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Nutrition as a Basic Need

A New Method for Utility-Consistent and Nutritionally Adequate Food Poverty Lines

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ABSTRACT

In most countries and globally, malnutrition rates exceed poverty rates. The World Bank estimates that about 9 percent (689 million) of the global population is poor, yet an estimated 25 percent (2 billion people) suffer from micronutrient deficiencies. Such a discrepancy begs the question: Do standard poverty metrics poorly reflect nutritional needs? The most prevalent methodology for measuring poverty in low- and middle-income countries – the cost of basic needs approach – estimates food baskets that satisfy a dietary energy standard while reflecting consumption patterns of poor households. However, poor households typically consume monotonous diets characterized by large quantities of calorically cheap staple foods that are poor sources of nutrients. This reality creates a circular logic whereby the cost of basic nutritional needs is estimated from populations who are consuming nutritionally inadequate diets. We argue that a healthy diet is a basic need and that the standard used to calculate cost of basic needs food poverty lines should be expanded to satisfy nutritional dietary recommendations, while continuing to reflect context-specific dietary patterns. We develop an approach to estimate food poverty lines that satisfies the food group proportionality associated with healthy diet recommendations while also adhering to observed within-food group consumption patterns of poor households. Furthermore, we address the limitation of estimating a single national food basket – which fails to capture variation in local consumption patterns driven by preferences, availability, and relative prices – by estimating utility-consistent regional poverty lines. We demonstrate the approach using data from Myanmar. Energy-based poverty lines significantly underestimate the cost of acquiring a healthy diet, are severely deficient in multiple micronutrients, and therefore result in a drastic underestimate of the rate of poverty based on a healthy diet standard. The resulting higher cost of basic needs also has important implications for inclusive economic growth strategies and nutrition-sensitive food policies and social protection.

Keywords: Poverty measurement; poverty lines; cost of a healthy diet; healthy diets; Myanmar; cost of basic needs.

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1. Introduction

Poverty lines in low- and middle-income countries (LMICs) are most commonly estimated through the cost of basic needs approach, which estimates the cost of attaining a minimum welfare level represented by a basket of goods. Conceptually, that basket of goods should allow households “to lead a healthy and active life, including fully participating in the society” (Ravallion, 1998). The cost of basic needs food poverty line is intended to reflect the cost of a food basket associated with achieving good health, defined by a nutrition standard, and social inclusion, reflected in the consumption patterns of relatively poor households, while non-food poverty lines reflect modest non-food needs essential to reaching a minimum welfare level (Ravallion, 1994, 1998; Ravallion and Sen, 1996).

In conventional practice, however, the nutrition-related standard is limited to dietary energy requirements. This energy standard was arguably an appropriate pragmatic target in the 1990s, when poverty measurement in LMICs expanded rapidly. Energy deficiency was a major nutrition and public health problem across a large swathe of LMICs at that time and, empirically, poverty measurement reflected that concern. In 1995, roughly one third of the world’s population lived below the \$1.90 per day international poverty line (World Bank, 2022b) while a similar proportion were estimated to be energy deficient (FAO, 2021). By 2020, both indicators were estimated to have fallen to about 10 percent of the global population, while the share suffering from micronutrient deficiencies is thought to be roughly 25 percent, or about two billion people. Anthropometric indicators point both to the persistence of undernutrition (22 percent of children under-5 are stunted, for example), but also the rapid emergence of overweight/obesity among adults in LMICs, which now account for 70 percent of the world’s overweight/obese adult population (Popkin et al., 2020). This “new nutrition reality” (Popkin et al., 2020) in LMICs calls for a policy and programmatic shift in poverty reduction strategies and food policies, away from a singular focus on ensuring energy needs and towards approaches that help individuals and households obtain diverse diets that meet macro- and micronutrient requirements and adhere to dietary guidelines.

In this study we argue that the nutrition standards used to evaluate poverty should likewise incorporate a more comprehensive definition of dietary needs – an operational change that is consistent with the fundamental objectives of the cost of basic needs approach – while still adhering to conventional principles of poverty measurement, such as welfare consistency (meaning that poverty lines for different

groups reflect the costs of a common welfare level across all groups).¹ In principle, an energy-based food basket *could* meet dietary requirements for food group diversity and micronutrient content, but the absence of additional nutrition standards virtually ensures that this is highly unlikely to be the case. Food baskets are intentionally selected to reflect the food preferences of the poor, who inevitably opt for foods that are cheap sources of energy but generally sparse in diversity and micronutrients as well as high quality proteins and fats (Subramanian and Deaton, 1996; Headey and Alderman, 2019).² As a result, conventional poverty lines will potentially identify large numbers of households as non-poor despite many of them being unable to afford healthy diets that meet recommendations.

Children whose nutritional needs are not met are at a higher risk of stunting and wasting, as well as slowed cognitive development resulting in reduced productivity and earnings in adulthood (Black et al., 2013; World Bank, 2006). Perhaps most alarmingly, malnutrition accounts for 45 percent of all under-5 deaths in low- and middle-income countries (Pelletier et al., 1995; Black et al., 2013). Deficiencies in essential nutrients have serious short and long-term consequences, resulting a wide array of health and behavioral disorders and diseases, including severe fatigue, night blindness, rickets and other bone diseases, and skin diseases (Bailey, West and Black, 2015). Poor diets, including those with excess energy consumption but inadequate micronutrient consumption, are also highly problematic in adulthood and later life and are now estimated to be the number one risk factor for noncommunicable diseases, which disproportionately affect poorer individuals who are least likely to have access to treatment (Gakidou et al., 2017, Engelgau et al., 2011).

Given the important limitations of the energy-based basic needs approach, what is an appropriate nutrition standard for a basic needs approach? Allen (2017) is explicit in advocating a least-cost nutrient-adequate diet as a substitute for conventional energy-based approaches to poverty. In doing so, Allen rejects the standard reference welfare approach of traditional basic needs estimates, arguing instead that food poverty

¹ The important limitations of an energy-based nutrition standard were in fact recognized in some of the earliest work on poverty lines by Rowntree (1901) – who consulted leading nutritionists to determine basic food needs for a study of poverty in New York City – but most subsequent work in the latter half of the 20th century at both the international level (Jolly, 1976) and national level tended to define basic needs purely in energy terms.

² Protein quality refers to the amino acid profile of different foods and diets as a whole. In general, diets that are adequate in energy are also adequate in protein in a purely quantitative sense. However, highly monotonous diets – especially those low in animal-sourced foods – pose a serious risk of amino acid deficiencies that can retard physical and cognitive development, especially in young children (FAO/WHO/UNU, 2007). The extent of protein deficiency (from a qualitative perspective) remains contentious, however, but is more likely to be problematic in poor countries where there are disproportionately large number of young children and very poor-quality diets.

lines should only represent the cost of basic nutrition needs, “not a level of satisfaction” (Allen, 2017, p. 3708).³ However adequate nutrition is not the only purpose of food consumption. If one accepts that social inclusion is fundamental component of basic welfare, then ignoring the social roles of food will likely lead to welfare-inconsistent poverty measurement (Ravallion, 2020).

This normative question aside, linear programming approaches to food poverty measurement are characterized by a range of conceptual and practical problems. First, by ignoring food preferences altogether, linear programming approaches will often select unrealistic diets that substantially diverge from dietary and cultural norms. Even if the objective of ensuring welfare consistency across time and space is set aside, poverty measurement should strive for specificity by defining realistic and relevant food baskets that reflect local conditions, norms, and preferences (Ravallion, 1994, 2016; Ravallion and Bidani, 1994). Second, linear programming as a methodology is unlikely to be robust, especially to any low-price outliers. Third, it is extremely unrealistic to assume that a person, no matter how knowledgeable, will be able to enter a market and identify the exact quantities of food items to satisfy an array of nutrient needs at the least possible cost. Finally, linear-programmed nutrient-adequate diets might very well fail to meet other dietary needs to sustain an active and healthy life. Food-based dietary guidelines, in addition to their main purpose of defining dietary patterns to meet nutrient needs, also factor in non-nutrient health properties of foods, recommending greater quantities of foods known to reduce risks of non-communicable diseases and fewer quantities of foods known to elevate such risks (e.g., processed red meat, trans fats, added sugars and salt).

Food-based dietary guidelines are increasingly available in a wide range of countries and invariably emphasize diversity in food items and proportionality of food groups (Herforth et al., 2019). They also constitute official government definitions of a healthy diet in countries where they have been developed. Here we propose that food-based dietary guidelines offer a superior nutritional standard for the construction of food poverty lines due to their broader mandate to advocate diets that achieve nutrient

³ Furthermore, Allen (2017) defines dietary needs as only meeting requirements for energy, protein, fat, and six micronutrients. This specification falls short in specifying a complete nutritional standard of dietary needs. Many other studies also use linear programming to estimate the cost of nutrient-adequate diets, going back to the early days of the development of linear programming (Stigler, 1945). Recent applications are less focused on poverty measurement specifically, and more on identifying nutrition interventions (for example, the Cost of the Diet (CotD) approach developed by Save the Children – see Deptford et al., 2017), or for analyzing access to adequate nutritious food (Bai et al., 2020; Herforth et al., 2020).

adequacy and that reduce risks of non-communicable disease, within culturally appropriate dietary patterns. An added advantage of these guidelines is that they offer recommended consumption quantities of food groups, not items (as in linear programming). From an economic viewpoint this approach is conceptually attractive because the categorization of food groups reflects the reality that both retailers and consumers categorize food marketing and food purchasing by food groups.⁴

The cost and affordability of a healthy diet, consistent with food based dietary guidelines, are now annually reported as food insecurity indicators in *The State of Food Security and Nutrition in the World* reports (FAO et al. 2020, FAO et al. 2021).⁵ The indicators have also been used to measure cost and affordability of healthy diets in South Asian and African countries (Mekonnen et al., 2021; Dizon, Wang, and Mulmi, 2021; Raghunathan, Headey, and Herforth, 2021; Dizon, Herforth, and Wang, 2019; Dizon and Herforth, 2018), in a similar vein as global comparisons of the cost and affordability of the EAT-Lancet reference diet (Hirvonen et al., 2020). One particularly relevant application in the current context is a study of healthy diet costs by Mahrt et al. (2019), who incorporate local food consumption shares within each food group to estimate a “preference-weighted” measure of the cost of a healthy diet. This approach reveals food item consumption patterns within food groups while meeting the food group proportionality characteristics of healthy diets. They show that food item preferences affect food group and total healthy diet costs, largely because of preferences for animal-sourced foods over leguminous proteins (Mahrt et al., 2019).

