Nutrition as a Basic Need: A new method for utility-consistent and nutritionally adequate food poverty lines

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ABSTRACT

Basic needs food poverty lines are typically derived from food baskets that satisfy a dietary energy standard while reflecting consumption patterns of poor households. However, since the poor consume unbalanced low-quality diets deficient in key micronutrients, the use of an energy-only nutrition standard incorporates a circular logic whereby the cost of basic nutritional needs is estimated from populations with nutritionally inadequate diets. We instead develop an alternative poverty line that satisfies the balanced diet criteria of food-based dietary guidelines, but which still incorporates preferences for specific food items within broad food groups, and utility consistency across regional food baskets. Using data from Myanmar, we show that an energy-based poverty line results in non-poor households who have severe micronutrient deficiencies; deficiencies which the more expensive healthy diet poverty line eliminates. If the normative proposition that nutrition is a basic need is accepted, then the world is much poorer than we think.

Keywords: Poverty measurement; poverty lines; 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 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 poverty line is intended to reflect the cost of a food basket associated with achieving good health (defined by a nutrition standard), the cost of other basic needs essential to reaching a minimum welfare level, and social inclusion (reflected in the consumption patterns of households that are poor or near-poor) (Ravallion, 1994, 1998, 2020; Ravallion and Sen, 1996).

In conventional practice, however, the nutrition-related standard in food poverty lines is limited to dietary energy requirements. This energy standard was arguably an appropriate pragmatic target in the 1990s, when poverty measurement in LMICs first expanded. At that time, energy deficiency was a major nutrition and public health problem across a large swathe of LMICs and, empirically, poverty measurement justifiably reflected that concern. In 1995, roughly one third of the world's population lived below the $2.15 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 sticky 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 the dietary guidelines set out by nutritionists.

Deficiencies in essential nutrients can result in a wide array of health and behavioral disorders and diseases, including severe fatigue, night blindness, rickets, bone and skin diseases, and increased risks of infections (Bailey, West and Black, 2015), while poor diets as a whole are now estimated to be the number one avoidable risk factor in the global burden of disease (Gakidou et al., 2017; Engelgau et al., 2011). The consequences of poor-quality diets for children are especially severe, putting them at greater risk of mortality and morbidity (Pelletier et al., 1995; Black et al., 2013), as well as slower cognitive development, poor schooling outcomes and lower earnings in adulthood (Black et al., 2013; World Bank, 2006). Hence, we make the normative claim that avoiding the harmful impacts of malnutrition should be regarded as a basic need.

In this study we argue that the nutrition standards used to evaluate poverty should therefore incorporate a more comprehensive definition of dietary needs – an operational change that is still 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

[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.

basket *could* meet dietary requirements for food group diversity and micronutrient content, but the absence of additional nutrition standards virtually ensures this is highly unlikely. 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 micronutrients as well as high quality proteins and fats (Subramanian and Deaton, 1996; Headey and Alderman, 2019). 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.

This paper makes two contributions to the literature. First, we introduce an approach to modify the standard cost of basic needs methodology to incorporate a more more comprehensive nutrition standard defined by dietary guidelines. In doing so, we preserve the cost of basic needs approach of deriving poverty lines from the observed consumption patterns of less well-off households in order to capture food preferences (given local prices and availability), and notions of consumption patterns that meets the social inclusion criterion (Ravallion, 1998, 2016,2020).

Second, a key principle of poverty measurement stipulates that poverty lines should represent the same minimum welfare level across time and space. This is typically achieved by estimating a single national poverty line. Recognizing that national-level poverty lines might not reflect important variations in local consumption patterns, Arndt and Simler (2005, 2007, 2010) develop a methodology for estimating subnational poverty lines that adhere to the principal of utility consistency (Ravallion and Lokshin, 2006; Ravallion, 2016; Arndt, Mahrt, and Tarp, 2017). In this paper, we choose to estimate utility-consistent regional poverty lines, adapting the methodology developed by Arndt and Simler to accommodate food group constraints specificized in dietary guidelines.

