Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries

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Running head: The cost of nutritious diets across countries

Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries

Abstract: Many policies and programs aim to bring nutritious diets within reach of the poor. This paper uses retail prices and nutrient composition for 671 foods and beverages to compute the daily cost of essential nutrients required for an active and healthy life in 177 countries around the world. We compare this minimum cost of nutrient adequacy with the subsistence cost of dietary energy and per-capita spending on all goods and services, to identify stylized facts about how cost and affordability relate to economic development and nutrition outcomes. On average, the most affordable nutrient adequate diet exceeds the cost of adequate energy by a factor of 2.66, costing US$1.35 per day to meet median requirements of healthy adult women in 2011. Affordability is lowest in Sub-Saharan Africa. The sensitivity of diet costs to each requirement reveals the high cost of staying within acceptable macronutrient ranges, particularly the upper limit for carbohydrates. Among micronutrients, total diet costs are most sensitive to requirements for calcium as well as vitamins A, C, E, B12, folate and riboflavin. On average, about 5% of dietary energy in the least-cost nutrient adequate diets is derived from animal source foods, with small quantities of meat and fish. Over 70% of all animal products in least-cost diets is eggs and dairy, but only in upper-middle and high-income countries. In lower income countries where egg and dairy prices are significantly higher, they are replaced by larger volumes of vegetal foods. When controlling for national income, diet costs are most significantly correlated with rural travel times and rural electrification. These data suggest opportunities for targeted policies and programs that reduce market prices and the cost of nutritious diets, while improving affordability through nutrition assistance, safety nets and higher earnings among low-income households.

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1. Introduction

Poor diets contribute to one in five adult deaths, through both insufficient intake of healthy foods and excess intake of unhealthy items (Afshin et al., 2019). Multiple burdens of malnutrition typically coexist, with symptoms of insufficiency (stunting, underweight, wasting, and micronutrient deficiencies) observed alongside the consequences of excess food intake such as cardiovascular diseases and diabetes (WHO, 2003). Diverse types of food are needed to sustain a healthy and active life, and food prices differ across countries in systematic ways that might contribute to poor diet quality and malnutrition around the world (Darmon and Drewnowski 2015, Headey and Alderman 2019; Hirvonen et al. 2020; Herforth et al. 2020).

This study uses worldwide retail prices and nutrient composition data to identify the most affordable combination of foods and beverages needed to meet requirements in 2011, and thereby quantify whether and how national food systems bring nutrient adequate diets within reach of the poor. Previous analyses of food prices for policy analysis typically use farmgate or wholesale prices of a few bulk commodities to address farm income (FAO 2018), or use retail prices weighted by expenditure shares to measure overall inflation (IMF 2020). Our focus on the cost and affordability of a nutritious diet is made possible by matching food items to their nutrient composition and solving for the least-cost diet to meet nutritional needs, allowing for substitution among the items actually available in each country. In so doing we build on Allen (2017) and other previous studies to make three specific contributions:

First, we update existing methods for measuring the cost of nutritious diets, adding macronutrient balance and upper levels as well as minimum requirements for 21 essential nutrients needed for long-term health (Institute of Medicine 2006, National Academies 2019). Previous least-cost diet studies have typically used older nutrient requirement specifications, without macronutrient balance and fewer if any upper bounds. Using updated evidence on nutrient requirements captures aspects of diet quality that matter greatly for health. Imposing a larger number of constraints may also lead to a larger number of foods included in each least-cost diet, in combinations that are more closely aligned with observed food choices than least-cost diets computed using older requirements.

Second, we use the cost of nutrient adequacy to identify a series of stylized facts about global food systems, using data visualizations and regression results to examine similarities and differences in least-cost diets across countries. We map which food groups deliver which nutrients, and quantify the sensitivity of diet costs to each requirement. This whole-of-the-diet approach to nutrient adequacy is particularly important for policy interventions in food systems, providing a framework that links agricultural supply and commodity markets to the retail items that could meet each nutrient need at least cost. Our focus on individual nutrients complements the food group approach of previous global analyses (e.g. Hirvonen et al. 2019, Herforth et al. 2020), and our global comparisons complement in-country work on how best to fill each nutrient gap between requirements and intake for specific populations (WFP 2020).

Third, we use cross-country regressions to explore how structural factors relate to variation in the cost of nutrient adequacy, and how diet costs relate to nutrition outcomes. We hypothesize that retail costs depend on the efficiency of value chains and food markets, including factors such as rural travel times and rural electrification, urbanization and service sector development as well as trade restrictions and other interventions. We also test whether each country's cost of nutrient adequacy is associated with their prevalence of undernutrition or diet-related obesity and non-communicable disease. Previous work along these lines has focused on individual foods (e.g. Headey and Alderman 2019), which may miss systemic factors related to the overall cost of an entire diet.

We conclude with the implications of our results for food policies and programs, social protection and poverty alleviation. Food policies in developing countries have historically focused on farm income and lowering the cost of starchy staples needed for daily energy, rather than the diverse diets needed for lifelong health (Global Nutrition Report 2018). Our work provides a robust, practical method for selecting and aggregating foods in the proportions required for nutrient adequacy, identifying targets of opportunity for agriculture and food systems to reduce diet costs and improve access to nutritious diets among low-income people. We focus primarily on guiding food policies and programs, but diet costs are also relevant to poverty measurement and social safety nets. Allen (2017) argues that the minimum cost of nutrient adequacy, plus similar least-cost housing and other basic needs, provides a measure of poverty that is more relevant to policymakers' development goals than conventional poverty lines. Hirvonen et al. (2019) and Herforth et al. (2020) compare alternative definitions of healthy diets, and other studies relate diet costs to food expenditure (Mahrt et al. 2019) or wages (Raghunathan et al. 2020). All of these studies show that nutritious diets are often far out of reach for low-income households, implying that achieving development goals will require transfer programs and income growth in addition to lower food prices and nutrition education programs that steer consumers towards healthier choices. The data and methods in this paper could help guide these strategies, policies and programs in a wide range of countries.

2. Methods

To compare the cost of a nutritious diet around the world, we use retail prices of the least expensive foods available in each location that meet estimated requirements for a median healthy woman of reproductive age. This builds on the concept of least-cost diets pioneered by Stigler (1945), which has long been used to recommend combinations of foods for low-income people in industrialized countries (Cofer et al. 1962, Gerdessen and De Vries 2015, Parlesak et al 2016, Maillot et al. 2017) and to guide intervention in lower-income settings (Chastre et al. 2007, Deptford et al. 2017, Vossenaar et al. 2017, WFP 2020). Our application compares least-cost diets across countries as a metric of the food environment, measuring each national food system's ability to deliver essential nutrients in the required proportions at low cost, using food and beverage items that are actually being sold in each country.

The use of least-cost diets to measure a country's food environment over time was pioneered by O'Brien-Place and Tomek (1983) for the U.S., and more recently applied to individual low-income countries by Omiot and Shively (2017) and Masters et al. (2018) among others. Here we update and extend the method for international comparisons, using the latest Dietary Reference Intake (DRI) requirements specified by the Institute of Medicine (2006) for which the most recent data are from the National Academies (2019). Requirements include upper bounds on various nutrients to avoid excess intake associated with chronic diseases, in addition to the lower bounds needed to avoid undernutrition in low-income settings. The health functions and typical sources of each nutrient along with all upper and lower bound requirements are detailed in the annex of supplemental information (Tables A1 and A2).

To address cross-country differences in access to nutritious foods, our principal measure is the Cost of Nutrient Adequacy (CoNA), defined as the minimum cost of foods that meet all known requirements for essential nutrients and dietary energy for a representative person. We compare this to the least-cost starchy staple providing just enough daily energy, which we call the Cost of Caloric Adequacy (CoCA). To measure CoNA, we use the price of each food and its nutrient content relative to lower bounds and upper limits needed for daily energy and long-term health:

(1) $\text{CoNA} = \min. \{ C = \Sigma_i p_i \times q_i \}$

Subject to:

(2) $\Sigma_i a_{ij} \times q_i \geq EAR_j$

(3) $\Sigma_i a_{ij} \times q_i \leq UL_j$

(4) $\Sigma_i a_{ij} \times q_i \leq AMDR_{j,upper} \times E / e_j$

(5) $\Sigma_i a_{ij} \times q_i \geq AMDR_{j,lower} \times E / e_j$

(6) $\Sigma_i a_{ie} \times q_i = E$

(7) $q_1 \geq 0,\ q_2 \geq 0,\ q_3 \geq 0, \ldots,\ q_i \geq 0$

In this notation, the quantity of the j^{th} nutrient in food i is denoted a_{ij}, which multiplied by its quantity consumed (q_i) must meet estimated average requirements (EAR) for each nutrient j, while remaining below upper levels (UL) for micronutrients and within a range for macronutrients determined by acceptable macronutrient distribution ranges ($AMDR_{lower}$ and $AMDR_{upper}$), at lowest total cost given all prices (p_i) within the further constraint of overall energy needs (E). Macronutrient ranges are defined as percentages of daily energy needs, given the energy density (e_j) of protein and carbohydrates which is 4 kcal per gram, and of lipids which is 9 kcal per gram. Solving this system of equations with all foods available at each time and place provides a lower bound on the cost of meeting all nutrient constraints, which we contrast with the cost of using only starchy staples to meet the daily energy constraint (2,109.3 kcal/day) in equation (6), which we call the cost of caloric adequacy (CoCA). We then compute the CoNA to CoCA ratio which represents the premium required to meet all nutrient requirements for lifelong health above the minimum cost of survival. To estimate the affordability of a nutritious diet, we also compute ratios of CoNA to average household food and total expenditure, which may be shown as a ratio or as the log of that ratio to address the exponential nature of variation in household expenditure across countries. The CoNA/CoCA premium and CoNA/expenditure ratio can both be computed from data in local currency units without use of exchange rates, but to compare the levels of CoNA and CoCA we convert prices to US dollars, using PPP exchange rates for all household expenditure.

For both CoNA and CoCA we report the foods needed in each country to meet nutritional needs at lowest cost. A key feature of our approach is to constrain nutritious diets to meet not only the EARs needed to avoid undernutrition, but also a balanced diet in terms of the three macronutrients through the AMDR, and upper bounds on micronutrients for which excess intake could be harmful. The resulting diets will differ from actual consumption patterns, which often fall below or above required levels of each nutrient as described for example in Schneider (2020).

Focusing on nutrient adequacy is helpful in part to guide interventions, using information such as the sensitivity of least cost diets in each location to a change in requirements for each nutrient. That sensitivity is known as the shadow price of each constraint:

(8) $$SP_j = \frac{\partial C^*}{\partial (e, EAR, UL, AMDR)_j^{+}}$$

here SP_j is the shadow price of each requirement for nutrient j or required total energy e, computed as ∂C^*, the change in minimum cost of meeting all constraints for each $\partial(e,\ EAR, UL, AMDR)_j^{+}$ change in one of the nutritional requirements. The units of measure for these requirements vary widely, so to compare across constraints we report all nutrient costs as semi-elasticities denoted *SP'*, defined as the increment of cost in dollars per day when each constraint is altered by 1%:

$$(9) \qquad SP'_j = \frac{\partial C^*}{\%\Delta(EAR,UL,AMDR)_j^+}$$

Solving for the least cost diet reduces shadow prices to zero for constraints that are not binding, and identifies the change in total cost if the binding requirements were to change by a small amount. If each food had only one nutrient, only lower-bound constraints would be binding, and all shadow prices would be the cost per unit of that nutrient from its most cost-effective source. Real foods have many nutrients, and reaching the lower bound for some may imply exceeding the upper bound for others. In certain settings the available foods may not be able to meet all constraints at once, for example at some times and places in rural Malawi (Schneider 2020), but the nationally representative set of items for each country in this study offers a sufficient diversity of foods for a feasible solution in each country using an average of 8 different items (Table A5 in the annex of supplemental information). Mathematically, there are as many binding nutrient constraints as there are foods in the least-cost diet, making analysis of shadow price elasticities particularly useful to show which constraints are most costly to meet given the composition and price of available foods.

Calculations for all equations were completed in RStudio (version 1.2.5042) and resulting index values exported to Stata 15, RStudio or Excel for visualization purposes, with model code and data for replication posted online at the project website referenced in this paper's acknowledgements.

3. Data

Our food price data comes from the World Bank's International Comparison Program (ICP), an initiative associated with the United Nations Statistical Commission to compare price levels and living standards across countries (ICP, 2018). The mandate of the ICP includes computation of purchasing power parity exchange rates, which requires assembling retail prices for similar goods and services in multiple countries. For this purpose, the ICP works with national statistical agencies and a set of regional offices to create a global list of the most widely consumed items, plus regional lists for items found primarily in Africa, East and South Asia, West Asia or Latin America. For the 2011 round of ICP data, the combined food lists feature a total of 823 items from 177 countries and territories around the world. The annex of supplemental information Figure A1 provides a flow chart for transformation of the raw data for our analyses, which omit alcoholic beverages, items of unknown size or composition, and specialized infant foods or condiments that would not be included in a representative adult diet. For cross-country analysis, due to missing income data we omit the small island territories of Anguilla, Bonaire and Montserrat, whose combined population in 2011 was around 36,000 people.

Our final analytical dataset consists of 671 items matched to their nutrient composition using the USDA (2013) standard reference database, complemented by food composition data for fish (FAO 2016) and some foods specific to Africa (FAO 2019) or South Asia (Shaheen 2013) that are not included in the USDA data. All prices are as reported by national statistical agencies to the IPC, except that 38 high-income countries had missing data for plain starchy staples such as wheat flour, white potatoes and rice. Given the potential importance of those items for least-cost diets, we used values imputed by Hirvonen et al. (2019), replacing the missing values with the average price of that item among nearby countries in their geographical subregion as shown in annex Table A17. The final sample consists of 28,273 prices for the 671 items, whose English names and global average prices are listed in annex Table A3 in order of frequency of observation. Each item is found in an average of 42 different countries, for an average of 160 items per country, with other descriptive statistics and country names provided in the annex.

Beyond the price and nutrient composition of available foods, a third kind of data needed to calculate CoNA and CoCA are nutrient requirements. For that we use updated DRI values from the U.S. Institute of Medicine (2006) and National Academies (2019) as described in the methods section above. The annex of supplemental information provides a complete list of all requirements used in this study and their role in human health (Tables A1 and A2).

After identifying the least-cost set of foods needed to reach nutrient adequacy in each country, this study then aims to establish stylized facts about how that cost of nutrient adequacy relates to national income and other characteristics of a country's development path. For this we draw on the World Development Indicators database compiled by the World Bank (2019), population estimates from the UN (2019) plus file data from IFPRI that matches rural population density at each location with spatial data on rural infrastructure. To test correlations with agricultural market policies we use estimates of nominal rates of protection (NRP) as compiled by the AgIncentives Consortium (IFPRI 2020). The NRP for each food is calculated as the difference between an observed border price and an observed farmgate price, after adjusting for the estimated cost of transport and handling in a competitive market. That gap is expressed in tariff-equivalent percentage terms, as a measure of the change in price attributable to trade restrictions such as tariffs, quotas, export taxes or other barriers.

To test the specific hypotheses described in our motivation, the variables we use are gross national income (GNI) per capita, measured in US dollars at PPP prices in 2011, and four indicators for each of our principal hypotheses: urbanization, defined here as the share of the population living in urban areas as defined by national authorities, from World Bank (2019); service orientation, defined as the fraction of the country's gross domestic product derived from its services sector as opposed to agriculture, mining or manufacturing, also from World Bank (2019); rural transportation infrastructure (average travel time for rural people to reach the nearest city with more than 50,000 people) and rural electrification (share of the rural population with access to an electricity grid), both from IFPRI file data. This specific list of variables results in a final estimation sample of 138 countries (Table 3).

The final aim of this study is to examine associations between the least-cost diets of nutritious diets and actual food consumption, anthropometric outcomes and each country's prevalence of micronutrient deficiencies. We contrast the composition of least-cost diets with each country's national average food consumption from the FAO's food balance sheets in the reference year (FAOSTAT, 2011), and also compare to national average dietary intake as estimated by the Global Dietary Database (GDD 2020). For obesity prevalence we use the WHO (2020a) Global Health Observatory data repository on the percent of adult population whose body mass index (BMI) is 30 kg/m^2 or higher, and for stunting rates we use the WHO (2020b) Global Database on Child Growth and Malnutrition for the percent of under-five children whose height-for-age z-score is more than 2 standard deviations below the median of the international reference population. For micronutrient deficiencies, we use prevalence data reported by Harding et al. (2018) where anemia prevalence is measured as a hemoglobin concentration less than 110 g/dL for under-five children, and less than 120 g/dL for non-pregnant women; zinc deficiency prevalence extrapolated from FAO's food balance sheets; and vitamin A deficiency (VAD) prevalence among children estimated based on serum retinol concentrations using a Bayesian hierarchical model. Due to data availability, the estimation sample for these association studies is reduced to 134 countries for most malnutrition indicators, with summary statistics for these variables in our annex of supplemental material (Table A6).

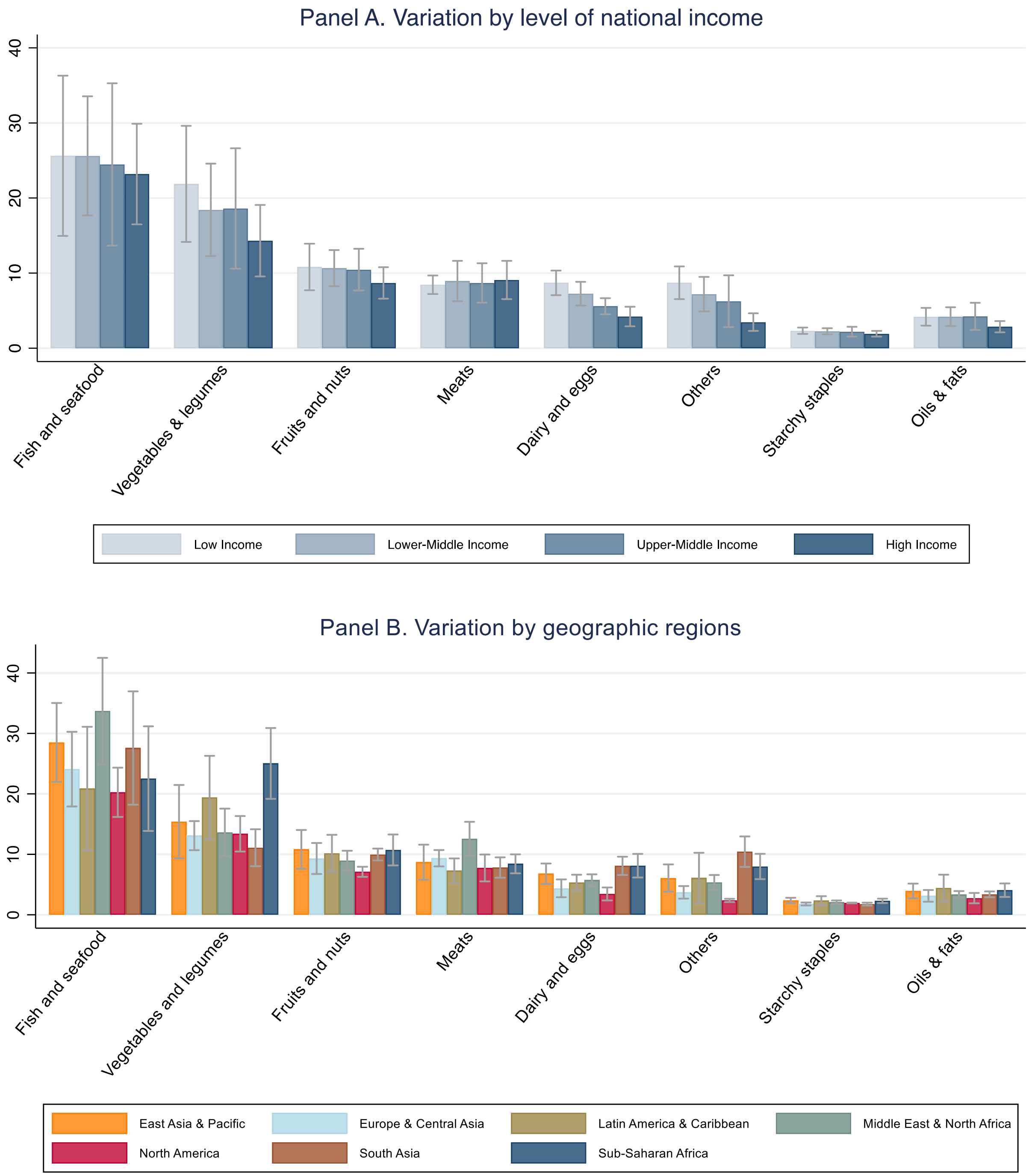
Results and discussion

3.1 Descriptive statistics and stylized facts

How does the cost of different foods vary by income level and regions?

Figure 1 shows the mean and standard deviation of all items in each food group, by level of national income (Panel A) and geographic region (Panel B). Prices are converted from local currency into US dollars at PPP exchange rates for all household consumption in 2011, and units of measure such as a kilogram of avocadoes are converted to units of dietary energy in the edible matter of each product. Results confirm that cost per calorie is higher for nutrient-dense foods such as fish and seafood, vegetables and legumes, fruits, nuts, meats, dairy and eggs, and lowest for starchy staples. Results also confirm the finding of Headey and Alderman (2019) that dairy and egg prices are higher in poorer countries, including in sub-Saharan Africa and South Asia.

Figure 1. Food prices for all available items, by category (2011 USD per 1,000 kcal)



Note: Data shown are means and standard deviations across countries in each income group or region, for the national average prices of all items in each category available in that country. Number of observations shown is 28,273 prices for 671 items in 173 countries and territories. The number of countries in each group are listed in Table 1. Income categories are from the World Bank, geographic regions are as defined by the UN statistical agencies for the ICP. Food categories are defined using the UN Classification of Individual Consumption According to Purpose (COICOP), and prices are reported in US dollars per 1000kcal of edible matter, converted from local currencies at purchasing power exchange rates for all household expenditure. Starchy staples include all cereals and white root vegetables, and the "Others" category includes sweets and caloric beverages.

