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**Food Budget Allocation Efficiency: A Missing Component to Help
Identify Robust Nutrition Policies, with Application to Rwanda**

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ABSTRACT

This paper presents two interrelated innovations to help identify diet-related nutrition policies. The first involves the development of a food budget allocation efficiency measure to quantify suboptimal food preferences, which is one key explanation of poor diets in addition to unaffordability. The second relates to the application of stochastic dominance to a portfolio of diet-related nutrition policies, defined by various levels of allocation efficiency and affordability. As no full specification is needed, the latter technique is particularly useful when lacking normative guidelines regarding the relative importance of nutrient deficiencies within one-dimensional diet quality measures as well as the exact content of culture-sensitive diets. The analytical innovations are illustrated using a 2013/14 household consumption survey of Rwanda, a country characterized by both high calorie and micronutrient deficiencies. The origins of these poor nutritional outcomes can be traced back to various combinations and levels of affordability and allocation efficiency constraints. By only excluding the most inequality averse diet quality specification, which may help to account for measurement error, a robust set of policy recommendations can be formulated for two thirds of all observations, most of which should focus on awareness raising activities.

Keywords: allocation efficiency, diet quality, affordability, stochastic dominance, Rwanda

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1. INTRODUCTION

In recent years, several indicators have been developed to estimate the minimal cost of nutritious diets (Cost of Nutritious Diets Consortium, 2018). These indicators generally make use of detailed food price data combined with diet requirements, the latter expressed either in food quantities or nutrient intake levels. To estimate the minimal resources needed to access nutritious diets, different methods can be used, ranging from selecting and costing the cheapest food item per calorie to reach the required amount within each food group (Hirvonen et al., 2020), to more complex linear programming procedures that estimate the precise quantities needed of each food item to exactly meet all nutrient requirements at the lowest cost (van Dooren, 2018).

Following the development of these new indicators and methods, and probably triggered by the recent publication of the EAT-*Lancet* healthy reference diet (Willett et al., 2019), many studies have started to examine the affordability of nutritious diets across time, place and population subgroups (Bai et al., 2021; Goulding et al., 2020; Herforth et al., 2020; Hirvonen et al., 2020; Masters et al., 2018; Pauw et al., 2021; Raghunathan et al., 2021; Rao et al., 2018). This focus on affordability has an important policy dimension: if people cannot afford a nutritious diet, then there is no use in promoting it – unless complementary measures are taken to support people’s incomes or lower prices of nutritious food.

However, these affordability studies are often limited to measuring economic access to nutritious diets, not what people actually decide to purchase and consume, a decision which is also driven by nutrition knowledge, convenience and taste (Irz et al., 2016). This implies that any policy aimed at increasing the affordability of nutritious diets might not prompt the intended outcomes, unless due attention is paid to people’s food budget allocation. In a similar vein, eating an unhealthy diet may not necessarily result from a lack of financial resources, it can also result from a lack of knowledge on what constitutes a healthy diet, or that one simply prefers to eat convenient, more tasty, yet unhealthy foods (Young, 2021).

To improve policy design, it is therefore key to identify the origins of a non-nutritious diet by neatly distinguishing affordability constraints and suboptimal food preferences. Compared to the straightforward comparison of budget and minimal diet cost in assessing affordability, there does not seem to exist a measure that evaluates food budget allocation efficiency: that is the efficiency by which people allocate their resources over different food items to yield a nutritious diet while accounting for differences in affordability level. Although aligned, it is important to underscore that such measure of allocation efficiency does not fully coincide with measures of diet quality, with the latter being driven by *both* food preferences and food purchasing power.

The objective of this paper is double. First, it proposes a conceptual measure of food budget allocation efficiency by combining information on two dimensions: diet quality and affordability. Second, because normative views and operational choices may differ, the paper applies a stochastic dominance approach to these composing dimensions for the empirical case of Rwanda. To achieve these objectives, the paper is structured as follows. After discussing key issues of one-dimensional diet quality indicators, Section 2 formally presents the food budget allocation efficiency measure. The same methodological section also introduces the household consumption and expenditure survey (HCES) as well as the linear programming parameters used to define least-cost diets and corresponding affordability levels. Section 3 presents the findings of the presented tools applied to Rwanda, a country characterized by persistently high child stunting rates (Weatherspoon et al., 2019). This results section subsequently focuses on diet quality outcomes, affordability gaps and dominance in diet-related nutrition policies. Section 4 concludes and discusses policy implications.

2. METHODS AND DATA

Diet quality indicators

Diet quality, defined as micronutrient adequacy (Leroy et al., 2015), can be measured by a wide range of different approaches. At the individual level, the gold standard among nutritionists has evolved from observed-weighed food records (OWFR) to 24-hour recall surveys, which corresponds to a change from weighing to querying the exact metric quantities of food intake (Fiedler et al., 2013). These food quantities are then converted into their corresponding nutrient equivalents, using food composition data, summed up and compared with the recommended nutrient intake levels per population subgroup as defined by joint FAO/WHO/UNU expert panels.¹ Although other distributional measures could be used, this assessment typically relies on the computation of nutrient adequacy rates (NARs), that is the share of recommended nutrient intake which is covered by current food consumption, with all shares being capped at 100% (Hatløy et al., 1998).

Given the high costs and often non-representative character of these approaches, individual-based diet diversity scores have been developed and often used in practice to proxy diet quality, such as the women's and individual dietary diversity score (WDDS and IDDS) and the infant and young child dietary diversity score (IYCN) (Fiedler et al., 2013; Leroy et al., 2015). The latter scores involve a simple count of the number of food groups consumed over the past 24 hours, while completely ignoring both exact food items within food groups and exact food quantities consumed. As a result, dietary diversity scores (DDS) are best validated against a more comprehensive diet quality benchmark before being used to inform policy.

This paper measures diet quality using HCES data, in which food purchases and consumption are captured in detailed modules covering prices, quantities and/or monetary equivalents of individual food items (Fiedler et al., 2013; Weisell & Dop, 2012). These HCES are often designed to be representative at sub-national level, conducted at regular intervals of 3-5 years and more cost-effective than the adjusted gold standard of 24-hour quantitative recall (Fiedler et al., 2013; Jones et al., 2013). In addition, compared to count-based dietary diversity scores, HCES data allow for the construction of more comprehensive indicators of diet quality. This observation stems from (i) the typically longer and thus more representative reference period, either through recall or by using diaries²; (ii) the recording of exact food quantities, either directly or by using metric conversion rates to non-metric local measurement units or by applying price data to convert food outlays; and (iii) the focus on individual food items, which can be linked to food composition data to derive the exact nutrient intake.

Despite additional conversion steps possibly needed while being less tailored to food consumption, HCES data are roughly similar to the data collected under the adjusted gold standard, however they fundamentally differ regarding the unit of analysis, that is household versus individual. To proxy diet quality at the individual level, this analysis applies nutrient-specific adult male equivalence (AME) scales, whereby diet requirements of population subgroups are expressed as a fraction of the corresponding AME requirements. Ideally, AME scales account not only for

¹ Despite being the most accurate, the OWFR method remains an approximate approach as well, in that recommended intake levels are set to cover the nutrient needs of only 97.5% of the population. In addition, the food items consumed are sometimes difficult to match with food composition records, given huge observed diversity in crop variety, color, maturation stage or breed.

