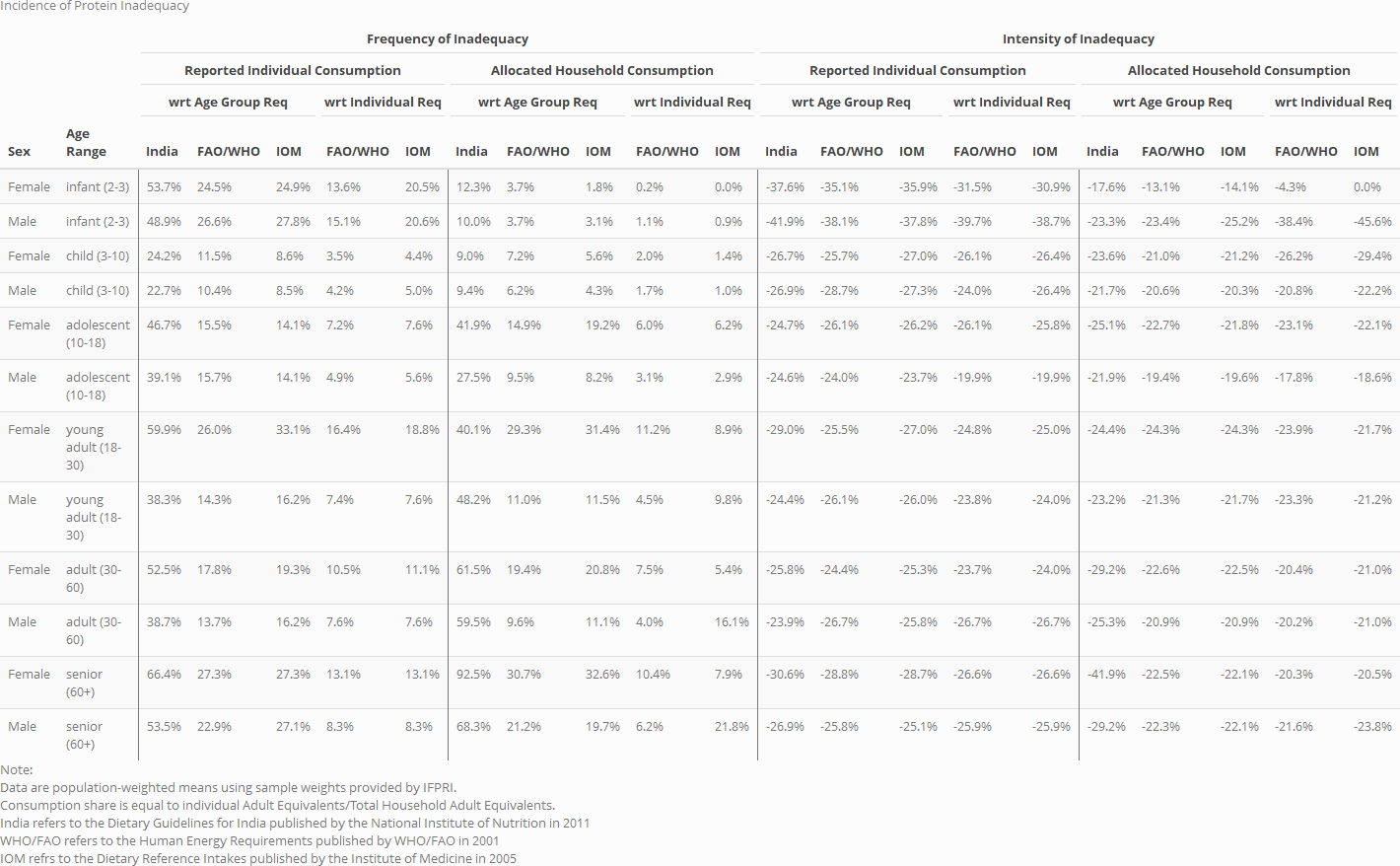


Table 5: Frequency and Intensity of Lipid Inadequacy

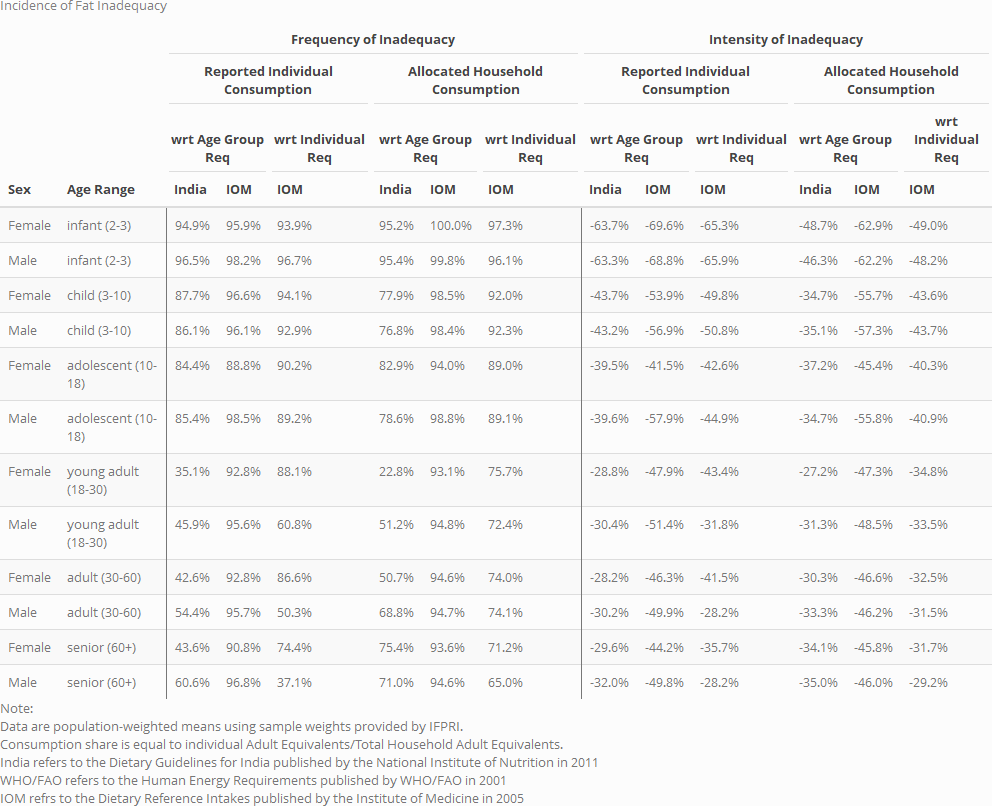
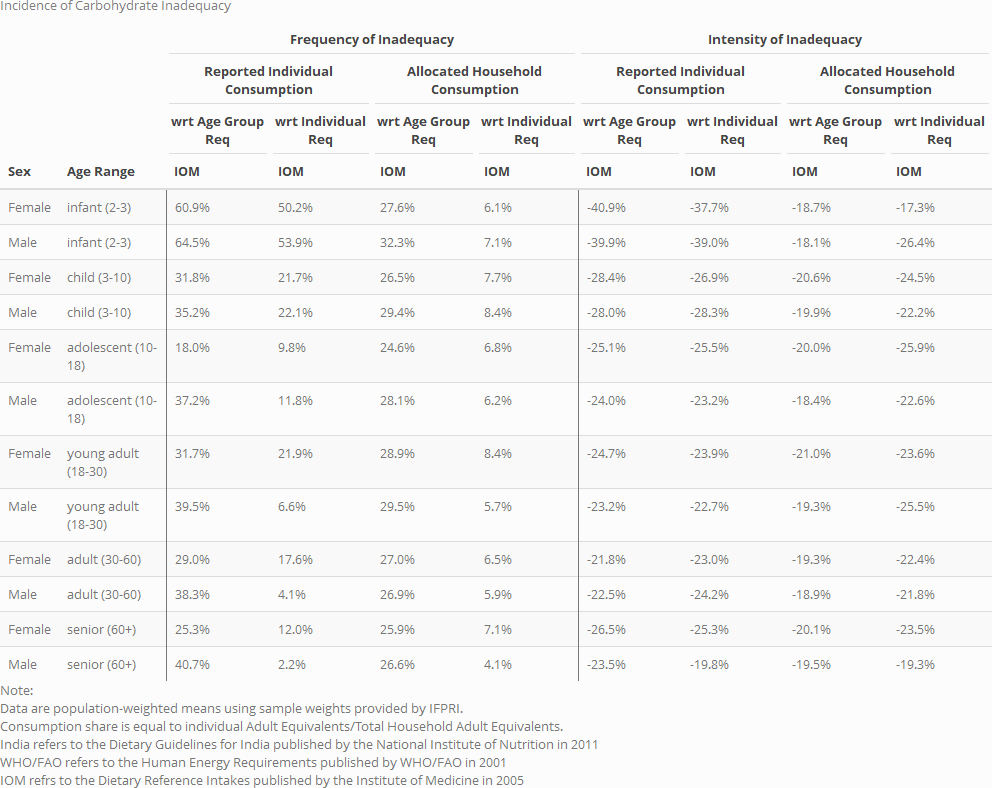


Table 6: Frequency and Intensity of Carbohydrate Inadequacy



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1. The IOM was renamed the National Academies of Science, Engineering, and Medicine (NASEM.) [↑](#footnote-ref-1)