Measuring food access as affordability of least-cost healthy diets worldwide

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Abstract

Since 2020, the World Bank, FAO and others have measured a population's access to sufficient nutritious food for an active and healthy life using a new metric known as the Cost and Affordability of Healthy Diets (CoAHD). This new kind of data measures food access using market prices of the least expensive locally available items that would meet nutritional criteria adopted by national governments, as summarized in a Healthy Diet Basket (HDB) level of intake balanced among six complementary food groups: starchy staples, vegetables, fruits, fats and oils, animal source foods, and legumes, nuts and seeds. CoAHD reflects the definition of food security introduced during the World Food Summit of 1996, and complements the earlier measures of global food security notably Prevalence of Undernourishment (PoU) based on total national availability and intake distribution of calories, and the Food Insecurity Experience Scale (FIES) based on survey data asking whether a household ran out of resources to acquire their usual diets. This paper briefly discusses the evolution of global food security measurement, then highlights updates to the methods used to compute CoAHD indicators and presents newly available CoAHD data obtained using this methodology and updated price data.

1. Defining and measuring global food security: from energy sufficiency to foods for health

The concept and measurement of food security has evolved with changing policy priorities and availability of new data sources (Herforth 2015, Masters, Finaret, and Block 2022). The first global definition of food security was introduced by the World Food Conference of 1974, where national governments responded to sharp price rises for traded commodities and recent famines in South Asia and Africa by declaring food security to be "*availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices*". Policies at that time focused on global concerns that population growth would outpace food supplies, which led to increased investment in production of staple crops as recommended by the official conference report (United Nations 1975).

Since 1974, world food security has been monitored by the UN's Food and Agriculture Organization (FAO) using a metric known as the Prevalence of Undernourishment (PoU), estimating the number and percent of people in each country whose total food intake is below the estimated energy requirements for a healthy population. The PoU approach was first developed by P.V. Sukhatme (1961), using recent household surveys to estimate inequality of food consumption as a log-normal distribution of energy intake within countries, and then shifting that distribution using the country's total available dietary energy and demographic projections to trace out changes in prevalence of intake below target levels associated with a healthy population (FAO 2001). PoU was a major step forward at the time, using food balance sheets to add up all kinds of food consumed in each country combined with distributional data from household surveys to go beyond per-capita averages and market prices for major staples such as wheat and rice used in previous food security metrics (Masters et al 2025). Fifty years after its introduction,

the PoU continues to be a widely cited metric tracking total availability for food of all kinds in each country and worldwide (FAO, IFAD, UNICEF, WFP and WHO 2024).

In the late 1980s, a new type of survey question was developed by Kathy Radimer (1990), measuring hunger and food insecurity by asking people whether they were unable to obtain their usual diet at any time over the previous year, due to a lack of money or other resources to acquire food. Radimer and colleagues asked whether a lack of resources had forced respondents to skip a meal, eat fewer foods, eat smaller quantities of food, go to bed hungry, go an entire day without eating, or experience other food-related hardships. Pilot studies showed that respondents' inability to obtain their usual diet due to lack of money is so memorable that recall over an entire year is feasible, and arises even when food prices are low. The resulting indicator, initially known as the Cornell-Radimer Hunger Scale, was first introduced for the U.S. in 1996 and is now measured using an updated set of Food Security Survey Modules (USDA Economic Research Service 2022), with similar questions adopted elsewhere such as Canada's Household Food Security Survey Module (Health Canada 2012). The U.S. scale is based on up to 18 distinct questions about different kinds of deprivation, counting people as food insecure if they answer yes to more than a threshold number of questions (USDA Economic Research Service 2022). International studies towards a scale whose results would be comparable across countries (Coates, Swindale, and Bilinsky 2007) led to the FAO's Food Insecurity Experience Scale (FIES) that uses only eight questions (Ballard, Kepple, and Cafiero 2013) with Rasch modeling to obtain a country-specific weight on each question (FAO 2024b).