How does the cost and affordability of the least cost nutritionally adequate diet vary by income and geographic region?

Table 1 below summarizes the population weighted means of CoNA, CoCA, the CoNA/CoCA ratio and CoNA/total household expenditure ratio by income and geographic region categories as defined by the World Bank. The regional CoNA average is generally lower than the World Bank's $1.90/day poverty line, which refers to total expenditure rather than food alone. The cost of day-to-day survival as measured by CoCA is much lower, in the range of $0.50-0.70/day. The premium for required nutrients, as measured by the CoNA/CoCA ratio, has wide variation between 2.05-3.53 reflecting differences in availability and price of low-cost options. Diet costs vary less than income, and affordability of CoNA ranges by a factor of ten from just 3% of household expenditure in high income countries to 36% in low income countries. Looking across regions, we see considerable variation in the premium for nutrients with the highest observed in South Asia [3.50 (0.97)] and the lowest in Middle East and North Africa [1.69 (0.42)]. Nutrients were least affordable in SSA as evidenced by the highest CoNA to household expenditure ratio [0.32 (0.16)] while it was the cheapest in North America [0.02 (0.00)].

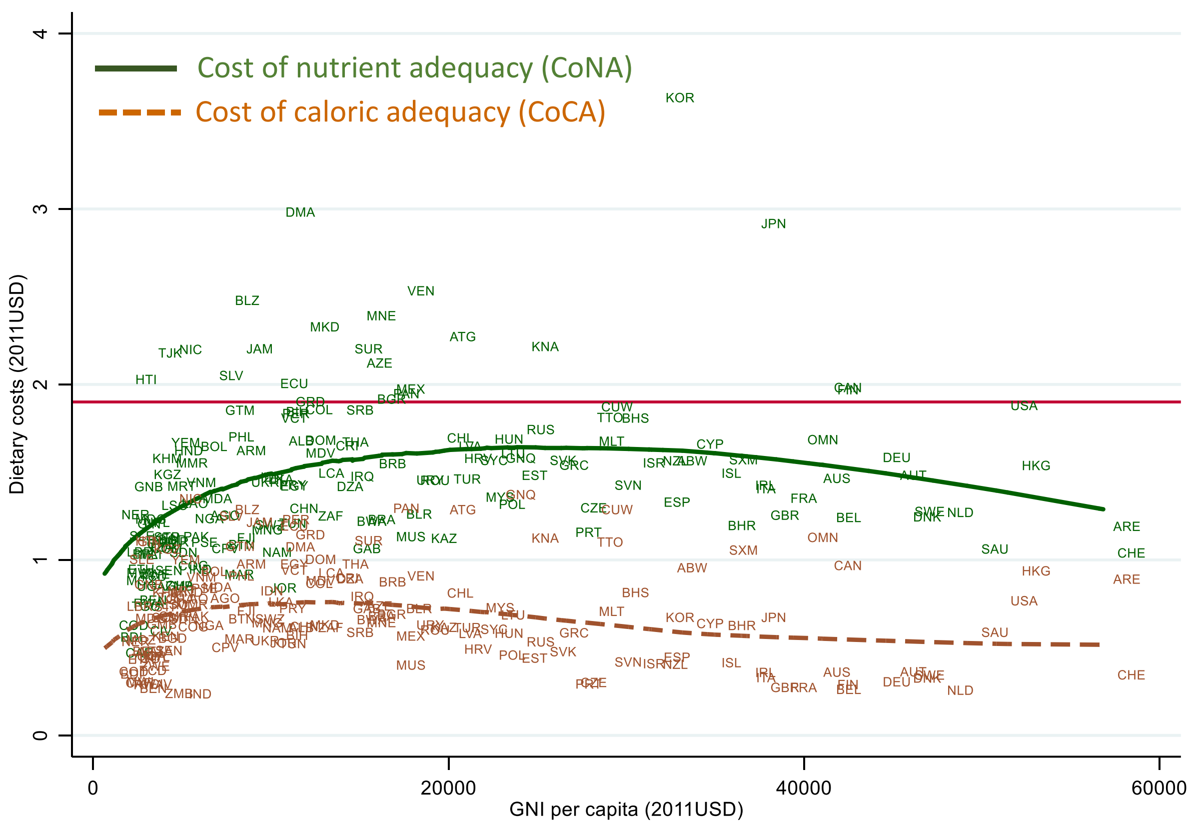
Table 1. Diet costs per day, by income category and geographic region

		N	Cost of nutrient adequacy (CoNA)	Cost of caloric adequacy (CoCA)	Premium for nutrients (CoNA /CoCA)	Affordability of nutrients (CoNA/ total expenditure)
Income levels	Low income	32	1.07 (0.29)	0.53 (0.17)	2.05 (0.34)	0.36 (0.14)
	Lower middle income	39	1.14 (0.27)	0.50 (0.29)	2.90 (1.13)	0.15 (0.04)
	Upper middle income	46	1.42 (0.27)	0.67 (0.15)	2.18 (0.48)	0.11 (0.04)
	High income	57	1.82 (0.64)	0.57 (0.24)	3.53 (1.22)	0.03 (0.02)
Geo-graphic regions	East Asia & Pacific	20	1.51 (0.51)	0.69 (0.13)	2.23 (0.80)	0.14 (0.05)
	Europe & Central Asia	45	1.49 (0.22)	0.45 (0.16)	3.60 (1.06)	0.05 (0.04)
	Latin America & Caribbean	37	1.68 (0.39)	0.81 (0.27)	2.21 (0.73)	0.09 (0.06)
	Middle East & North Africa	17	1.32 (0.24)	0.81 (0.20)	1.69 (0.42)	0.10 (0.06)
	North America	3	1.89 (0.04)	0.79 (0.07)	2.41 (0.15)	0.02 (0.00)
	South Asia	7	1.00 (0.10)	0.33 (0.18)	3.50 (0.97)	0.14 (0.03)
	Sub-Saharan Africa	45	1.02 (0.21)	0.54 (0.16)	1.97 (0.40)	0.32 (0.16)
Worldwide		174	1.35 (0.44)	0.57 (0.24)	2.66 (1.04)	0.14 (0.10)

Note: Data shown are population weighted means, with standard deviations in parentheses, over the number of countries indicated in each region. Underlying food prices are as shown for Figure 1, from which diet costs computed as described in the text. Data for column (5) omit Cuba due to missing data on total household expenditure.

To describe patterns in diet costs by level of national income, we use non-parametric locally weighted scatterplot smoothing (LOWESS) regressions to show local means of all countries at each income level. Figure 2 reveals that CoNA clusters close to $1.90/day in many low and middle income countries (LMICs) and is lower in countries with the highest levels of national income. Outliers are clearly identifiable, revealing the specific countries that account for regional differences shown in Table 1, with notably high cost of nutrients in Latin American & Caribbean and high-income Eastern Asian countries (Korea and Japan). CoCA is more uniform across income levels. In LMICs, caloric adequacy costs roughly 40% of total expenditure for people at the $1.90/day poverty line, while nutrient adequacy would cost over 70% of their budget.

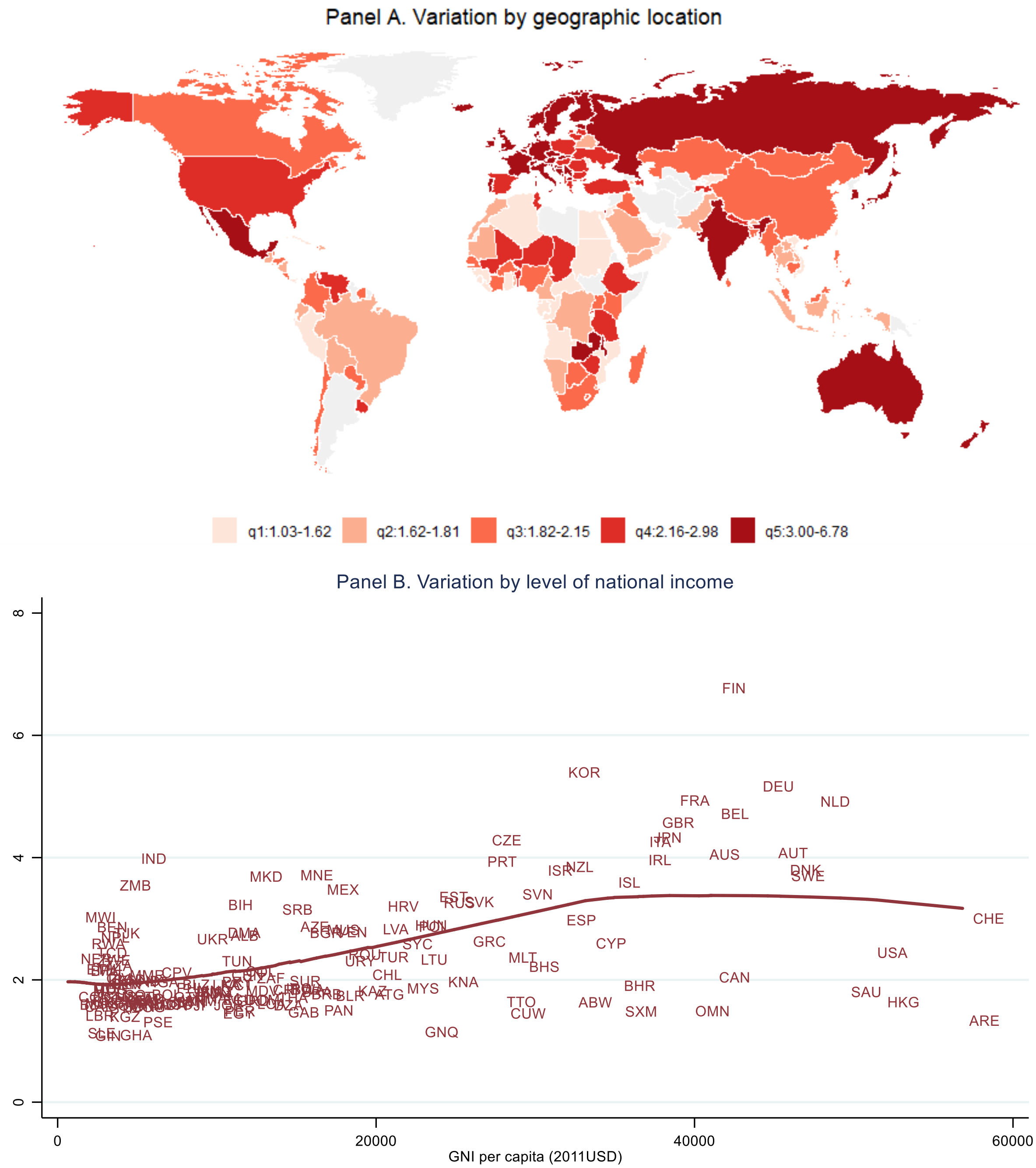
Figure 2. Cost per day for nutritious diets and daily energy by level of national income



Note: Data shown are each country's diet cost per day, with a LOESS regression for the estimated mean at each level of GNI per capita, computed for a representative woman of reproductive age as described in the text. Total number of countries and territories shown is 160, accounting for 99.75% of the global population. Omissions are due to missing GNI data for 8 places (Anguilla, Bonaire, Cuba, Djibouti, Montserrat, Taiwan, Turks & Caicos, and the British Virgin Islands, totaling 35 m. people), and for visual clarity we also omit the 9 territories with reported GNI per capita above 60,000 (Qatar, Macao, Kuwait, Brunei, Singapore, Bermuda, Luxembourg, Norway and the Cayman Islands, totaling 17 m. people).

Figure 3 explores the proportional premium for nutrient adequacy above the least-cost source of daily energy, expressed as the ratio of CoNA to CoCA. We find that the nutrient premium is highest in European countries with national income around $40,000 per capita, with wide variation around the mean at each income level. These differences in national food systems are detailed in the hypothesis-testing section of this paper.

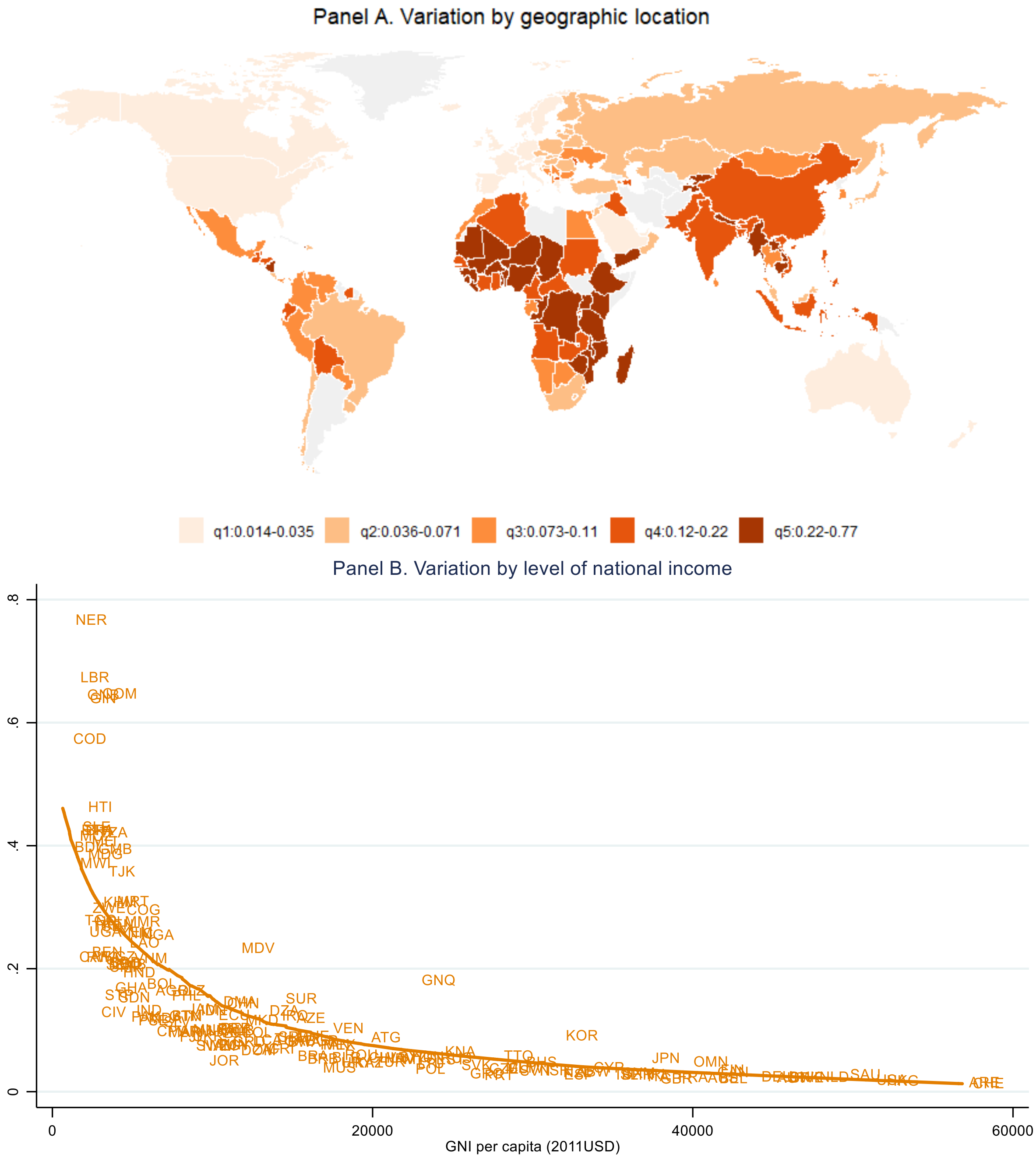
Figure 3. Premium in cost of nutrient adequacy over caloric adequacy (CoNA/CoCA ratio)



Note: Data shown are the ratio between cost of nutrient adequacy (CoNA) and the cost of caloric adequacy (CoCA), for 160 countries in 2011 as detailed in the note to Figure 2 and the text.

Figure 4 reveals the extremely high level of CoNA as a fraction of average total household expenditure in the lowest-income countries, as food prices vary much less than income. The online annex of supplementary materials reveals a similar pattern for CoNA as a fraction of household food expenditure (Figure A4).

Figure 4. Cost of nutrient adequacy as a fraction of mean household expenditure

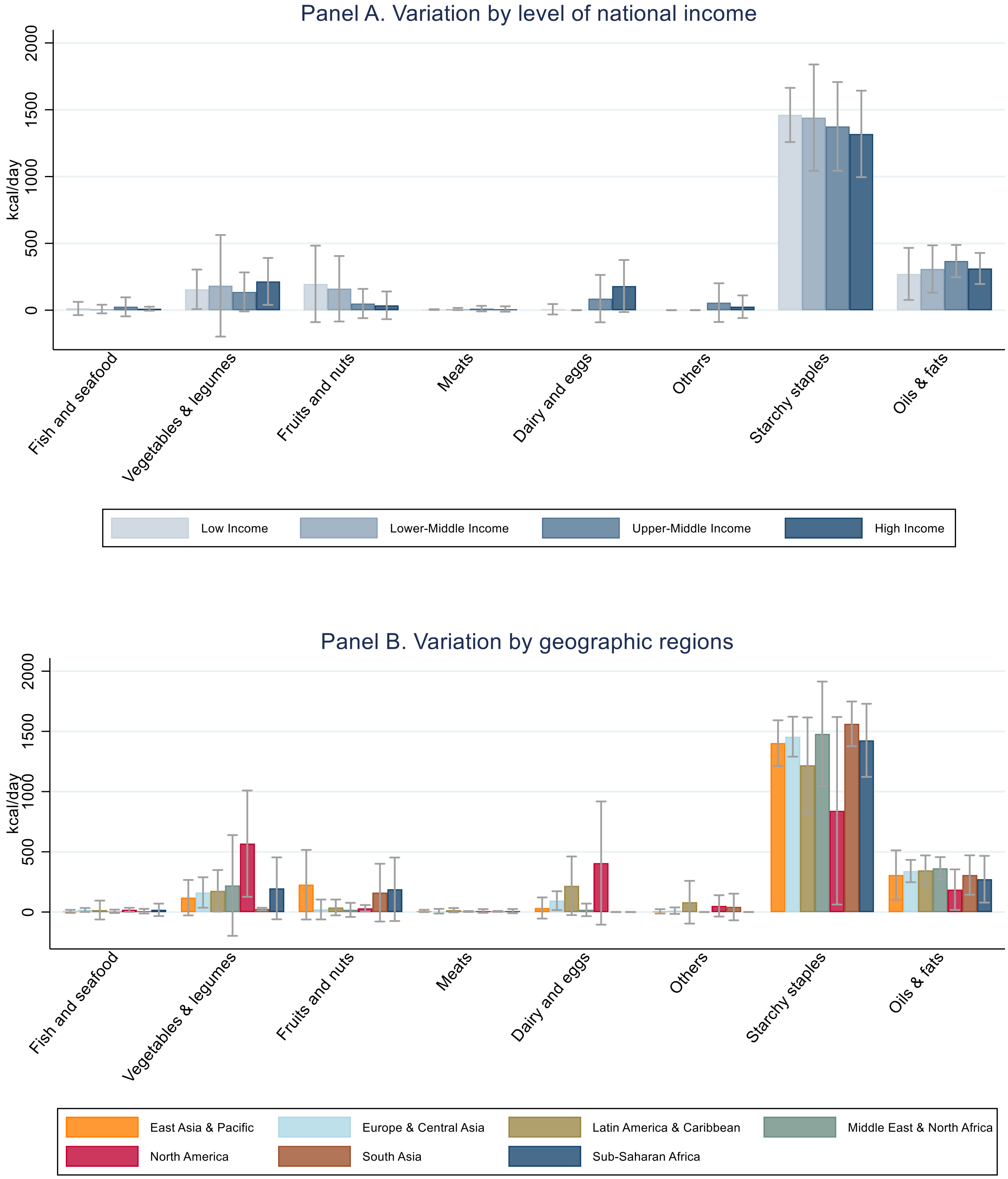


Note: Data shown are ratios of CoNA per day to total household expenditure per capita per day on all goods and services, for 160 countries in 2011 as detailed in the note to Figure 2 and the text.

Which food combinations typically provide complete nutrition at the lowest cost?

The composition of least-cost diets for nutrient adequacy in countries at each income level and geographic region are shown in Figure 5, in terms of dietary energy (kcal/day) from each category of food. This reveals that adequate protein and micronutrients needed by our representative adult woman can be achieved with diets whose primary source of energy is starchy staples, complemented by oils and fats plus vegetal sources of micronutrients and very small quantities of animal-sourced foods. Animal sources of dietary energy are significant in these least-cost diets only for dairy and eggs in upper middle and high income countries, where they replace fruits and nuts which play a larger role in low and lower middle income countries. That substitution can be traced to the price gradient for dairy and eggs shown in Figure 1. Higher prices for dairy and eggs exclude them entirely from least-cost diets in all low and lower middle income countries except one (Haiti). The possibility of substitution among food groups to meet each nutrient requirement depends on the composition and price of available foods in each country, which in turn affects the degree to which each nutrient requirement contributes to total diet costs as shown in Figures 5 and 6.