The paper begins by examining various approaches to estimating the cost of healthy and nutritious diets, followed by a description of our methodology. Using a national survey from Myanmar as example, 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, and that the traditional calorie-focused basic needs approach to poverty estimation results in non-poor households whose observed diets indicate severe micronutrient deficiencies. We conclude the paper with a discussion of important extensions to this research, potential adoption by national and international agencies, and implications for development strategies that aim to reduce poverty when nutrition is regarded as a basic need.

2. Background

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 lines should only represent the cost of basic nutrition needs, "not a level of satisfaction" (Allen, 2017, p. 3708).[2] However, adequate nutrient intake is not the only purpose of food consumption. If one accepts

[2] 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

that social inclusion is a fundamental component of basic welfare, then ignoring the social roles of food could lead to welfare-inconsistent poverty measurement (Ravallion, 2020).

But even if one sets 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 will often select unrealistic diets that substantially diverge from dietary and cultural norms. 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. In contrast, food-based dietary guidelines factor in both nutrient and non-nutrient health properties of foods (Herforth et al. 2019), including 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).

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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).

Food-based dietary guidelines (FBDGs) 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); i.e. a balanced diet. They also constitute official government definitions of a healthy diet in countries where they have been developed. Here we propose that FBDGs offer a superior nutritional standard for the construction of food poverty lines due to their broader mandate to advocate diets that achieve nutrient adequacy and reduce risks of non-communicable disease, within culturally appropriate dietary patterns. An added advantage of FBDGs 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/purchasing by food groups.[3]

The affordability of a global healthy diet is now annually reported as a food insecurity indicator in UN's *The State of Food Security and Nutrition in the World* (SOFI) reports (FAO et al. 2020, 2021, 2022, 2023).[4] The FAOs measure defines a healthy diet in terms of the Healthy Diet basket which is derived from FBDGs representative of ten global regions (Herforth et al., 2022). Other studies have measured the 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 affordability of the EAT-Lancet

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

[4] 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).

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” version 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 FBDGs. Mahrt et al. (2019) show that even quite poor consumer do not necessarily prefer the cheapest food items within each food group, with preferences for animal-sourced “proteins” over leguminous “proteins” being a particularly strong preference.

3. Methodology

The present study develops a more rigorous approach to improving the measurement of food poverty lines, one which unifies Allen’s (2017) notion of complete nutrition as a basic need with the longstanding view that poverty lines should reflect social inclusion criteria and utility consistency (Ravallion, 1998, 2016). To meet the complete nutrition criterion we use the food group reference intakes set out by FBDGs (Herforth et al., 2020) and adopted by the FAO in its suite of food security indicators (FAO et al., 2021). However, we also continue the cost of basic needs approach of deriving poverty lines from the observed consumption patterns of less well-off households in order to capture food preferences given local prices and availability, and notions of consumption patterns that meet the social inclusion criterion (Ravallion, 1998, 2016, 2020). In other words, healthy diet food poverty lines defined such that food group quantities adhere to FBDG while within food group quantities are proportional to observed consumptions patterns (Mahrt et al, 2019).

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 this minimum welfare level using utility theory with the poverty line representing a money metric of the minimum utility level. In practice, poverty lines are typically estimated using a single national food basket and non-food allowance, which ensures utility consistency. 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 "unadjusted" food poverty lines – i.e. prior to adjusting for revealed preference constraints to ensure utility consistency – based on observed consumption patterns "reference poor households" (defined below) 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.

Unadjusted poverty lines

Energy-based poverty lines

We first estimate initial 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).[5] In each sub-national domain, the initial energy-based food poverty basket meets dietary energy requirements given consumption patterns of reference poor households (defined below) and the energy-based food poverty line is the cost of attaining that basket at median prices observed in reference poor households.[6]

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, as defined by 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

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[5] 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.

[6] We eliminate from the basket any food consumed away from home (which typically lacks the details necessary to assign caloric values). Also, 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

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). In contrast, households with *food expenditure* near the energy-based food poverty line are able to meet food energy requirements and by extension are assumed to have also met essential non-food needs. Hence, non-food expenditure in these households is regarded as providing an upper bound estimate of the cost of basic non-food needs (Ravallion, 1998). Next, the unadjusted non-food allowance is measured as the average of these lower and upper bound estimates in each sub-region, and unadjusted energy-based poverty lines are the sum of sub-national food poverty lines and non-food allowances. 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.