The PoU and FIES are currently used to track global progress towards achieving Sustainable Development Goal 2.1 to "*end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient*

food all year round" (United Nations 2016), but it is widely understood that neither the PoU nor FIES measure access to *nutritious* food. To fill that gap, a new indicator known as the Cost and Affordability of a Healthy Diet (CoAHD) was developed by Herforth et al. (2020) and adopted alongside PoU and FIES for annual global monitoring (FAO, IFAD, UNICEF, WFP and WHO 2020; FAO 2024a; World Bank 2024a).

The new CoAHD metric of food security has two parts: first using data on retail prices, food composition and nutritional requirements to compute the Cost of a Healthy Diet (CoHD), and then using household survey data to compare that benchmark diet cost to income available for food. CoHD is defined as the cost of purchasing the least expensive locally available foods to meet food-based dietary guidelines (Herforth et al. 2020, FAO 2024a, Bai et al. 2024a). Income available for food can be defined in a variety of ways, but since 2024 for global monitoring the FAO and World Bank use the total value of consumption (including own production of food) per person in each household, minus the nonfood spending of households near the international poverty line relevant to their country (FAO 2024a, Bai et al. 2024b).

The CoAHD approach defines the foods needed for health using national dietary guidelines because those are government documents representing a country's scientific and policy consensus about what constitutes a healthy diet for the general population. Dietary guidelines recommend target quantities from specific food groups in proportions needed to achieve nutrient adequacy and protection from diet-related diseases. Each national dietary guideline typically refers to commonly consumed food items and dishes in each country, with adherence to the guideline allowing for a wide range of choices and substitution among items within each food group. Consumer-facing guidelines specify the total target quantity of items in each food group using everyday units such as grams and liters or cups and ounces, recognizing

that each food's volume and weight may be affected by its air or water content. For example, the U.S. dietary guidelines specify that one cup of fresh fruit is nutritionally equivalent to one-half cup of dried fruit (USDA and HHS 2020). Dietary guidelines also specify the need to maintain energy balance, which depends on a person's height, weight, physical activity, life stage and other factors. For diet costing, target quantities of the reference foods mentioned in dietary guidelines are converted into dietary energy from that type of food, netting out water weight so that substitution among items within each category provides a balanced diet between food groups for overall health over time.

To compute CoHD, the items for which price data are available are matched with a food composition database, and the price per calorie of each item is then used to identify the least expensive locally available source of each food group. The lowest cost items within groups vary over time and space, but the quantity of food from each group remains fixed to meet dietary guidelines. The resulting least-cost foods provide a benchmark diet against which to compare actual food consumption. In very low-income settings, most people's food consumption costs less than CoHD, primarily because they consume more than target quantities of low-cost starchy staples, and less than target quantities of higher-cost, nutrient-rich food groups. In higher-income populations, people's food consumption typically costs more than CoHD because they switch from lower-cost starchy staples to higher-cost food groups, especially animal source foods and discretionary items not needed to meet dietary guidelines. People also spend more than CoHD because they choose foods other than least expensive item within each food group, for reasons such as taste and preferences, time use and cooking cost, or aspirations shaped by marketing efforts and cultural heritage.

Using locally available items to compute CoHD provides an operational metric for food security based on the definition that "*food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (World Food Summit 1996). Measuring access allows analysts to distinguish between three causes of unhealthy diets, guiding action towards policies and programs that would remedy each barrier to change:

(a) Comparing costs over space and time provides operational guidance for agriculture and food distribution, revealing what prices are unusually high and which food value chains have demonstrated potential for cost reduction that would improve access to healthy diets;
(b) Comparing costs to income available for food provides operational guidance for poverty reduction, safety nets and nutrition assistance, revealing which people have low incomes or high nonfood costs that block access to healthy diets;
(c) Comparing least-cost items to actual food consumption provides operational guidance about barriers to healthy eating other than local availability and price, including time use and cooking costs as well as taste and aspirations that guide food choice.