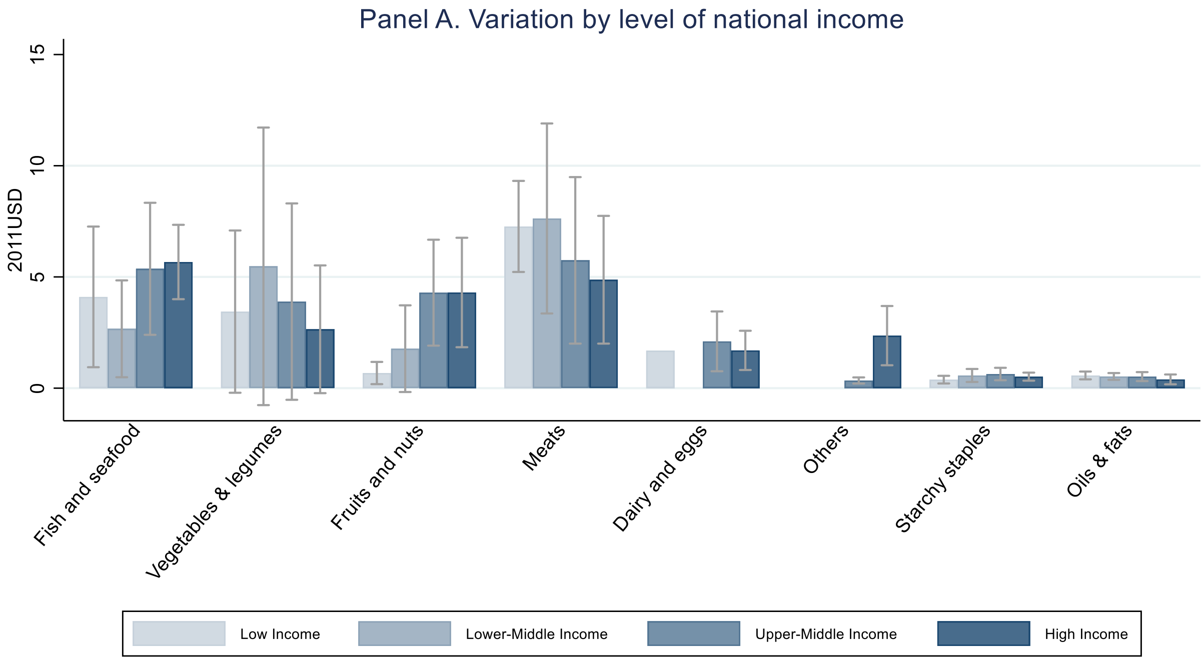
Figure 5. Foods quantities selected for least-cost nutrient adequate diets (kcal/day)

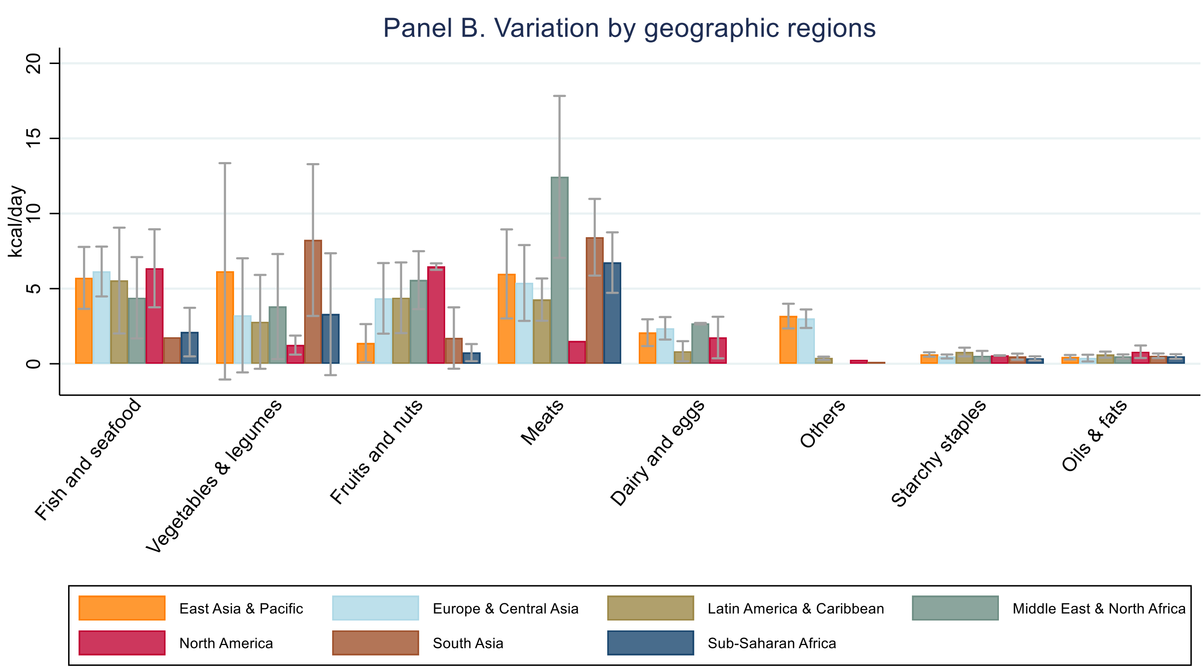


Note: Data shown are means and standard deviations across countries in each income group or region, for the sum of all items in each food group shown. Item selection is based on price data shown in Figure 1.

Figure 6 summarizes the cost per unit of dietary energy of the foods that are included in least-cost diets, at each national income level and geographic location. These are the most affordable foods needed for nutrient adequacy in each country, and may be very different from the full set of all foods in each category shown in Figure 1. The items included in least-cost diets shown in Figure 6 have much lower cost per calorie than the average item in their food category, and much more variation across regions due to differences in availability of low-cost options within each category. For example, low income countries have very low-priced items in the fruit and nut category that enter least-cost diets, but there are few such lower-cost options for dairy and eggs. In least cost diets, dairy or eggs appear in only one low income country (Haiti) and in none of the lower middle income countries. In those countries, the only animal source foods included in least-cost diets are small quantities of meat or fish and seafood.

Figure 6. Food prices for items included in least cost diets (2011 USD per 1,000 kcal)





Note: Data shown are means and standard deviations for the cost per calorie of foods selected for least-cost diets in each country, in each region and food category. Items selected are a subset of those shown in Figure 1.

Table 2 shows the extent to which each of the required micronutrients, energy and macronutrients is provided by items from each of the 8 food groups. For energy, protein, carbohydrates, a majority of elements and three B vitamins, more than half of daily intakes in the least cost diet come from starchy staples. For folate, vitamin A and C, vegetables and legumes are the major food source. Small quantities of meat in the least-cost diets supply a majority of the required vitamin B12 and substantial vitamin A, while oils and fats bring most vitamin E and lipids. These results highlight the importance of considering the entire diet across diverse food groups needed to meet all requirements at least cost in each food environment (Table A5 in Annex).

Table 2. Share of energy and nutrients in least cost diets, by food group

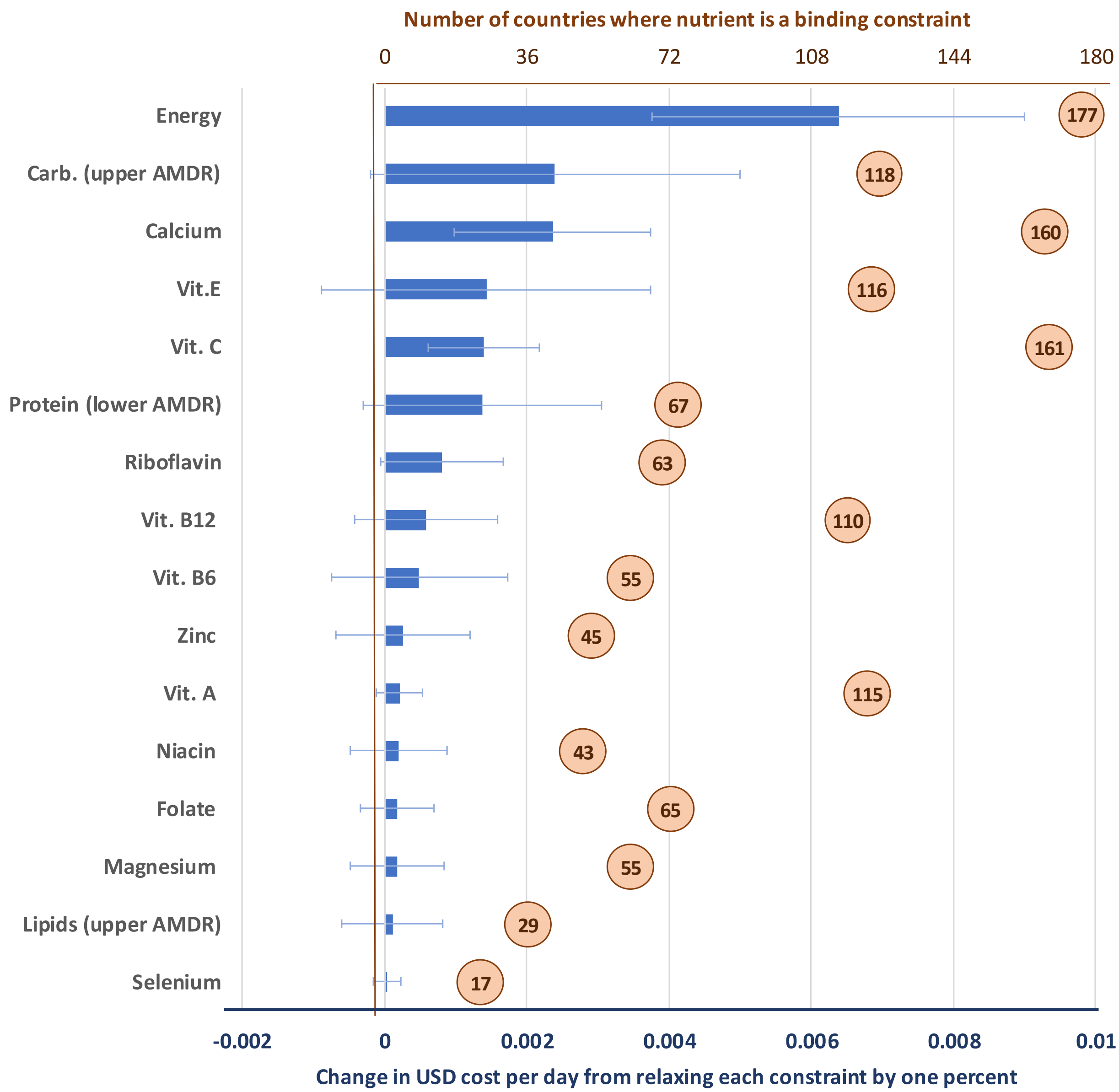
	Starchy Staples	Veg. & legumes	Fruits & nuts	Meat	Dairy & eggs	Fish & seafood	Oils & fats	Others
Energy	**65.6**	8.4	4.6	0.4	4.4	0.7	15.0	1.1
Protein	**65.0**	19.3	6.0	1.9	5.0	2.7		0.1
Carbohydrate	**85.6**	9.6	1.6	0.1	1.4			1.8
Lipids	16.9	1.4	11.9	0.5	11.0	1.3	**57.1**	0.0
Elements								
Calcium	**61.6**	19.6	2.4	0.1	13.3	2.5		0.5
Iron	**60.1**	31.8	4.1	2.1	0.4	1.2	0.1	0.2
Magnesium	**67.6**	21.8	6.6	0.3	2.7	0.7		0.3
Phosphorus	**65.5**	16.2	5.2	1.9	8.2	2.8		0.1
Zinc	**67.2**	18.9	5.4	2.5	4.8	1.1		0.0
Copper	47.8	22.3	7.7	20.7	0.5	0.8		0.2
Selenium	**87.6**	3.0	1.1	2.2	2.8	3.2		0.1
Vitamins								
Vitamin C	14.9	**59.7**	20.4	0.3	1.1	0.1		3.5
Thiamin	**70.2**	21.2	5.6	0.6	1.9	0.3		0.2
Riboflavin	46.2	22.6	2.9	12.1	14.6	1.5		0.1
Niacin	**73.1**	10.1	9.9	4.1	0.5	2.1		0.1
Vitamin B6	**70.3**	19.4	3.8	3.2	2.4	0.7		0.2
Folate	36.2	**50.6**	8.2	3.1	1.2	0.3		0.4
Vitamin B12	0.2			**73.6**	9.7	16.5		
Vitamin A	3.3	48.1	0.5	39.3	8.1	0.5	0.2	0.1
Vitamin E	12.1	9.5	8.1	0.1	0.9	0.9	**68.4**	0.1

Note: Data shown are the percent of total energy and of each nutrient obtained from each food group in the least cost diets, summed horizontally to equal the total required for nutrient adequacy. Darker colors are larger shares, with numbers over 50% shown in bold. Starchy staples include all cereals and white root vegetables. The "others" category includes sugar, sweets and caloric beverages.

The nutrients whose requirements most influence the affordability of nutritious diets are listed in Figure 7, which shows the number of countries where each nutrient affects the least-cost diet, and the increase in diet costs per day for a one percent change in that requirement. These shadow price semi-elasticities reveal that, given the composition and prices of available foods, diet costs are most sensitive to variation in the need for energy, the upper bound for carbohydrates and the lower bound for protein within the AMDR, and lower bounds set by the AER for a variety of vitamins and minerals. These results have several important implications.

First, consideration of AMDRs is clearly important to avoid the excess carbohydrates in starchy staples and include more expensive protein-rich foods. Then for micronutrients, a wide range of different requirements are binding, requiring foods from diverse sources to meet all constraints at once. Some nutrient constraints such as for vitamin A and B12 are often binding but each one percent change in adequacy comes at a low cost with small quantities of available foods, whereas any change in constraints such as calcium and vitamin C would be much more expensive. There is a wide range of sensitivity to each constraint across countries, reflecting differences in availability and prices of items able to meet those constraints at low cost. Finally, upper level constraints other than the AMDRs do not appear on this list, because enough nutrient-rich foods are available with moderate levels of sodium and other potentially harmful nutrients to stay below those upper bounds.

Figure 7. Sensitivity of diet costs to changes in nutrient requirements



Note: Data shown are the number of countries where each nutrient constraint is binding (in circles), and the population-weighted global mean for the cost per day of a one percentage point change in that requirement (bars, with range of standard deviation). Values are shown for nutrients that are binding in ten or more of the 177 countries, all of which are lower-bound AERs except for energy and the AMDRs.

How do calorie shares of foods compare across the least cost nutritious diet and national food balance sheets?

Least-cost diets use available foods to meet nutritional criteria without reference to actual consumption, so the link between them and a population's food choices reveals how tastes and preference relate to nutrient adequacy. At very low income levels people may be unable to afford nutrient adequacy even if they wanted it, while higher income people may not need to consume the least-cost sources of each nutrient. Furthermore, people at any income level might not know what nutrients are in each food, or what are their personal nutrient requirements. Figure 8 compares least cost diets to each country's national average consumption pattern, as measured by the share of total dietary energy obtained from each food group as recorded in FAO food balance sheets. In those FAO data, quantities consumed are estimated by subtraction, from production plus imports minus exports, nonfood uses, and losses prior to acquisition by each household (FAOSTAT 2011). We use these estimates here because the balance sheets provide a complete accounting of total calories from all foods consumed, and are therefore directly comparable to the least-cost diets. In contrast, estimated intake of dietary risk factors derived from survey information such as the Global Dietary Database often concerns aspects of diet quality that are not calorie shares such as dietary fiber.

The contrast in calorie shares between least cost diets and food balance sheets is shown in Figure 8, using scatter plots and a nonparametric estimate of the mean and its confidence interval at each income level. The patterns are striking. In the poorest countries, starchy staples provide about the same share of least cost diets as of actual consumption, and actual consumption of all vegetal foods actually exceeds its fraction of energy in least cost diets. Unlike least cost diets, low income countries' national average consumption in food balance sheets may be deficient in several nutrients. At higher income levels, the share of calories actually provided by starchy staples falls sharply, a pattern known as Bennett's Law (Clements and Si 2017), and the food groups that replace starchy staples are primarily animal-sourced, especially meat whose average consumption rises from under 5 to over 10% of dietary energy with increases in income from 4,000 to 40,000 dollars per year. More meat consumption at higher incomes is clearly driven by preferences rather than prices or nutrient requirements, since nutrient adequacy can be reached at lowest costs with meat and fish typically providing less than 2% of total dietary energy. In contrast, high prices lead dairy and eggs to be omitted entirely from least-cost diets in almost all low- and lower-middle income countries, but in high income countries they are included in large quantities providing around 8% of dietary energy in the least-cost diets. Other food groups that provide a larger share of least cost diets than of actual food consumption are vegetables and legumes at high income levels, and fruits and nuts at lower income levels. This comparison provides useful guidance on the role of nutrients in food system development, including particularly how more meat consumption at higher income levels is not needed for nutrient adequacy, while changes in the price of dairy and eggs do affect their inclusion in least cost diets on a large scale.

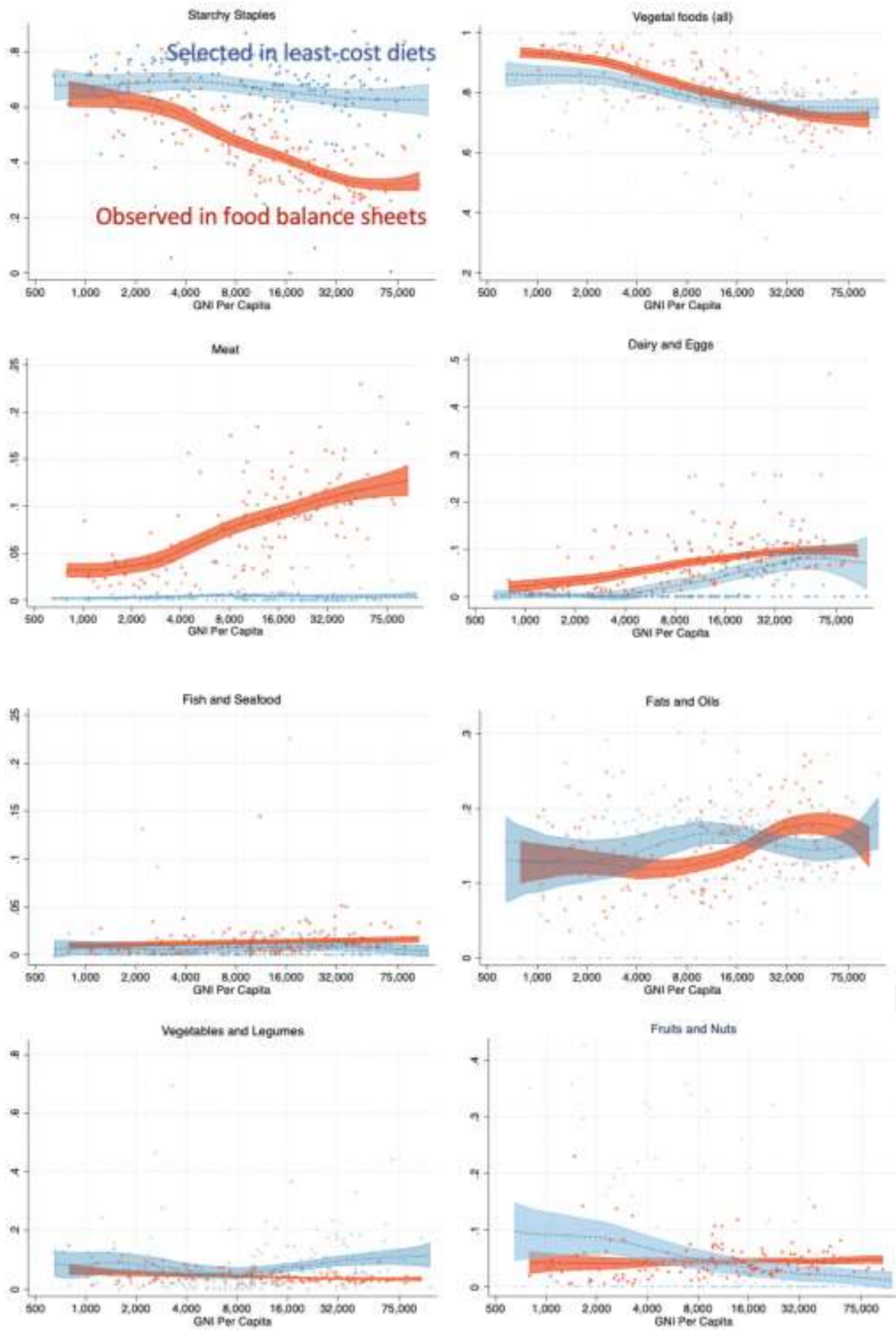


Figure 8. Calorie shares of major food groups as observed in national Food Balance Sheets (dark color, red in online versions) and in each country's most affordable nutrient adequate diet (light color, blue in online versions). Lines show means at each income level with their 95% confidence from a local polynomial regression, dots show individual countries (n=151)

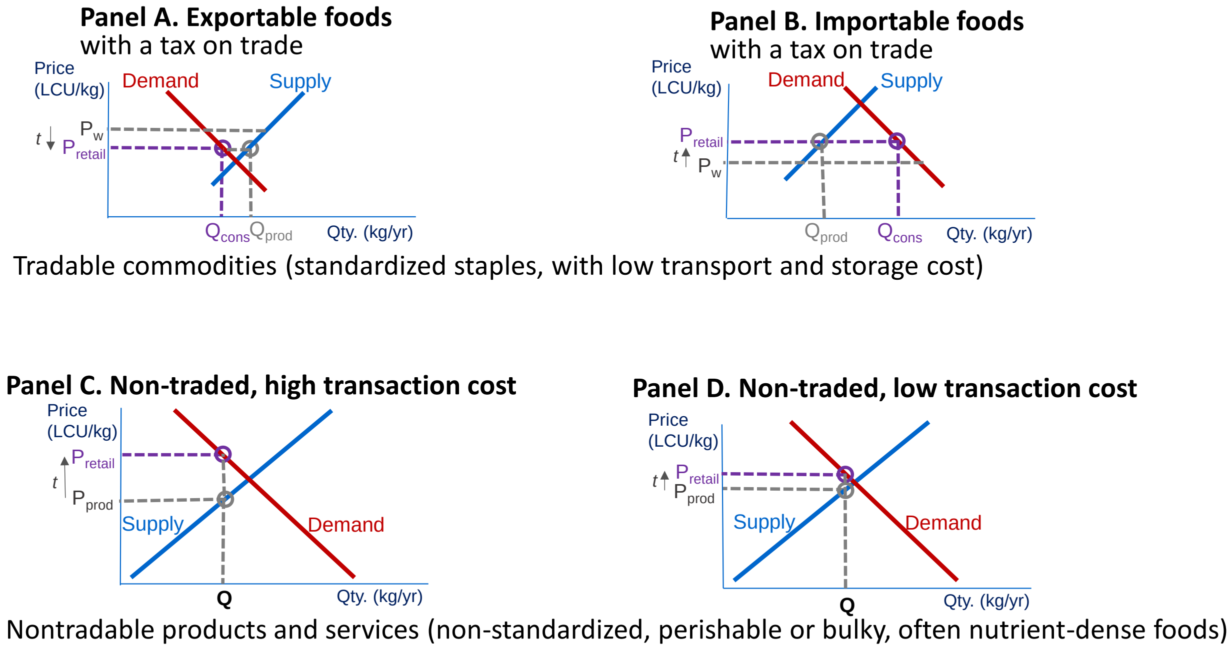
3.2 Hypothesis tests

Is the cost of nutritious diets associated with structural indicators of economic development?