Unadjusted healthy diet poverty lines

We define a healthy diet to be a diet that meets the quantified food group recommendations outlined in food-based dietary guidelines. (Herforth et al., 2022) while preserving household consumption patterns within food groups. These guidelines target consumption levels for a variety of healthy food groups and may also include a maximum allowance for non-essential sugary or discretionary foods items.[7]

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 reference poor households'

[7] 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).

consumption patterns by using within food group quantity shares to scale food item quantities in each food group proportional to observed consumption patterns.[8] The healthy diet poverty line is the cost of the healthy diet basket evaluated at median prices plus the non-food allowance identified in the final iteration of the initial energy-based poverty line estimations.

Utility-consistent cost of basic needs regional 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.[9] 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.[10] 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).

[8] 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).
[9] 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.
[10] 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.

Estimating energy-based food baskets adjusted for utility-consistency

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).

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

subject to:

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

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

$$\sum_i calpg_i \, q_{ir} = cal \qquad \forall \, r \qquad (1c)$$

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

where:

q_{ir}	variables representing quantities consumed;
s_{ir}^{ent}	variables representing food expenditure shares of the reference basket;
s_{ir}^{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.

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 healthy diet food baskets adjusted for utility-consistency

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.

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

subject to:

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

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

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

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

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

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, $s_{i_f r}^{ent}$, as a function of the modified quantities, $q_{i_f r}$.

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 (this means we derive a single non-food allowance so that total poverty line only vary due to the food poverty component). Energy-based and healthy diet total poverty lines therefore 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.

Notably, households with total expenditure above either poverty line are considered not poor even if expenditures are not allocated to meet the energy or healthy diet standards, respectively. This is because, normatively, poverty is defined as the lack of financial capability of meeting basic needs, not as the choice to avoid meeting basic needs when financial means are available.

Healthy diet poverty lines versus Cost and Affordability of a Healthy Diet

This measure of poverty based on a healthy diet standard differs in several important regards to the Cost and Affordability of a Healthy Diet measure developed by Herforth et al. (2020, 2023) and reported in the UN's *SOFI* reports (FAO et al. 2020, FAO et al. 2021). First, healthy diet affordability 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. Our approach allows for variation in household allocation between food and non-food needs. Second, our approach allows for food preferences and social inclusion criteria, whereas the food affordability only selects the cheapest items in each food group, irrespective of whether that item is consumed or consistent with prevailing dietary patterns or customs. Third, our approach imposes utility-consistency by ensuring that revealed preference conditions are satisfied. However, since healthy diet affordability is now a widely reported food security indicator, we provide comparisons between the (least-cost) healthy diet affordability measure and our own healthy diet food poverty indicator 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, consistent with the approach adopted in the UN"s *SOFI* reports (Herforth et al. 2020; FAO et al. 2020).[11] For macronutrients, we compare the carbohydrate, protein, and fat content of each basket to the acceptable macronutrient distribution ranges (AMDRs) specified in IOM (2006).

4. Empirical application to Myanmar

Myanmar is an appropriate case study for gauging sensitivity to alternative food poverty lines.[12] The official national poverty headcount – derived from an energy-based cost of basic needs approach – was relatively low in 2017 (25 percent) but micronutrient deficiencies were more widespread, with over half of pregnant women and pre-school children being anemic, for example (MoHS, 2019; MoHS and ICF, 2017). In terms of food habits, 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

[11] EARs are estimates of the nutrient intake that satisfies the nutrient needs of half the healthy individuals in a population of specified gender age group and sex (IOM, 2006).
[12] The intent of this paper is to demonstrate an approach for poverty estimation that includes greater attention to nutrition and health standards. Given the age of the data and the extent of the ongoing political crisis, the results are not meant to challenge Myanmar's official poverty rates or be informative of current poverty conditions in Myanmar.