The operational value of computing benchmark least-cost healthy diets for each population led to the rapid adoption of CoAHD. Since 2020, the metric has been used for global monitoring of access to healthy diets, complementing PoU and FIES in the UN system flagship report on *The State of Food Security and Nutrition in the World* (FAO, IFAD, UNICEF, WFP and WHO 2020; 2021; 2022; 2023; 2024). Methods were updated in the 2022 and 2024 reports, and since 2022 all results have been published simultaneously by both FAO and the World Bank, with downloadable data in the World Bank's Food Prices for Nutrition DataBank (World Bank 2024a) as well FAOSTAT (FAO 2024a). Those data are then republished on other platforms

such as the Food Systems Dashboard (Fanzo et al. 2020; Food Systems Dashboard 2024) and the Food Systems Countdown Initiative (Schneider et al. 2023), and Our World in Data (Ritchie, Rosado, and Roser 2024). Global monitoring of CoAHD uses national average prices and household incomes over an entire year, while national monitoring can track geographic and seasonal variation within countries. The indicator has been calculated from national data in several countries (Alemayehu et al. 2023; Fatima et al. 2024; Van et al. 2023; Ballard, Kepple, and Cafiero 2013; Herforth et al. 2024), with Nigeria as the first country to introduce monthly bulletins tracking healthy diet costs as an official national statistic alongside their traditional consumer price index (NBS 2024), and Ethiopia as the first country whose public health authorities use least-cost diets to track the cost of meeting their own national dietary guidelines (EPHI 2025).

Selecting only the lowest cost items in each food group provides a new kind of price index, designed to measure access to foods for health. Using least-cost items by food group to meet an international dietary standard was first introduced by Masters et al. (2018) for access to the Minimum Diet Diversity for Women (MDD-W), and by Herforth et al. (2020) to measure access to sufficient quantities in proportions needed for national dietary guidelines, as well as Hirvonen et al. (2020) for access to the EAT-Lancet reference diet. Food group targets developed for dietary guidelines are designed to meet all nutrient requirements, but these studies showed that diets can meet nutrient requirements at a lower cost than CoHD. Calculating least cost diets for nutrient adequacy is more difficult than computing CoHD, requiring linear programming to select diets that fall within lower and upper bounds for energy, macronutrients and/or micronutrients (Deptford et al. 2017; Bai, Herforth, and Masters 2022). To guide food assistance in humanitarian settings, the cost of a diet with adequate nutrients that might not also meet diet

guidelines is used by the World Food Programme in countries around the world (Knight et al. 2024), complementing CoAHD monitoring (Wallingford et al. 2024).

The remainder of this paper provides an overview of the CoAHD approach, discusses methodological advancements in the calculation of its affordability component, presents a new analysis of updated global CoAHD data using newly available food price data for 2021, and describes important limitations of those results to be addressed in future work.

2. Measuring the cost and affordability of healthy diets within countries and globally

The CoAHD approach was initially developed and can still be implemented using a country's own national dietary guidelines, as done for example in Ethiopia (Alemayehu et al. 2023, EPHI 2025), while global monitoring is done using the international Healthy Diet Basket (HDB) standard developed by Herforth et al. (2022, 2025) that can also be used within countries that do not have their own guidelines as done in Nigeria (NBS 2024).

2.1 The Healthy Diet Basket and illustrative examples of least cost healthy diets

The purpose of the HDB standard is to capture commonalities among national guidelines, specifying energy balance across eleven items in six food groups as shown in Table 1.

Table 1. The Healthy Diet Basket

Food group	Number of items	Energy content (kcal)	Energy share (% kcal)
Starchy staples	2	1,160	50
Vegetables	3	110	5
Fruits	2	160	7
Animal-source foods	2	300	13
Legumes, nuts & seeds	1	300	13
Oils and fats	1	300	12
Total	**11**	**2330**	**100**

Source: Herforth et al. (2022), Herforth et al. (2025).