The patterns shown in Figures 2-8 suggest that a wide variety of factors may affect the cost of adequate nutrients across geographic regions and national income levels. To explore potential links between these factors and a country's economic development, we test for associations between cost of nutritious diets and a variety of structural and market development indicators. The correlations we find are unlikely to be causal, as structural transformation is an inherently circular process with many feedback loops, but patterns could reveal useful stylized facts about how economic development relates to the cost of nutrient-adequate diets.

The central hypothesis motivating our work is that systemic factors in food production and distribution, including differences in post-harvest food systems, play an important role in the retail cost of a nutritious diet. The economic principles behind this hypothesis are illustrated in Figure 9. The top row shows drivers of food consumption, production and price for those food commodities that are easily transported and stored, whether they are exportable (Panel A) or importable (Panel B). In both cases, long-distance trade links the price at each location to world market prices (P_{world}), plus or minus any taxes, tariffs or transport margins denoted t, separating the quantity consumed (Q_{cons}) at each location from its quantity produced (Q_{prod}). The bottom row shows the mechanisms that drive consumption, production and price of location-specific services and items that are highly perishable, bulky or fragile for long-distance trade. For those foods, the bottom row of Figure 9 shows how each location's quantity consumed and produced (Q) depends on the cost of transactions (t) between producers who receive P_{prod} and local retail prices (P_{retail}) which may be high (Panel C) or low (Panel D).

Figure 9. Models of price formation influencing the cost of a nutritious diet



Source: Authors' illustration of hypothesized mechanisms affecting consumer prices (P_{retail}), based on differences in agricultural policy and food systems across countries and types of food.

Nutritious diets involve a combination of items whose overall cost per day depends on different combinations of the market forces shown in Figure 9. Cereal grains, legumes and pulses as well as sugar, vegetable oil and other commodities are stored and traded over long distances, so consumption is separated from local supply, and prices depend on access to trade. For these products, agricultural production is geographically concentrated so most of the world's population lives in importing regions, and as shown in Panel B higher transaction costs would raise consumer prices. Higher transaction costs for nontradable bulky or perishable products like eggs, fresh dairy and many fruits and vegetables also raise prices as shown in Panels C and D, but their price also depends on the level of local supply and demand (Maestre et al. 2017).

Figure 9 shows each market separately, but in food systems they are all interconnected. For example, feed grains are widely traded so their prices affect the cost of eggs and dairy, and foods substitute for each other so supply and demand are linked across markets. System-level changes discussed in Reardon and Timmer (2012) and other descriptions of structural transformation suggest that, at each level of per-capita income, countries might have a relatively lower cost of essential nutrients when they have:

1. A larger service sector, offering more horizontal competition but also more vertical integration in post-harvest handling across markets;
2. Greater urbanization, which concentrates consumers in space and allows for scale economies in farm-to-market supply chains;
3. Easier rural transportation and access to electricity, thereby improving the efficiency of transport and storage from farm to market; and
4. Easier access to international markets, including lower import tariffs, for tradable items that enter local food systems.

These four hypotheses predict stylized facts about the retail prices shown in Figure 9. In the short run and for any particular food, many diverse factors would intervene to shift supply and demand, and those factors would also influence our macroeconomic variables such as urbanization and service orientation of the economy, roads and electrical infrastructure, and trade policy.

With this foundation, we run robust regressions (the *rreg* command in STATA v15, which limits the influence of outliers) to examine associations between the cost and affordability of nutritious diets and key predictor variables that are summarized in Appendix Table A8. We present regression results for three outcome variables: log of CoNA, log of CoNA as a share of household food expenditure, and log of CoNA as a share of all household expenditure. Our regression models control for national income, population and region fixed effects to absorb the differences in agroecology, culture and data-collection systems associated with ICP regions, while are main transformation indicators reflect urbanization, travel times to cities, electrification

Table 4 presents results for CoNA, in logarithmic form. Our results show that rural travel time to cities is significantly correlated with CoNA, providing suggestive evidence that CoNA is linked to the remoteness of rural populations (indicated by shorter travel times to cities). Doubling such travel times is associated with nearly 6.2 percent higher CoNA. Results for rural population with access to electricity and service sector labor share are not statistically different from zero. However, we see that CoNA decreases when the urban population share increase at 10 percent level of statistical significance.

Table 4. Structural transformation and the minimum cost of nutrient adequacy

	(1)	(2)	(3)	(4)	(5)	(6)
lnGNI p.c.	-5.567**	-5.041*	-5.174**	-2.583	-5.407**	-2.062
	(2.563)	(2.579)	(2.561)	(2.523)	(2.599)	(2.535)
lnGNI p.c., squared	0.683**	0.625**	0.641**	0.353	0.670**	0.299
	(0.288)	(0.289)	(0.287)	(0.283)	(0.293)	(0.285)
lnGNI p.c., cubed	-0.027**	-0.025**	-0.026**	-0.015	-0.027**	-0.014
	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)
Services share of labor force		0.002				0.003
		(0.002)				(0.002)
Urban share of population			-0.002			-0.003*
			(0.001)			(0.002)
Rural travel time to cities (log)				0.058***		0.062***
				(0.021)		(0.021)
Rural electricity access (pop share)					-0.001	-0.000
					(0.001)	(0.001)
N	138	138	138	138	138	138
R2	0.579	0.585	0.587	0.616	0.581	0.637
F	14.349	13.423	13.566	15.325	13.235	13.253

Note: Dependent variable is the natural log of CoNA in purchasing power parity (PPP) terms for all goods and services consumed by households, which is the same deflator as GNI per capita. Standard errors in parentheses, with significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications control for log population size (level, squared and cubed) and include indicator variables for ICP regions (these coefficients are not shown in this table).

Table 5 repeats these specifications replacing the dependent variable with log CoNA as a share of household food expenditure. Our results show that both access to electricity and rural travel time are significantly associated with the affordability of nutritious diets. We detect that a doubling of travel time to the nearest city is associated with an 12.4 percent higher ratio of CoNA to household food expenditure, while a doubling of the share of the population with access to rural electricity is associated with an 0.4 percent lower ratio of CoNA to household food expenditure. Moreover, we also find that an increase in the service share of the labor force is correlated with higher ratio of CoNA to household food expenditure.

Table 5. Structural transformation and affordability of nutritious diets

	(1)	(2)	(3)	(4)	(5)	(6)
lnGNI per capita	-5.968	-8.591*	-6.709	-4.319	-7.425*	-7.947**
	(4.555)	(4.438)	(4.575)	(4.206)	(4.412)	(3.995)
lnGNI per cap., sq.	0.570	0.855*	0.643	0.387	0.772	0.807*
	(0.511)	(0.498)	(0.513)	(0.472)	(0.497)	(0.450)
lnGNI per cap., cu.	-0.019	-0.030	-0.022	-0.012	-0.028	-0.029*
	(0.019)	(0.018)	(0.019)	(0.017)	(0.018)	(0.017)
Services share of labor force		0.009***				0.009***
		(0.003)				(0.003)
Urban share of population			0.004			0.001
			(0.003)			(0.002)
Rural travel time to city >50k (log)				0.126***		0.124***
				(0.035)		(0.033)
Rural electricity access (pop share)					-0.005**	-0.004**
					(0.002)	(0.002)
N	138	138	138	138	138	138
R2	0.650	0.681	0.658	0.704	0.671	0.751
F	19.336	20.365	18.352	22.679	19.455	22.777

Note: Dependent variable is the natural log of the ratio of CoNA to per-capita household expenditure on food and non-alcoholic beverages. Standard errors in parentheses, with significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications control for log population size (level, squared and cubed) and include indicator variables for ICP regions (not shown).

Results in Table 5 are robust to replacing the outcome variable with the log CoNA to all household expenditure, as shown in the Annex Table A10, suggesting that nutritious diets may be more affordable in countries with more rural electricity and less rural remoteness. Regression results for other outcome variables such as CoCA and CoNA/CoCA ratio showed no significant association with any of the structural and market development indicators.

In the annex of supplemental information (Table A11), we extend these results to address the potential effects of agricultural trade policies. Nominal rates of protection were available for 54 of the 136 countries included in Tables 4 and 5. We aggregate the NRPs for calorie-dense foods (grains and starchy staples) and nutrient-dense foods (fruits and vegetables, diary, animal-sourced foods, etc.). Including those indicators in the specifications shown in Table A11 demonstrates a clear association between higher tariffs on nutrient-dense foods and higher CoNA. We estimate that the mean tariff on nutrient-dense foods (23.5% in this limited sample) increases CoNA by $0.10 per day compared to no tariffs; adding one standard deviation above the mean tariff on nutrient-dense foods increases CoNA by $0.27 per day – a large increase relative to the mean CoNA of $1.07 for low-income countries. In contrast, tariffs on calorie-dense foods have no significant association either CoNA or CoCA.

Is the affordability of nutritious diets associated with nutrition outcomes and dietary intake?

The last aim of this study is to describe the relationship of diet costs with nutrition outcomes and dietary intake at the national level. Since we have a large number of variables, regression results are provided in the annex of supplemental information, describing links with anthropometric outcomes (prevalence of adult obesity and child stunting), symptoms of malnutrition (prevalence of female and child anemia as well as vitamin A and zinc deficiency), and estimated intake of eight specific dietary risk factors (total fruits, total vegetables, whole grains, leguminous grains, nuts and seeds, fiber, seafood, and milk).

To visualize the relationship of diet costs with nutrition outcomes allowing for variation in functional forms, we used semi-parametric regressions reported in Figures A5-A7. These compare the association of each outcome with our two metrics that do not require currency conversion, namely affordability of CoNA as a share of all household expenditure (in log form) and the CoNA premium as a multiple of CoCA. In countries where nutritious diets are least affordable, we observe more prevalence of stunting and a smaller prevalence of obesity, as well as more prevalence of anemia, vitamin A deficiency, and zinc deficiency. This relationship holds only for affordability as a share of household expenditure, revealing that cross-country variation in diet costs relative to income is much larger and more significant than variation in the nutrient premium relative to starchy staples. Parametric tests of the link between affordability and nutrition outcomes is reported in Table A13, showing significance only for adult women's anemia prevalence and not for the other outcomes, after controlling for a cubic function of GNI per capita, urbanization and sanitation as well as indicator variables for geographic region. We then used similar regressions to describe the relationship between affordability, again measured as CoNA's share of average household expenditure (in log form) with a variety of controls such as a cubic function of GNI per capita, urbanization, rural travel times and rural electrification. Those show significance for 3 of the 8 dietary factors (fruits, fiber and milk), whereas the others are significantly correlated only with the control variables.

4. Discussion

This study uses nutrient composition and retail prices of available items to describe food systems in nutritional terms, identifying stylized facts about food prices, the cost of meeting all nutrient requirements, the sensitivity of diet costs to variation in each individual nutrient, relationships between least-cost diets and food consumption patterns, and links between diet costs and other aspects of national food systems such as rural electrification as well as nutrition outcomes.

Limitations of the study

We use a single, nationally representative average set of prices to obtain a single diet cost for each country, whose relevance to any particular question is limited by our data and methods.

First, the standardization imposed by the IPC provides a transparent method with which to compare countries, but international lists may omit the lowest-cost foods use by specific populations, and national average prices omit a country's lowest-cost marketplaces or other ways of acquiring food such as donations or self-provisioning. The timing of observation also matters, as 2011 was an unusually high-priced year for many internationally traded commodities, and using a single price omits seasonality and fluctuations that allow people to substitute between foods over time. Future work could use our methods to address similarities and differences in ICP data from 2011 to newly released 2017 prices (Bai and Masters 2020), and track changes such as the COVID pandemic (Akter 2020, Narayanan and Saha 2020).

Second, our focus on international comparisons also leads us to select a single set of nutrient requirements, notably EARs for a representative adult woman of reproductive age which aims to meet median requirements in a healthy population. In related work we explore variation in needs around that benchmark (Bai and Masters 2019), and address how individual variation affects whole households (Schneider 2020). Focusing on nutrients is useful to guide interventions designed to help a population avoid specific deficiencies (WFP 2020), and also reveals opportunities for nutrient needs to be met by different food groups (as we found for substitution from eggs and dairy to vegetables and legumes), but a nutrient-by-nutrient approach misses the role of other food attributes such as phytochemicals and other compounds, bioavailability and the food matrix that are addressed in national dietary guidelines and other recommendations such as the EAT-Lancet reference diets. The resulting cost of recommended diets (CoRD) is more expensive than just nutrients as shown by Hirvonen et al. (2019) and Herforth et al. (2020).

A final limitation of our study concerns the focus on affordability. Counting only the most affordable items to meet requirements helps identify substitutions that improve cost-effectiveness, but selecting on extreme values makes least-cost diets more vulnerable to measurement error than methods that use a weighted average of all foods. Ongoing research aims to overcome these limitations with improved data and measurement methods, in partnership with national statistical services and international development agencies.

Key findings

Our primary finding is that nutrient adequacy remains out of reach for the world's poorest people. It costs an average of $1.35 per day in 2011 purchasing power parity terms, more than twice the cost of daily subsistence from a starchy staple which averages $0.57 per day (Table 1). In the nutrient-adequate diets, starchy staples provide about two-thirds of dietary energy and also deliver 50% of supply for 11 of the 20 essential nutrients we consider (Table 2), but the remaining nutrients are expensive to obtain. The nutrients for which other food groups are needed include lipids and vitamin E that are mostly supplied from vegetal oils and fats, vitamin C and folate that come mostly from vegetables and leguminous grains, B12 that is provided mostly by meat, and vitamin A that comes from both meat and vegetal sources. Worldwide, the sum of all animal-source foods adds up to 5.5% of dietary energy in these nutrient adequate diets, primarily dairy and eggs (4.4%), with much smaller quantities of fish and seafood (0.7%) or meat (0.4%).

Our second finding is substantial variation among countries at each level of national income and within geographic regions. Most differences among income groups and regions are not statistically significant (Figure 1), with the exception that higher income countries have lower prices for dairy and eggs as noted earlier by Headey and Alderman (2019). Overall diet costs and the premium for nutrient adequacy over daily energy varies relatively little with national income (Figures 2 and 3), as a result of which nutritious diets are often out of reach for households in low-income countries (Figure 4). The only significant differences within the least-cost diets at each level of economic development is substitution into dairy and eggs to meet nutrient needs in higher-income countries, displacing primarily vegetables and leguminous grains (Figure 5). In lower-income countries, vegetables and legumes play a larger role, as do lower-priced fruits and nuts that are available and selected for least-cost diets (Figure 6) even more than their actual share of total consumption as estimated by food balance sheets (Figure 8).

A third finding concerns sensitivity of dietary costs to energy and nutrient constraints. For example, each one percent increase in daily energy needs would cost an average of 0.6 cents per day (Figure 7), which amounts to 2.8 cents per 100 additional calories. This is below the whole diet's average level of 6.4 cents per 100 calories, which costs $1.35 for 2,109 kcal/day, because additional energy can be obtained from low-priced starchy staples and vegetable oil (Figure 6), although the upper-bound AMDRs for carbohydrates and lipids are often binding and may require substitution into a more balanced mix of energy sources. The micronutrients that are binding in a majority of countries are calcium and vitamins A, C, E and B12, driving the composition of least-cost diets towards foods that deliver just enough of those nutrients while also meeting all other requirements.

Finally, we show that differences in least-cost diets could potentially be explained with the standard economic models used to address price formation and food choice (Figure 9). These models show how transaction costs affect retail prices, and how the local agriculture affects prices for bulky and perishable items more than internationally traded items whose prices are determined in world markets. We use these insights to test whether cross-country differences in a few systemic variables can help explain the level of diet costs, finding statistically evidence primarily for rural travel time (Tables 4 and 5). We interpret these results as being consistent with value chain inefficiencies inflating the cost of perishable but nutrient-dense foods in countries where the rural population is geographically dispersed. We also find some significant but modest associations with nutrition outcomes, particularly the prevalence of micronutrient deficiencies (not shown in the main text). Given the small sample size and many confounders we cannot expect robust findings from any cross-country regression, but these results do indicate that overall diet costs could potentially provide actionable information in more future studies with more statistical power.

Policy implications

Our findings have four important implications for nutrition-sensitive food policies.

First, we demonstrate the value of using retail prices, nutrient composition data and least-cost diets to quantify food systems in nutritional terms, identifying how human requirements can be met in the most affordable way. Previous use of food prices to guide policy has long focused on individual foods especially agricultural commodities to address farm income and food choice, or analysis of all retail prices in proportion to expenditure shares to measure overall inflation. Calculating the cost of diets chosen to meet nutritional targets helps guide intervention to the most important populations, foods and nutrients, for example the need to lower the cost of low-carbohydrate foods to stay within average macronutrient distribution ranges, and opportunities for lower-priced eggs and dairy to improve affordability as suggested by Headey and Alderman (2019).

Second, we confirm earlier findings that nutrient-adequate diets are currently out of reach for the poorest, reinforcing results such as Allen (2017), Hirvonen et al. (2019) and Herforth et al. (2020). Many nutrition interventions in the developing world have focused on improving nutritional knowledge (Dewey 2008) which could be of life-saving importance for infants and young children who need only small quantities of each food, but if the larger volumes needed by older children and adults remain unaffordable then nutritional adequacy can be achieved only through transfer programs and social protection. Safety nets and other interventions to help people meet nutritional needs at low cost would need to address not only the differences across countries presented in this study, but also take account of seasonal, spatial and demographic variation within countries as shown by Masters et al. (2018) and other country studies.

Third, while targeted nutrition-sensitive interventions and safety nets are important now, large and sustained improvements in the long run depends on higher earnings among low-income households. Systemic linkages between international trade, migration and urbanization, agricultural production and rural demography provide a variety of mechanisms to promote pro-poor economic growth beyond what can be discerned from household surveys, calling for modelling evidence on the poverty impacts of specific agri-food investments and policies such as Benfica, Cunguara and Thurlow (2019).

Finally, to inform food system policies and programs, our findings reveal the usefulness of tracking the nutritional value and prices of available foods at each time and place. The cost of nutritious diets has already been integrated into policy dashboards (Fanzo et al. 2020) and official reports (FAO et al. 2020), and offers a promising metric for monitoring food system changes in response to shocks such as the COVID pandemic in high-income countries (Akter 2020), low-income countries (Narayanan and Saha 2020) and worldwide (Masters 2020).

Accurate targeting of food system interventions will require updated prices for a wide range of representative items available at each time and place, matched to food composition and nutritional requirements. We hope that this study spurs both demand for and supply of the data needed to make nutritious foods more affordable for low-income people, guided by new evidence on market prices and diet costs.

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Annex of supplementary information for

Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries

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Supplemental tables and charts

TABLES

FIGURES

Table A1. Essential nutrients included in least-cost diets, their functions and food sources

Nutrient	Daily Requirements[a]	Health functions	Nutrient-dense foods
Calcium	800 mg	Bone growth and health; blood clotting; nerve impulse transmission, muscle contractions, enzyme regulation	Dairy products (milk, yoghurt, cheese, etc.), Chinese cabbage, kale, broccoli
Iron	8.1 mg	Functional component of hemoglobin and other key compounds used in respiration, immune function, cognitive development and energy metabolism	The most bioavailable (heme) iron comes from meat, poultry and fish. Other less readily absorbed (non-heme) sources of iron include fortified plant-based foods such as breads, cereals and breakfast bars
Magnesium	255 mg	Bone formation, enzyme function, nerve and heart function	Green leafy vegetables, whole grains, nuts, chocolate and legumes
Phosphorous	580 mg	Bone/ teeth growth and health; plays a role in maintaining a normal pH and tissue growth; integral part of several metabolic processes	Dairy products, processed foods, fish, soft drinks, bakery products, meats
Zinc	6.8 mg	Required for many enzymes; immune function; growth and development; regulation of gene expression; stabilizes cell membranes and body proteins	Meat, shell fish, legumes, fortified cereals and whole grains
Copper	0.7 mg	Plays role in enzyme function, growth, cardiovascular integrity, lung elasticity, neovascularization, neuroendocrine function, and iron metabolism	Organ meats, sea foods, nuts, seeds, wheat-bran cereals and whole grain products
Selenium	45mcg	Serves as antioxidant and catalyst for the production of active thyroid hormone; needed for proper functioning of immune system	Meat, sea food, grains, dairy products, fruits and vegetables
Vitamin C	60mg	Serves as an antioxidant and a cofactor in enzymatic and hormonal processes; biosynthesis of carnitine, neurotransmitters, collagen; modulates the absorption, transport, and storage of iron	Fruits and vegetables including citrus fruits, tomatoes, potatoes, strawberries, spinach, and cruciferous vegetables
Vitamin B1 (Thiamin)	0.9 mg	Serves as a coenzyme in the metabolism of carbohydrates and energy release	Grain product, pork, ham and fortified meat substitutes

Vitamin B2 (Riboflavin)	0.9 mg	Functions as a coenzyme in numerous oxidation–reduction reactions in several metabolic pathways and in energy production	Dairy product, bread products, and fortified cereals
Vitamin B3 (Niacin)	11 mg	Coenzyme in reduction-oxidation reactions such as intracellular respiration, the oxidation of fuel molecules, and fatty acid and steroid synthesis	Meat, liver, poultry, fish, whole grain breads, and fortified cereals
Vitamin B6	1.1 mg	Coenzyme in the metabolism of amino acids, heme synthesis, lipid metabolism; homocysteine metabolism	Highly fortified cereals, beef liver and other organ meats, and highly fortified, soy-based meat substitutes
Folate	320 mcg	Coenzyme in DNA synthesis, homocysteine metabolism	Dark green vegetables, beans and legumes and fortified grain products.
Vitamin B12	2 mcg	Serves as a cofactor in DNA synthesis and in both amino acid and fatty acid metabolism; plays a role in normal functioning of the nervous system and development of red blood cells.	Animal products such as meat, milk, eggs and fish; fortified plant-based foods (cereals)
Vitamin A	500 μg RAE[b]	Vision, gene expression, reproduction, embryonic development, growth and immune function.	Liver, dairy products, fruits and vegetables (carrots, broccoli, squash, peas, spinach, etc.), fortified grains, etc.
Vitamin E	12 mg	Functions as a chain-breaking antioxidant in the body by preventing the spread of free-radical reactions.	Vegetable oils and spreads, unprocessed cereal grains, nuts, fruits, vegetables, and meats (especially the fatty portion)

[a]The daily requirements refer to the estimated average requirement (EAR) for a representative woman of reproductive age based on the dietary reference intake (DRI).