The present study develops a more rigorous and unified approach to improving the measurement of food poverty lines. First, on the grounds that an array of nutrition targets must be met to live a healthy life, we incorporate the healthy diet criteria expressed by national governments in food-based dietary guidelines (Herforth et al., 2020) and adopted by the FAO in its suite of food security indicators (FAO et al., 2021). Second, we continue the cost of basic needs approach of deriving poverty lines from the observed consumption patterns of relatively poor households, thus capturing preferences given local prices and availability and in turn aspects of consumption relevant to social inclusion (Ravallion, 1998, 2016). Third,

⁴ One reason food-based dietary guidelines utilize food groups is that they are heuristically easy for consumers to follow.

⁵ The cost of a healthy diet is defined as the cost of the least expensive locally-available foods to meet requirements for energy and food-based dietary guidelines, per capita, per day (Herforth et al., 2020). This indicator has been adopted because it reflects the concept of “economic access to food to meet dietary needs...for an active and healthy diet” more fully than the “prevalence of undernourishment” indicator, which is the long-used standard of access to sufficient dietary energy (FAO, 1996, FAO et al. 2020).

recognizing that national poverty lines might not reflect important variations in local consumption patterns, we estimate subnational poverty lines while also adhering to the principal of utility consistency (Ravallion and Lokshin, 2006; Ravallion, 2016; Arndt, Mahrt, and Tarp, 2017). Specifically, we adopt an approach developed by Arndt and Simler (2005, 2007, 2010) which draws on information theory to enforce revealed preference constraints and thereby ensure utility-consistency. We then compare poverty rates and the costs and composition of food baskets based on the energy-based standard and the expanded nutritional standards for a healthy diet. As expected, we find that poverty rates are much higher when healthy diet standards are incorporated into food poverty lines. We conclude the paper with a discussion of possible extensions to this research, including more widespread adoption by national and international agencies, as well as implications for strategies that aim to reduce poverty when nutrition is regarded as a basic need.

2. Methodology

Two desirable principles of poverty measurement stipulate that poverty lines should represent the same minimum welfare level across time and space (consistency) while maintaining relevance to local conditions and perceptions of poverty (specificity) (Ravallion, 1994, 2016; Ravallion and Bidani, 1994). The cost of basic needs poverty line reflects a minimum welfare level at which an individual is able to live a healthy life while attaining social inclusion (Ravallion, 1998). Economists define welfare using utility theory with the poverty line representing a money metric of the minimum utility. In practice, poverty lines are typically estimated using a single national food basket and non-food allowance. However, Ravallion (1994, 2016) and Tarp et al. (2002) note that the single basket approach ignores variations in local consumption patterns as well as substitutability among goods in response to availability and price differentials over space and time.

Defining subnational food baskets accounts for differences in local conditions but forfeits the guarantee that poverty lines represent the same utility level. Utility-*in*consistent poverty lines introduce the possibility that households with a given real expenditure level could be deemed poor in regions where more expensive baskets represent higher welfare, yet non-poor in regions with less expensive, lower utility baskets, resulting in noncomparable poverty rates. Revealed preference theory provides a method for testing whether regional food poverty lines are utility-consistent, without requiring specification of an explicit utility function (Gibson and Rozelle, 2003; Ravallion and Lokshin, 2006). Arndt and Simler (2005, 2007, 2010) use an information-theoretic approach to resolve utility inconsistency by imposing revealed preference constraints, which has been applied to estimate utility-consistent regional poverty

lines in a number of African countries, Pakistan, and Papua New Guinea (Arndt and Tarp, 2017; Schmidt et al., 2021).

Utility-consistent sub-national energy-based and healthy diet food poverty lines are estimated in two steps. First, we estimate initial food poverty lines based on observed consumption patterns in poor households plus the relevant nutrition target – a dietary energy target for the energy-based poverty line and healthy dietary guidelines for the healthy diet food poverty line. Second, sub-national food baskets are adjusted to satisfy revealed preference constraints yielding utility-consistent energy-based and healthy diet food and total poverty lines.

Initial food poverty lines

Initial energy-based food poverty lines

We estimate initial (prior to imposing revealed preference constraints to ensure welfare consistency) sub-national energy-based food baskets and poverty lines utilizing the approach described in Arndt and Mahrt (2017) and operationalized in a standardized Stata and GAMS code stream called Poverty Line Estimation Analytical Software (PLEASE, Arndt et al., 2017).⁶ In each sub-national domain, the initial energy-based food poverty basket meets dietary energy requirements given consumption patterns of reference poor households and the energy-based food poverty line is the cost of attaining that basket at median prices observed in reference poor households.⁷

We adopt the cost of basic needs approach of defining a non-food allowance as the non-food expenditure necessary to achieve minimum health and a level of social inclusion necessary to escape poverty (Ravallion, 1998). Some non-food expenditure is required before consuming food beyond survival needs. Households with *total expenditure* near the energy-based food poverty line forego food expenditure in order to meet essential non-food needs. Non-food expenditure in these households provides a lower bound estimate of the cost of basic non-food needs (Ravallion, 1998). Households with

⁶ The energy-based Poverty Line Estimation Analytical Software code stream is available for download. <https://www.wider.unu.edu/publication/measuring-poverty-and-wellbeing-developing-countries>. GAMS (General Algebraic Modeling System) is a modeling software package.

⁷ We eliminate from the basket any food consumed away from home (which typically lacks the details necessary to assign caloric values).

food expenditure near the energy-based food poverty line are able to meet food energy requirements and by extension have also met essential non-food needs (Ravallion, 1998). Non-food expenditure in these households provide an upper bound estimate of the cost of basic non-food needs.

The initial non-food allowance is the average of these lower and upper bound estimates in each sub-region, and initial energy-based poverty lines are the sum of sub-national food poverty lines and non-food allowances. In order to ensure that poverty lines reflect the consumption patterns of reference poor households, an iterative procedure is implemented whereby households identified as being poor are updated after each iteration until poverty rates converge.

Initial healthy diet food poverty lines

We define a healthy diet to be a diet that meets the quantified food group recommendations outlined in national food-based dietary guidelines. Recognizing that people choose foods falling outside food groups essential for a healthy diet, dietary guidelines often include a maximum allowance for sugary or discretionary foods items, meaning foods or beverages that can fit into a healthy diet in moderation but are not required. Inclusion of discretionary foods is consistent with the cost of basic needs approach which stipulates that poverty lines represent diets actually consumed by poor households, including nutritionally unnecessary foods (Ravallion, 2016, 2020).

The initial healthy diet food basket is obtained by scaling quantities of items consumed within food groups to meet recommended food group quantities. We preserve consumption patterns in reference poor households by using within food group quantity shares to scale food items in each food group proportional to observed consumption.^{8 9 10} The healthy diet poverty line is the cost of the healthy diet basket evaluated at median prices.

⁸ As with the energy-based poverty line estimation, the goal is to identify consumption patterns of relatively poor households and the prices they face, so we restrict the sample to the set of reference poor households identified in the final iteration of the initial energy-based poverty estimations.

⁹ In order to compare food quantities within food groups, we convert grams to food group equivalent grams for atypical foods based on the ratio of a reference macronutrient contained in each item to the average macronutrient content among typical foods in the food group (see Appendix A).

¹⁰ Unlike energy-based food baskets, healthy diet baskets are restricted to foods that can be clearly classified into food groups specified in dietary guidelines. Consequently, in addition to food away from home, foods such as spices and alcoholic beverages are excluded from the healthy diet.

Utility-consistent poverty lines

In this study we follow the approach described in Arndt and Mahrt (2017) and operationalized in PLEASE (Arndt et al. 2017) to impose revealed preference constraints and attain utility-consistent poverty lines.

Specifically, we use a cross-entropy criterion to estimate food baskets for which utility consistency cannot be rejected, given observed prices.¹¹ In doing so we preserve, to the greatest degree possible, the information content of the initial food poverty baskets, which incorporates both observed household consumption shares and nutritional targets.¹² Estimation draws on basic utility theory to specify revealed preference conditions that utility-consistent baskets must satisfy. The cross-entropy estimation approach is “efficient” in that it uses all available information in estimation (theoretical and empirical) but does not assume any information not available (Zellner, 2002).

Estimating utility-consistent energy-based food baskets

The following constrained optimization problem is solved to minimally modify initial energy-based food basket quantities such that revealed preference conditions are satisfied (Arndt and Simler, 2005, 2007, 2010).

$$\min \sum_r \sum_i s_{i,r}^{ent} \ln \left(\frac{s_{i,r}^{ent}}{s_{i,r}^{orig}} \right) \quad (1)$$

subject to:

$$\sum_i p_{ir} * q_{is} \geq \sum_i p_{ir} * q_{ir} \quad \forall r, s \quad r \neq s \quad (1a)$$

$$s_{ir}^{ent} \sum_{i'} p_{i'r} q_{i'r} = p_{ir} q_{ir} \quad \forall i, r \quad (1b)$$

$$\sum_i cal p_i q_{ir} = cal \quad \forall r \quad (1c)$$

$$0 \leq s_{i,r}^{ent} \leq 1, q_{ir} \geq 0 \quad \forall i, r \quad (1d)$$

where:

- q_{ir} variables representing quantities consumed;
- $s_{i,r}^{ent}$ variables representing food expenditure shares of the reference basket;
- $s_{i,r}^{orig}$ parameters representing initial food shares of the reference basket;
- i, i' indices of goods in the consumption basket; and
- r, s indices of subnational domains across space.