² Whereas the use of diaries can be seen as a sequence of multiple 24-hour recalls, HCES data are also increasingly trying to capture seasonal effects by visiting the same households and applying the 7-day food diaries at various times throughout the agricultural year.

differences in nutrient needs across sex and age groups, but also in terms of pregnancy status, labor profile and other relevant contextual factors. The HCES data of Rwanda however only allow to account for differences between sex and age groups. The implicit assumption behind AME is that every household member gets an equal share of what it needs, implying that a nutrient deficiency rate of 25% estimated at the household level translates into the same deficiency rate at the individual level. Although this assumption of fair intra-household allocations can be largely dismissed (Coates et al., 2018; Fadare et al., 2018; Haddad et al., 1997; Harris-Fry et al., 2017), this issue rather falls under the utilization pillar of food security, whereas this paper is mainly concerned with the access dimension (Jones et al., 2013).

For monitoring and policy purposes, diet quality indicators are often aggregated in one-dimensional measures or indices. By default, such aggregation procedure always involves a loss of information, which stems from the *selection* of components, their corresponding *cut-offs* and their associated *weight* (Alkire & Santos, 2014). Conveniently, the nutrition science offers a set of prescriptive yardsticks, both in terms of food groups or nutrients (selection) and their minimal recommended intake levels or acceptable ranges (cut-offs). In contrast, there are no real normative guidelines on the relative importance of each component (weight). This should not surprise as it would basically imply that trade-offs between various diet-related health risks are known and could be quantified in a universal way, or in other words, that impaired cognitive development as a result of iron deficiency is, for instance, twice as severe as osteoporosis resulting from calcium deficiency.

Lacking guidance and perhaps out of operational convenience, it seems that most indexation procedures simply assign an equal weight to all components. This not only applies to most DDS³ within the food dimension, the same holds true within the nutrient space, where adequacy rates (truncated at 100%) are typically averaged across all nutrients of interest to yield the Mean Adequacy Ratio (MAR) (Hatløy et al., 1998). The latter indicator has become a popular one-dimensional measure of diet quality on its own, while being often used to validate DDS or other proxy indicators (Acham et al., 2012; Becquey et al., 2010; Marivoet et al., 2019; Rathnayake et al., 2012; Steyn et al., 2006).

Despite its frequent use and easy computation, it is important to underline that MAR is not a normative-neutral diet quality measure. As a matter of fact, MAR by construction implies that deficiency rates of 10% for iron and calcium should be valued the same way, and so are the associated health risks. It also means that an increase in iron deficiency with 5% points could be compensated with a similar reduction in calcium deficiency. In addition, taking the average as an aggregation rule is not the most or only pragmatic approach either. To oppose MAR as the dominant diet quality measure within the nutrient space, one could also consider the Lowest Adequacy Ratio (LAR) as the diet quality reference. LAR simply considers the weakest link of all food components under investigation as another possible indication of a person's diet quality.

Drawing from the literature on social welfare, the distinction between MAR and LAR broadly corresponds to applying either a utilitarian or maximin criterion when assessing different types of nutrient deficiency within households (Harsanyi, 1955; Rawls, 1971). Whereas the first criterion aims to maximize average nutrient adequacy while being neutral to differences in adequacy rates among nutrients, the second pursues the maximization of the lowest nutrient adequacy rate while being neutral regarding the rates observed for other nutrients. Lacking agreement on the exact mix of efficiency (cf. MAR) and equity (cf. LAR) concerns in defining diet quality status, this paper

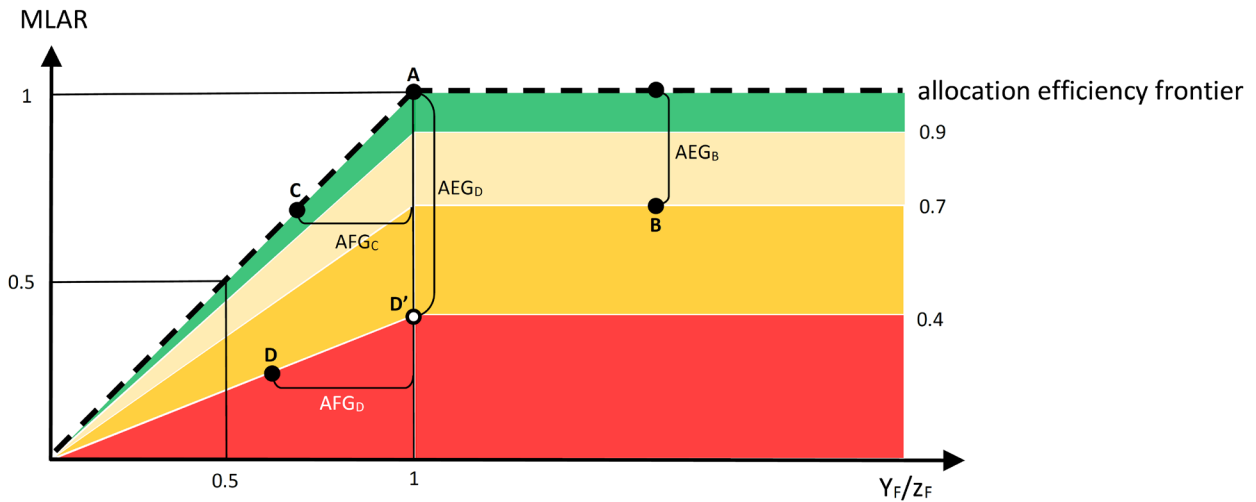
³ One exception in this respect is the food consumption score, developed by WFP (2008), which assigns weights according to each food group's nutrient density profile.

roughly follows the standard approach in welfare economics by checking for empirical dominance; in this case by comparing policy categorizations across the full range bounded by both opposite distributive rules (Foster & Shorrocks, 1988).

Food budget allocation efficiency

To introduce the new measure of food budget allocation efficiency (hereafter abbreviated to “allocation efficiency”), consider Figure 1 which maps diet quality on the Y-axis against affordability on the X-axis. While diet quality can be approximated by MAR, LAR or any intermediate specification as discussed above (which is generally indicated by MLAR), affordability is specified by the ratio of the food budget (Y_F) over the minimal cost of a nutritious diet (Z_F). As such, a ratio equal to one corresponds to a food budget which is just enough to reach a nutritious diet, while ratios above (below) one point to higher levels of (un)affordability.

Figure 1. Affordability, diet quality and allocation efficiency



Notes: In generic terms, MLAR stands for either the Mean Adequacy Rate, the Lowest Adequacy Rate, or any possible intermediate specification; Y_F is the household food budget; Z_F is the minimal cost of a nutritious diet; and AFG and AEG respectively refer to affordability and allocation efficiency gap.

Source: Author.

Given that individual NARs are capped at 100%, both MAR (the average) and LAR (the lowest) are also confined between zero and one. For food budgets below the minimal cost of a nutritious diet, however, MAR and LAR are further constrained by their corresponding affordability levels. Indeed, with a food budget equal to a fraction of the minimal cost of a nutritious diet, one can only access the same fraction of all constituent food items composing the optimal diet as well as their corresponding individual nutrients. As a result, the highest allocation efficiency is captured by the dashed line in Figure 1, where it equals the affordability level for $Y_F < Z_F$, and one for $Y_F \geq Z_F$. The full allocation efficiency space is then defined proportional to this allocation frontier as shown by the green-to-red color scheme.