[b]RAE = Retinol activity equivalent, 1μg RAE=1μg Retinol 12 μg β-carotene, and 24 μg α-carotene or β-cryptoxanthin.

Sources: Wardlaw's Perspectives in Nutrition (2016), and Dietary Reference Intakes: The Essential Guide to Nutrient Requirements, National Academy of Sciences (2006).

Table A2. Nutrient constraints used for computation of least-cost diets

Nutr No.	Nutrient	unit	EAR	AMDR lower	AMDR upper	UL	UL Note
1	Energy	kcal	2,109[1]				
2	Protein	g	37.6	52.7	184.6		
3	Lipids	g		46.9	82.0		
4	Carbohydrate	g	100	237.3	342.8		
5	Calcium	mg	800			2500	
6	Iron	mg	8.1			45	
7	Magnesium	mg	255			350	supplements
8	Phosphorous	mg	580			4,000	
9	Zinc	mg	6.8			40	
10	Copper	mg	0.7			10	
11	Selenium	mcg	45			400	
12	Vitamin C	mg	60			2,000	
13	Thiamin	mg	0.9				
14	Riboflavin	mg	0.9				
15	Niacin	mg	11			35	supplements
16	Vitamin B6	mg	1.1			100	
17	Folate	mcg	320			1,000	supplements
18	Vitamin B12	mcg	2				
19	Vitamin A	mcg	500				
20	Retinol	mcg				3,000	preformed Vit.A only
21	Vitamin E	mg	12			1,000	supplements
22	Sodium	mg				2,300	CDRR[2]

Note:
1. Energy intake for a woman with age of 24.5, weight of 57kg and height of 163cm, and at low active physical activity level;
2. CDRR refers to the Chronic Disease Risk Reduction Intake for sodium.

Table A3. Number of countries and food items included in ICP data and in least-cost diets

	Number of countries using each food list	Number of items on each food list	Number of items for CoNA generation	Number of items ever included in any least-cost diet	Number included in significant quantities (≥50g/day)
All foods	177	823	671	150	90
Global list	177	201	166	67	43
Regional lists					
Africa	50	203	162	29	19
Asia	23	167	132	27	17
W. Asia	12	177	150	15	2
LAC	16	75	61	12	9

Note: ICP data include 79 countries with food prices from only the global list of internationally-standardized items, outside the four continents with region-specific food lists.

Table A4. Number of price observations and example items by food category

Food category using ICP classification (COICOP)	Number of price observations	Typical examples in each category
Fish and seafood	2,592	Canned sardine with skin, Dried small fish, Fishball
Fruits and nuts	3,175	Orange, Banana, Grapes, Roasted groundnuts
Meat	4,312	Whole chicken, Pork liver, Mutton/goat liver, Beef liver, Mutton liver
Milk, cheese and eggs	2,665	Milk (unskimmed pasteurized), Powdered milk, Sour cream, Ghee
Oils and fats	2,770	Sunflower oil, Olive oil, Corn oil, Palm oil, Soybean oil, Peanut oil, Vegetable oil
Starchy staples (cereals & white root vegetables)	6,371	White rice, Brown rice, Wheat flour, oats, Maize flour, Millet, Sorghum, Baguette, White bread, Roll, Short pasta, Cream crackers, Dried noodles, Brown potatoes, Cassava, Tinned sweet corn
Others (sweets and beverages)	2,009	White sugar, Brown sugar, orange juice, carbonated beverages
Vegetables and legumes	4,379	Bean curd, Spinach Chinese, Bell pepper, Carrots, Onion, Green cabbage, Cassava leaves, Sweet potato leaves, Rape leaves, Chives, Taro leaves, Dried white beans, Dried black beans, Lentils, Green/Mung beans, Pigeon peas
Total	28,273	

Table A5. Number of foods included in least-cost diets, by food category

Food category using ICP classification (COICOP)	Pct. of countries	Ave number of items	Ave # where included
Starchy Staples (cereals & white root veg.)	99%	3.01	3.03
Vegetables & legumes	94%	1.74	1.86
Oils and fats	89%	1.15	1.29
Meat	67%	0.69	1.03
Fruits and nuts	48%	0.53	1.11
Milk, cheese and eggs	38%	0.40	1.06
Fish and seafood	32%	0.33	1.02
Others (sweets and beverages)	11%	0.11	1.00
Total number of items included in least-cost diets needed for nutrient adequacy		8.02	8.02

Table A6. Food and beverage prices available from ICP 2011 global and regional lists

ICP Food item (sorted by number of observations)	Regional/ Global	Number of observations	Mean price[1] (2011USD/kg)
Banana, standard	Global	175	3.2
Carrots	Global	174	2.5
Cucumber	Global	174	3.1
Spaghetti	Global	174	4.3
Wheat flour, not self-rising	Global	173	1.8
Strawberry/apricot jam	Global	172	10.4
Onion	Global	172	2.0
Orange	Global	171	3.3
Round tomato, loose	Global	171	3.2
Margarine, regular fat	Global	170	8.8
Carbonated soft drink [specified brands] (large)	Global	170	1.7
Brown potatoes	Global	168	2.3
Olive oil	Global	168	19.8
Carbonated soft drink [specified brands] (small)	Global	168	3.2
Sliced white bread	Global	167	4.4
Butter, unsalted	Global	166	17.0
Eggplant (aubergine)	Global	165	3.2
Potato chips	Global	164	17.9
Canned sardine with skin	Global	163	14.6
Watermelon	Global	163	3.5
100% beef, minced	Global	163	12.1
Canned tuna without skin	Global	163	19.7
Cheese, processed	Global	163	21.4
Salted butter	Global	162	17.5
Flavored biscuits/cookies sweet	Global	162	10.0
Lemon	Global	162	5.7
Bell pepper	Global	162	5.4
White sugar	Global	162	2.3
Chicken legs	Global	161	9.4
Pineapple	Global	161	5.9
Milk, un-skimmed UHT	Global	160	2.7
Yoghurt, plain	Global	159	6.7
Lettuce	Global	159	4.8
Beef, Rump steak	Global	158	17.2
Natural honey, mixed blossoms	Global	158	18.1
Tomato paste (small)	Global	157	8.2
Beef, fillet	Global	157	24.9
Sandwich biscuits/cookies	Global	157	9.8
Cauliflower	Global	156	9.5
Large size chicken eggs	Global	155	7.3
Sunflower oil	Global	153	5.4
Milk, un-skimmed pasteurized	Global	153	2.5
Butter biscuits	Global	152	11.7
Chicken breast without skin	Global	152	21.4
Pork, ribs	Global	152	16.7
Cream cheese	Global	151	19.3
Whole chicken	Global	151	9.9
Salted crackers	Global	151	12.5
Instant noodles	Global	151	12.8

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Vegetable oil	Global	150	4.6
Oats, rolled	Global	149	7.2
Milk, low-fat, pasteurized	Global	149	2.6
Ice cream, packed	Global	147	14.7
Whole wheat bread	Global	146	4.4
All-butter croissant	Global	145	20.7
Whole chicken - broiler	Global	145	10.5
Tinned sweet corn/maize	Global	144	5.9
Ice cream, cornetto-type	Global	143	32.2
Vermicelli (angel hair)	Global	141	4.8
Short pasta	Global	141	3.7
Pork, loin chop	Global	140	14.3
Green olives (with stones)	Global	138	12.9
Fruit drops (hard candies)	Global	137	13.2
Pork, fillet	Global	136	20.1
Beef, center brisket	Global	135	11.8
Garlic (white)	Global	134	12.9
Lentils, dry	Global	134	5.3
Lamb whole leg	Global	134	22.0
Spinach	Global	133	4.5
Shrimps	Global	133	42.6
Tinned green peas	Global	131	5.9
Lamb chops	Global	131	25.1
Apple juice	Global	130	3.1
Orange juice	Global	128	3.4
Baguette	Global	127	4.7
Grapes, green	Global	126	9.3
Cheese, gouda type	Global	126	24.2
Macaroni	Global	126	4.9
Long grain rice - parboiled	Global	124	3.4
Basmati rice	Global	124	6.0
White bread	Global	121	3.4
Frozen chipped potatoes	Global	121	4.6
Green cabbage	Global	121	2.5
Tinned pineapple	Global	120	6.0
Chocolate bar	Global	119	25.1
Roasted groundnuts/peanuts	Global	119	13.0
Beef with bones	Global	118	13.4
Bacon, smoked	Global	117	23.8
Chilies (long)	Global	117	15.0
Milk, powdered	Global	116	22.2
Orange marmalade	Global	116	10.7
Beef liver	Global	115	9.2
Apple, Red Delicious	Global	114	4.5
Tinned white beans in tomato sauce	Global	112	6.4
Sweet potatoes	Global	112	2.7
Cheese, cheddar	Global	112	26.9
Canned mackerel fillet in vegetable oil	Global	111	21.0
Pork ham, pressed	Global	111	28.5
Medium size chicken eggs	Global	110	6.9
Dried noodles	Global	110	6.4

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Sour cream	Global	109	7.9
Apple, typical local variety	Global	108	4.0
Pineapple jam	Global	108	10.8
Mixed fruits in syrup	Global	107	8.4
Long grain rice - non-parboiled	Global	106	2.9
Toffee	Global	106	15.8
Peach	Global	104	7.0
Dried white beans	Global	102	4.4
Grapefruit	Global	100	5.4
Melon	Global	100	5.7
Papaya	Global	98	3.9
Dried dates	Global	98	10.6
Chocolate cake (whole)	Global	98	19.2
Soybean oil	Global	96	6.1
Cheese, camembert type	Global	96	35.0
Chicken breast with skin and bones	Global	96	11.9
Maize	Global	95	2.4
Avocado	Global	95	6.1
Mango	Global	95	4.6
Mackerel, un-cleaned	Global	92	27.9
Roll	Global	91	5.0
Carp	Global	90	15.9
Brown sugar	Global	89	4.1
Squid	Global	84	19.7
Ginger (mature)	Global	80	6.8
Milk, condensed	Global	77	6.8
Tilapia	Global	75	11.7
Smoked salmon	Global	75	64.7
Maize flour white	Global	75	2.0
Pita bread	Global	74	4.0
Veal breast (non-refrigerated), with bones	Global	74	12.6
Tinned button mushrooms	Global	73	11.4
Beef, for stew or curry	Global	73	13.0
Jasmine rice	Global	71	4.6
Whole shrimps	Global	70	37.5
Chocolate cake (Individual serving)	Global	68	13.7
Short-grained rice	Global	67	2.3
Lemonade	Global	66	2.7
White rice, medium grain	Global	66	2.5
Wheat semolina (suji)	Global	66	4.3
Live chicken	Global	65	16.5
Sea bass	Global	64	30.9
Mutton mixed cut	Global	64	14.6
Corned beef	Global	63	15.8
Long grain rice - family pack	Global	62	3.0
White rice, 25% broken	Global	61	2.4
Veal chops	Global	61	19.9
Pork, shoulder	Global	60	16.2
Goat mixed cut/with bones (non-refrigerated)	Global	59	16.4
Tomato paste (large)	Global	59	6.3
Dried almonds	Global	58	78.9

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Palm oil	Global	58	5.9
Dried shrimp	Global	51	94.7
Cassava - manioc - yuka	Global	51	2.6
Yoghurt with natural fruits	Regional	49	8.8
Milk chocolate	Regional	49	33.6
Dark chocolate	Regional	48	35.8
Brown rice - Family Pack	Global	48	3.7
Simple cookie	Regional	48	7.9
Green beans	Regional	48	4.3
Mango juice	Regional	47	4.3
Carbonated soft drink [specified brands and model]	Regional	47	3.4
Condensed milk sweetened	Regional	47	8.9
Chocolate biscuit	Regional	47	16.0
Canned chicken	Global	47	17.1
Carbonated soft drink, can [specified brands & model]	Regional	47	4.4
Round onions, red	Regional	47	2.7
Sea crab	Global	47	52.4
Couscous	Global	46	6.2
Pineapple juice	Regional	46	4.2
Doughnuts	Regional	46	5.2
Tonic	Regional	46	4.1
Powdered milk	Regional	46	23.7
Orange drink	Regional	46	3.7
Fresh cheese edam	Regional	45	36.8
Beef without bones	Regional	45	11.8
Orange juice - nectar	Regional	45	4.0
Packed peas	Regional	45	8.3
Peanut oil	Global	45	7.3
Sardines in tomato sauce	Regional	45	16.9
Lemon-lime flavoured carbonated soft drink [specified brand and model]	Regional	44	4.0
Beef prepacked	Regional	44	14.4
Long-grained rice	Regional	44	2.0
Tuna in vegetable oil	Regional	43	24.1
Guava juice	Regional	43	4.4
Grapes, red	Regional	43	14.9
Eggs, traditional production	Regional	43	12.3
Cola Drink	Regional	43	2.6
Banana, short finger length	Regional	43	2.7
Traditionally bred live chicken	Regional	43	19.2
Packed White sugar	Regional	42	3.5
Fresh cheese emmental	Regional	42	36.7
Spotted beans	Regional	42	3.0
Round bread	Regional	42	3.7
Local soft drink	Regional	42	2.9
Lasagne (sheets)	Regional	42	16.2
Liquid Yoghurt	Regional	42	6.7
Sausage	Regional	42	24.3
Regular chewing gum	Regional	41	29.3
Natural groundnuts	Regional	41	4.2
Gherkins	Regional	41	17.6

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Oxtail	Regional	41	12.9
Maize flour yellow	Regional	41	2.0
Large mango (grafted)	Regional	40	3.2
Shells	Regional	40	4.6
Maizena	Regional	40	10.1
Mutton chop	Regional	40	21.6
White maize grains	Regional	40	1.4
Beetroots	Regional	40	6.3
Crème fraîche	Regional	40	19.8
Live goat	Regional	40	5.4
Peas	Regional	39	3.8
Chillies	Regional	39	29.0
Red snapper	Global	39	20.7
Chocolate croissant	Regional	39	20.1
Wafers	Regional	39	17.1
Live sheep	Regional	39	6.3
Roasted groundnuts	Regional	39	6.6
Sweet bread	Regional	38	6.2
Pork meat	Regional	38	12.4
Sirloin steak	Regional	38	20.5
Peas	Regional	38	4.1
Fresh okra	Regional	38	4.8
Ice cream cone	Regional	38	16.9
Peppers	Regional	37	31.9
Beef feet/trotters (uncleaned)	Regional	37	6.6
Sour (clotted) milk	Regional	37	3.8
Sponge Cake	Regional	37	15.3
Lamb	Regional	37	14.8
Spring onions	Regional	37	5.2
Fresh small sardines	Regional	36	4.7
Chicken wings	Regional	36	11.8
Frozen shrimps	Regional	36	67.5
Mushroms	Regional	36	16.6
Green plantain	Regional	36	3.4
Whole cassava	Regional	36	1.6
Tomato juice	Regional	36	5.4
Packed Brown sugar	Regional	36	4.1
Palm oil unrefined	Regional	35	4.8
Yellow maize grains	Regional	35	1.7
Spinach	Regional	35	12.5
Turnips	Regional	35	4.0
Mackerel in vegetable oil	Regional	35	16.6
Mix frozen chicken parts	Regional	35	12.9
Tuna	Regional	35	17.5
Gizzard	Regional	34	7.6
Radish	Regional	34	4.9
Sesame	Regional	34	5.2
Peeled tomatoes	Regional	34	7.0
Sliced brown bread	Regional	34	5.9
Beef ham	Regional	34	28.8
Ghee	Regional	34	14.9

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Coconut	Regional	34	3.1
Yellow maize grains, branless	Regional	33	2.0
Mullet	Global	33	17.1
Sorghum white grains	Regional	33	1.5
Bean curd - tofu	Global	32	14.3
Maize oil	Regional	32	9.1
Millet whole grain	Regional	31	1.6
Beef Merguez (spiced)	Regional	31	23.6
Veal without offals	Regional	31	22.2
Tinned peaches	Regional	31	9.3
Giant shrimps	Regional	31	63.6
Red snapper	Regional	30	18.9
Celery	Regional	30	6.8
Black pomfret	Global	30	24.0
Sorghum red grains	Regional	30	1.5
Green/Mung Beans, dried	Global	30	4.4
Butter, sold loose	Regional	29	13.3
Cassava leaves	Regional	29	1.8
Mutton tripes	Regional	29	6.5
Frozen Sea-bream	Regional	29	16.6
Duck - dressed	Regional	29	22.4
Dried small fish	Regional	29	13.3
Broccoli	Regional	28	19.3
Yellow broken maize grains	Regional	28	1.6
Chives	Regional	28	5.1
Pineapple juice freshly squeezed	Regional	28	4.2
Broad beans	Regional	28	3.5
Turkey breast	Regional	28	19.9
Capitaine	Regional	27	19.0
Brown sugar cubes	Regional	27	6.1
Cod (Gadus morhua)	Global	26	32.0
Sole fish	Regional	26	22.2
Pumpkin leaves	Regional	26	5.0
Black olives	Regional	26	21.0
Dried sardines	Regional	26	12.6
Powdered glucose	Regional	26	15.7
Millet flour	Regional	26	2.1
Dried plums	Regional	26	23.1
Lobster, chilled	Regional	25	127.6
Cashew nuts	Regional	25	25.0
Lime juice	Regional	25	3.1
Flatbread	Regional	25	6.9
Dried okra	Regional	25	7.5
Clementine	Regional	24	9.7
Pigeon peas	Regional	24	3.4
Pumpkin	Regional	23	2.4
Live turkey	Regional	23	25.2
Ginger juice (fresh)	Regional	23	2.1
Passion fruit	Regional	23	6.5
Bean leaves	Regional	23	2.1
Grouper	Regional	23	14.4

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Sweet potato leaves	Regional	23	2.0
Tuna steaks	Global	23	16.5
Dried apricots	Regional	23	18.2
Cream crackers	Regional	23	8.7
Smoked carp	Regional	23	18.0
Sorrel leaves	Regional	22	3.2
Smoked shrimps/prawns	Regional	22	46.0
Snack crackers	Regional	22	12.1
Couscous (millet)	Regional	22	6.0
Coffee whitener [Specified brand 1], packet	Regional	22	13.8
Frozen Capitaine in Sea Water	Regional	22	18.2
Fruit juice, not from concentrate, ready to drink	Regional	21	3.9
Bream	Regional	21	14.4
Radish, white	Regional	21	2.6
Grapes, violet, with seed	Regional	21	10.3
Infant powdered milk, tin	Regional	21	36.6
Chicken egg, 1	Regional	21	7.6
Roll or bun, prepacked	Regional	21	6.5
Chicken eggs, 10, loose	Regional	21	7.4
Chillies, dried	Regional	21	10.5
Caramel groundnuts	Regional	21	7.0
Instant noodles	Regional	21	17.8
Red mullet	Regional	21	14.3
Anchovy	Regional	20	6.3
Chocolate bar [specified brand]	Regional	20	38.9
Jam, high fruit content	Regional	20	13.8
Sesame oil	Regional	20	11.0
Fresh whole chicken	Regional	20	11.3
Coffee whitener [specified brand 1], jar	Regional	20	18.5
Cake mix	Regional	20	11.0
Catfish	Regional	20	15.0
White potato	Regional	20	2.5
Olive oil, standard	Regional	20	26.1
Sponge cake	Regional	19	25.2
Prawn/Shrimp, medium	Regional	19	51.4
Chicken drumsticks	Regional	19	11.9
Breakfast sausage, chicken	Regional	19	11.7
Chicken wings	Regional	19	13.3
Taro	Regional	19	2.5
Lime	Regional	19	4.5
Cheese spread	Regional	19	34.2
Prawn/Shrimp, small	Regional	19	35.1
Corn oil	Regional	19	8.1
Cup cakes	Regional	18	21.7
Nile perch	Regional	18	12.7
Jam, low fruit content	Regional	18	10.8
White sugar, loose	Regional	18	2.3
Infant powdered milk, box	Regional	18	32.4
Taro leaves	Regional	18	3.9
Dried machoiron	Regional	18	14.0
Sirloin steak	Regional	18	17.0