¹¹ A seminal reference on the application of information theory to estimation in economics is Golan, Judge, and Miller (1997). Golan (2018) discusses uses of information theory in economic modeling as well as estimation. Drawing on information theory, the appropriate measure of the information content of a food basket is the Shannon entropy metric.

¹² The cross-entropy measure is the Kullback-Leibler relative entropy measure, or informational distance function. See Golan (2018), Chapter 3, for a discussion of the underlying theory. This method is theoretically very close to Bayesian estimation.

The objective function is the Kullback-Leibler cross entropy measure. Condition 1a ensures that revealed preference conditions are satisfied across regions, given prices p_{ir} . Condition 1b defines entropy budget shares, $s_{i,r}^{ent}$, as a function of the modified quantities, q_{ir} . Condition 1c constrains the basket to attain energy requirements of a reference adult (parameter cal), which are held constant across regions.

Estimating utility-consistent healthy diet food baskets

We adapt the PLEASE method of ensuring utility consistency of food baskets to incorporate the additional constraint that food group consumption must adhere to healthy diet guidelines. In effect, we specify a two-stage utility function with a preference for food groups and for the commodity composition of the food groups. The modified model has two key differences from the energy-based model: (1) food shares in the objective function are specified as quantity shares within food groups rather than expenditure shares of the entire basket, and (2) an additional constraint is added to ensure that the food group quantities are fixed by requiring food item quantities within food groups to meet recommended food group quantities (equation 2b). Equation set (2) is used to minimally modify initial healthy diet food basket quantities such that revealed preference conditions are satisfied.

$$\min_{q_{i,r}, s_{i,r}^{ent}} \sum_r \sum_f \sum_{i_f} s_{i_f,r}^{ent} \ln \left(\frac{s_{i_f,r}^{ent}}{s_{i_f,r}^{orig}} \right) \quad (2)$$

subject to:

$$\sum_f \sum_{i_f} p_{i_f,r} * q_{i_f,s} \geq \sum_f \sum_{i_f} p_{i_f,r} * q_{i_f,r} \quad \forall r, s \quad r \neq s \quad (2a)$$

$$\sum_{i_f} q_{i_f,r} = g_f \quad \forall i_f, r, f \quad (2b)$$

$$s_{i_f,r}^{ent} \sum_{i_f'} q_{i_f',r} = q_{i_f,r} \quad \forall i_f, r, f \quad (2c)$$

$$\sum_f \sum_{i_f} cal p_{i_f,r} q_{i_f,r} = cal \quad \forall r \quad (2d)$$

$$0 \leq s_{i_f,r}^{ent} \leq 1, q_{i_f,r} \geq 0, q_{i,r} \geq 0 \quad \forall i_f, r \quad (2e)$$

Where:

- $q_{i_f,r}$ variables representing quantities consumed in food group f;
- $s_{i_f,r}^{ent}$ variables representing quantity shares of the reference bundle in food group f;
- $s_{i_f,r}^{orig}$ parameters representing initial quantity shares of the reference bundle in food group f;
- g_f parameters representing the average recommended quantities for food group f.
- f index of food groups;
- i_f, i_f' indices of goods in the consumption bundle of food group f; and
- r, s indices of domains across space.

Key differences from equation 1 include condition 2b which constrains the sum of food quantities in each food group to approximate food group quantities specified in dietary guidelines and condition 2c which defines entropy food group quantity shares, $s_{i_{fr}}^{ent}$, as a function of the modified quantities, $q_{i_{fr}}$.

Total utility-consistent poverty lines

Finally, non-food allowances are re-estimated based on the average non-food expenditures of households with food and total expenditures close to the utility-consistent energy-based food poverty line. Energy-based and healthy diet poverty lines equal the sum of non-food allowances and the respective utility-consistent food poverty lines. Individuals living in households with total expenditure falling below the energy-based total poverty line are deemed poor based on an energy standard, and households with total expenditure falling below the healthy diet total poverty line are deemed poor based on a healthy diet standard.

This measure of poverty based on a healthy diet standard differs from the simpler measure of the affordability of healthy diets (Herforth et al., 2020), which compares the cost of a least-cost healthy diet food basket to food expenditure or total income assuming a fixed proportion of expenditures on food. Hence a key advantage of measuring poverty over unaffordability is that comparing the total healthy diet poverty line to total expenditure allows for variation in household allocation between food and non-food needs. For comparative purposes, we present least-cost healthy diet baskets and respective estimates of diet affordability in Appendix C.

Evaluating nutrient adequacy of different food baskets

Nutrient adequacy is a necessary condition of a healthy diet. Therefore, to test whether food baskets meet basic nutrient needs, we compare the nutrient content of energy-based and healthy diet baskets for macronutrients and 14 micronutrients to estimated average requirements (EAR) specified in Allen et al. (2020) for a 30 year-old adult woman.¹³ For macronutrients, we compare the carbohydrate, protein, and

¹³ EARs are estimates of the nutrient intake that satisfies the nutrient needs of half the healthy individuals in a specified age-gender group (IOM, 2006). The reference population (30-year-old adult woman) is the same used in global analyses (Herforth et al., 2020, FAO et al., 2020).

fat content of each basket to the acceptable macronutrient distribution ranges (AMDRs) specified in IOM (2006).

3. Empirical application to Myanmar

Myanmar is an appropriate case study for gauging sensitivity to alternative food poverty lines¹⁴ The official national poverty headcount – derived from an energy-based cost of basic needs approach – was relatively low (25 percent in 2017 percent) but micronutrient deficiencies are widespread (MoHS, 2019; MoHS and ICF, 2017). Myanmar is a highly diverse country both ecologically and ethnically, with climates, agroecologies and ethnic traditions affecting diets, as well as market access and urbanization. Rice is the staple food in almost the entire country, but there is large variation in non-staple foods. Given this variation, the incorporation of local consumption patterns and prices into poverty lines has important consequences for poverty measurement.

Dietary recommendations for Myanmar

The government of Myanmar developed preliminary food based dietary guidelines which describe six food groups (starchy staples; vegetables; fruits; dairy; meat, fish, eggs, and legumes; nuts and oils) plus sugary foods (MoHS, 2007). However, these guidelines are not quantified and therefore we substitute the dietary guidelines from neighboring Bangladesh (Nahar et al., 2013), which uses similar food groupings (Table 1). We use guidelines on sugary foods to represent discretionary food items.

¹⁴ It is important to note that the intent of this paper is not to challenge Myanmar's official poverty rates but to demonstrate an approach for poverty estimation within and across countries that includes greater attention to nutrition and health standards.

Table 1. Bangladesh recommended diet adapted for Myanmar, per person

Food Group	Sub-food group	Recommended number of servings			Serving size (grams)	Recommended average quantity (grams)
		Min.	Max.	Avg.		
Starchy staples		9	15	11	30	330
Pulses		1	2	1.5	30	45
Meat/Fish/Eggs		1	4	2.5	40	100
<i>Adapted to include small fish and dried crustaceans</i>						
Dairy and substitutes		1	2	1.5	150	225
Vegetables	Dark green leafy vegetables	1	2	1.5	100	150
	Other vegetables	2	4	3	100	300
Fruits		1	3	2	100	200
Fats		3	6	4.5	7	30
Discretionary foods		-	5	5	5	25

Note: In this study we use the average recommended quantity in each food group with the exception of starchy staples where we use one serving less than the average in order to more closely align with the energy needs of a reference 30-year adult woman. Serving sizes and quantities are specified in the key messages and the food pyramid of the guidelines. A food exchange list provides further clarity on serving sizes of pulse and animal source foods. A guideline to eat at least one citrus fruit and one vitamin A rich fruit could not be applied due to the season in which the household survey was collected. A very small share of the Myanmar population consumes dairy products in significant quantities, while consumption of small freshwater or marine fish is common throughout the country. We, therefore, adapt the Bangladesh dietary guidelines to the Myanmar context by including small fish and dried crustaceans as dairy substitutes.¹⁵

Source: Nahar et al. (2013)

Household consumption and expenditure data

The primary data source in this analysis is the 2015 Myanmar Poverty and Living Conditions Survey (MPLCS), implemented by the Government of Myanmar and the World Bank with the purpose of monitoring socio-economic conditions (MoPF and World Bank, 2017a and 2017b). The MPLCS sampled 3,648 households and is representative at the national and urban/rural levels as well as for four agroecological-zones and Yangon.¹⁶ Households report quantities of 154 foods consumed from purchases,

¹⁵ In a report of a calcium taskforce assembled to assess global calcium deficiencies, Bourassa et al. (2022) present the merits of food-based interventions in populations with low calcium intake, including promoting the consumption of small fish with bones. Hansen et al. (1998) demonstrate that fish consumed with bones provide calcium absorption at levels comparable to calcium in milk. Furthermore, fish species from tropical areas contain higher concentrations of calcium, iron, and zinc relative to cooler areas (Hicks et al., 2019).

¹⁶ Each household was visited once between January and April 2015, a period which corresponds to the end of the cool season and the dry pre-monsoon season. The four agroecological-zones are defined as follows. Hills and Mountains (Chin, Kachin, Kayah, Kayin, Shan); Dry Zone (Magway, Mandalay, Nay Pyi Taw, Sagaing); Coastal (Rahkine, Tanintharyi); Delta (Ayeyarwaddy, Bago, Mon).

own production, and in-kind sources in the last 7 days.^{17 18} In order to compare food quantities within food groups, we convert grams to food group equivalent grams for atypical foods based on the ratio of a reference macronutrient contained in each item to the average macronutrient content among typical foods in the food group (see Appendix A). All food quantities and prices are expressed in terms of food group equivalent edible grams.

A diet of typical Myanmar foods consumed in average recommended quantities approximates the energy requirements of an adult woman. Therefore, household expenditure and food consumption quantities are expressed per adult women equivalent per day. The equivalency scale is based on daily age-sex energy needs of individual household members relative to that of a 30-year-old adult woman, 2,195 kilocalories (Mahrt et al., 2019).¹⁹

Poverty line estimation parameters

To capture important spatial differences in both prices and food consumption patterns, the costs of the energy-based and healthy diet food baskets and the non-food expenditure allowances are estimated separately in five sub-national domains described in Table 2. The domains were selected to capture these differences while also maintaining a sufficiently large sample of relatively poor households in each domain. Additional parameters specific to the Myanmar poverty estimation are detailed in Appendix B.