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 for the general population which describe six food groups (starchy staples; vegetables; fruits; dairy; meat, fish, eggs, and legumes; nuts and oils) plus sugary foods (MoHS, 2016). However, these guidelines are not quantified and therefore we incorporate quantified food group recommendation from neighboring Bangladesh (Nahar et al., 2013), which uses similar food groupings and has similar dietary patterns (Table 1). We use guidelines on sugary foods to represent discretionary food items. We also allow an adjustment where Myanmar households can substitute small fish or crustaceans for dairy products, since dairy is much less common in much of Myanmar, and small fish and crustaceans also contain high levels of calcium and other key nutrients.[13]

[13] 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).

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
Dairy and substitutes (e.g. small fish)[a]		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 (sugary 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. 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.
Source: Adapted from 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 (Hills and Mountains, Dry Zone, Coastal, Delta) and the more urbanized Yangon region. Households report quantities of 154 foods consumed from purchases, own production, and in-kind sources in the last 7 days.[14] [15] 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).[16]

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

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[14] 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 consumption-expenditure (MoPF and World Bank, 2017b). For simplicity, throughout the paper 'consumption-expenditure' is referred to as 'expenditure'.

[15] 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.

[16] We 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).

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.

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

5. Results

Entropy-based estimates of utility-consistent poverty lines

Table 3 shows the energy-based and healthy diet food poverty lines (in 2011 international dollars) before and after adjustments for ensuring utility consistency. A key finding is that, in most regions, the cost of the energy-based basket is about 45 percent lower than the healthy diet basket, reflecting the higher caloric cost of the non-staple foods that are recommended in the healthy diet but which are heavily under-consumed in actual diets of the poor.

A second finding of interest is that adjusted poverty lines can be lower or higher than unadjusted lines. 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, a relatively better-off region that has higher quality unadjusted food basket compared to the rest of the country; adjustments for utility consistency reduce Yangon's food poverty line by 18 percent for the energy-based diet standard and 6 percent for the healthy diet standard. Larger overall adjustments are made to the energy-based food basket because the latter are additionally constrained to meet recommended quantities within food groups. Moreover, 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). Within Yangon's healthy diet meat/fish/eggs food group, for example, the recommended food group quantity is maintained but consumption shares are shifted away from chicken, pork, beef, and certain varieties of fish towards cheaper preserved fish. In all other regions, the opposite kind adjustment occurs. Finally, it is also notable that there are larger spatial differences in non-food poverty lines, with Yangon having much higher non-food cost of living requirements than other more rural regions of Myanmar, as one would expect.

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	
	Unadjusted	Utility-consistent	Unadjusted	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

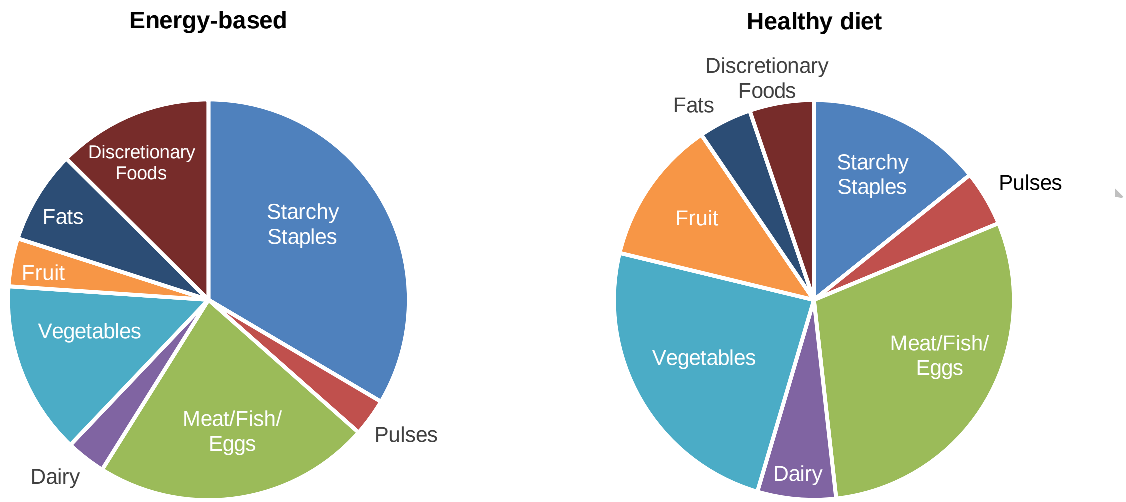
Source: MoPF and World Bank (2017a) and authors' calculations

Composition of food poverty lines

Food group costs in both the energy-based and healthy diet food baskets are based on the same observed consumption patterns, but the healthy diet basket reflects consumption patterns scaled to meet food group proportionality in the dietary guidelines. 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.