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Yoghurt, fruit	Regional	18	8.7
Mushrooms, dried	Regional	18	33.8
Carbonated soft drink [specified brands], small bottle	Regional	18	2.7
Powdered milk, box	Regional	18	21.6
Powdered juice mix [specified brand]	Regional	18	10.0
Egg noodles	Regional	18	5.1
Spinach chinese	Regional	18	3.0
Muffin	Regional	17	13.2
Roll or bun, loose	Regional	17	4.9
Smoked kapenta	Regional	17	14.2
Native house chicken	Regional	17	22.5
Rice flour	Regional	17	2.7
Dried bonga	Regional	17	12.5
Softdrinks, small bottle	Regional	17	3.2
Round steak	Regional	17	14.7
Peanuts in shell	Regional	17	4.1
Yoghurt drink	Regional	17	6.7
Pork, without bones, non-specific cut	Regional	16	12.0
Squid, small	Regional	16	14.0
Salted & semi-dried fish	Regional	16	13.9
Premium rice #2	Regional	16	3.4
Small fresh fish	Regional	16	7.8
White rice #3	Regional	16	1.9
Sliced ham, pork	Regional	16	30.4
Coconut, young green	Regional	16	3.5
Smoked kingfish	Regional	16	17.1
Pork loin, without bones	Regional	16	13.5
Beef, without bones, non-specific cut	Regional	16	12.8
White rice #1	Regional	15	1.9
Water Spinach	Regional	15	2.5
Rape Leaves	Regional	15	3.6
Wheat flour, loose	Regional	15	1.8
Bacon, pork	Regional	15	24.3
Canned peach halves	Regional	15	8.9
Chicken, non-specific cuts, frozen	Regional	15	12.3
Pork thigh, with bones	Regional	15	13.2
Mud Crab	Regional	15	76.2
White Pomfret	Regional	15	34.9
Beef, with bones, non-specific cut	Regional	15	14.8
Chicken, non-specific cuts, not frozen	Regional	15	11.5
Frozen Nile Perch	Regional	14	16.6
Salted duck egg	Regional	14	6.6
Dried red beans	Regional	14	4.8
Pork and beef sausages	Regional	14	12.3
Brown rice - small pack	Regional	14	3.3
Milk, low-fat, UHT	Regional	14	2.2
Doughnuts	Regional	14	24.8
Glutinous rice	Regional	14	2.4
Peanut butter	Regional	14	15.5
Catfish	Regional	14	14.2
White bread, unsliced loaf	Regional	14	3.7

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Spanish mackerel	Regional	14	14.1
Smoked mboto	Regional	14	19.0
Canned beef, chunks	Regional	13	12.1
Fresh cheese	Regional	13	12.5
Sports drink	Regional	13	3.6
Beetroot	Regional	13	4.1
Instant fruit-juice flavored drink, powder	Regional	13	19.2
Goat leg	Regional	13	17.4
Canned sardines with skin, in tomato sauce	Regional	13	17.3
Pork liver	Regional	13	8.7
Dulce de leche	Regional	13	11.4
Fresh rice noodles	Regional	13	2.0
Yoghurt, with flavor	Regional	13	6.8
Pork, with bones, non-specific cut	Regional	13	16.4
Duck, whole	Regional	13	10.3
Wholemeal flour, atta	Regional	12	1.9
Buttercup squash	Regional	12	2.0
Pork ham, pressed, bulk or loose	Regional	12	16.9
Dark raisins	Regional	12	15.5
Powdered milk, in bag or box	Regional	12	16.9
Cheese, mozzarella type	Regional	12	22.2
Plum tomatoes	Regional	12	3.0
Sole	Regional	12	23.1
Maize	Regional	12	1.6
Olive Oil	Regional	12	12.7
White sugar, family size pack	Regional	12	2.0
Fishball	Regional	12	7.2
Sea Lobster	Regional	12	94.3
Tuna Steak	Regional	12	15.6
Milk, not pasteurized	Regional	12	2.4
Fruit nectars (single flavor)	Regional	12	3.6
Mortadella, prepacked	Regional	12	10.5
Passion fruit	Regional	12	7.1
Mortadella, loose	Regional	12	9.4
Orange juice	Regional	11	2.9
Frozen Whiting	Regional	11	23.7
Hard candy, filled	Regional	11	11.1
Poultry sausages (chicken or turkey)	Regional	11	10.7
Celery	Regional	11	3.9
Yogurt drink	Regional	11	5.0
Dried black beans	Regional	11	4.0
Green asparagus	Regional	11	16.7
Buffalo, without bones, non-specific cut	Regional	11	10.8
Tilapia fillet	Regional	11	15.6
White rice #10	Regional	11	2.5
Smoked fish	Regional	11	17.4
Tamarind	Regional	11	15.7
Orange	Regional	10	3.2
Whole chicken (Frozen)	Regional	10	9.0
Cheese, haloumi	Regional	10	21.6
Canned tuna/water	Regional	10	14.4

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
Chicken wings	Regional	10	10.2
Imported apricots	Regional	10	7.2
Cheese, feta	Regional	10	8.1
Almonds, unhusked	Regional	10	44.7
Regular cake(multiple) with cream topping	Regional	10	20.3
Chinese cake/moon cake	Regional	10	20.0
Mutton chops	Regional	10	19.5
Processed honey, pure	Regional	10	19.3
Malanga / yautia / tannia / tannier / macabo	Regional	10	3.6
Milk, low-fat, pasteurized in plastic bag	Regional	10	1.7
Knefeh	Regional	10	14.4
Imported plums	Regional	10	6.2
Thailand rice	Regional	10	2.9
Sanbousik	Regional	10	9.8
Dhal, split peas	Regional	10	2.9
Grouper (Hamour) fish	Regional	10	53.0
Domestic Fillet Steak(excluding round &sirloin)	Regional	10	18.3
Liquid tahina	Regional	10	9.6
Guava jam	Regional	10	13.2
Imported pears, premium	Regional	10	5.2
Baklawa	Regional	10	21.5
Imported fillet steak(excluding round &sirloin)	Regional	10	15.7
Moong dahl, loose	Regional	10	5.0
Ripe(black) Olives, can or unpackaged	Regional	10	8.0
Imported peanuts	Regional	10	22.3
Zucchini	Regional	10	2.7
Apple	Regional	10	3.0
Domestic green bell peppers	Regional	9	3.1
Mutton with bones (refrigerated), Non-specific cut	Regional	9	24.3
Doughnuts	Regional	9	22.7
Imported zucchini	Regional	9	2.2
Lasagne	Regional	9	10.7
Orange	Regional	9	2.7
Imported coconut	Regional	9	6.5
Cream biscuits	Regional	9	7.3
Chicken soup	Regional	9	21.7
Labneh	Regional	9	8.4
Ghee, cow/buffalo	Regional	9	18.7
Dhal, musur	Regional	9	4.2
Fresh milk, 3-4%	Regional	9	2.7
Domestic red dates	Regional	9	4.0
Live mutton	Regional	9	78.2
Imported White onion	Regional	9	1.8
Imported garlic	Regional	9	6.1
Imported grapes	Regional	9	7.3
Veal, boneless (refrigerated)	Regional	9	17.3
Kaak (bakssamat)	Regional	9	4.0
Kiln bread	Regional	9	1.8
Ice cream, mixed	Regional	9	11.7
Veal, boneless (fresh unchilled)	Regional	9	19.7
Imported cherries	Regional	9	10.2

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
White or brown chicken eggs, small size [domestic]	Regional	9	7.9
Domestic tomatoes	Regional	9	2.1
Biscuit assortment	Regional	9	11.2
Savoury pie	Regional	9	17.6
Corn/Maize Flour, loose	Regional	9	2.2
Fresh wet cheese	Regional	9	11.8
Vegetarian vegetable soup	Regional	9	25.4
Maize oil	Regional	9	6.4
Imported tomatoes	Regional	9	2.1
Cheese, mozzarella	Regional	9	21.7
Goat, boneless. Non-specific cut	Regional	9	18.6
Peanut butter	Regional	9	12.5
Veal with bones (Refrigerated)	Regional	9	20.1
Orange juice (fresh)	Regional	9	3.2
Premium rice #1	Regional	9	2.8
Imported peas	Regional	9	5.9
Lamb (fresh), boneless, non-specific cut	Regional	9	21.9
Mutton liver (fresh)	Regional	9	18.6
Imported ground mutton (fresh)	Regional	9	16.6
Lamb (fresh) with bones, non-specific cut	Regional	9	26.9
Rice [Specified brand]	Regional	9	4.3
Fillet (round or sirloin)	Regional	9	19.2
Mutton/goat liver	Regional	8	11.8
Animal fats	Regional	8	17.1
Mustard oil	Regional	8	7.1
Live lamb	Regional	8	71.9
Green beans	Regional	8	5.9
Imported guava	Regional	8	6.0
Imported green beans (pulses)	Regional	8	4.2
Breakfast wheat cereal	Regional	8	13.8
Ghee, vegetable	Regional	8	21.0
Imported okra	Regional	8	4.5
Fresh milk, 3-4%	Regional	8	2.4
Imported beetroot	Regional	8	2.9
Imported pomegranate	Regional	8	9.4
Domestic carrots	Regional	8	1.9
Watermelon seeds	Regional	8	29.7
Imported Red bell peppers	Regional	8	3.6
Fresh milk, 1.5-2.5%	Regional	8	2.8
Imported peas	Regional	8	3.1
Katayef	Regional	8	6.1
Imported red dates	Regional	8	5.2
Beef, Fillet, frozen	Regional	8	17.5
Mutton liver (chilled)	Regional	8	16.7
Pure sesame oil	Regional	8	17.8
White rice #9	Regional	8	2.2
Tahina	Regional	8	9.5
White sugar, bulk	Regional	8	2.2
Coconut oil	Regional	8	10.9
Flat (Iranian) bread	Regional	8	4.2
White rice #5	Regional	8	1.9

ICP Food item (sorted by number of observations)	Regional/ Global	Number of observations	Mean price[1] (2011USD/kg)
Domestic beetroot	Regional	8	3.2
White rice, medium grain - prepacked	Regional	8	2.4
Imported Melon	Regional	8	3.7
Semi sweet baking chocolate	Regional	8	14.5
Macadamia nuts	Regional	8	109.4
Hazelnuts	Regional	8	59.6
Flank or skirt beef, for shredding	Regional	8	10.6
Corn tortilla	Regional	8	8.2
Domestic Ground mutton (Fresh)	Regional	8	21.2
Domestic zucchini	Regional	8	2.8
Walnuts	Regional	7	50.8
Fresh milk, 0% (import)	Regional	7	2.6
Caviar	Regional	7	368.2
Veal, with bones	Regional	7	14.8
White rice #4	Regional	7	1.7
Hard loose bulgur	Regional	7	2.7
Imported dates	Regional	7	6.6
Domestic peas	Regional	7	4.2
Fruit jellies	Regional	7	9.7
Domestic okra	Regional	7	6.7
Domestic broad beans (pulses)	Regional	7	3.6
Domestic red bell peppers	Regional	7	5.1
Imported broad beans (Pulses)	Regional	7	2.8
Giant shrimp	Regional	7	65.6
Cheese, cottage (halloum)	Regional	7	12.9
Light whipping or whipping	Regional	7	13.0
Red porgy	Regional	7	30.6
Processed honey, pure	Regional	7	21.1
Maigre fillet	Regional	7	20.4
Dometic dates	Regional	7	4.6
Corn	Regional	7	3.0
Cheese, kashkaval	Regional	7	20.7
White sugar, granulated, cane	Regional	7	2.5
Hake fillet	Regional	7	11.8
Imported kiwi	Regional	7	5.8
Maigre	Regional	7	16.6
Cucumber pickles	Regional	7	4.9
Tamarind, preserved	Regional	7	5.2
Figs	Regional	7	9.0
Oranges jam	Regional	7	6.6
Imported figs	Regional	7	5.3
Domestic green beans (Pulses)	Regional	7	3.6
Local hard, dry cheese	Regional	7	11.4
White rice #7	Regional	7	2.3
Sesame oil or oil alserg	Regional	7	18.6
Ground beef (frozen)	Regional	7	9.6
White wheat	Regional	7	1.4
Tuna	Regional	7	14.8
Peas, tinned	Regional	7	3.7
Premium rice #3	Regional	7	2.7
Cashew	Regional	6	56.1

ICP Food item (sorted by number of observations)	**Regional/ Global**	**Number of observations**	**Mean price[1] (2011USD/kg)**
White rice #6	Regional	6	2.1
Soft/ loose bulgur	Regional	6	3.8
Suckers lollipops	Regional	6	45.4
Emperor fish	Regional	6	27.5
Millet, Sorghum	Regional	6	1.9
Local cheese	Regional	6	20.7
Domestic Strawberries	Regional	6	14.8
Toast petit beurre brown crunchy	Regional	6	2.6
Long grain rice - loose	Regional	6	1.9
Sattu	Regional	6	3.2
Semolina, suji	Regional	6	2.3
Dhal, khesari	Regional	6	2.9
Domestic white onion	Regional	6	1.9
Fruit cocktail, canned	Regional	6	4.6
White rice, 20% broken	Regional	6	2.5
Pita bread	Regional	6	7.7
Ghee	Regional	6	11.8
Tuna fish fresh	Regional	6	21.4
Okra	Regional	6	6.8
Ripe(black) Olives	Regional	6	7.9
Caramels and toffees	Regional	6	12.8
Yellow maize flour	Regional	6	2.4
Sandwich biscuits/cookies packaged	Regional	6	10.2
Domestic plums	Regional	5	4.1
Processed shrimp	Regional	5	28.5
Domestic garlic	Regional	5	6.0
Domestic pears	Regional	5	4.7
Domestic pomegranate	Regional	5	5.0
Melon, honeydew	Regional	5	7.9
Zubaida fish	Regional	5	44.5
Guava jelly	Regional	5	7.6
Coarse #5	Regional	5	1.6
Domestic apricots	Regional	5	4.9
Domestic round red radish	Regional	5	1.9
Buffalo milk, not pasteurized	Regional	5	2.3
Tonic water [specified brand]	Regional	5	5.6
Apricots	Regional	5	7.6
Roll	Regional	5	3.9
Maize flour white	Regional	5	2.8
Domestic guava	Regional	5	4.5
Beaten rice, chira	Regional	5	2.3
Domestic peanuts	Regional	4	34.8
Coarse #6	Regional	4	1.7
Domestic figs	Regional	4	5.7
Red porgy fillet	Regional	4	21.5
Palm oil	Regional	4	4.4
Spaghetti, with eggs	Regional	3	4.4
Short-grained rice - prepacked	Regional	3	3.5
Coarse #3	Regional	3	1.1
Domestic mango	Regional	3	6.8
Domestic cherries	Regional	3	6.4

ICP Food item (sorted by number of observations)	Regional/ Global	Number of observations	Mean price[1] (2011USD/kg)
Buffalo milk, pasteurized	Regional	3	2.7
Domestic grapes	Regional	3	5.4
Maize semolina	Regional	3	5.5
Coarse #2	Regional	3	1.1
Bajra flour	Regional	2	1.3
Surubi fillet	Regional	2	20.2
Salted dry cod	Regional	2	20.4
Local curd	Regional	2	8.4
Short past with eggs	Regional	2	3.1
Sardines	Regional	2	3.2
Vermicelli (angel hair), with eggs	Regional	1	3.7
	N	28,273	

Note: Computed from file data obtained by permission from the International Comparison Program (ICP). Price is measured in 2011USD per 1 kg of edible portion.

Table A7. Cost of nutrient adequacy (CoNA), caloric adequacy (CoCA) and CoNA premium (CoNA/CoCA) by country

Country or territory	CoNA	CoCA	CoNA premium	Country	CoNA	CoCA	CoNA premium
Albania	1.68	0.62	2.7	Kyrgyzstan	1.49	1.06	1.4
Algeria	1.42	0.89	1.6	Lao PDR	1.32	0.78	1.7
Angola	1.26	0.78	1.6	Latvia	1.65	0.58	2.8
Anguilla	1.82	1.20	1.5	Lesotho	1.31	0.75	1.8
Antigua and Barbuda	2.27	1.29	1.8	Liberia	1.05	0.74	1.4
Armenia	1.62	0.98	1.7	Lithuania	1.61	0.69	2.3
Aruba	1.57	0.96	1.6	Luxembourg	1.28	0.25	5.1
Australia	1.47	0.36	4.1	Macao SAR, China	1.86	0.88	2.1
Austria	1.48	0.36	4.1	Macedonia, FYR	2.33	0.63	3.7
Azerbaijan	2.12	0.74	2.9	Madagascar	1.23	0.67	1.8
Bahamas, The	1.81	0.82	2.2	Malawi	0.93	0.31	3.0
Bahrain	1.20	0.63	1.9	Malaysia	1.36	0.73	1.9
Bangladesh	1.12	0.56	2.0	Maldives	1.61	0.88	1.8
Barbados	1.55	0.88	1.8	Mali	1.03	0.48	2.2
Belarus	1.26	0.72	1.7	Malta	1.68	0.71	2.4
Belgium	1.24	0.26	4.7	Mauritania	1.42	0.82	1.7
Belize	2.48	1.29	1.9	Mauritius	1.13	0.40	2.8
Benin	0.77	0.27	2.9	Mexico	1.97	0.57	3.5
Bermuda	1.41	1.17	1.2	Moldova	1.35	0.85	1.6
Bhutan	1.09	0.66	1.6	Mongolia	1.17	0.64	1.8
Bolivia	1.65	0.94	1.8	Montenegro	2.39	0.64	3.7
Bonaire	1.75	0.90	1.9	Montserrat	2.56	1.12	2.3
Bosnia and Herzegovina	1.85	0.57	3.2	Morocco	0.92	0.55	1.7
Botswana	1.22	0.66	1.8	Mozambique	0.88	0.55	1.6
Brazil	1.23	0.68	1.8	Myanmar	1.55	0.75	2.1
Brunei Darussalam	1.30	0.53	2.5	Namibia	1.04	0.61	1.7
Bulgaria	1.92	0.69	2.8	Nepal	1.22	0.45	2.7
Burkina Faso	1.03	0.48	2.2	Netherlands	1.27	0.26	4.9
Burundi	0.56	0.35	1.6	New Zealand	1.57	0.41	3.9
Cambodia	1.58	0.81	1.9	Nicaragua	2.20	1.35	1.6
Cameroon	1.10	0.68	1.6	Niger	1.26	0.54	2.3
Canada	1.98	0.97	2.0	Nigeria	1.24	0.63	2.0
Cape Verde	1.07	0.50	2.1	Norway	1.52	0.34	4.4
Cayman Islands	1.41	0.99	1.4	Oman	1.69	1.13	1.5
Central African Republic	0.47	0.30	1.6	Pakistan	1.13	0.68	1.7
Chad	0.91	0.37	2.4	Palestinian Territc	1.10	0.84	1.3
Chile	1.70	0.81	2.1	Panama	1.95	1.30	1.5
China	1.29	0.62	2.1	Paraguay	1.43	0.72	2.0
Colombia	1.86	0.87	2.1	Peru	1.84	1.23	1.5
Comoros	1.07	0.67	1.6	Philippines	1.70	0.91	1.9
Congo, Dem. Rep.	0.63	0.36	1.7	Poland	1.32	0.46	2.9

Congo, Rep.	0.97	0.62	1.6	Portugal	1.16	0.29	3.9
Costa Rica	1.65	0.90	1.8	Qatar	1.20	0.87	1.4
Côte d'Ivoire	0.60	0.29	2.0	Romania	1.45	0.60	2.4
Croatia	1.58	0.49	3.2	Russian Federation	1.74	0.53	3.3
Cuba	1.94	1.89	1.0	Rwanda	0.75	0.29	2.6
Curaçao	1.87	1.29	1.5	São Tomé and Principe	1.13	0.73	1.5
Cyprus	1.66	0.64	2.6	Saudi Arabia	1.06	0.59	1.8
Czech Republic	1.30	0.30	4.3	Senegal	0.94	0.49	1.9
Denmark	1.25	0.33	3.8	Serbia	1.86	0.59	3.2
Djibouti	0.92	0.60	1.5	Seychelles	1.57	0.61	2.6
Dominica	2.98	1.08	2.8	Sierra Leone	1.14	1.00	1.1
Dominican Republic	1.68	1.00	1.7	Singapore	1.42	0.67	2.1
Ecuador	2.01	1.19	1.7	Sint Maarten	1.57	1.06	1.5
Egypt, Arab Rep.	1.42	0.98	1.5	Slovakia	1.57	0.48	3.3
El Salvador	2.05	1.25	1.6	Slovenia	1.43	0.42	3.4
Equatorial Guinea	1.58	1.37	1.2	South Africa	1.25	0.62	2.0
Estonia	1.48	0.44	3.4	Spain	1.33	0.45	3.0
Ethiopia	0.95	0.44	2.2	Sri Lanka	1.46	0.76	1.9
Fiji	1.13	0.71	1.6	St. Kitts and Nevis	2.22	1.13	2.0
Finland	1.97	0.29	6.8	St. Lucia	1.50	0.93	1.6
France	1.35	0.27	4.9	St. Vincent and the Grenadines	1.81	0.94	1.9
Gabon	1.07	0.72	1.5	Sudan	1.04	0.67	1.6
Gambia, The	1.09	0.63	1.7	Suriname	2.20	1.11	2.0
Germany	1.59	0.31	5.2	Swaziland	1.20	0.66	1.8
Ghana	0.86	0.78	1.1	Sweden	1.28	0.34	3.7
Greece	1.54	0.59	2.6	Switzerland	1.04	0.35	3.0
Grenada	1.90	1.14	1.7	Taiwan, China	1.64	1.19	1.4
Guatemala	1.85	1.08	1.7	Tajikistan	2.18	0.79	2.8
Guinea	1.21	1.11	1.1	Tanzania	1.07	0.48	2.2
Guinea-Bissau	1.42	0.86	1.6	Thailand	1.67	0.98	1.7
Haiti	2.03	1.11	1.8	Togo	0.74	0.44	1.7
Honduras	1.62	0.82	2.0	Trinidad and Tobago	1.81	1.10	1.6
Hong Kong SAR, China	1.54	0.94	1.6	Tunisia	1.21	0.52	2.3
Hungary	1.69	0.58	2.9	Turkey	1.46	0.62	2.4
Iceland	1.50	0.42	3.6	Turks and Caicos	1.29	0.72	1.8
India	0.95	0.24	4.0	Uganda	0.85	0.45	1.9
Indonesia	1.47	0.82	1.8	Ukraine	1.44	0.54	2.7
Iraq	1.48	0.79	1.9	United Arab Emirates	1.19	0.89	1.3
Ireland	1.43	0.36	4.0	United Kingdom	1.26	0.27	4.6
Israel	1.55	0.41	3.8	United States	1.88	0.77	2.4

Italy	1.41	0.33	4.3	Uruguay	1.46	0.63	2.3
Jamaica	2.20	1.22	1.8	Venezuela, RB	2.53	0.91	2.8
Japan	2.92	0.67	4.3	Vietnam	1.44	0.90	1.6
Jordan	0.84	0.53	1.6	Virgin Islands, British	2.62	1.15	2.3
Kazakhstan	1.12	0.62	1.8	Yemen	1.67	1.00	1.7
Kenya	1.12	0.57	2.0	Zambia	0.85	0.24	3.5
Korea, Rep.	3.64	0.67	5.4	Zimbabwe	0.92	0.40	2.3
Kuwait	0.84	0.51	1.6				

Note: Data shown are costs per day in 2011 for a representative adult woman, converted from local currency units to international dollars at PPP exchange rates for all household expenditure.