¹⁷ The MPLCS poverty estimation technical report provides specific details on the calculation of key household variables used in this analysis, including household level food prices, food consumption quantities, and total expenditure (MoPF and World Bank, 2017b).

¹⁸ Households report expenditure on foods consumed away from home and prepared foods purchased for at home consumption. We exclude foods that do not fit into any food group, namely spices, alcoholic beverages, food consumed away from home, and prepared foods purchased for home consumption. Nutrient rich foods consumed as condiments (bean/fish/shrimp pastes and sauces) are allowed in the healthy diet food basket in their original quantities but are not scaled to meet the food group recommended quantity.

¹⁹We calculate the energy needs of individual household members following the methodology described by Waid et al. (2017), the stature of the Myanmar population (MoH, WHO, and WDF, 2015), and energy guidelines detailed by the FAO (2004).

Table 2. Sub-national domains used in diet and poverty line estimations

	Number of households	Number of relatively poor households	State/Regions
Hills and Mountains	720	240	Chin, Kachin, Kayah, Kayin, Shan
Dry Zone	720	181	Magway, Mandalay, Nay Pyi Taw, Sagaing
Delta	720	231	Ayeyarwaddy, Bago, Mon,
Coastal	720	162	Rahkine, Tanintharyi
Yangon	768	311	Yangon

Note: Number of relatively poor households in the final iteration of the initial (pre-entropy adjusted) energy-based poverty estimates.

Source: MoPF and World Bank (2017a) and authors' calculations

4. Results

Entropy-based estimates of utility-consistent poverty lines

Table 3 shows the energy-based and healthy diet food poverty lines before and after adjustments to ensure utility consistency. A decrease in a food poverty line after imposing revealed preference conditions indicates the regional basket was initially relatively high quality and vice versa. The largest changes to the regional baskets occur in Yangon, which has relatively high-quality initial energy-based and healthy diet food baskets (18 and 6 percent decreases, respectively). The energy-based food poverty line increases by 14 percent in Coastal areas indicating a relatively low-quality initial food basket.

Larger overall adjustments are made to the energy-based food basket, which is aligned to consumption shares in poor households, compared to the healthy diet food basket, which is additionally constrained within food groups to meet recommended quantities. The alignment of the healthy diet basket to dietary guidelines reduces some of the overall quality differences between regions (i.e., expensive food groups may have different compositions but sum to the same quantity across regions) and explains the lower level of adjustments needed to ensure utility consistency. For example, entropy adjustments in the Yangon energy-based basket increase shares of rice and palm oil while decreasing shares of all other foods while essentially the opposite occurs in the Coastal, Dry Zone, and Hills and Mountains areas. Within Yangon's healthy diet meat/fish/eggs food group, for example, the recommended food group quantity is maintained while consumption shares are shifted away from chicken, pork, beef, and certain varieties of fish toward primarily preserved fish. In all other regions, the opposite adjustment occurs.

Table 3. Regional poverty lines, daily per adult woman equivalent (2011 \$PPP)

	Energy-based food poverty line		Healthy diet food poverty line		Non-food poverty line	Total poverty line	
	Initial	Utility-consistent	Initial	Utility-consistent		Energy-based	Healthy diet
Hills & Mountains	1.84	1.91	3.42	3.42	1.21	3.12	4.63
Dry Zone	1.72	1.78	3.15	3.12	1.16	2.94	4.28
Delta	1.80	1.76	3.13	3.27	1.25	3.01	4.52
Coastal	1.53	1.75	3.32	3.32	0.87	2.62	4.19
Yangon	2.43	2.00	3.80	3.60	1.80	3.80	5.40

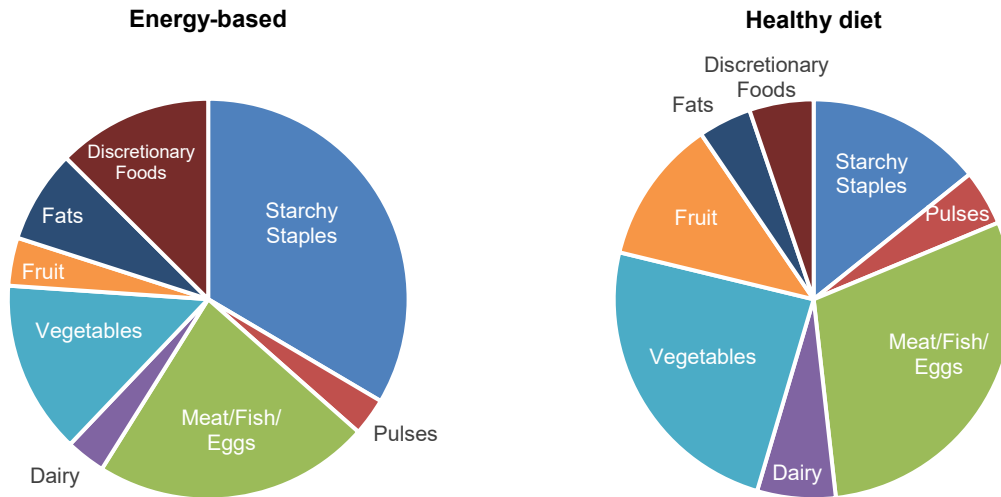
Source: MoPF and World Bank (2017a) and authors' calculations

Composition of food poverty lines

In most regions, the cost of the energy-based basket is about 45 percent lower than the healthy diet basket (Table 3). Food group costs in both baskets are based on the same actual consumption patterns, but the healthy diet basket reflects consumption patterns scaled to meet food group guidelines/proportionality. Thus, differences in the costs of the two baskets are driven by differences in the nutrition standard rather than by differences in prices, availability, or preferences.

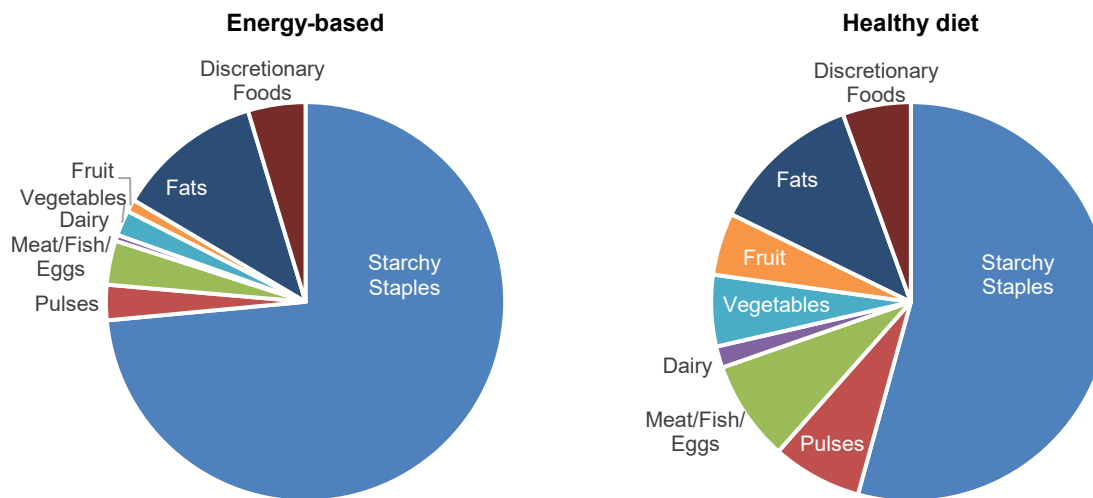
Figure 1 compares cost shares by food group for the energy-based and healthy diet, while Figure 2 makes the comparison in terms of energy shares. As expected, there are large differences in composition. The cost share of starchy staples in the energy-based basket (Figure 1) is more than double that of the healthy diet (33 percent versus 14 percent). Not surprisingly, nearly three-quarters (74 percent) of dietary energy in the energy-based basket are derived from starchy staples compared to just over half (54 percent) in the healthy diet basket, which allocates a greater share of dietary energy diet to more nutrient-dense foods.

Figure 1. Cost shares of energy-based and healthy diet baskets, by food group



Note: Figure displays population weighted averages of regional food basket cost shares.
 Source: MoPF and World Bank (2017a) and authors' calculations

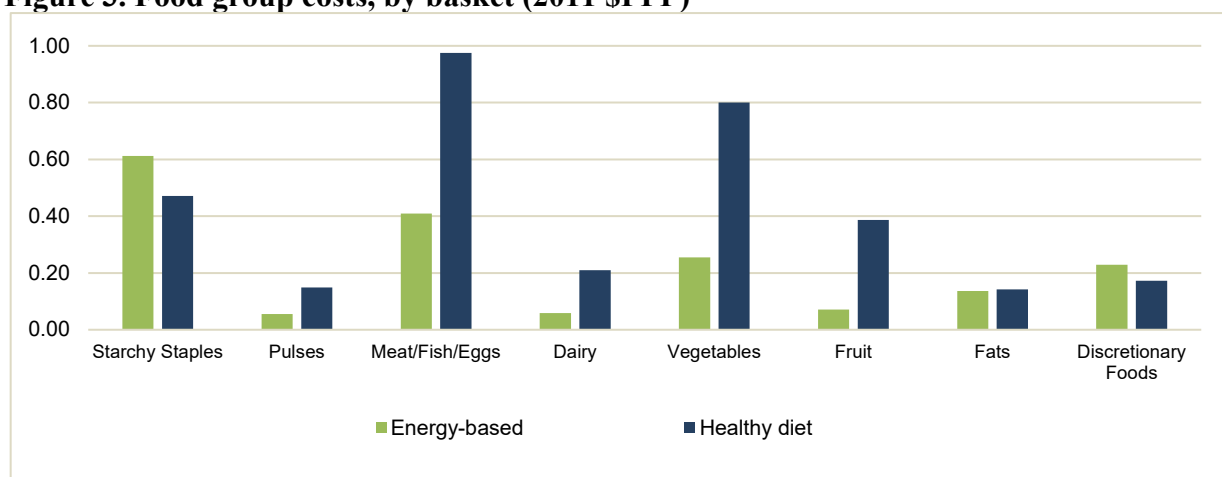
Figure 2. Energy shares of energy-based and healthy diet baskets, by food group



Note: Figure displays population weighted averages of regional food basket energy shares.
 Source: MoPF and World Bank (2017a) and authors' calculations

Figure 3 presents costs by food group for each basket, which align with differences in the energy composition of the baskets. Specifically, the cost of nutrient dense food groups in the healthy diet basket are 2 (meat/fish/eggs), 3 (vegetables and pulses), 4 (dairy), and 5 (fruit) times higher than the respective costs in the energy-based basket.