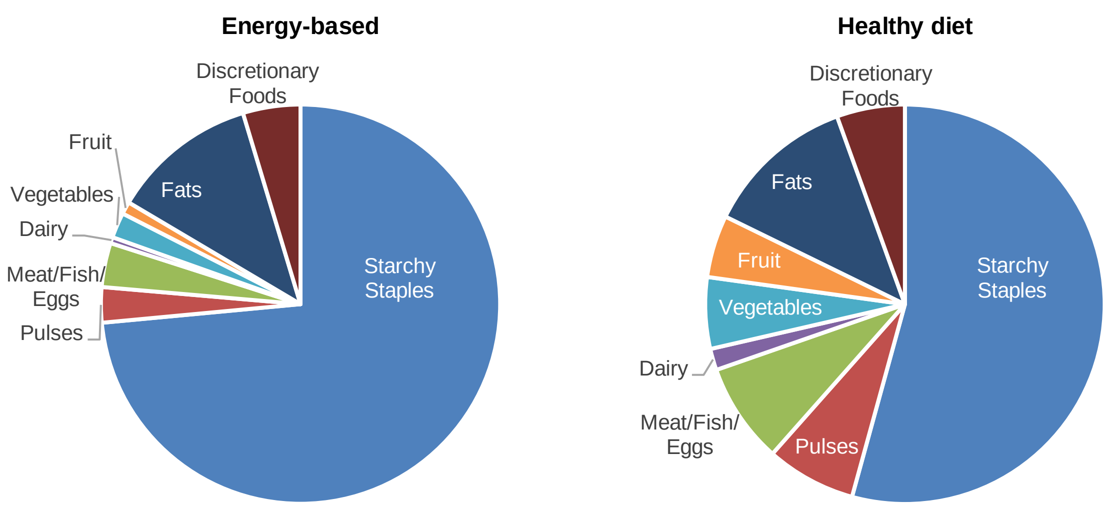
Figure 1 compares cost shares by food group for the energy-based and healthy diet, while Figure 2 makes the comparison in terms of energy shares. As expected, there are large differences in composition. The cost share of starchy staples in the energy-based basket (Figure 1) is more than double that of 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. Indeed, most dietary guidelines around the world recommend that only around half of all energy come from carbohydrates or carbohydrate-dense foods (Herforth et al. 2019).

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

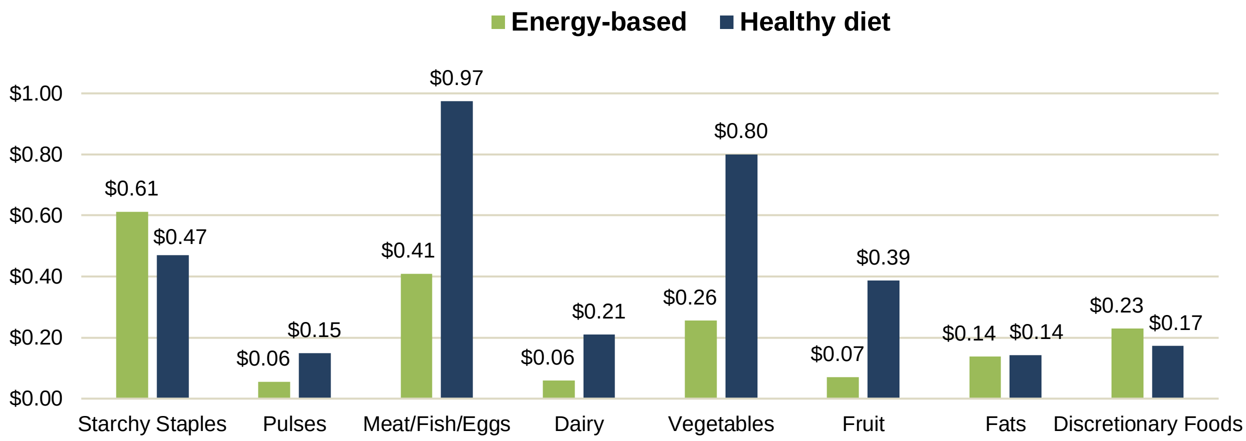
Figure 2. Energy shares of energy-based and healthy diet baskets, by food group



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 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 stark, with the average depth of poverty increasing from 5 to 14 percent at the national level.