Table A8. Structural variables used for hypothesis tests

	N	Mean	Std. Dev.	Min	Max
Income (log GNI per capita, PPP adjusted, 2011 Int. $)	138	9.09	1.17	6.60	11.32
Service sector size (share of labor in services, %)	138	50.84	19.31	6.10	85.41
Urbanization (share of population in urban areas, %)	138	56.55	21.60	10.91	100.00
Rural transport (log travel time to nearest city of > 50k pop.)	138	8.71	8.83	1.07	55.97
Rural electrification (share of rural pop. with access in 2011, %)	138	69.84	37.55	0.29	100.00

Note: All variables are from the World Bank's Global Development Database. GNI per capita (NY.GNP.PCAP.PP.KD) is obtained from World Bank's International Comparison Program Database, service sector size (SL.SRV.EMPL.ZS); urbanization (SP.URB.TOTL.IN.ZS); rural electrification (EG.ELC.ACCS.RU.ZS) come from World Bank's World Development Indicators (WDI) database.

Table A9. Nutritional outcomes used to test for associations with diet costs

	N	Mean	Std. Dev.	Min	Max
Anemia prevalence in non-pregnant women (%)	138	28.19	13.24	8.10	64.40
Anemia prevalence in children under 5 (%)	138	36.44	21.13	6.40	87.40
Zinc deficiency prevalence in 2005 (%)	138	17.10	10.33	3.10	48.40
Obesity prevalence in men (%)	136	12.35	8.34	1.00	31.90
Obesity prevalence in women (%)	136	18.19	8.82	1.90	43.60
Vit. A deficiency prevalence in children under 5 (%)	93	0.28	0.19	0.03	0.67
Stunting prevalence in children under 5 (%)	26	29.33	12.27	4.00	46.60

Note: Data on anemia prevalence is from Stevens et al. (2013) where anemia for under 5 children is defined as those with hemoglobin concentration < 110 g/dL and among non-pregnant women defined as those with hemoglobin concentration < 120 g/dL. Data on zinc deficiency prevalence is adopted from Wessells and Brown (2012) who estimated the prevalence of inadequate zinc intake using FAO food balance sheet data and average zinc requirements. Data on obesity prevalence is from WHO's Global Health Observatory Data Repository. Data on vitamin A deficiency (VAD) prevalence is from Stevens et al. (2015) which estimated VAD among children based on serum retinol concentrations using a Bayesian hierarchical model. Data on stunting (under-5 children whose height for age is more than two standard deviations below the median for the international reference population) prevalence is from WHO's Global Database on Child Growth and Malnutrition.

Table A10. Structural transformation and the cost of nutrient-adequate diets as a share of all household expenditure

	(1)	(2)	(3)	(4)	(5)	(6)
lnGNI per capita	-3.136	-3.312	-3.294	-1.555	-4.122	-2.861
	(4.000)	(4.056)	(3.917)	(3.748)	(3.874)	(3.729)
lnGNI per cap., sq.	0.316	0.336	0.331	0.139	0.457	0.303
	(0.449)	(0.455)	(0.440)	(0.421)	(0.436)	(0.420)
lnGNI per cap., cu.	-0.014	-0.014	-0.014	-0.007	-0.020	-0.014
	(0.017)	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)
Services share of labor force		0.001				-0.000
		(0.003)				(0.003)
Urban share of population			0.003			0.001
			(0.002)			(0.002)
Rural travel time to city >50k (log)				0.111***		0.100***
				(0.031)		(0.031)
Rural electricity access (pop share)					-0.004**	-0.003*
					(0.002)	(0.002)
Constant	3.724	3.448	-1.354	-4.946	7.452	-2.386
	(16.566)	(16.652)	(16.281)	(15.595)	(16.170)	(15.634)
N	138	138	138	138	138	138
R2	0.909	0.909	0.914	0.922	0.916	0.927
F	104.270	95.522	101.647	113.081	103.733	95.885

Note: Dependent variable is the natural log of the ratio of CoNA to per-capita household expenditure on food and non-alcoholic beverages. Standard errors in parentheses, with significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications control for log population size (level, squared and cubed) and include indicator variables for ICP regions (not shown).

Table A11. Structural transformation and the premium for nutrients

	(1)	(2)	(3)	(4)	(5)	(6)
lnGNI per capita	21.134***	21.204***	21.586***	21.168***	21.399***	21.434***
	(7.149)	(7.273)	(7.183)	(7.264)	(7.265)	(7.525)
lnGNI per cap., sq.	-2.597***	-2.605***	-2.645***	-2.601***	-2.630***	-2.630***
	(0.802)	(0.816)	(0.806)	(0.815)	(0.818)	(0.847)
lnGNI per cap., cu.	0.105***	0.106***	0.107***	0.105***	0.107***	0.107***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)
Services share of		-0.000				0.002
labor force		(0.005)				(0.005)
Urban share of			-0.005			-0.005
population			(0.004)			(0.005)
Rural travel time tc				0.003		0.011
city >50k (log)				(0.060)		(0.062)
Rural electricity					0.000	0.000
access (pop share)					(0.003)	(0.003)
Constant	-43.221	-43.268	-43.042	-43.371	-44.567	-44.724
	(29.607)	(29.862)	(29.851)	(30.223)	(30.326)	(31.550)
N	138	138	138	138	138	138
R2	0.771	0.770	0.771	0.770	0.769	0.766
F	35.061	31.878	32.045	31.901	31.749	24.790

Note: Dependent variable is the CoNA:CoCA ratio. Standard errors in parentheses, with significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications control for log population size (level, squared and cubed) and include indicator variables for ICP regions (not shown).

Table A12. Agricultural trade restrictions and the cost of nutrient adequacy

	(1)	(2)	(3)	(4)	(5)	(6)
NRP, nutrient-dense foods	0.003***	0.003***	0.003***	0.003***	0.003***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
NRP, grains & starchy staples	0.001	0.000	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
lnGNI per capita	5.444	3.596	5.442	5.558	2.747	1.389
	(4.013)	(3.885)	(4.089)	(4.110)	(3.918)	(3.926)
lnGNI per cap., sq.	-0.562	-0.385	-0.562	-0.573	-0.213	-0.082
	(0.456)	(0.439)	(0.466)	(0.467)	(0.451)	(0.450)
lnGNI per cap., cu.	0.019	0.013	0.019	0.019	0.005	0.000
	(0.017)	(0.016)	(0.018)	(0.018)	(0.017)	(0.017)
Services share of labor force		0.009**				0.011**
		(0.004)				(0.004)
Urban share of population			-0.000			-0.004
			(0.003)			(0.004)
Rural travel time to city >50k (log)				0.010		0.032
				(0.041)		(0.038)
Rural electricity access (pop share)					-0.006**	-0.005*
					(0.003)	(0.003)
Constant	-13.878	-12.978	-13.436	-16.830	-10.987	-19.960
	(21.808)	(20.714)	(22.297)	(24.986)	(20.388)	(22.498)
Number of observations	54	54	54	54	54	54
R2	0.817	0.839	0.815	0.813	0.842	0.859
F	13.724	14.565	12.299	12.104	14.885	12.901

Note: Dependent variable is the natural log of CoNA in purchasing power parity (PPP) terms for all goods and services consumed by households, which is the same deflator as GNI per capita. Agricultural trade restrictions are measured as the mean nominal rate of protection (NRP) in each country for the food category shown, compiled by the AgIncentives Consortium with data and input from the World Bank, Agrimonitor at the Inter-American Development Bank (IDB), the Monitoring and Analyzing Food and Agricultural Policies (MAFAP) unit at the Food and Agriculture Organization, and the Organization for Economic Cooperation and Development (OECD).Standard errors in parentheses, with significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications control for log population size (level, squared and cubed) and include indicator variables for ICP regions (these coefficients are not shown in this table).

Table A13. Nutritional outcomes and the affordability of nutritious diets

	(1)	(2)	(3)	(4)	(5)	(6)
	Obesity (adults)	**Stunting (children U5)**	**Anemia (women)**	**Anemia (children U5)**	**VitA Deficiency**	**Zinc Deficienc y**
lnCoNA/hhld	-0.787	1.118	4.467**	2.898	-0.003	3.082
	(0.629)	(2.792)	(2.090)	(2.192)	(0.013)	(1.931)
lnGNI per capita	-73.449***	-146.836	-97.863	-78.075	-0.727	-128.633
	(27.932)	(127.169)	(97.352)	(102.085)	(0.655)	(90.352)
lnGNI per cap., sq.	9.098***	15.491	12.504	9.376	0.068	12.843
	(3.144)	(14.656)	(11.028)	(11.564)	(0.076)	(10.237)
lnGNI per cap., cubed.	-0.370***	-0.541	-0.507	-0.373	-0.002	-0.420
	(0.117)	(0.556)	(0.411)	(0.431)	(0.003)	(0.382)
Urban pop. share (%)	0.104***	-0.341***	0.042	-0.007	0.002***	-0.043
	(0.017)	(0.082)	(0.058)	(0.061)	(0.000)	(0.053)
Population share with basic sanitation (%)		-0.139*	-0.307***	-0.407***	-0.001***	-0.027
		(0.074)	(0.056)	(0.058)	(0.000)	(0.052)
Constant	208.198**	521.361	293.357	288.773	2.790	451.505*
	(81.671)	(363.687)	(283.380)	(297.156)	(1.871)	(262.956)
Number of observations	142	69	143	143	97	144
R2	0.912	0.766	0.694	0.863	0.950	0.596
F	122.541	15.302	24.579	68.128	134.290	16.075

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust regressions. All specifications include indicator variables for ICP regions. U5 stands for children under 5 years of age.

Table A14. Dietary intake and the affordability of nutritious diets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
lnCoNAfoodexp	-0.188*	-0.224	-0.044	0.056	-0.425	-0.125***	0.144	-0.326**
	(0.106)	(0.159)	(0.264)	(0.244)	(0.307)	(0.045)	(0.146)	(0.160)
Urban share of population (%)	0.005	-0.003	-0.002	-0.014*	0.018*	-0.002	0.017***	-0.006
	(0.003)	(0.005)	(0.009)	(0.008)	(0.010)	(0.001)	(0.005)	(0.005)
Rural travel time to city >50k (log)	-0.037	-0.031	0.223*	0.125	-0.026	0.002	-0.028	0.139*
	(0.047)	(0.070)	(0.116)	(0.107)	(0.135)	(0.020)	(0.064)	(0.070)
Rural electricity access (pop share)	0.003	0.008**	-0.023***	-0.015**	0.011	-0.001	-0.003	-0.006
	(0.002)	(0.004)	(0.006)	(0.006)	(0.007)	(0.001)	(0.003)	(0.004)
lnGNI per capita	1.942	0.040	-1.389	-19.810	3.174	-1.014	5.891	8.391
	(5.404)	(8.082)	(13.446)	(12.421)	(15.606)	(2.296)	(7.409)	(8.130)
lnGNI per cap., sq.	-0.279	-0.030	0.128	2.483*	-0.566	0.117	-0.727	-0.788
	(0.610)	(0.913)	(1.519)	(1.403)	(1.763)	(0.259)	(0.837)	(0.919)
lnGNI per cap., cu.	0.012	0.001	-0.000	-0.100*	0.025	-0.005	0.029	0.025
	(0.023)	(0.034)	(0.056)	(0.052)	(0.066)	(0.010)	(0.031)	(0.034)
Constant	1.522	5.684	7.457	54.936	-1.575	5.751	-12.374	-23.940
	(15.798)	(23.629)	(39.311)	(36.314)	(45.625)	(6.714)	(21.660)	(23.769)
Number of observations	114	114	114	114	114	114	114	114
R2	0.432	0.236	0.402	0.746	0.283	0.691	0.380	0.508
F	5.854	2.370	5.172	22.616	3.031	17.174	4.719	7.947

Note: Dependent variable is the natural log of daily consumption of fruits (Model 1), vegetables (Model 2), whole grains (Model 3), legumes (Model 4), nuts and seeds (Model 5), fiber (Model 6), sea food (Model 7) and milk (Model 8), as estimated by the Global Dietary Database. Significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications include indicator variables for ICP regions (not shown).

Table A15. The cost of the least-cost nutritious diet and calorie shares of different food groups available for food consumption from FAO's food balance sheet

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Services share of labor force	0.006***	0.007***	0.006***	0.006***	0.006***	0.007***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Urban share of population	-0.002*	-0.002	-0.002	-0.003*	-0.002*	-0.002	-0.003*	-0.003*	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rural travel time to city >50k (log)	0.033*	0.033*	0.023	0.036*	0.038**	0.021	0.035*	0.035*	0.035*
	(0.019)	(0.018)	(0.019)	(0.019)	(0.018)	(0.017)	(0.019)	(0.019)	(0.019)
Rural electricity access (pop share)	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Starchy staples	0.170								
	(0.206)								
Vegetables and Legumes		1.178*							
		(0.691)							
Oils and Fats			-0.513						
			(0.316)						
Meat				-0.057					
				(0.536)					
Fruits and Nuts					-0.273				
					(0.464)				
Fish and Seafood						1.814*			
						(1.049)			
Dairy and Eggs							-0.067		
							(0.499)		
Animal Products								-0.063	
								(0.304)	
Vegetal Products									0.063
									(0.303)
Constant	17.960*	13.990	20.733**	17.137*	15.400	10.933	17.078*	16.258*	16.195*
	(9.811)	(9.180)	(9.563)	(9.721)	(9.419)	(9.407)	(9.743)	(9.674)	(9.692)
Number of observations	129	129	128	129	128	126	129	129	129
R2	0.830	0.846	0.838	0.831	0.842	0.854	0.830	0.831	0.831
F	31.804	35.787	33.560	32.069	34.361	37.186	31.947	32.126	32.126

Note: Dependent variable is the level of CoNA in each country. The predictors from row 5-13 represent the calorie shares of the different food groups that are available for food consumption from FAO's food balance sheet. Significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications include indicator variables for ICP regions and 2011 population in levels, squared and cubed forms (not shown).

Table A16. Affordability of the least-cost nutritious diet and calorie shares of different food groups available for food consumption from FAO's food balance sheet

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Services share of labor force	-0.001	-0.002	-0.000	-0.001	-0.002	-0.003	-0.002	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Urban share of population	0.002	0.002	0.002	0.002	0.003	0.001	0.002	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Rural travel time to city >50k (log)	0.082***	0.092***	0.085***	0.094***	0.094***	0.090***	0.092***	0.097***	0.097***
	(0.031)	(0.031)	(0.031)	(0.032)	(0.031)	(0.030)	(0.031)	(0.032)	(0.032)
Rural electricity access (pop share)	-0.003	-0.002	-0.003	-0.003	-0.002	-0.002	-0.002	-0.003	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Starchy Staples	0.904***								
	(0.337)								
Veg. and Legumes		-0.870							
		(1.197)							
Oils and Fats			-0.928*						
			(0.528)						
Meat				-0.092					
				(0.880)					
Fruits and Nuts					-1.030				
					(0.788)				
Fish and Seafood						7.075***			
						(1.880)			
Dairy and Eggs							-0.944		
							(0.821)		
Animal Products								-0.776	
								(0.506)	
Vegetal Products									0.774
									(0.506)
Constant	11.118	6.522	8.775	5.374	6.805	14.027	4.874	3.860	3.076
	(16.039)	(15.911)	(15.979)	(15.959)	(16.008)	(16.854)	(16.044)	(16.132)	(16.159)
Number of observations	129	129	128	129	128	126	129	129	129
R2	0.937	0.939	0.938	0.938	0.937	0.941	0.937	0.936	0.936
F	96.513	99.792	98.182	98.018	95.594	101.154	97.111	95.729	95.779

Note: Dependent variable is the natural log of the CoNA to household overall expenditure ratio. The predictors from row 5-13 represent the calorie shares of the different food groups that are available for food consumption from FAO's food balance sheet. Significance levels denoted *** p<0.01, ** p<0.05, * p<0.1, from robust regressions (rreg). All specifications include indicator variables for ICP regions and 2011 population in levels, squared and cubed forms (not shown).

Table A17. Countries for which the price of one or more starchy staples was imputed

Sub-region	Country	Number of imputed prices
Alpine countries	Austria	3
Australasia	Australia	1
Australasia	New Zealand	4
Balkans	Albania	5
Balkans	Bosnia and Herzegovina	2
Balkans	Macedonia, FYR	7
Balkans	Montenegro	6
Baltic States	Estonia	1
Benelux countries	Belgium	1
Benelux countries	Luxembourg	1
Carpathian states	Belarus	4
Carpathian states	Czech Republic	7
Carpathian states	Hungary	7
Carpathian states	Poland	6
Carpathian states	Romania	8
Carpathian states	Serbia	6
Carpathian states	Slovakia	8
Carpathian states	Ukraine	4
Caucasus	Armenia	2
Caucasus	Azerbaijan	2
Central Asia	Kazakhstan	1
Central Asia	Kyrgyzstan	8
Central Asia	Moldova	3
Central Asia	Tajikistan	9
Korea & Japan	Japan	4
Korea & Japan	Korea, Rep.	1
Mediterranean countries	Italy	2
Mediterranean countries	Portugal	1
Mediterranean countries	Slovenia	1
Mediterranean countries	Turkey	3
Nordic countries	Denmark	1
Nordic countries	Finland	2
Nordic countries	Iceland	2
Nordic countries	Norway	4
Nordic countries	Sweden	4
North-America	Canada	2
North-America	Mexico	4
North-America	United States	7

Source: Reproduced from Hirvonen et al. (2019), annex of supplemental information Table S5.

Figure A1. Flow chart of exclusion criteria for foods and locations from ICP data

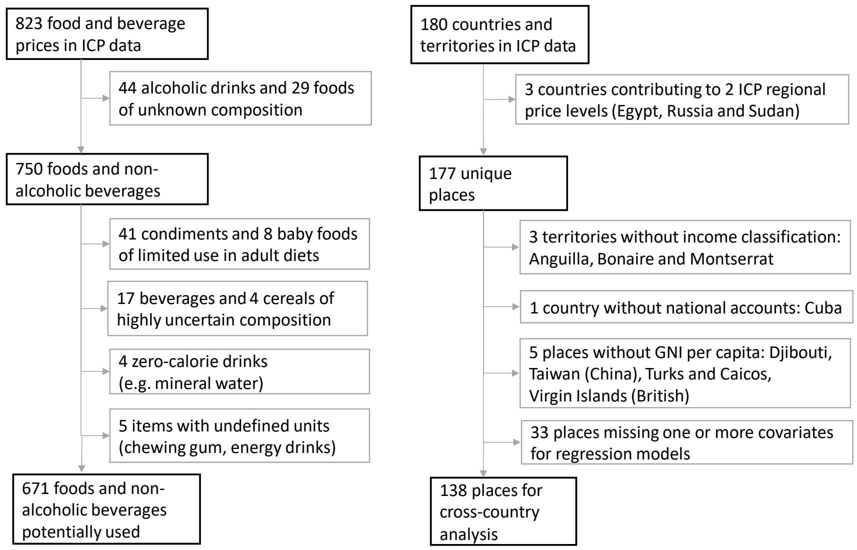
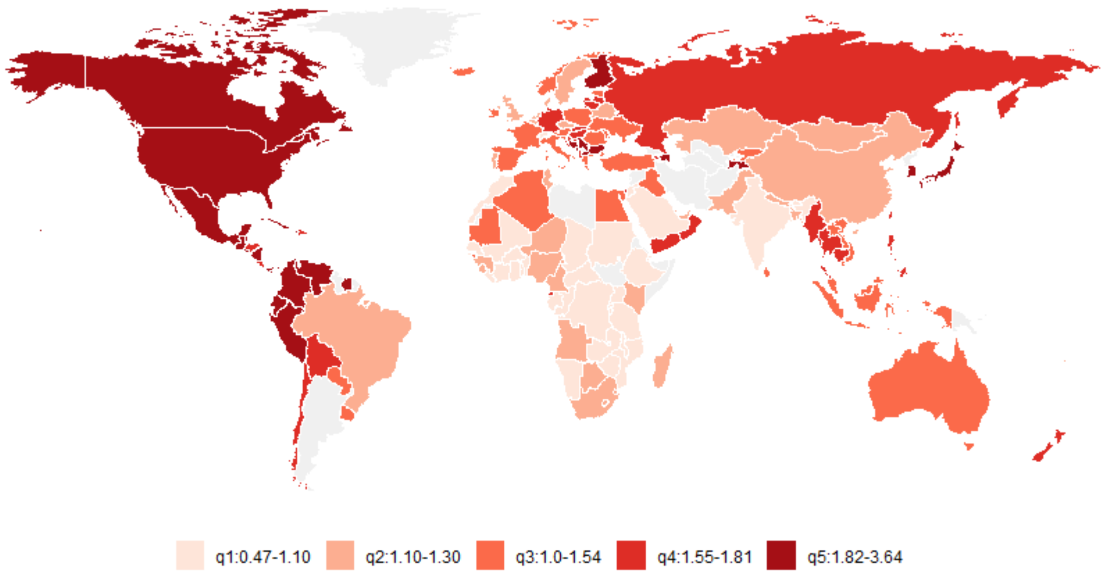
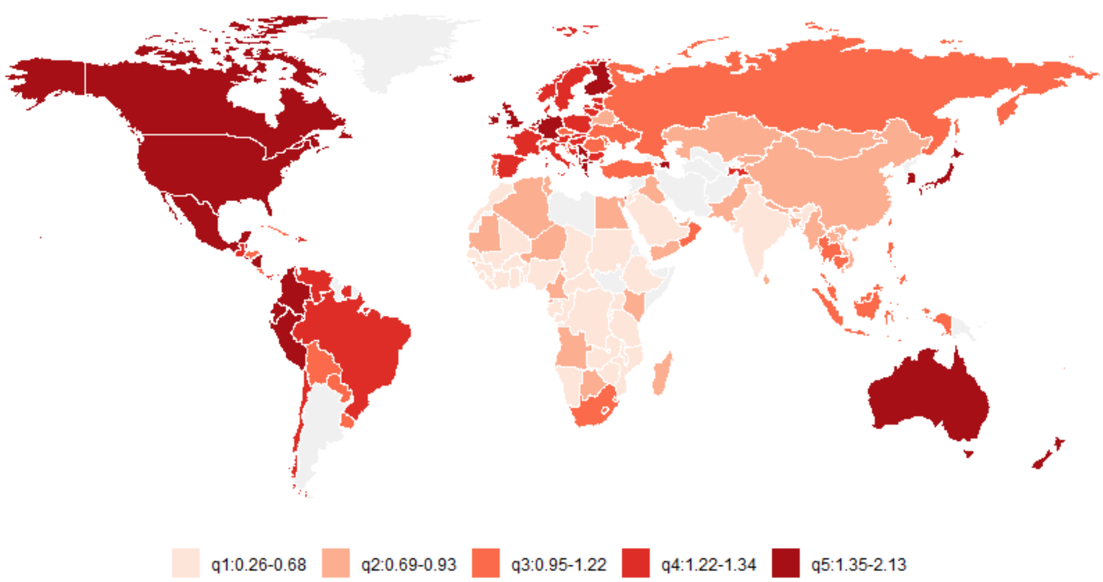