In mathematical terms, to account for the discrete junction at $Y_F = Z_F$, Equation (1) defines allocation efficiency (AE) over two non-overlapping affordability intervals as

$$(1a) \quad AE = MLAR \cdot \left(\frac{Y_F}{Z_F}\right)^{-1} \quad \text{if } Y_F < Z_F$$

$$(1b) \quad AE = MLAR \quad \text{if } Y_F \geq z_F$$

with MLAR being any possible diet quality specification that combines efficiency and equity considerations when aggregating underlying NARs. With NARs truncated at 100%, all MLAR specifications as well as the resulting AE levels will range between [0-1].

Combining information on affordability and allocation efficiency is useful to guide the design of diet-related nutrition policies. A key reference point is household A in Figure 1, which manages to avoid nutrient deficiency by perfectly allocating the minimal resources needed to reach a nutritious diet. As reflected in their diet quality level, but less restricted by available resources, the same applies to households located on the dashed line to the right of household A: they can both afford ($Y_F/z_F > 1$) and choose to consume a nutritious diet (MLAR=1). This context does not require much policy attention.

In contrast, households B, C and D not only perform worse than household A in terms of diet quality (MLAR<1), but each of them also requires a different set of policies. Household B for example has more than enough financial resources to meet the household's nutrient needs, yet deficiencies occur. To overcome this allocation efficiency gap (AEG_B), policies should aim at changing food choice behavior and increasing nutrition awareness, or, if that is not feasible, introducing supplementation or food (bio)fortification schemes based on currently preferred food items.

Despite nutritional efficient food choices (AE=1), household C simply lacks the required financial resources to obtain a nutritious diet (MLAR<1). This situation requires policies aimed at closing the household's affordability gap (AFG_C), either through social protection measures to strengthen people's incomes, or through policies that lower food prices. In fact, under constant food preferences, household C will reach the same diet quality status as household A if provided with additional resources to close its affordability gap, either in cash or in kind.

The situation of household D is a combination of challenges faced by the previous two households, that is non-nutritious food choices combined with insufficient financial resources. A combination of corresponding policies is thus required to overcome the household's allocation efficiency gap (AEG_D) and affordability gap (AFG_D). In this scenario, any cash transfer *should* be accompanied by raising the household's awareness, such that the diet quality of household D further improves from D' to A. If the impact of an awareness campaign is too uncertain, policies could focus on distributing food vouchers to help household D reach a nutritious diet.

It is important to underscore the crucial difference between measures of diet quality and allocation efficiency, whereby the latter is based on the former but additionally accounts for differences in unaffordability levels. This is most prominently illustrated by households B and C, which share the same level of diet quality (MLAR=0.7), yet the underlying factors are entirely opposite: inefficient allocation of a sufficient budget for B versus efficient allocation of an insufficient budget for C. The double information requirement to obtain the proposed measure of allocation efficiency (that is diet quality and affordability) perhaps explains why such measure has not yet emerged.

Rwanda case study and linear programming parameters

The proposed innovations of this paper are illustrated using the Rwanda Integrated Household Living Conditions Survey (EICV4) conducted in 2013/14 with 14,419 households (NISR, 2016). In total, this survey contains more than 2 million food consumption records covering about 120 different food items obtained by households from purchases and own production. For purchases,

consumption quantities are estimated by imputing regional food prices on total food outlays. These quantities combined with the food from own production are then converted into corresponding levels of energy and nutrient intake using food composition data compiled for nine African countries (Stadlmayr et al., 2012).⁴

Nutrient adequacy rates are obtained by dividing actual by recommended intake levels for each food component based on the age/sex structure of each household combined with nutrient guidelines from various FAO/WHO/UNU Joint Expert Panels (FAO, 2001; WHO/FAO, 2004), while truncating all values above 100%. In operational terms and relying on the assumption of perfect equity in intra-household allocations, both the actual and recommended intake levels are expressed using AME scales that are specific to each food component.

The selected AME reference is a 30-year-old male person with a physical activity level equal to 1.75 and a body mass of 60 kg. For food energy, the corresponding estimated average requirement (EAR) amounts to 2,750 kilocalories, which is the intake level at which the needs of 50% of the population are met (FAO, 2001). For the micronutrients considered in this analysis (i.e., calcium, iron, zinc, folate, vitamin B12, vitamin A), recommended dietary allowances (RDA) are obtained from WHO/FAO (2004), which provide the intake levels at which the needs of 97.5% of the population are met. The exact RDA values together with the calorie requirement are summarized in Table 1.

To estimate allocation efficiency, information on diet quality and affordability needs to be integrated. Following the discussion above, diet quality is approached in two distinct ways. The first, MAR, takes the arithmetic mean of energy and six micronutrient adequacies, while the second, LAR, takes the lowest value of all same adequacies. To set the affordability cut-off, standard linear programming techniques are used to estimate the minimal cost of a nutritious diet in each of six price zones of Rwanda. The input data used for this linear optimization procedure involve standardized regional food prices as captured by EICV4 (2013/14), food composition data (Stadlmayr et al., 2012), and two scenarios with increasingly restrictive diet requirements (see Table 1).

⁴ More detail on the exact calculations regarding regional food prices and food composition data used for each item can be requested from the author.

Table 1. Two diet scenarios with corresponding constraint types, characteristics and thresholds

Diet	Constraint type	Characteristics	Thresholds per day, AME (30 years, 60 kg, PAL 1.75)						
Diet 1	Energy	- Food energy adequacy (EAR)	2,750 kcal						
	Micronutrients	- Micronutrient adequacy (RDA)		Ca (mg.)	Fe (mg.)	Zn (mg.)	Folate (mcg.)	B12 (mcg.)	A (mcg.)
		- Micronutrient upper limits (UL)	RDA	1,000	27.4	14	400	2.4	600
			UL	2,500	45.0	40	1,000	-	3,000
Macronutrients	- Macronutrient balance - Total portion limit - Sugar limit	15-30% (fat); 55-75% (carbohydrate); 10-15% (protein) <3,000 gram <10% (sugar)							
Diet 2	Energy/micro/macronutrients Acceptability	- Diet 1 characteristics - Cultural acceptability	above thresholds >= 75% of average budget share spent on each of the 10 most important locally produced food items by all households within 25-75% of the food consumption distribution per AME						

Notes: For dietary iron and zinc, bioavailability levels are assumed at 5% and 15% respectively. Due to lacking data on sugar as part of the carbohydrate content in all food items, calculations on maximum sugar intake are based only on energy obtained from the food item “sugar”, resulting in a less binding sugar constraint overall. EAR stands for estimated average requirement; RDA for recommended dietary allowance; UL for upper limit; PAL for physical activity level; and AME for adult male equivalent.

Source: Author based on FAO (2001), Omiat & Shively (2017), and WHO/FAO (2003, 2004).

The first set of diet constraints (Diet 1) recycles the minimal energy and nutrient requirements used to derive the above adequacy rates, but adds tolerable upper limits (UL) for all micronutrients as well as three macronutrient constraints. The latter involve macronutrient balance among the main food energy sources (typically set as 15-30% from fat, 55-75% from carbohydrate and 10-15% from protein), a restriction on sugar consumption to a maximum of 10% of all calorie intake, and the total daily portion limit of 3 kg (FAO, 2001; Omiat & Shively, 2017; WHO/FAO, 2003, 2004). The second set of diet requirements (Diet 2) is based on the same constraints as Diet 1 but also introduces a component of cultural acceptability. In the absence of clear guidelines, Diet 2 requires the inclusion of the ten most important food items consumed by the middle 50% of the population in each price zone, expressed in total food consumption per AME. For each of those items, the minimal required quantity for a diet to be culture-sensitive is arbitrarily set at 75% of the average corresponding budget share observed. The latter constraint assures that diets, although nutritious in all clinical aspects, are not completely unfamiliar to the culinary habits of the Rwandan population.