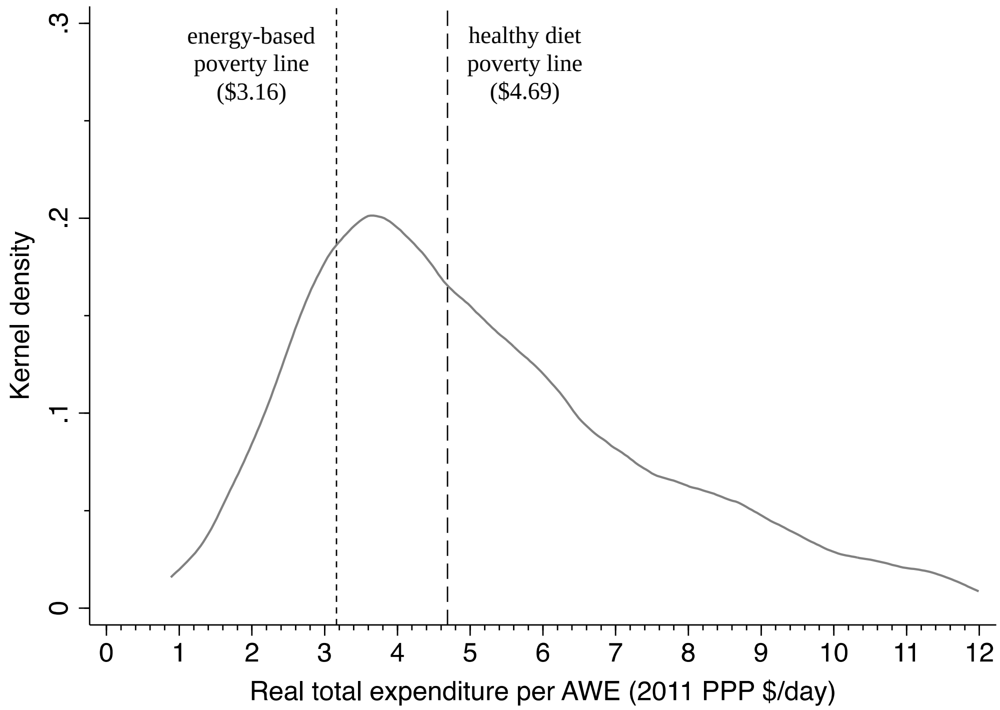
Table 4. Poverty and poverty gaps, by area and expenditure quintile[17]

		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

[17] The official 2015 poverty rate indicates that 32 of the population is poor (MoPF and World Bank (2017a). Much of this l2 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 two food baskets compared to the estimated average requirements of a 30-year old. Specifically, Table 5 tells us whether a hypothetical individual with household expenditure exactly equal to each of these poverty lines would experience nutrient deficiencies *if* they consumed the hypothetical food basket in their particular region; it does not measure actual food choices or actual deficiencies of poor or non-poor populations. Also note that both baskets contain sufficient energy from protein, fats, and carbohydrates (see Appendix Table A5 for information on acceptable proportions of macronutrients), although this is virtually guaranteed by both poverty lines having a common calorie target, and by the fact that we only measure protein quantity, not quality.[18]

Table 5 shows that the healthy diet food baskets meet or exceed the EARs of all key micronutrients, with the exceptions of riboflavin (82 percent). In contrast, the energy-based basket meets about half of the EARs for riboflavin, calcium, vitamin B12, and vitamin A, and 60-80 percent of the EARs for vitamin C, folate, and thiamin. 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. Perhaps most worryingly for populations still undergoing a demographic transition, such as Myanmar, is the size of deficiencies in micronutrients critical for healthy pregnancies and physical and cognitive development in early childhood (Riboflavin, Calcium, Thiamin, B12), as well as the strengthening immune systems (Vitamin A and C) (Bailey et al. 2015; Bhutta et al. 2013).