Figure A2. Spatial variation in the cost of nutrient adequacy at PPP prices

A. CoNA converted by 2011 PPP for all household goods and services



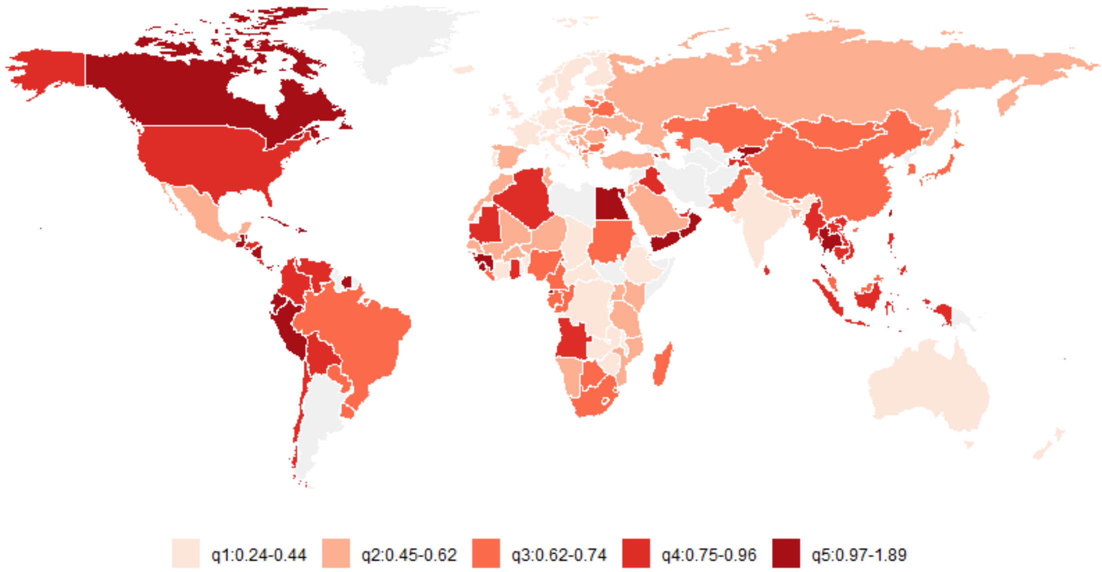
B. CoNA converted by 2011 PPP for foods



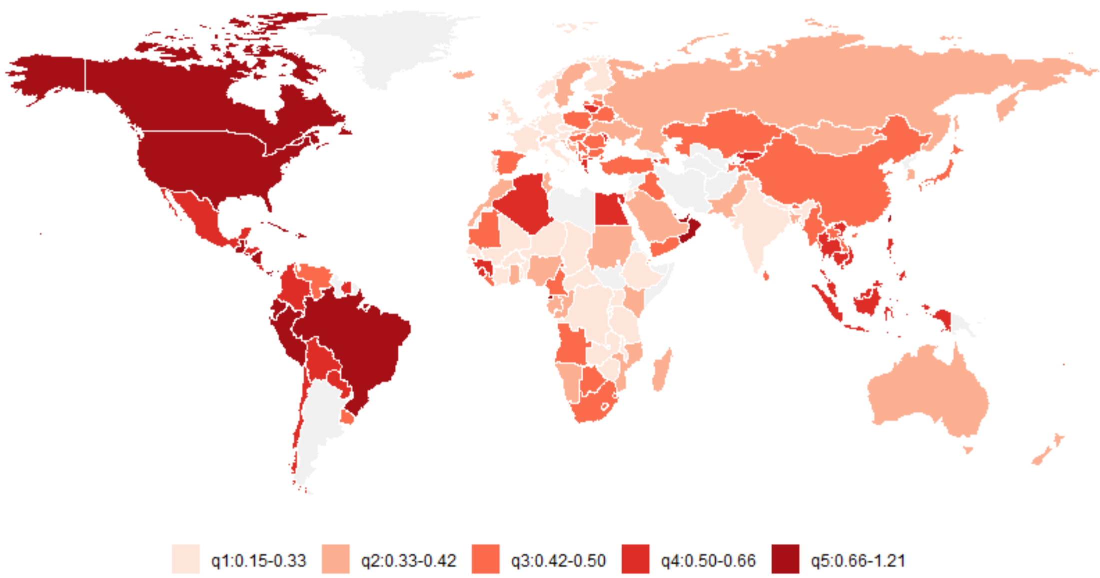
Note: Data shown are the cost per day of a least-cost diet meeting all nutrient constraints for a healthy adult woman across 177 countries in 2011, converted to international dollars at purchasing power parity (PPP) price levels for all household goods and services in each country (panel A), and at purchasing power parity (PPP) price levels for all food and non-alcoholic beverages in each country (B). Methods are described as detailed in the text. Higher income countries often have higher prices in PPP terms, due to higher wages and other costs. Food prices are often relatively high in lower-income countries, compared to average prices in other sectors and the price level of each sector in higher-income countries.

Figure A3. Spatial variation in the cost of caloric adequacy at PPP prices

A. CoCA converted by 2011 PPP for all household goods and services

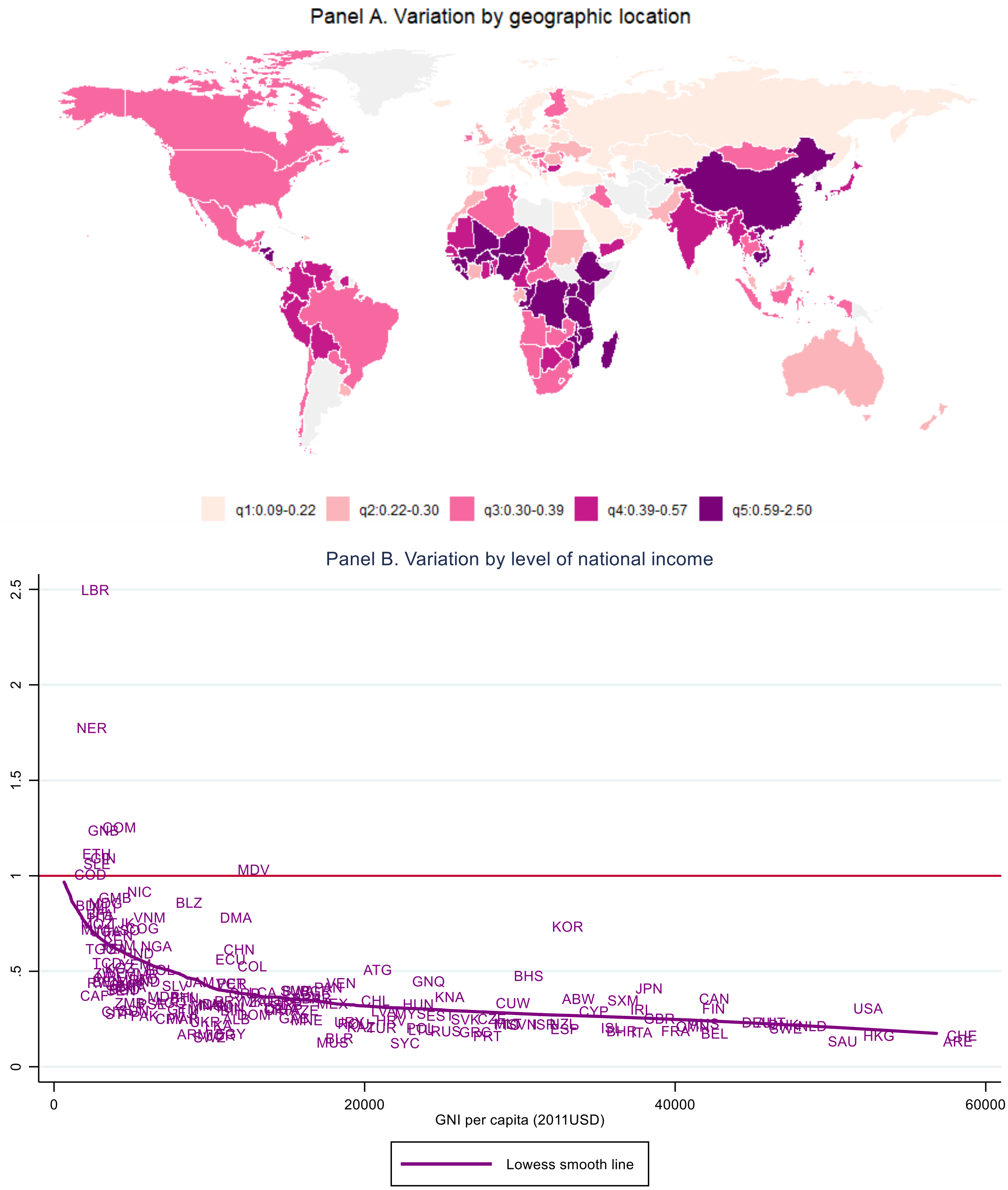


B. CoCA converted by 2011 PPP for foods



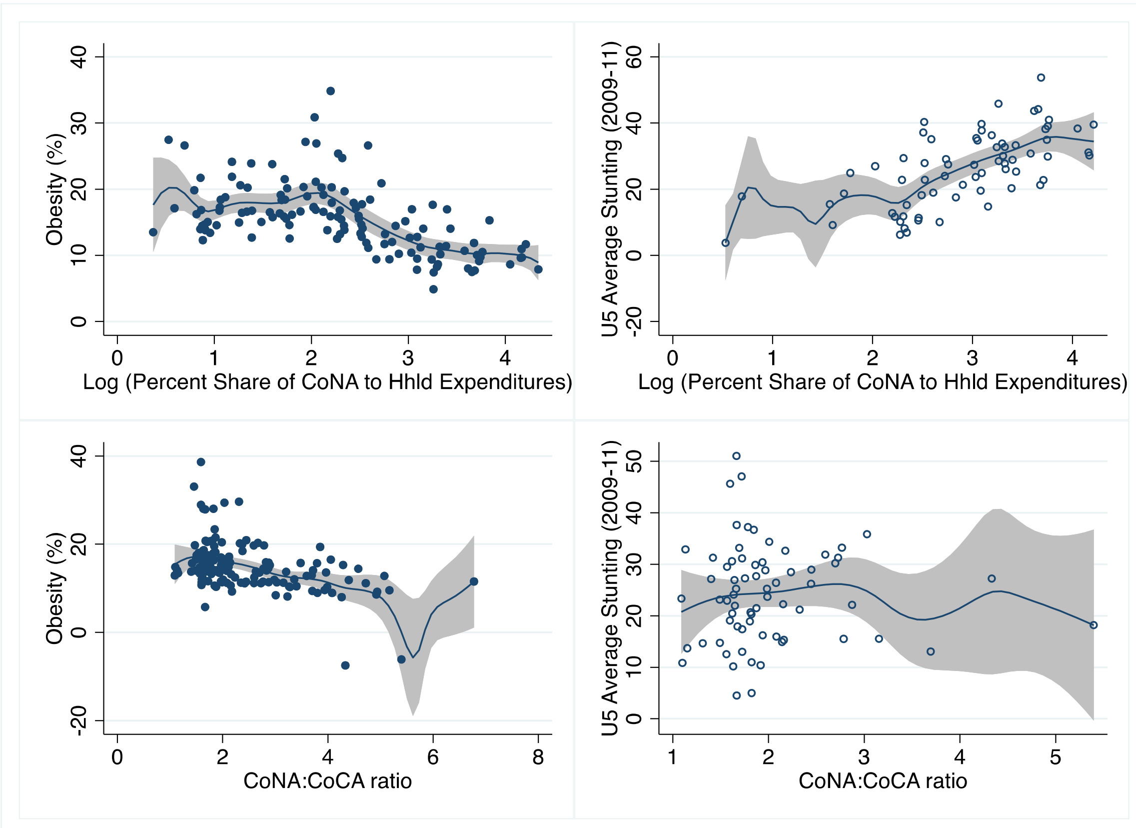
Note: Data shown are the cost per day of a least-cost diet meeting all nutrient constraints for a healthy adult woman across 177 countries in 2011, converted to international dollars at purchasing power parity (PPP) price levels for all household goods and services in each country (panel A), and at purchasing power parity (PPP) price levels for all food and non-alcoholic beverages in each country (B). Methods are described as detailed in the text. Higher income countries often have higher prices in PPP terms, due to higher wages and other costs. Food prices are often relatively high in lower-income countries, compared to average prices in other sectors and the price level of each sector in higher-income countries.

Figure A4. The cost of nutrient adequacy as a fraction of mean food expenditure



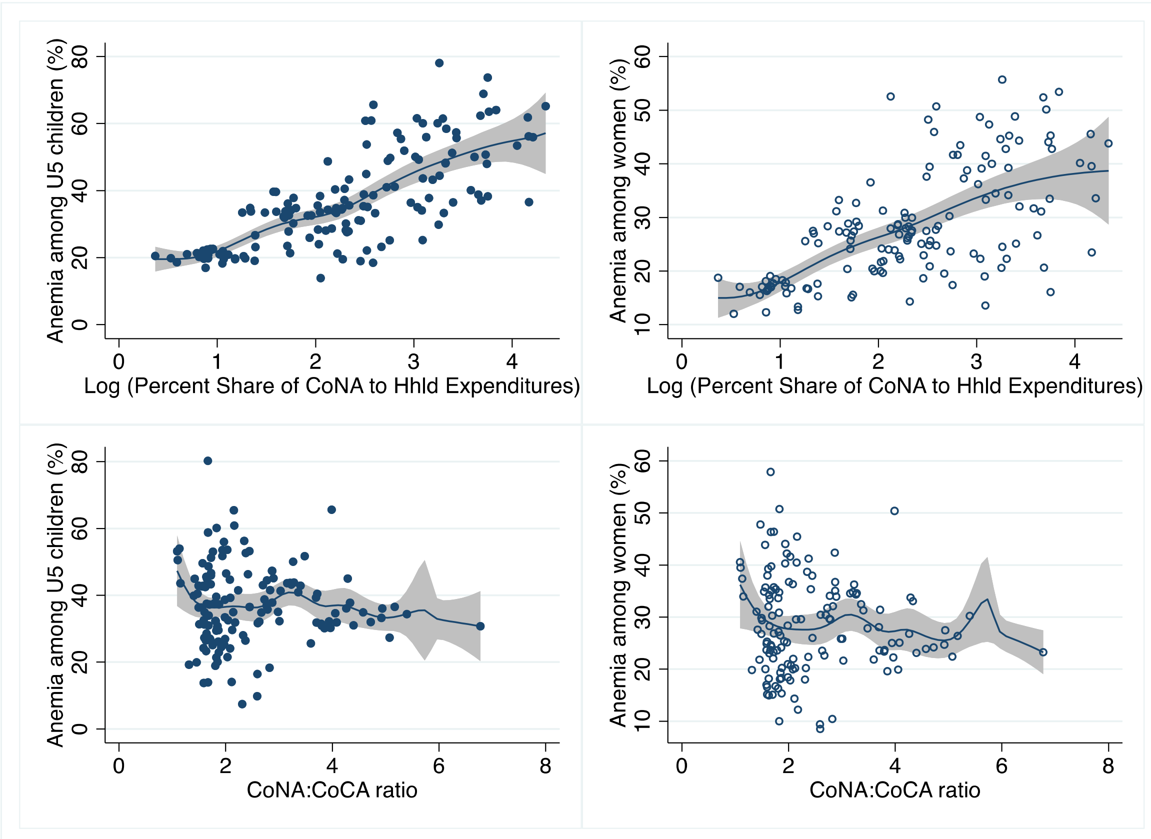
Note: Data shown are ratios of CoNA per day to food expenditure per capita per day, as detailed in the text, for 176 countries in 2011 as food expenditure is not available in Cuba. Panel B further excludes Anguilla, Bonaire, Cuba, Djibouti, Montserrat, Taiwan (China), Turks and Caicos Islands, Virgin Islands (British) and shows countries with GNI per capita lower than 60,000 in 2011 USD.

Figure A5. Affordability of nutritious diets and anthropometric outcomes



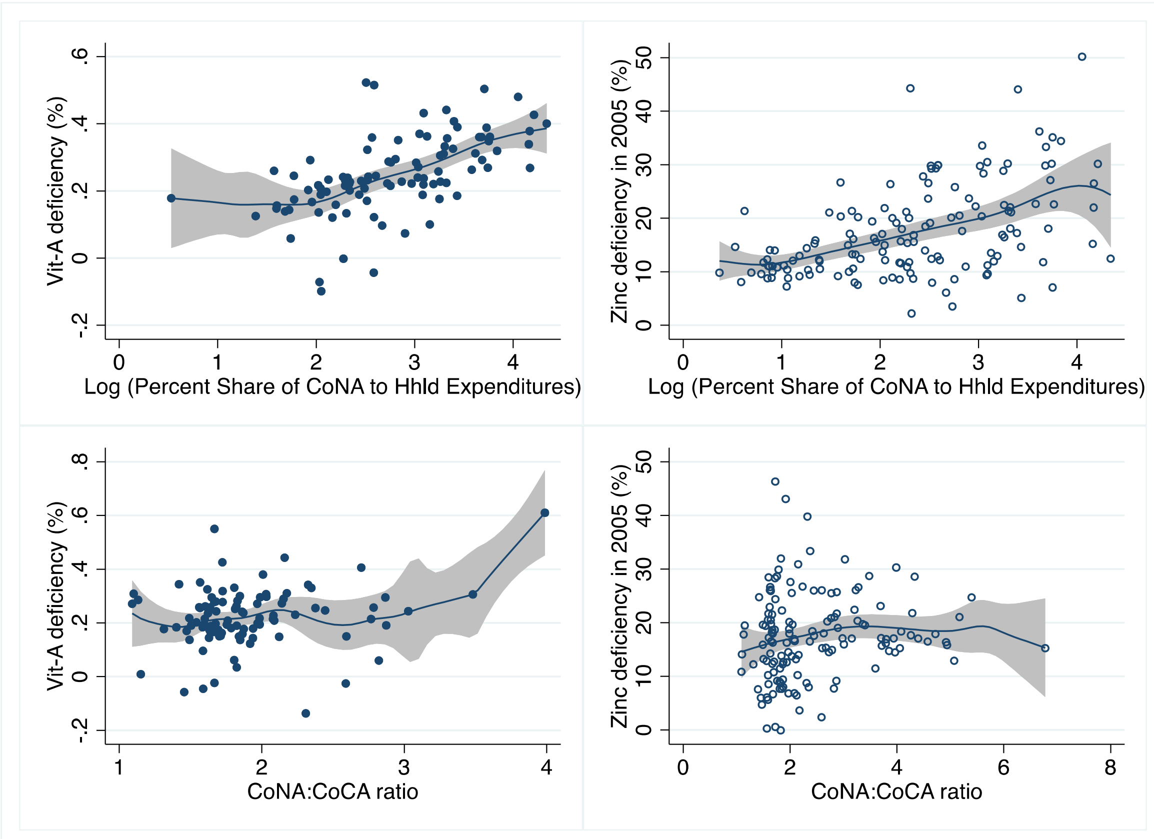
Note: Data shown are residuals and semi-parametric estimates of the mean and its 95% confidence interval after controlling for a quadratic function of log GNI and indicators for ICP regions. U5 stands for children under 5 years of age. Obesity prevalence is for the year 2011 (N=1142) while prevalence of under-five stunting is an annual average of the years between 2009-2011 (N=69)

Figure A6. Affordability of nutritious diets and anemia prevalence



Note: Data shown are residuals and semi-parametric estimates of the mean and its 95% confidence interval after controlling for a quadratic function of log GNI and indicators for ICP regions. Anemia prevalence among women represents the share of non-pregnant women in a country's population (N=143) with hemoglobin concentration <120 g/dL while under five children the threshold is <110 g/dL.

Figure A7. Affordability of nutritious diets and Vitamin A or zinc deficiency



Note: Data shown are residuals and semi-parametric estimates of the mean and its 95% confidence interval after controlling for a quadratic function of log GNI and indicators for ICP regions. Prevalence of zinc deficiency (N=144) represents the share of a country's population with intakes below physiological requirements (adopted from Wesseles et al., 2012). Prevalence of vitamin A deficiency represents the share of children in a country (N=97) under 5 years of age with serum retinol levels < ≤ 0.70 µmol/l).