3. RESULTS

Diet quality of Rwandan households

Table 2 presents basic descriptive statistics of adequacy rates for energy, the six micronutrients, and the two diet quality measures, MAR and LAR, discussed above. On average, only 60% of the population's total food energy needs are covered by current food consumption. This observation neatly matches the data on the bottom 40% of the population, which is used to define the minimal food basket and corresponding food poverty line. The lowest two quintiles have an average intake of around 1,300 kcal per AME/day while their daily food portion amounts to 1 kilogram, consisting of mainly low-calorie food items, such as roots and tubers (NISR, 2015).

Table 2. Adequacy in energy, micronutrients and diet quality, Rwanda (2013/14)

Food component adequacy	Mean	Std. dev.	Min	Max
Energy - Kilocalories	0.595	0.241	0.182	1.000
Micronutrients				
- Calcium	0.476	0.234	0.008	1.000
- Iron	0.477	0.221	0.010	1.000
- Zinc	0.504	0.240	0.031	1.000
- Folate	0.923	0.179	0.000	1.000
- Vitamin B12	0.099	0.232	0.000	1.000
- Vitamin A	0.568	0.305	0.000	1.000
Diet quality				
- MAR	0.520	0.179	0.065	1.000
- LAR	0.072	0.165	0.000	1.000

Note: Following data cleaning, sample size is reduced to 11,470 households. The most important reduction involves the removal of observations with improbable calorie intake levels, that is outside the bracket of 500-5,000 kcal per day/AME (Lovon & Mathiassen, 2014). Population sampling weights are adjusted to reflect the initial demographical distribution and total population size of 11,266,678 inhabitants. MAR and LAR respectively stand for Mean and Lowest Adequacy Rate.

Source: Author with data from EICV4 (2013/14).

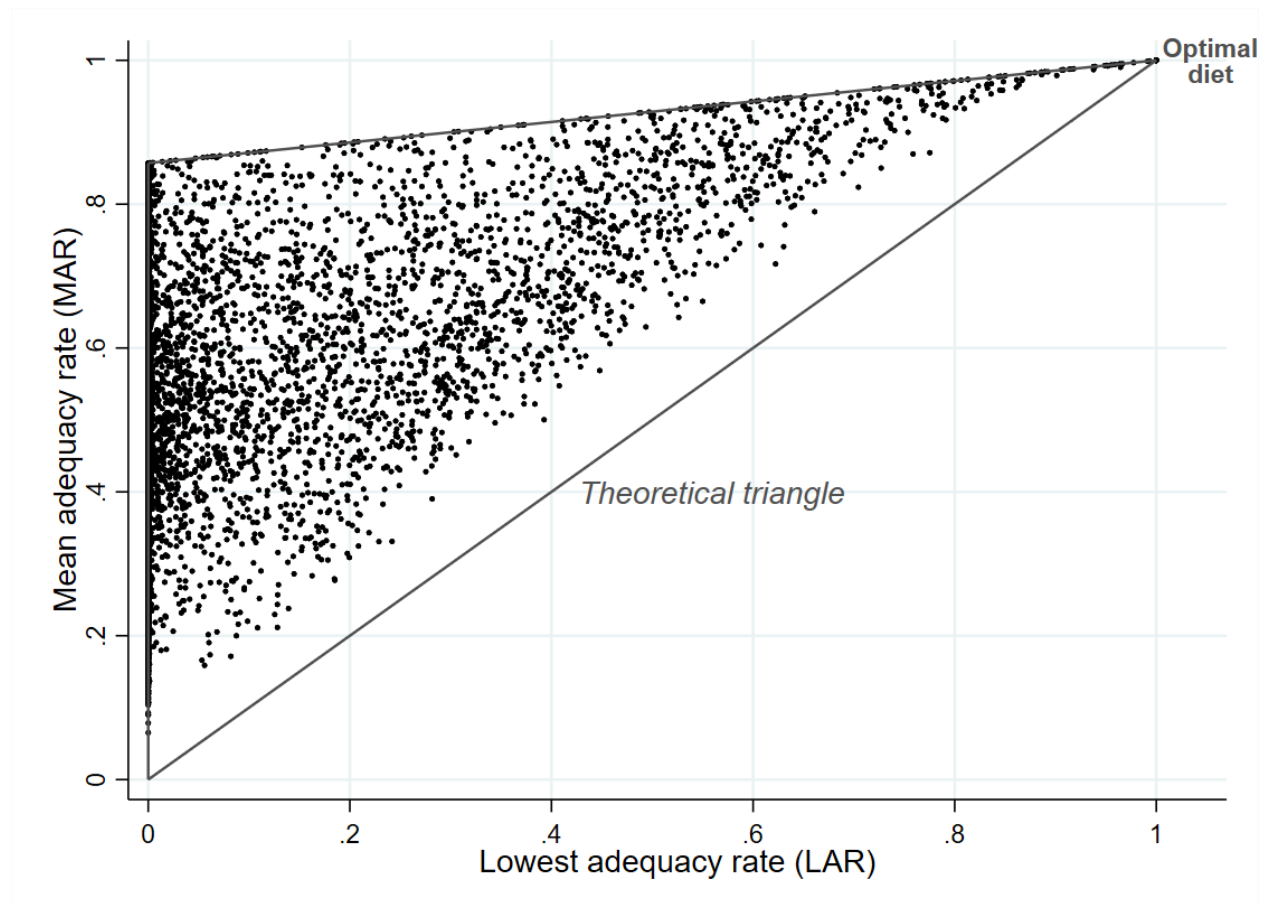
Except for folate (92%), micronutrient intake is far from sufficient, which further exacerbates the problem of calorie deficiency with a component of “hidden hunger” (FAO/WFP/IFAD, 2012). While the adequacy rate of vitamin A is still close to that of energy (57%), it is distinctly lower for calcium, iron and zinc (48-50%), and much lower for vitamin B12 (10%) – the latter which can only be sourced from animal-based food items. These observations of nutrient deficiency align with data from the country's Demographic and Health Survey conducted in 2014/15. Around 70% of breastfeeding children aged between 6-23 months eat foods rich in vitamin A; 37% of children between 6-59 months are suffering from anemia (often caused by iron deficiency); and only 17% of breastfeeding children aged between 6-23 months consume meat or fish (NISR/MOH/ICF, 2015). Although there is no strict way to compare both, the order in nutrient adequacies and food group consumption frequencies is generally respected for vitamin A, iron and vitamin B12.

When combining all seven adequacy rates in one diet quality measure, MAR indicates that, on average, around half of all energy and micronutrient needs (52%) are covered by current food consumption, while this coverage rate shrinks to 7% if we opt to use LAR as the indicator to approach diet quality. Whereas LAR is mainly driven by low intakes of vitamin B12, MAR appears to result from a general leveling of high folate and low vitamin B12 intakes, with other adequacy rates being close to the outcome of 52%. These empirical observations illustrate the limits of both aggregation rules. MAR is more sensitive to the number of selected nutrients than LAR: discarding folate or adding other non-critical nutrients with low deficiency rates will significantly affect the level of MAR, while such methodological change has less impact on LAR (at least as long as vitamin B12 is considered a key nutrient in assessing diet quality). Conversely, given the exceptionally low intake level observed for one nutrient (vitamin B12), LAR almost completely ignores information from energy and all other nutrient intakes, which renders this diet quality indicator much less comprehensive compared to MAR.