[18] 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.

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
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 (B2)	47%	82%
Niacin	105%	128%
Vitamin B6	95%	130%
Folate	71%	166%
Vitamin B12	525	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 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 for details). For micronutrients, light red shading indicates shortfalls in the 80-97 percent of EAR range, and red indicates below 80 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).

6. 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 should be regarded as basic needs.

Our first contribution is a conceptual critique of the continued use of an energy-standard alone in the cost of basic needs approach to poverty line estimation. Since relatively poor households are likely to consume poor quality diets, their consumption patterns should definitely not be held up as any kind of dietary standard, even for basic needs. The over-representation of starchy staples in the energy-based food poverty basket was readily apparent in Myanmar, but recent studies also show that populations in Africa

(Headey et al. 2023) and India (Sharma et al. 2020) have similarly poor quality diets.[19] Consequently, the energy-based food poverty line is tied to a nutritionally inadequate bundle of foods, which helps explain micronutrient inadequacies typically far exceed national poverty headcounts, or the $2.15/day headcounts used by the World Bank for low income countries.

A second contribution is methodological, incorporating richer nutritional standards that go beyond energy alone, but also beyond nutrient-adequacy approaches (Allen 2017; Bai et al. 2020) that do capture complete dietary needs, and which will often produces food baskets that depart from realistic consumption patterns. Our approach instead merges the estimation of least-cost healthy diets defined by balanced diets with proportionality in consumption of different foods (Herforth et al., 2020; FAO et al., 2020) with a cost of basic needs methodology rooted in the observed consumption patterns of poor and near poor households (Ravallion, 1994, 1998), by extending 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, our approach is no more computationally complex than the traditional energy-based cost of basic needs approach.

A third contribution of this paper is that the food poverty lines constructed in this approach meet national food-based dietary guidelines, which are potentially important national policy tools. Our approach provides poverty indicators – and hence poverty reduction targets – more consistent with existing nutrition strategies as well as cultural norms around diets. While a methodology that invariably results in

[19] 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.

a higher poverty rate is potentially politically contentious, aligning the methodology with 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). Can a country claim to have eliminated poverty when malnutrition is still widespread, at least in part because "non-poor" households cannot afford a healthy diet? Indeed, from a policy strategy point of view it would seem risky for a country to assume that malnutrition persists for non-economic reasons, when in reality affordability of a healthy diet is a major cause of malnutrition.

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).[20] 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

[20] In Myanmar in 2017, for example, just 13.8 percent of the population received any form of social protection (World Bank, 2022a), in contrast to the 48 percent poverty rate calculated under the utility-consistent healthy diet poverty line developed in this paper.

or behavioral interventions to nudge preferences towards foods that are both healthier and cheaper (Headey et al. 2023). Third, higher poverty rates imply that the poorest countries will require higher and more sustained economic growth rates to eradicate poverty.

This approach is not without challenges, and there is scope for extensions and refinements. The imposed reallocation of food consumption between food groups in accordance with dietary guidelines introduces a hypothetical scenario that 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 to explore how households at the healthy diet poverty line might adjust their consumption choices in this way. Allen (2017) also raises interesting questions regarding the context-specific nature of non-food basic needs, which can be highly context-specific (e.g. heating requirements in cold climates). Certainly, there is a case for improving the conceptualization and estimation of total poverty, not just food poverty.

In summary, this study presents a new method for defining utility-consistent regional poverty lines that meet the food group consumption recommendations encompassed in dietary guidelines. With increasing recognition from policymakers that energy-based diets are not sufficient for a healthy and productive population (FAO et al. 2021), 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.

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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, healthy diet, and least-cost health 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)			
		Energy-based	**Least-cost healthy diet**	**Preference-weighted healthy diet**	**Median household daily food expenditure (2011 $PPP per AWE)**
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 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		Estimated average requirement 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).