Figure 3. Food group costs, by basket (2011 \$PPP)



Note: Figure displays population weighted averages of food group costs in regional food baskets.
 Source: MoPF and World Bank (2017a) and authors' calculations

Poverty estimates based on energy and healthy diet standards

Table 4 shows the percentage of the population living in households with total expenditure below the energy-based poverty line (20 percent nationally) and the healthy diet poverty line (48 percent nationally). Figure 4 illustrates this concentration of 28 percent of the population between the two poverty lines where they are deemed non-poor according to the energy-based poverty line but are likely lacking the resources to acquire a nutritionally balanced and adequate diet without sacrificing basic non-food needs. In the second and third expenditure quintiles, 100 and 38 percent of the population is poor relative to healthy diet poverty lines compared to none of the population when using traditional energy-based poverty lines. Differences in the poverty gap metric are no less striking, with the average depth of poverty increasing from 5 to 14 percent at the national level.

Table 4. Poverty and poverty gaps, by area and expenditure quintile²⁰

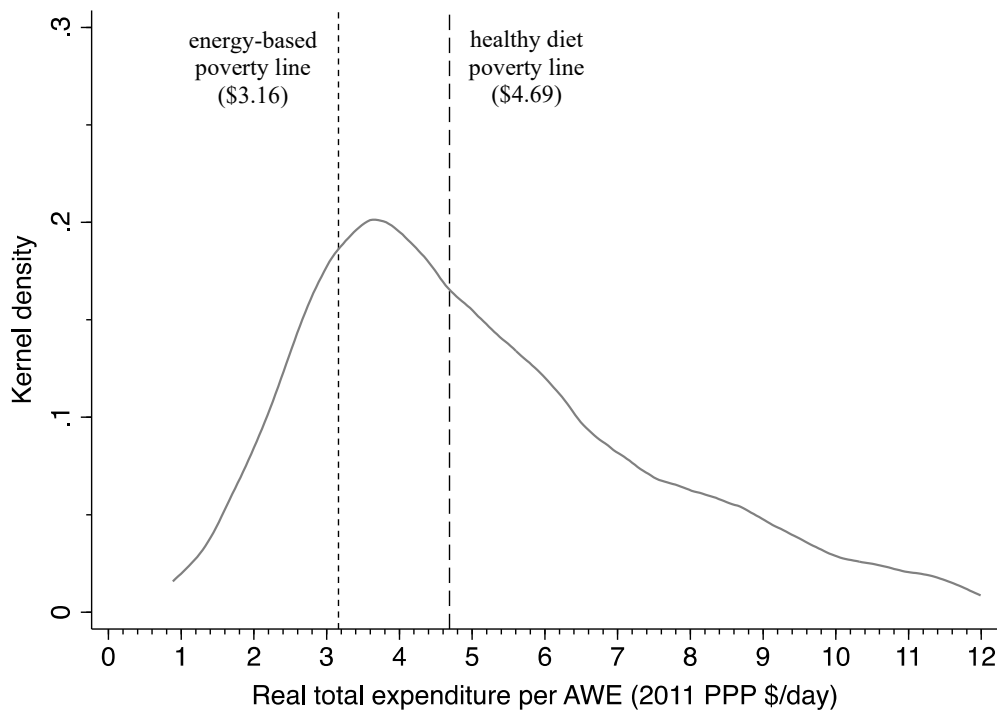
		Poverty rate (% of population)		Poverty gap (%)	
		Energy-based poverty line	Healthy diet poverty line	Energy-based poverty line	Healthy diet poverty line
All Households		20	48	5	14
Urban/Rural	Urban	8	27	2	7
	Rural	24	56	6	17
Zones	Hills	29	55	7	19
	Dry Zone	15	43	3	11
	Delta	22	56	5	17
	Coastal	22	51	6	17
	Yangon	13	33	3	9
Expenditure Quintiles	Q1	98	100	23	48
	Q2	0	100	0	21
	Q3	0	38	0	2
	Q4	0	0	0	0
	Q5	0	0	0	0

Note: Q1 to Q5 refer to expenditure quintiles that are estimated using spatially deflated total household expenditure per adult equivalent.

Source: MoPF and World Bank (2017a) and authors' calculations

²⁰ The official 2015 poverty rate indicates that 32 of the population is poor (MoPF and World Bank (2017a)). Much of this 12 percentage point difference can be explained by methodological choices: including the use of a single national basket rather than regional baskets, choice of reference poor households, and inclusion of food away from home in the official food basket.

Figure 4. Distributions of total expenditure and the energy-based and healthy diet poverty lines (spatially adjusted 2011 \$PPP)



Note: A spatial price deflator is derived from regional energy-based poverty lines. The real healthy diet poverty line equals population weighted mean spatially adjusted regional poverty lines.

Source: MoPF and World Bank (2017a) and authors' calculations

Nutrient adequacy of food baskets

Finally, we compare the nutrient composition of the baskets compared to the EAR of a 30-year old woman (Table 5) and present acceptable proportions of macronutrients in Appendix Table A 5. Both baskets contain energy from macronutrients (protein, fats, and carbohydrates) consistent with the Bangladesh dietary guidelines, which contains slightly more carbohydrates than the acceptable macronutrient distribution ranges (AMDR). Healthy diets meet or exceed the EARs of all key nutrients, with the exceptions of riboflavin. In contrast, the energy-based basket meets approximately half or less of the EARs for calcium (48 percent), vitamin C (62 percent), riboflavin (47 percent), folate (71 percent), vitamin B12 (52 percent), and vitamin A (56 percent), and less than 80 percent of the EAR for thiamin (79 percent). These serious micronutrient shortfalls demonstrate that an energy-based standard does not represent a bundle of goods that provides basic dietary needs for a healthy life.

Table 5. Percentage of estimated average requirements (EARs) by nutrient for a 30-year old woman in the energy-based and healthy diet food baskets

	Energy-based	Healthy diet
Protein	152	207
Calcium	48	110
Iron	100	136
Magnesium	89	137
Phosphorous	132	172
Zinc	85	105
Copper	200	266
Vitamin C	62	212
Thiamin	79	119
Riboflavin	47	82
Niacin	105	128
Vitamin B6	95	130
Folate	71	166
Vitamin B12	52	146
Vitamin A	56	136

Note: The table displays the population weighted average of regional food basket nutrient composition. Data shown are percentages of EARs by nutrient content in food baskets that meet the energy needs of a representative 30-year old woman with a 2,195 kilocalorie diet. Nutrient composition of foods baskets is based on the nutrient content of raw foods (See Appendix Table A 5 for details). For micronutrients, light red shading indicates shortfalls in the 75-97 percent of EAR range, and red indicates below 75 percent of EARs. EARs are drawn from Allen et al. (2020) with the following assumptions:

1. The protein EAR is calculated based 0.66 g/kg/day and a median weight for attained height of 49.4 kg;
2. Iron takes the assumption of a moderate-absorption diet;
3. Zinc takes the assumption of a semi-undefined diet.

Source: Authors' calculations based MoPF and World Bank (2017a), the Bangladesh food-based dietary guidelines (Nahar et al., 2013), EARs (Allen et al., 2020), and various food composition tables (Stadlmayr et al., 2012; Shaheen et al., 2013; Institute of Nutrition, 2014; MEXT, 2015; USDA, 2016; Scott, 2019).

5. Discussion

This study calls for a re-evaluation of how food poverty lines are determined, focusing on how they could be constructed in a way that accounts for nutritional needs, which we argue are basic needs.

Our first contribution is a conceptual critique of the continued use of an energy-standard alone in the traditional cost of basic needs approach to poverty line estimation. The cost of basic needs approach assumes that poor households are best able to determine how to allocate their resources, given their preferences, and thus hinges on their observed behaviors (Ravallion, 2016). However, relatively poor households are likely to consume disproportionately high quantities of calorically cheap staple foods that are sparse in micronutrients (Subramanian and Deaton, 1996; Headey and Alderman, 2019). Over-representation of starchy staples in the energy-based food poverty basket is readily apparent in Myanmar (see Figure 1 and Figure 2), but it is likely universally the case that energy-based food baskets in poor

countries will be deficient in most micronutrients (see Table 5).²¹ Consequently, without the use of additional nutritional criteria, the energy-based food poverty line is tied to a nutritionally inadequate bundle of foods. The depth of the shortfall between current food poverty lines and the cost of meeting dietary needs helps explain why estimates of micronutrient inadequacies – as well as stunting prevalence among preschool children – typically far exceed national poverty estimates, as well as the low \$1.90/day poverty line used by The World Bank, which is an average of national poverty lines from fifteen of the lowest income countries (Ravallion et al., 2009).

A second contribution is methodological. The cost of basic needs approach in theory would embrace nutrition as a basic need, but in practice the only nutritional standard used has been energy adequacy. This tradition is at least in part because a viable method for incorporating richer nutritional standards beyond energy had not been identified. Previous nutrient-based approaches did not capture complete dietary needs and departed from observed and realistic consumption patterns. The healthy diet approach to estimating poverty lines merges the estimation of least-cost healthy diets (Herforth et al., 2020, FAO et al. 2020) with the cost of basic needs methodology that is rooted in the observed consumption patterns of poor and near poor households (Ravallion, 1994, 1998). Our approach estimates poverty based on a healthy diet standard rather than the energy-based standard of traditional cost of basic needs poverty lines. The risk of ignoring either the nutritional standard or food item preferences is the estimation of a food poverty line that does not meet nutritional needs, is insufficient to cover the costs of foods that people are willing to actually eat, or both.