Figure 2 plots the values of MAR and LAR for all households in the sample. Given the number of food components considered in this analysis, the triangle with theoretically feasible options is bounded by the coordinates (0, 0), (1, 1) and (0, 6/7). By default, the variation of possible MAR levels decreases with increasing values of LAR, which is evident since the lowest adequacy rate is gradually squeezing all other possible rates into a shorter interval. Eventually, both LAR and MAR will equal one, which represents the point of optimal diet quality, and it is at this point that all energy and micronutrient needs are fully covered.

Manifested in the dispersion of observations within the theoretical triangle, there is a huge variation in energy and micronutrient intakes among Rwandan households. However, there is a higher density of dots at lower levels of LAR and a lower density close to the triangle's side where LAR equals MAR, which can both be explained by the distinctively low adequacy rates observed for vitamin B12. Given the triangle shape of actual observations, Pearson's correlation coefficients between both diet quality indicators increase from 0.151 for the first segment of 25% of LAR to 0.488, 0.496 and 0.816 for the second, third and fourth segments, respectively. These coefficients also show that the right aggregation rule (mean or lowest) is not an empirically trivial question, especially if one is most concerned about poor diets.

Figure 2. Mean and lowest adequacy rates, Rwanda (2013/14)



Note: The theoretical triangle is naturally bounded by the coordinates (0, 0) and (1, 1) while the upper-left corner is defined by the number of food components considered. In this case, the maximum value of MAR, when LAR equals zero, is 6/7. This maximum is reached when all other NARs are equal to 1.

Source: Author with data from EICV4 (2013/14).

Optimal diet compositions, minimal costs and affordability gaps

To help demarcate the drivers behind suboptimal diet quality in Rwanda, Table 3 presents the cost and composition of optimal diets for each price zone under two sets of minimal diet requirements, a clinical one (Diet 1) and a culture-sensitive one (Diet 2), as discussed in the methodological section.

Table 3. Composition and cost of two diet scenarios per price zone, Rwanda (2013/14)

	Kigali		Other Urban		Rural Southern		Rural Western		Rural Northern		Rural Eastern		
	<i>Item</i>	<i>gram</i>	<i>Item</i>	<i>gram</i>	<i>Item</i>	<i>gram</i>	<i>Item</i>	<i>gram</i>	<i>Item</i>	<i>gram</i>	<i>Item</i>	<i>gram</i>	
Diet 1	Dry maize (grain)	672	Dry maize (grain)	663	Dry maize (grain)	668	Dry maize (grain)	665	Dry maize (grain)	672	Dry maize (grain)	670	
	Fresh milk	400	Fresh milk	400	Fresh milk	400	Fresh milk	400	Fresh milk	400	Fresh milk	400	
	Amaranth	132	Amaranth	96	Amaranth	133	Cassava leaves	68	Amaranth	132	Amaranth	102	
	Dry beans	13	Soya (dry)	30	Soya (dry)	23	Amaranth	60	Dry beans	17	Dry beans	15	
	Soya Flour	9	Carrots	13			Soya (dry)	16	Avocado	10	Soya (dry)	11	
							Dry beans	3	Soya Flour	4	Carrots	11	
	Cost in RwF	290	Cost in RwF	247	Cost in RwF	270	Cost in RwF	227	Cost in RwF	204	Cost in RwF	243	
Diet 2	Dry maize (grain)	602	Dry maize (grain)	515	Dry maize (grain)	518	Dry maize (grain)	451	Dry maize (grain)	454	Dry maize (grain)	422	
	Fresh milk	400	Fresh milk	400	Fresh milk	397	Fresh milk	400	Fresh milk	400	Fresh milk	400	
	Amaranth	131	Irish Potato	90	Sweet potato	163	Sweet potato	265	Sweet potato	294	Cooking banana	183	
	Irish Potato	69	Cooking banana	77	Amaranth	103	Irish Potato	101	Irish Potato	136	Sweet potato	96	
	Cooking banana	31	Sweet potato	72	Cassava (root)	52	Cooking banana	46	Amaranth	73	Cassava (root)	65	
	Dry beans	21	Amaranth	56	Avocado	37	Dry beans	40	Dry beans	47	Irish Potato	61	
	Cassava (flour)	20	Dry beans	48	Dry beans	36	Cassava (root)	40	Cooking banana	39	Dry beans	59	
	Soya Flour	18	Avocado	36	Irish Potato	33	Avocado	39	Soya Flour	30	Amaranth	43	
	Sweet potato	16	Cassava (root)	23	Cassava (flour)	26	Maize (fresh)	36	Avocado	30	Soya (dry)	38	
	Cassava (root)	8	Cassava (flour)	22	Soya (dry)	21	Soya (dry)	33	Cassava (root)	24	Avocado	37	
	Avocado	7	Fresh bean	20	Cooking banana	20	Fresh bean	28	Maize (fresh)	21	Maize (fresh)	33	
	Maize (fresh)	3	Soya (dry)	19	Tarot/amateke	15	Cassava (flour)	22	Fresh bean	20	Cassava (flour)	30	
	Fresh bean	3	Carrots	19	Fresh bean	12	Tarot/amateke	18	Corn (flour)	11	Fresh bean	27	
			Corn (flour)	13	Maize (fresh)	8	Amaranth	36	Cassava (flour)	8	Carrots	24	
					Curdled Milk	5	Cassava leaves	15			Corn (flour)	16	
							Carrots	10					
		Cost in RwF	316	Cost in RwF	287	Cost in RwF	292	Cost in RwF	271	Cost in RwF	261	Cost in RwF	302

Note: RwF stands for Rwandan Francs. The exchange rate at the time of the survey was approximately 677 RwF per USD.