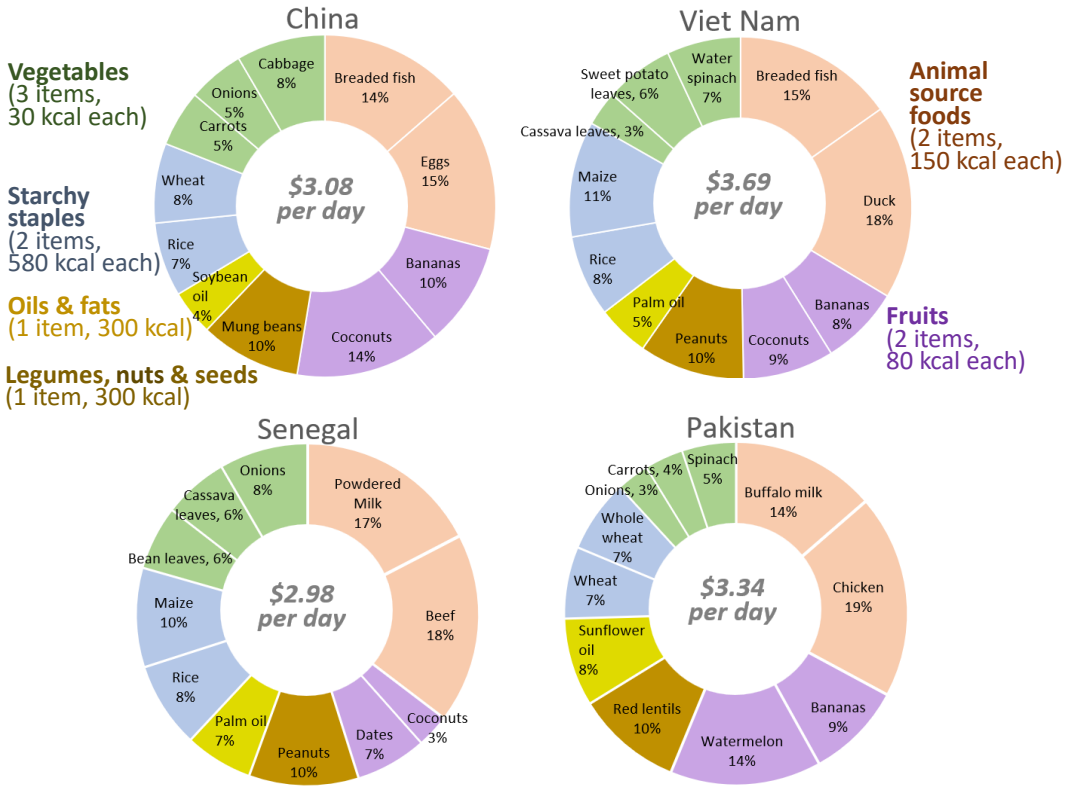
The HDB's total of 2330 kcal, shown in the bottom row of Table 1, represents daily needs for a 30-year-old woman of median height and weight in the WHO global reference population (Schneider and Herforth 2020), which happens to also be the simple average for the median healthy person across all age-sex strata (Herforth et al. 2025). When choosing the least expensive locally available items in each country, meeting the HDB targets by food group reaches nutrient adequacy as or more often than when following individual dietary guidelines, thereby validating the HDB as a composite metric of commonalities among them (Herforth et al. 2025). The HDB is designed to reflect foods needed not only for nutrient adequacy but also protection from some diet-related diseases, and generally meets WHO guidelines on sugar, sodium, and other risk factors as shown by Herforth et al. (2025). Limited quantities of items from that seventh discretionary food group are allowed under many national dietary guidelines, but they are not required for health so are not included when measuring the minimum cost of access to sufficient foods for an active and healthy life.

Data sources and computational methods for computing the Cost of a Healthy Diet (CoHD) indicator are specified in FAOSTAT (FAO 2024a), and software tools for anyone to compute CoHD from local price data are available from the Food Prices for Nutrition project at Tufts University (Food Prices for Nutrition 2024). Adding up costs for the least expensive items

reported to be locally available allows analysts to distinguish between access to a healthy diet and foods actually consumed, recognizing that other more costly items often have desirable attributes such as preferred tastes, ease of use in meal preparation, cultural significance or aspirational branding.

Specific items selected as least cost healthy diets when calculating CoHD for global comparison across four example countries are shown in Figure 1, illustrating the range of items and cost shares by food group underlying the CoHD data available from FAOSTAT (FAO 2024a) and the World Bank's Food Prices for Nutrition DataBank (The World Bank 2024a).