One challenge of this approach is that the imposed reallocation of food consumption between food groups in accordance with dietary guidelines introduces a hypothetical scenario without observable household consumption patterns, and in so doing overlooks the possibility that a reallocation from the relatively cheap staple food group to nutrient rich yet more expensive food groups would likely be accompanied by a reallocation toward cheaper items within those food groups. In a companion paper, we develop a linear expenditure system with an expenditure function for food groups. This model allows us to explore how households at the healthy diet poverty line adjust their consumption choices, within the limitations of a healthy diet (Robinson et al., forthcoming).

²¹ Indeed, Myanmar's GDP per capita in 2015 was \$3,663 in 2017 PPP terms, making it substantially richer than the average sub-Saharan African country.

We also develop an extension of Arndt and Simler's (2005, 2007, 2010) use of utility theory (revealed preference) to estimate utility-consistent poverty lines across different regions. However, with the use of a single national poverty line rather than regional poverty lines, the healthy diet poverty line methodology requires no more computational ability or tools to implement than the traditional energy-based cost of basic needs poverty line methodology.

A third and policy-relevant contribution of this paper is that the food poverty lines constructed in this approach meet national food-based dietary guidelines, which are important national policy and education tools. This approach provides poverty indicators and targets consistent with existing nutrition strategies as well as cultural norms around diets. While developing a methodology that invariably results in a higher poverty rate is potentially politically contentious, aligning the methodology with existing and accepted government nutrition guidelines provides scope for closer alignment between poverty and malnutrition reduction strategies, which are both highly multi-sectoral in nature (Ruel and Alderman, 2013). Moreover, poverty and malnutrition have complex bidirectional causal relationships. Poverty is an important underlying determinant of malnutrition, while malnutrition is a key dimension of poverty traps. Nutritional deprivation elevates risks of disease but also induces physical and mental fatigue, which reduce labor productivity,²² limits child growth and survival, and impedes full cognitive development and human potential (World Bank, 2006).

What are the policy implications of a higher poverty rate and poverty gap when measuring poverty based on a healthy diet standard? One obvious policy implication is that it is harder to reduce poverty. First, social protection programs clearly face a much larger shortfall than would be indicated by standard energy-based poverty lines. Social protection transfers are already greatly inadequate in the poorest and most fiscally constrained countries in terms of both scope of the population targeted and the average size of transfer (World Bank, 2018). The higher rates of poverty under a more comprehensive nutrition standard implies larger social protection gaps and may further explain why many social protection programs have yielded disappointing results from a nutritional perspective (Alderman, 2016). In Myanmar in 2017, for example, just 13.8 percent of the population received any form of protection (World Bank, 2022a), in contrast to the 48 percent poverty rate calculated under the utility-consistent

²² Anemia, in particular, is highly prevalent in adults, especially women, and causes fatigue and lower labor productivity, even at subclinical levels (Marcus et al. 2021).

healthy diet poverty line developed in this paper. Second, another way to close the social protection gap is to develop policies to reduce the cost of healthy diets from both the supply side (e.g., through healthy food procurement and distribution policies) and the demand side (e.g., through targeted subsidies/price reductions of non-staple foods), and to use education or behavioral interventions to nudge preferences towards foods that are both healthier and cheaper. Third, higher poverty rates imply that the poorest countries will require higher and more sustained economic growth rates to eradicate poverty.

In summary, this study presents a new method for defining utility-consistent regional poverty lines that meet the food group criteria encompassed in food-based dietary guidelines. Utility-consistent poverty comparisons are important, as are the food preferences of the poor. With increasing recognition from policymakers that energy-based diets are not sufficient for a healthy and productive population, it is time for poverty estimation to also incorporate a broader set of health and nutritional properties into its standard of what it really means to escape poverty.

REFERENCES

- Alderman, H.H. 2016. Leveraging Social Protection Programs for Improved Nutrition: summary of evidence prepared for the Global Forum on Nutrition-Sensitive Social Protection Programs, 2015. Global Forum on Nutrition-Sensitive Social Protection Programs. Washington, D.C.: World Bank Group. <https://documents.worldbank.org/curated/en/462981467040874717/Leveraging-Social-Protection-Programs-for-Improved-Nutrition-summary-of-evidence-prepared-for-the-Global-Forum-on-Nutrition-Sensitive-Social-Protection-Programs-2015>
- Allen, L.H., Carriquiry, A.L., & Murphy, S.P. 2020. Perspective: Proposed Harmonized Nutrient Reference Values for Populations. *Advances in Nutrition*, 11(3): 469–483 <https://doi.org/10.1093/advances/nmz096>
- Allen, R.C., 2017. Absolute poverty: when necessity displaces desire. *American Economic Review*, 107(12):3690-3721.
- Arndt, C. and K.R. Simler. 2005. ‘Estimating Utility-Consistent Poverty Lines’, Food Consumption and Nutrition Division Discussion Paper No. 189. Washington, DC: International Food Policy Research Institute (IFPRI).
- . 2007. ‘Consistent Poverty Comparisons and Inference’, *Agricultural Economics*, 37: 133–9.
- . 2010. ‘Estimating Utility-Consistent Poverty Lines with Applications to Egypt and Mozambique’, *Economic Development and Cultural Change*, 58(3): 449–74.
- Arndt, C. and K. Mahrt. 2017. ‘Estimation in Practice.’ In C. Arndt and F. Tarp (Eds.), *Measuring Poverty and Wellbeing in Developing Countries*, WIDER Studies in Development Economics. Oxford, New York: Oxford University Press.
- Arndt, C., K. Mahrt, and F. Tarp. 2017. ‘Absolute Poverty Lines.’ In C. Arndt and F. Tarp (Eds.), *Measuring Poverty and Wellbeing in Developing Countries*, WIDER Studies in Development Economics. Oxford, New York: Oxford University Press.
- Arndt, C. and F. Tarp. 2017. *Measuring Poverty and Wellbeing in Developing Countries*, WIDER Studies in Development Economics. Oxford, New York: Oxford University Press.
- Bai, Y., R. Alemu, S.A. Block, D. Headey and W.A. Masters, W.A. 2020. ‘Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries.’ *Food Policy*, e101983.
- Bailey R.L., West K.P. Jr, Black R.E. 2015. ‘The epidemiology of global micronutrient deficiencies’. *Annals of Nutrition and Metabolism*. 66 Suppl 2:22-33. doi: 10.1159/000371618.
- Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Uauy, R. 2013. ‘Maternal and child undernutrition and overweight in low-income and middle-income countries.’ *The Lancet*, 382(9890), 427-451.
- Bourassa, M.W., Abrams, S.A., Belizán, J.M., Boy, E., Cormick, G., Quijano, C.D., Gibson, S., Gomes, F., Hofmeyr, G.J., Humphrey, J., Kraemer, K., Lividini, K., Neufeld, L.M., Palacios, C., Shlisky, J., Thankachan, P., Villalpando, S. and Weaver, C.M. 2022. ‘Interventions to improve calcium intake through foods in populations with low intake.’ *Annals of the New York Academy of Sciences*. <https://doi.org/10.1111/nyas.14743>

- Deptford, A., T. Allieri, R. Childs, C. Damu, E. Ferguson, J. Hilton, P. Parham, A. Perry, A. Rees, J. Seddon, and A. Hall. 2017. 'Cost of the Diet: A Method and Software to Calculate the Lowest Cost of Meeting Recommended Intakes of Energy and Nutrients from Local Foods.' *BMC Nutrition* 3(26): 1–17.
- Dizon F. and A. Herforth. 2018. The cost of nutritious food in South Asia. Policy Research Working Paper Series, 8557. Washington, D.C.: The World Bank Group.
- Dizon, F., A. Herforth and Z. Wang. 2019. 'The cost of a nutritious diet in Afghanistan, Pakistan and Sri Lanka.' *Global Food Security*, 21(June): 38-51.
- Dizon, F., Z. Wang, and P. Mulmi, 2021. 'The Cost of a Nutritious Diet in Bangladesh, Bhutan, India, and Nepal'. Policy Research Working Paper Series, 9578. Washington, D.C.: The World Bank Group.
- Engelgau, M., Rosenhouse, S., El-Saharty, S. and Mahal, A., 2011. The economic effect of noncommunicable diseases on households and nations: a review of existing evidence. *Journal of Health Communication*, 16(sup2), pp.75-81.
- FAO (Food and Agriculture Organization). 1996. *Rome Declaration on World Food Security and World Food Summit Plan of Action*. Rome, Italy: FAO.
- . 2004. *Human Energy Requirements*. Report of a Joint FAO/WHO/UNU Expert Consultation. FAO Food and Nutrition Technical Report Series 1. Rome.
- . 2021. FAOSTAT. Food and Agriculture Organization, Rome. <http://faostat.fao.org/default.aspx>
- FAO/WHO/UNU, 2007. *Protein and amino acid requirements in human nutrition*. WHO Technical Report Series 935. World Health Organisation, Geneva.
- FAO, IFAD, UNICEF, WFP, and WHO. 2020. *The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets*. Rome, FAO.
- . 2021. *The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all*. Rome, FAO.
- Gakidou, E., Afshin, A., Abajobir, A. A., Abate, K. H., Abbafati, C., Abbas, K. M., Murray, C. J. L. 2017. 'Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2016.' *The Lancet*, 390(10100), 1345-1422. doi: 10.1016/S0140-6736(17)32366-8
- Gibson, J., and S. Rozelle. 2003. 'Poverty and Access to Roads in Papua New Guinea. Economic Development and Cultural Change', 52(1), 159–185. <https://doi.org/10.1086/380424>
- Golan, A., G. Judge, and D. Miller. 1997. *Maximum Entropy Econometrics: Robust Estimation with Limited Data*. John Wiley and Sons.
- . 2018. *Foundations of Info-Metrics: Modeling, Inference, and Imperfect Information*. Oxford University Press.
- Hansen, M., Thilsted, S. H., Sandström, B., Kongsbak, K., Larsen, T., Jensen, M., & Sørensen, S. S. (1998). Calcium absorption from small soft-boned fish. *Journal of Trace Elements in Medicine and Biology*, 12(3): 148–154. [https://doi.org/10.1016/S0946-672X\(98\)80003-5](https://doi.org/10.1016/S0946-672X(98)80003-5)