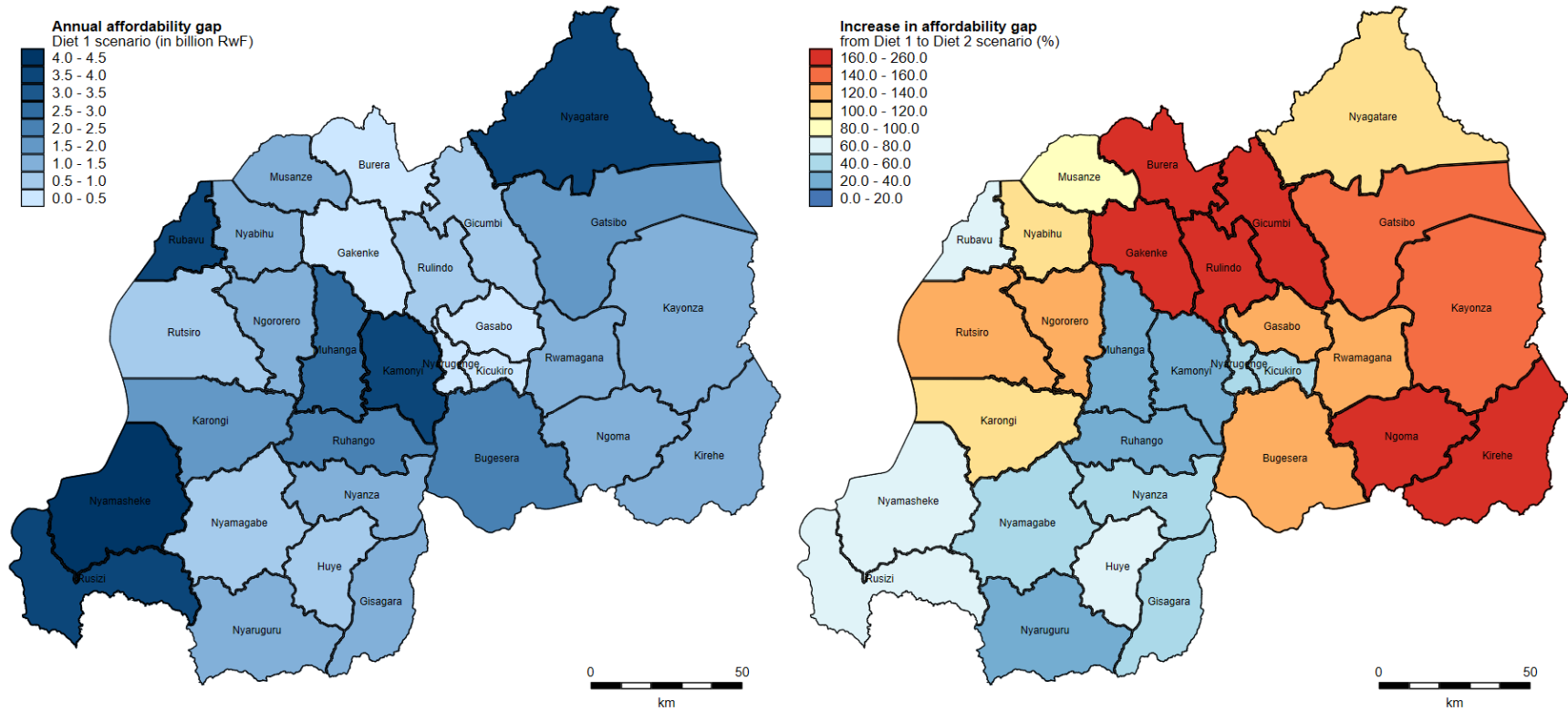
Source: Author with data from EICV4 (2013/14).

In addition to minimal calorie intake, Diet 1 imposes lower and upper limits for six micronutrients as well as three macronutrient conditions. To meet all these requirements with the least resources, a daily food budget ranging from 204 RwF to 290 RwF is sufficient for every AME to access a diet consisting of 4-6 food items with a total portion size of roughly 1.2 kg. While exact items and corresponding quantities are determined by prevailing prices, the intake of dry grain maize (around 670 grams per day/AME) provides for cheap calories in all six price zones while it is also a main source of iron, zinc and to a lesser extent folate. Fresh milk is solely responsible for critical intakes of vitamin B12, the daily consumption of which should amount to 400 grams. In addition, milk accounts for roughly half of all calcium intake while the other half is provided by amaranth or cassava leaves (if intake amounts to roughly 120 grams) – these dark green leafy vegetables being also major sources of vitamin A. Depending on the price zone, these core diets are further complemented with minor quantities of dry beans, soya, carrots and avocado. The LP results also reveal that calories, folate, vitamin A and vitamin B12 are the most constraining requirements in each price zone, while the iron content within each optimal diet slightly exceeds its corresponding threshold.

Accounting for food preferences following the method described above, optimal diets become much more diversified and more expensive. Increases in the minimal cost of such nutritious diets range between 8% in the rural southern and 28% in rural northern price zones. Regarding diversification, there is a substantial increase in the number of food items, increasing from at most six items under Diet 1 to at least thirteen items under Diet 2. To some extent, this is not surprising given the operational definition of cultural acceptability, which imposes the inclusion of at least 10 food items. It also indicates that current food preferences of Rwandan households are often not cost-effective in meeting their nutritional requirements. Such preferences mainly include various roots and tubers, such as Irish potato, sweet potato, cassava and cooking banana. Despite shortcomings and arbitrary choices to account for cultural acceptability, the LP results indicate that a person can be adequately nourished in Kigali with only 316 RwF per day while lower food budgets suffice in other price zones of Rwanda.

Based on the estimated minimal cost to access nutritious food in each price zone, Figure 3 presents district-level affordability gaps for the first diet scenario (left-hand side map) and corresponding increases in affordability gaps when adding the cultural constraints of the second diet scenario (right-hand side map). The affordability gaps are obtained by summing up all shortfalls between the actual and minimal food budget needed in each price zone, while accounting for differences in demographic weight observed across districts. As such, the gaps represent the total amount of financial resources needed to allow every household to purchase a nutritious diet. Overall, the country would need 49 billion RwF per year to provide every household with additional resources to meet all nutritional requirements of the clinical diet (Diet 1) while this budget should almost double to 94 billion RwF in case the cultural-sensitive diet (Diet 2) is used as benchmark.

Figure 3. Affordability gaps by diet scenario, Rwanda (2013/14)



Source: Author with data from EICV4 (2013/14).

According to the left-hand side map of Figure 3, most of the budget to reach the clinical diet would flow to Nyamasheke, Rusizi, Nyagatare, Rubavu and Kamonyi, for which the affordability gap falls within RwF 3.5 to 4.5 billion per year. In contrast, there are ten districts whose annual gap is lower than RwF 1 billion. Despite their demographic weight, the three districts of Kigali (Gasabo, Kicukiro and Nyarugenge) require the least additional resources (less than 0.5 billion RwF), which indicates that most households in the capital city have a food budget close to or higher than the cost of the clinical diet. When adding the constraint of cultural acceptability, the right-hand side map of Figure 3 shows that a culture-sensitive diet is relatively more expensive in various districts in the northeastern part of the country while being relatively less expensive in the southwestern part, both compared to the cost of the clinical diet. To some extent, this observation can be traced back to price differences of various roots and tubers that enter the culture-sensitive diet, of which the main production sites are located in the southwestern districts of the country where generally lower prices prevail as a result.⁵