- Headey, D. and H. Alderman. 2019. 'The Relative Caloric Prices of Healthy and Unhealthy Foods Differ Systematically across Income Levels and Continents.' *Journal of Nutrition*, nxz158. doi.org/10.1093/jn/nxz158.
- Herforth, A., Arimond, M., Álvarez-Sánchez, C., Coates, J., Christianson, K. and Muehlhoff, E. 2019. 'A global review of food-based dietary guidelines.' *Advances in Nutrition*, 10(4), pp.590-605.
- Herforth, A., Y. Bai, A. Venkat, K. Mahrt, A. Ebel, W.A. Masters. 2020. Cost and affordability of healthy diets across and within countries. Background paper for the State of Food Security and Nutrition in the World 2020. Rome: FAO.
- Hirvonen K, Y. Bai, D. Headey, W.A. Masters. 2020. 'Affordability of the EAT-Lancet reference diet: a global analysis'. *Lancet Global Health*. 8(1):e59-e66. doi: 10.1016/S2214-109X(19)30447-4.
- Hicks, C.C., P.J. Cohen, N.A.J. Graham, K.L Nash, E.H. Allison, C. D'Lima, D.J. Mills, M. Roscher, S.H. Thilsted, A.L Thorne-Lyman, M.A. MacNeil 2019. 'Harnessing global fisheries to tackle micronutrient deficiencies.' *Nature* 574: 95–98.
- IOM (Institute of Medicine of the National Academies). 2006. *Dietary reference intakes: The Essential Guide to Nutrient Requirements*. Washington, DC: The National Academies Press.
- Institute of Nutrition, Mahidol University. 2014. ASEAN Food Composition Database, Electronic version 1, February 2014. Thailand. http://www.inmu.mahidol.ac.th/aseanfoods/composition_data.html
- Jolly, R. 1976. 'The World Employment Conference: The Enthronement of Basic Needs'. *Development Policy Review*. A9 (2): 31–44. doi:10.1111/j.1467-7679.1976.tb00338.x.
- Mahrt, K., D. Mather, A. Herforth, and D. Headey. 2019. Household dietary patterns and the cost of a nutritious diet in Myanmar. IFPRI Discussion Paper 1854. Washington, DC: International Food Policy Research Institute (IFPRI). <https://doi.org/10.2499/p15738coll2.133344>
- Marcus, H., Schauer, C., & Zlotkin, S. (2021). Effect of Anemia on Work Productivity in Both Labor- and Nonlabor-Intensive Occupations: A Systematic Narrative Synthesis. *Food and Nutrition Bulletin*, 42(2), 289–308. <https://doi.org/10.1177/03795721211006658>
- Mekonnen, D.A., Akerele, D., Achterbosch, T., De Lange, T. and Talsma, E.F., 2021. Affordability of Healthy and Sustainable Diets in Nigeria. *Front. Sustain. Food Syst.* 5: 726773. <https://doi.org/10.3389/fsufs.2021.726773>
- MEXT (Ministry of Education, Culture, Sports, Science and Technology). 2015. Standard Tables of Food Composition in Japan - 2015 - (Seventh Revised Edition). Tokyo. https://www.mext.go.jp/en/policy/science_technology/policy/title01/detail01/1374030.htm
- MoH, World Health Organization (WHO) and World Diabetic Foundation (WDF). 2015. Report on National Survey of Diabetes Mellitus and Risk Factors for Non-Communicable Diseases in Myanmar (2014). Nay Pyi Taw, Myanmar.
- MoHS (Ministry of Health and Sports). 2007. Food-Based Dietary Guidelines for Myanmar. Nay Pyi Taw, Myanmar.
- . 2019. *Myanmar Micronutrient and Food Consumption Survey MMFCS (2017-2018): Interim Report*. Nay Pyi Taw, Myanmar.

- MoHS and ICF. 2017. Myanmar Demographic and Health Survey 2015-16. Nay Pyi Taw, Myanmar, and Rockville, Maryland USA.
- MoPF and World Bank. 2017a. An Analysis of Poverty in Myanmar: (Part 2) Poverty Profile. Nay Pyi Taw, Myanmar.
- . 2017b. Myanmar Poverty and Living Conditions Survey: Technical Poverty Estimate Report. Nay Pyi Taw, Myanmar.
- Nahar, Q., S. Choudhury, M.O. Faruqu, S.S.S. Sultana, M.A. Siddiquee. 2013. Dietary Guidelines for Bangladesh. Dhaka: Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders.
- Pelletier, D.L., Frongillo Jr, E.A., Schroeder, D.G. and Habicht, J.P., 1995. The effects of malnutrition on child mortality in developing countries. *Bulletin of the World Health Organization*, 73(4), p.443.
- Popkin, B.M., Corvalan, C., Grummer-Strawn, L.M., 2020. Dynamics of the double burden of malnutrition and the changing nutrition reality. *The Lancet* 395(10217), p. 65-74.
- Raghunathan, K., D. Headey, and A. Herforth. 2021 Affordability of nutritious diets in rural India. *Food Policy*, 99:101982. <https://doi.org/10.1016/j.foodpol.2020.101982>.
- Ravallion, M. 1994. Poverty comparisons. Chur, Switzerland; Langhorne, Pa.: Harwood Academic Publishers.
- . 1998. Poverty lines in theory and practice. Technical Report LSM133, The World Bank.
- . 2016. *The Economics of Poverty: History, Measurement, and Policy*. Oxford: Oxford University Press.
- . 2020. On Measuring Global Poverty. *Annual Review of Economics*, 12:167–88.
- Ravallion, M. and B. Bidani. 1994. ‘How robust is a poverty profile?’ *World Bank Economic Review*, 8(1), 75–102.
- Ravallion, M. and M. Lokshin. 2006. ‘Testing Poverty Lines’. *Review of Income and Wealth* 52(3), 399–421.
- Ravallion, M. and B. Sen. 1996. When Method Matters: Monitoring Poverty in Bangladesh.
- Ravallion, M., S. Chen, P. Sangraula, 2009. ‘Dollar a Day Revisited’. *The World Bank Economic Review* 23(2), 163-184.
- Robinson, S., C. Arndt, D. Headey, A. Herforth, K. Mahrt. Forthcoming. Modeling Resilience to Shocks by Poor Households: Meeting Dietary Needs Under Stress. IFPRI Discussion Paper. Washington, DC: International Food Policy Research Institute (IFPRI).
- Rowntree, B.S. 1901. Poverty: A Study in Town Life. New York: Macmillan and Co. p. 298.
- Ruel M.T. and H. Alderman. 2013. Maternal and Child Nutrition Study Group. ‘Nutrition-Sensitive Interventions and Programmes: How Can They Help to Accelerate Progress in Improving Maternal and Child Nutrition?’ *Lancet*, 382(9891):536-51. doi: 10.1016/S0140-6736(13)60843-0.

- Schmidt E.R. Gilbert, B. Holtemeyer, K. Mahrt. 2021. 'Poverty analysis in the lowlands of Papua New Guinea underscores climate vulnerability and need for income flexibility'. *Australian Journal of Agricultural and Resource Economics*. 65(1): 171-191.
- Scott, J. 2019. Nutrient Database for Fish in Myanmar. Unpublished database. Yangon, Myanmar: World Fish.
- Shaheen, N., A.T.M.A. Rahim, M. Mohiduzzaman, C.P.Banue, M.L. Bari, A.B. Tukun, M.A. Mannan, L. Bhattacharjee, and B. Stadlmayr. 2013. Food Composition Table for Bangladesh. Dhaka, Bangladesh: University of Dhaka, Institute of Nutrition and Food Science.
- Stadlmayr, B., U.R. Charrondiere, V.N, Enujiugha, R.G. Bayili, E.G Fagbohoun, B. Samb, P. Addy, I. Barikmo, F. Ouattara, A. Oshaug, I. Akinyele, G.A. Annor, K. Bomfeh, H. Ene-Obong, I.F. Smith, I.Thiam, B. Burlingame. 2012. West African Food Composition Table. Rome: FAO.
- Stigler, G. 1945. 'The Cost of Subsistence'. *Journal of Farm Economics*, 27(2), 303–14.
- Subramanian, S. and A. Deaton. 1996. 'The demand for food and calories.' *Journal of Political Economy*, 104(1), 133-162.
- USDA (US Department of Agriculture), Agricultural Research Service, Nutrient Data Laboratory. 2016. USDA National Nutrient Database for Standard Reference, Release 28. Version Current: May 2016. Accessed at <http://www.ars.usda.gov/ba/bhnrc/ndl>
- Tarp, F., K. Simler, C. Matusse, R. Heltberg, and G. Dava. 2002. 'The Robustness of Poverty Profiles Reconsidered.' *Economic Development and Cultural Change*, 51(1), 77–108.
- Waid, J.L., J.R. Bogard, S.H. Thilsted, and S. Gabrysch. 2017. 'Estimates of Average Energy Requirements in Bangladesh: Adult Male Equivalent Values for use in Analyzing Household Consumption and Expenditure Surveys.' *Data in Brief*. Volume 14, October 2017.
- World Bank. 2006. Repositioning Nutrition as Central to Development : A Strategy for Large Scale Action. Washington, DC:World Bank. <https://openknowledge.worldbank.org/handle/10986/7409>
- . 2018. The State of Social Safety Nets 2018. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/29115>
- . 2022a. 'Coverage of social protection and labor programs.' *World Development Indicators*. World Bank Group. https://data.worldbank.org/indicator/per_allsp.cov_pop_tot. Accessed 15 February 2022.
- . 2022b. 'Poverty headcount ratio at \$1.90 a day.' *World Development Indicators*. World Bank Group. <https://data.worldbank.org/indicator/SI.POV.DDAY>. Accessed 15 February 2022.
- Zellner, A. 2002. 'Information processing and Bayesian analysis.' In Amos Golan, ed., Information and Entropy Econometrics, *Journal of Econometrics*, 107, 41-50.

Appendix A Food group equivalent quantities

Serving sizes in dietary guidelines apply to typical foods within each food group but are often not specified for atypical foods such as dried fish or bean curd. Following Herforth et al. (2020), we estimate serving sizes for atypical foods using the ratio of a reference macronutrient contained in each item to the average macronutrient content among typical foods in the food group. This process enables conversion of atypical food quantities to food group equivalent quantities. Throughout the paper, quantities refer to food group equivalent quantities.

Table A 1. Serving sizes and conversion to food group equivalent grams based on equivalence of reference nutrient content, by food group

Food group and reference nutrient	Item	Item specific serving (g)	Standard serving for the food group in the FDDG (g)	Conversion factor
Pulses (Protein)	Bean curd	106	30	3.45
Meat/Fish/Eggs (Protein)	Dried striped snakehead	15	40	0.39
	Dried Mackerel	13	40	0.33
	Other dried medium river fishes	17	40	0.42
	Other dried medium sea fishes	16	40	0.40
	Shrimp paste	39	40	0.98
	Fish/ shrimp sauce	82	40	2.06
	Salted fish	18	40	0.44
	Dried Bombay duck	11	40	0.29
	Chicken eggs	54	40	1.36
	Duck eggs	53	40	1.31
Dairy (Calcium)	Sardines	61	150	0.41
	Other small river fishes	16	150	0.11
	Other small sea fishes	37	150	0.25
	Other dried small river fishes	5	150	0.03
	Other dried small sea fishes	19	150	0.12
	Dried Prawns	16	150	0.11
Discretionary Foods (Sugar)	Branded condensed milk	9	5	1.83
	Cake	15	5	2.99
	Biscuits	24	5	4.72
	Coffee mix or tea mix	7	5	1.50

Note: Fish/shrimp pastes and sauces are allowed in the healthy diet food basket in their original quantities but are not scaled up with other foods to meet the meat/fish/eggs food group quantity.

Source: Authors' calculations based MoPF and World Bank (2017a) and various food composition tables (Stadlmayr et al., 2012; Shaheen et al., 2013; Institute of Nutrition, 2014; MEXT, 2015; USDA, 2016; Scott, 2019). Standard recommended serving sizes are from the Bangladesh food-based dietary guidelines (Nahar et al., 2013).

Appendix B Poverty estimation parameters

The energy-adequate and healthy diet baskets are calculated in terms of the food consumption patterns and prices of foods purchased by relatively poor reference households. In the iterative procedure used to ensure that poverty lines reflect consumption patterns of poor households, households are selected using the previous round's energy-based poverty rate. In this analysis, we select households with total expenditures between the fifth percentile and 20 percentage points above the energy-based poverty rate, in each region. This range allows overlap with households that are poor in terms of the healthy diet poverty line. We exclude households below the bottom fifth percentile, for whom observations are more likely to be prone to error. Regional energy-based poverty rates converge within five iterations. The consumption patterns of reference households selected in the fifth iteration are used to determine both the energy-based, healthy diet, and least cost healthy diet food baskets and associated prices.

After making entropy adjustments to ensure utility consistency between regional food poverty lines, regional non-food allowances are estimated to be the average of the non-food expenditure levels of (1) households with total expenditure within ten percentage points of the utility-consistent energy-based food poverty line and (2) households with food expenditure within ten percentage points of the utility-consistent energy-based food poverty line in each spatial domain. Greater weight is given to households with expenditure closer to the food poverty line (Arndt and Mahrt, 2017; Ravallion, 1998). Energy-based and healthy diet total poverty lines are the sum of the respective utility-consistent food poverty line and the non-food allowance in each region.

Appendix C Least-cost healthy diets and diet affordability

We follow Herforth et al. (2020) in calculating the least-cost healthy diet. First, we identify the cheapest items per serving in each food group. In food groups with a variety of foods, we select the two to three cheapest items, reflecting an emphasis in dietary guidelines on consumption diversity within food groups. The cost of each selected food item equals the recommended food group quantity from the dietary guidelines evaluated at median prices. Least-cost healthy diet food group costs are the unweighted average costs of the cheapest items in each food group. The food basket and its total cost are scaled to meet the dietary energy requirements of a reference adult.

In contrast, the healthy diet basket used for poverty calculations weights all items in each food basket in accordance with consumption patterns of relatively poor households. For clarity, in this section, we refer to this healthy diet as the preference-weighted healthy diet.

Table A 2 presents total costs of the energy-based, preference-weighted healthy diet, and least-cost healthy diet baskets. In most regions, the cost of the energy-based basket is about 40 percent lower than the preference-weighted healthy diet basket, while the least-cost healthy diet basket is about 28 percent lower than the preference-weighted healthy diet basket. Differences in the costs of the three baskets are driven by two factors: composition of the baskets and the costs of items selected in each food group. Basket composition is the primary factor driving differences in food group costs of the energy-based and the preference-weighted healthy diet baskets. Food group costs in both baskets are based on the same actual consumption patterns, but the preference-weighted healthy diet basket is derived from consumption patterns scaled to meet food group guidelines/proportionality. The least-cost and preference-weighted healthy diets both meet food group guidelines, but differences between the costs of the cheapest foods and the weighted average of the most consumed foods in each group drives cost differences. Preferences for higher-priced animal source foods and vegetables are the main drivers of the higher cost of preference-weighted baskets.

Table A 2. Cost of food baskets compared to median daily household food expenditure per adult woman equivalent (2011 \$PPP)

		Cost of food basket per day (2011 \$PPP)			Median household daily food expenditure (2011 \$PPP per AWE)
		Energy-based	Least-cost healthy diet	Preference-weighted healthy diet	
All Households		1.83	2.35	3.31	2.72
Urban/Rural	Urban	1.88	2.37	3.39	3.13
	Rural	1.81	2.34	3.27	2.59
Zones	Hills & Mountains	1.91	2.42	3.42	2.50
	Dry Zone	1.78	2.37	3.12	2.59
	Delta	1.76	2.13	3.27	2.85
	Coastal	1.75	2.73	3.32	2.58
	Yangon	2.00	2.41	3.60	3.27

Note: AWE refers to adult woman equivalent.

Source: MoPF and World Bank (2017a) and authors' calculations

Assessments of affordability of healthy diets are typically conducted by comparing diet costs to household food consumption expenditure, so we follow that approach here for comparison to previous research (bearing in mind the strong assumption that food expenditure is non-adjustable). The cost of the energy-based, least-cost healthy diet, and preference-weighted healthy diet baskets exceed reported household food expenditure for a large share of the population (Table A 3). Nationally in 2015, 21 percent of the population lived in households that could not afford the energy-based basket without shifting non-food expenditure to food expenditure, 38 percent could not afford the least-cost healthy diet basket, while 64 percent could not afford the preference-weighted healthy diet.

Table A 3. Comparisons of affordability and affordability gaps of different food baskets relative to household food expenditure, by area and expenditure quintile

		Percentage of individuals who cannot afford the basket (% of population)			Gap between basket costs and actual food expenditures (%)		
		Energy-based	Least-cost healthy diet	Preference-weighted healthy diet	Energy-based	Least-cost healthy diet	Preference-weighted healthy diet
All Households		21	38	64	5	11	23
Urban/Rural	Urban	16	29	56	4	7	18
	Rural	23	42	68	6	12	24
Zones	Hill	29	48	73	8	14	28
	Dry Zone	23	44	64	5	12	22
	Delta	14	27	61	4	7	20
	Coastal	25	55	69	6	18	26
	Yangon	18	27	58	4	7	19
Expenditure Quintiles	Q1	70	94	100	20	34	54
	Q2	22	56	98	4	12	32
	Q3	8	24	69	1	5	16
	Q4	3	11	35	0	2	7
	Q5	2	6	18	0	1	4

Note: Q1 to Q5 refer to expenditure quintiles that are estimated using spatially deflated total household expenditure per adult equivalent.

Source: MoPF and World Bank (2017a) and authors' calculations

Appendix D Supplemental tables

Table A 4. Macronutrient percentages of dietary energy

		Protein	Total fat	Carbohydrate
Targets	Acceptable Macronutrient Distribution Range	10-35	20-35	45-65
	Bangladesh FBDG target	10	20	70
Food Baskets	Energy-based	9	16	72
	Healthy diet	12	19	68

Note: The table displays the population weighted average of regional food basket nutrient composition.
 Source: AMDR (IOM, 2006), Bangladesh FBDG (Nahar et al., 2013), authors' calculations based MoPF and World Bank (2017a), and various food composition tables (Stadlmayr et al., 2012; Shaheen et al., 2013; Institute of Nutrition, 2014; MEXT, 2015; USDA, 2016; Scott, 2019). Recommended serving sizes are from the Bangladesh food-based dietary guidelines (Nahar et al., 2013).

Table A 5. Comparisons of the nutrient content of food baskets

	Nutrient content of food baskets		EAR for 30-year old adult women
	Energy-based	Healthy diet	
Protein, g	50	68	33
Calcium, mg	360	874	750
Iron, mg	11	17	11
Magnesium, mg	236	363	265
Phosphorous, mg	764	1,023	580
Zinc, mg	8	9	9
Copper, mg	1.4	1.9	1
Vitamin C, mg	49	169	80
Thiamin, mg	0.7	1.1	0.9
Riboflavin, mg	0.6	1.0	1.3
Niacin, mg	12	14	11
Vitamin B6, mg	1.2	1.7	1.3
Folate, µg	178	411	250
Vitamin B12, µg	1.0	2.6	2.0
Vitamin A, µg RAE	274	627	490

Note: The table displays the population weighted average of regional food basket nutrient composition.
 Source: Authors' calculations based MoPF and World Bank (2017a) and various food composition tables (Stadlmayr et al., 2012; Shaheen et al., 2013; Institute of Nutrition, 2014; MEXT, 2015; USDA, 2016; Scott, 2019). Standard recommended serving sizes are from the Bangladesh food-based dietary guidelines (Nahar et al., 2013)

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