Dominance of diet-related nutrition policies

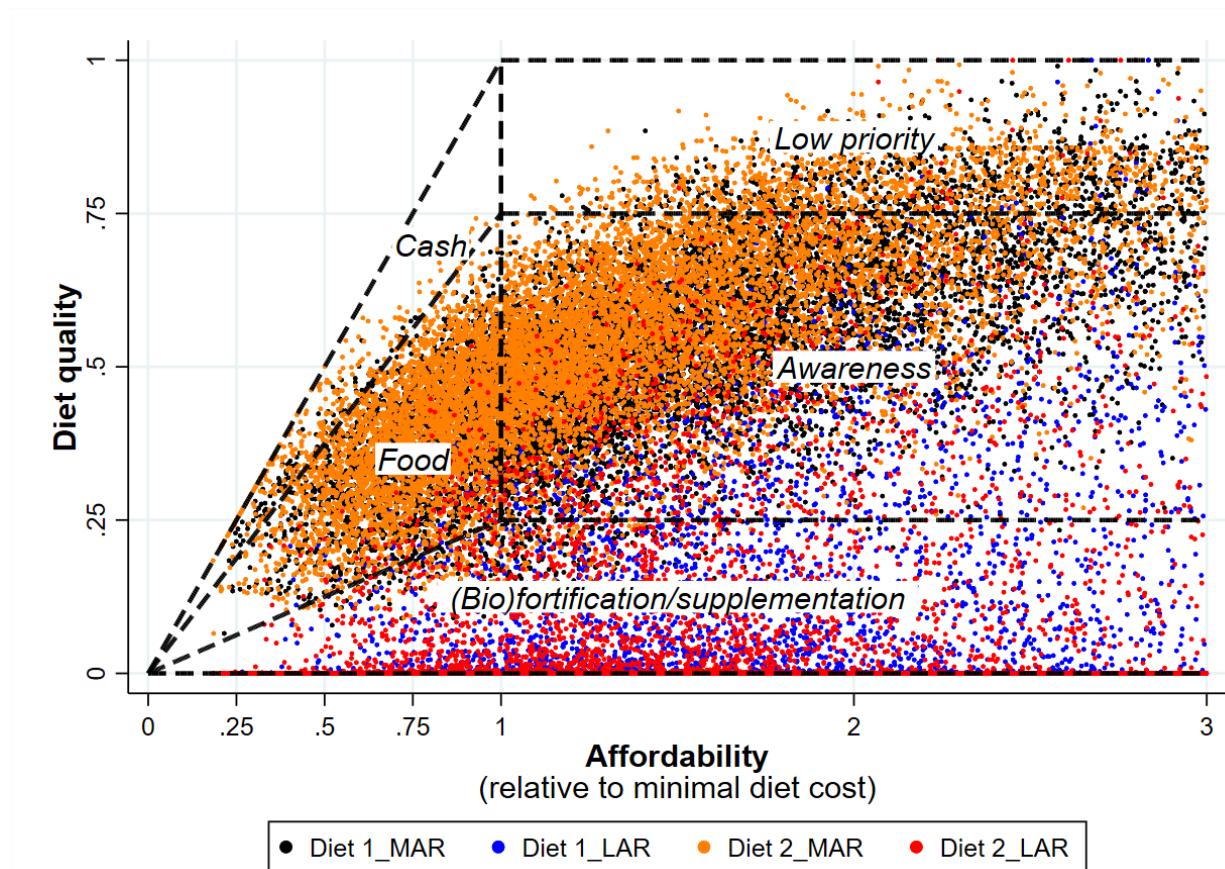
With the core building blocks defined, estimated and discussed, Figure 4 populates the schematic overview above with actual values based on four specifications. Each specification is a distinct combination of the two diet quality measures (MAR and LAR) and the two relative affordability levels (based on the minimal cost of either Diet 1 or Diet 2). Given that data ranges of each dimension are comparable across the four specifications, observations can be sensibly overlaid, which will be useful when checking for dominance. In line with the key reference points discussed in Figure 1, we also demarcate five areas – each of which corresponds to a typical diet-related nutrition policy. Whereas a natural threshold exists between affordability and unaffordability, the delimitations in terms of allocation efficiency are arbitrarily set at 0.75 and 0.25, whereby values lower than 0.25 are considered to correspond with food preferences that are too difficult to be altered. In such circumstances, biofortification (in rural areas), food fortification (in urban areas) and nutrient supplementation are considered to be more feasible strategies.⁶

The four scatter plots in Figure 4 indicate that the difference in distribution is more pronounced between MAR and LAR specifications than between Diet 1 and Diet 2 specifications. This means that in the case of Rwanda it is more important to agree on the “right” diet quality measure to design the appropriate policy mix than to debate the usefulness of accounting for food preferences. In addition, the MAR distributions are more densely concentrated while the LAR versions appear to be more dispersed. Of course, the latter observation is in part due to MAR being a central tendency measure (whereas LAR is not), though it again underscores that choosing the appropriate diet quality measure is not a trivial issue.

⁵ District-level agricultural statistics can be obtained from the Seasonal Agricultural Survey webpage of NISR (URL: www.statistics.gov.rw/datasource/seasonal-agricultural-survey).

⁶ Whereas biofortification relates to technologies to increase the nutritional value of seeds, food fortification involves the process of improving nutrient content of food crops during processing.

Figure 4. Four combinations of diet quality and affordability, Rwanda (2013/14)



Notes: This scatter plot contains 11,470 observations for each specification, totaling 45,880 observations for all four combinations. For clarity, relative affordability values higher than 3 are not shown in the figure and represent less than 10% of all observations. MAR and LAR respectively stand for Mean and Lowest Adequacy Rate.
 Source: Author with data from EICV4 (2013/14).

More specifically, Table 4 presents the various policy mixes associated with each combination of the two affordability thresholds and diet quality measures. Under the “Diet 1-MAR” version, most policy attention should be devoted to awareness raising, given that 62% of households have a sufficient food budget, of which the allocation could be substantially improved in nutritional terms. Another 20% of households should be provided with nutritious food directly (or indirectly, through a combination of cash and education) as they lack both financial resources and nutrition knowledge. Given acceptable nutritional allocation efficiencies and sufficient resources, less priority should be given to 14% of the households. Increasing the diet threshold to include socially preferred food items (i.e., “Diet 2-MAR”), the same policy mix generally applies. However, for roughly 10% of all households, food transfers (instead of awareness raising) will be a more appropriate strategy to increase nutrient intake, as they simply cannot afford the more expensive culture-sensitive diet.

Table 4. Nutrition policy mix by specification of Diet 1/2 and MAR/LAR, Rwanda (2013/14)

Nutrition policy (% of households)	Diet 1		Diet 2		Dominance	
	MAR	LAR	MAR	LAR	Strong	Weak
Low priority	13.8	1.1	13.8	1.1	1.1	1.1
Awareness raising	62.2	9.8	51.8	9.4	4.2	4.2
Cash transfers	1.1	0.0	2.6	0.0	0.0	0.0
Food transfers	20.1	0.4	30.1	1.0	0.2	0.4
(Bio)fortification/supplementation	2.9	88.8	1.9	88.6	1.9	2.9
No dominance	na	na	na	na	92.7	91.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Notes: MAR, LAR and “na” respectively stands Mean Adequacy Ratio, Lowest Adequacy Rate and non-applicable. Dominance refers to the percentage of households being categorized under the same diet-related nutrition policy across all four specifications (strong) or at least three specifications (weak).

Source: Author with data from EICV4 (2013/14).

In line with the scatter plots above, the diet-related nutrition policy scheme of both LAR specifications is very different from those using MAR as the diet quality measure. In addition, both specifications (i.e., “Diet 1-LAR” and “Diet 2-LAR”) are almost identical with 89% of all households recording such low nutritional allocation efficiencies that neither awareness raising or food transfers are likely to be effective strategies to improve diet quality. In such circumstances, (bio)fortification and nutrient supplementation might be more appropriate intervention strategies. Defining strong and weak dominance as being categorized under the same nutrition policy across all four and at least three specifications, respectively, it is no surprise to see that the above policy matrices are robust for only less than 9% of all observations. In other words, unless the exact measures of diet quality or composition of optimal diets are further specified, no conclusive policy recommendations can be formulated based on EICV4 data of Rwanda.

Alternatively, one might wish to discard the LAR measure as it completely ignores adequacy rates of the other food components under investigation. In addition, the very low intake rates observed for vitamin B12 might simply relate to underreporting of consumption of animal-based food items, and therefore may relate to measurement error. If one or both reasons apply, while inequality in nutrient intake is still important to consider (at least to some non-specified degree), one can propose the results of Table 5, which presents the same dominance analysis but replaces LAR with the Second-Lowest Adequacy Rate (SLAR). This alternative measure of diet quality is less inequality averse compared to LAR, while it illustrates one of many intermediate options of combining efficiency and equity considerations.

Table 5. Nutrition policy mix by specification of Diet 1/2 and MAR/SLAR, Rwanda (2013/14)

Nutrition policy (% of households)	Diet 1		Diet 2		Dominance	
	MAR	SLAR	MAR	SLAR	Strong	Weak
Low priority	13.8	7.2	13.8	7.2	7.1	7.1
Awareness raising	62.2	55.0	51.8	49.2	42.6	42.6
Cash transfers	1.1	0.0	2.6	0.1	0.0	0.1
Food transfers	20.1	11.9	30.1	21.5	9.8	13.9
(Bio)fortification/supplementation	2.9	25.9	1.9	22.0	1.9	2.9
No dominance	na	na	na	na	38.6	33.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Notes: MAR, SLAR and “na” respectively stands Mean Adequacy Ratio, Second-Lowest Adequacy Rate and non-applicable.
Source: Author with data from EICV4 (2013/14).

Using SLAR instead of LAR as the most inequality averse diet quality reference, we observe that around half of all households could benefit from awareness raising, which is roughly 40% points higher compared to the previous specification. A similar observation applies to the prevalence of households with less priority and those requiring food transfers, which increases from at best 1% under the LAR specification to 7% and between 12%-22%, respectively, when relying on SLAR. As a result, whereas (bio)fortification and nutrient supplementation was by far the most common diet-related nutrition policy under LAR (89%), it should target between 22%-26% of all households when diet quality is defined by SLAR. For the latter group of households, depending on whether the issue of measurement error applies, the allocation efficiency to avoid severe deficiency rates for at least one and perhaps two nutrients is so low that interventions aimed at altering food preferences are unlikely to improve diet quality much.

Given increased overlaps for both SLAR and MAR specifications, the dominance results sharply improve from less than 9% to at least 61% of all households falling under the same diet-related nutrition policy. When the weak dominance definition is used, this prevalence further increases to roughly two thirds with 64% of the dominant results pointing to awareness raising as the most promising policy, followed by 21% to food transfers, 11% to low-priority interventions, 4% to (bio)fortification and nutrient supplementation, and a negligible fraction to cash transfers. With the policy matrix being more robust if LAR is excluded as a possible measure of diet quality, policymakers should be less concerned with the exact definition of optimal diets and corresponding costs. In addition, there is less need to fully assess the relative importance of different nutrients and associated health risks, before one can start designing policies. However, those insights will still be helpful to identify the most promising policy for the remaining one third of all households.

4. CONCLUSIONS AND POLICY IMPLICATIONS

The objective of this paper is to present a series of analytical tools to help design diet-related nutrition policies in developing countries, which is illustrated with household consumption data of Rwanda. A key innovation entails the development of a measure that captures food budget allocation efficiency, or the extent by which households are optimizing the use of their available resources in reaching a nutritious diet. To construct this new measure, it is critical to underscore the importance of combining information on diet quality and affordability: if nutritious diets are unaffordable, even an optimal use of the food budget will still result in suboptimal outcomes.

Because diet quality and affordability can be approximated in different ways, this analysis resorts to the literature on social welfare by applying the concept of stochastic dominance on two opposite aggregation rules (for diet quality) and two diet scenarios (for affordability). Indeed, in the absence of normative or theoretical guidelines to weigh nutrient adequacies and related health risks, or regarding the exact composition and cost of nutritious diets, a complete or partial categorization of diet-related nutrition policies may still occur in *empirical* settings. For affordability, standard LP techniques are used to derive a clinical and a more culture-sensitive diet. To approximate diet quality, the inequality averse LAR is suggested as a possible alternative for the more commonly accepted MAR. The purpose of LAR is not to advocate for a new one-dimensional diet quality measure within the nutrient space, or to dismiss MAR, but to stretch the range of possible diet quality specifications before applying the stochastic dominance approach.

In the case of Rwanda, clinical diets (which meet energy, macro- and micronutrient requirements, cf. Diet 1) can be accessed with a daily budget per AME ranging from 204-290 RwF (in 2013/14 prices) depending on the country's region, while this range increases to 261-316 RwF in case some allowance is made for local food preferences (Diet 2). This cultural acceptability criterion results in increased diet diversification, from at most six food items under Diet 1 to at least thirteen items under Diet 2. Despite the modest costs of optimal diets, total affordability gaps are significant and amount to 49 billion RwF per year for all households to meet the nutritional requirements of Diet 1, while it almost doubles to 94 billion RwF to reach Diet 2, the latter being relatively more expensive in the northeastern part of the country.

Next to affordability constraints, Rwandan households make suboptimal decisions in allocating their food budget, which results in an average adequacy rate of 60% for food energy and rates below 50% for calcium, iron, zinc, and especially vitamin B12 (10%). This double burden of hunger and hidden hunger is roughly in line with secondary data from DHS and reflected in both diet quality reference measures. According to MAR, on average around half (52%) of all food energy and micronutrient needs of households are covered by current food consumption, while LAR points to a mean coverage rate of only 7%.

Based on the new allocation efficiency measure, five generic diet-related nutrition policy areas are delineated and populated with actual values according to four distinct combinations of affordability (Diet 1/2) and diet quality (MAR/LAR). The policies range from interventions focusing on (bio)fortification and nutrient supplementation in case allocation efficiency is very low (<0.25), over food transfers and nutrition awareness raising when efficiency is between 0.25 and 0.75, to cash transfers and low priority interventions when efficiency exceeds 0.75; with policies in the latter two groups being distinguished by the affordability cut-off. For each specification, it shows whether poor diets could best be addressed by promoting more rational budget allocations, by supporting incomes (in cash or in kind), or through other approaches when preferences are much stickier.

Given the diverse findings between the MAR- and LAR-specifications, no conclusive policy recommendations can be formulated, an observation which mainly stems from the exceptionally low vitamin B12 intake levels. However, when excluding LAR from the range of possible diet quality measures, the dominance results markedly improve with a robust policy matrix emerging for 67% of all cases (that is under the weak definition of dominance). This matrix mainly consists of awareness raising activities (64% of dominant results), followed by food transfers (21%) and low-priority interventions (11%). In addition to being less inequality averse regarding diet-related health risks, the exclusion of LAR might be legitimate given potential underreporting of animal-based food consumption. In any case, it is important to remind that the results of this analysis are based on one cross-section only.

In ideal circumstances, analytical tools directly feed into policy action while being embedded in the broader realities faced by policymakers. Compared to aspects of affordability, the dimension of allocation efficiency seems relatively neglected. In addition, policymaking is often more driven by pragmatism than idealism, an observation which favors a flexible approach that is capable to accommodate different viewpoints of a policymaker's constituency. The development of a food budget allocation efficiency measure combined with applying stochastic dominance techniques to a portfolio of diet-related nutrition policies are two innovations to respond to these realities. While the presented case study could be further advanced by examining changes in affordability, diet quality, and allocation efficiency using more recent data, public debate could help further narrow the range of real policy concerns regarding trade-offs in diet-related health risks and constraints in cultural acceptability.

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