Figure 1. Item selection and cost shares in four least-cost healthy diets for 2021



Note: Data shown are abbreviated item names, with colors showing each food group's share of the cost shown for each country, as reported in FAO (2024a). Foods selected are the least expensive items in each Healthy Diet Basket food group, based on prices and item descriptions reported by national statistical organizations to the International Comparison Program (The World Bank 2024c). Legend outside the data in the top row show the number of food items per food group and recommended intake in kcal per food item based on the Healthy Diet Basket (Herforth et al., 2022, Herforth et al. 2025).

Each panel of Figure 1 shows abbreviated names for a specific item, whose average price as reported by the country's national statistical organization revealed that item to be among the least expensive locally available options to meet HDB targets in 2021. The total cost per day is shown at the center of each plate, with cost shares shown in the color-coded area drawn proportional to that variable. Figure 1 illustrates how item selection and cost shares forming CoHD reflect local agroecology and food systems, with characteristic differences and similarities across countries. The items, range of cost shares and cost per day shown in Figure 1 are typical

of least-cost diets observed around the world, with variation due partly to actual differences among food systems, but also to measurement error and systematic differences such as the type of vendor or date and time when prices were collected.

2.2 Food item price data for healthy diet cost and affordability measurement

Food prices for global monitoring come from the ICP, a global initiative to assemble national average prices of internationally standardized items. The purpose of the ICP is to compute the Purchasing Power Parity (PPP) value of each currency and hence real incomes in each population (The World Bank 2024c). To calculate PPP exchange rates, the ICP needs to assemble nationally representative local currency prices for standard items of similar quality and packaging sold in multiple countries, and to cover the entire world economy they must obtain prices for all countries and territories. This process takes several years, so is done periodically with a lag. For example, prices for 2017 were released in 2020, and prices for 2021 were released in 2024. To project CoHD forward or backward for years when item prices are not available, the CoAHD metric uses each country's overall food price inflation as reported by their statistical organization to the FAO and the International Monetary Fund (Bai et al. 2024a). For example, the updated CoAHD estimates published in 2024 used the prices reported for 2021, projected back to 2017 and forward to 2022 by deflating or inflating diet costs according to the country's consumer price index for all foods.

2.3 Healthy diet affordability measurement

Affordability of healthy diets globally is reported by the FAO and the World Bank as the number and percentage of people whose incomes available for food are below CoHD, based on each country's national income distribution from household survey data compiled by the World

Bank's Poverty and Inequality Platform (The World Bank 2024b). In the original CoAHD estimates released in 2022 and 2023, a healthy diet was deemed unaffordable if it cost more than 52 percent of a household's total income or expenditure. This threshold was based on the only globally available data at that time, using the average food expenditure share in low-income countries as reported to the ICP in national accounts for 2017 (FAO, IFAD, UNICEF, WFP and WHO 2022, 2023; Herforth et al. 2022). The affordability threshold was then updated in 2024 as detailed below, based on more recent available survey data about spending on required nonfood items such as housing, education, and health care, which must be subtracted from total income to obtain a household's income available for food (FAO, IFAD, UNICEF, WFP and WHO 2024, Bai et al. 2024b).

2.4 An updated threshold for measuring the affordability of healthy diets

Expenditure on nonfood needs rise with country income, as reflected in government poverty lines that tend to be higher in higher-income countries (Jolliffe and Prydz 2021). One reason for this is Engel's Law, stating that demand for goods and services rises with income faster for other things than for food, but another reason is that tradable services are more expensive in higher-wage countries (Masters and Finaret 2024). To account for differences in item prices, researchers have applied the least-cost method by identifying the minimum quantities of nonfood items required in each country, and then assembling prices for the lowest cost version of those items. Such a quantity-based approach was used by Allen (2017) and Headey et al. (2024), but only for housing, energy, clothing and soap. For services such as education, health care, communications and transportation, it is more difficult to distinguish differences in prices from demand for higher quality and quantity associated with higher incomes.

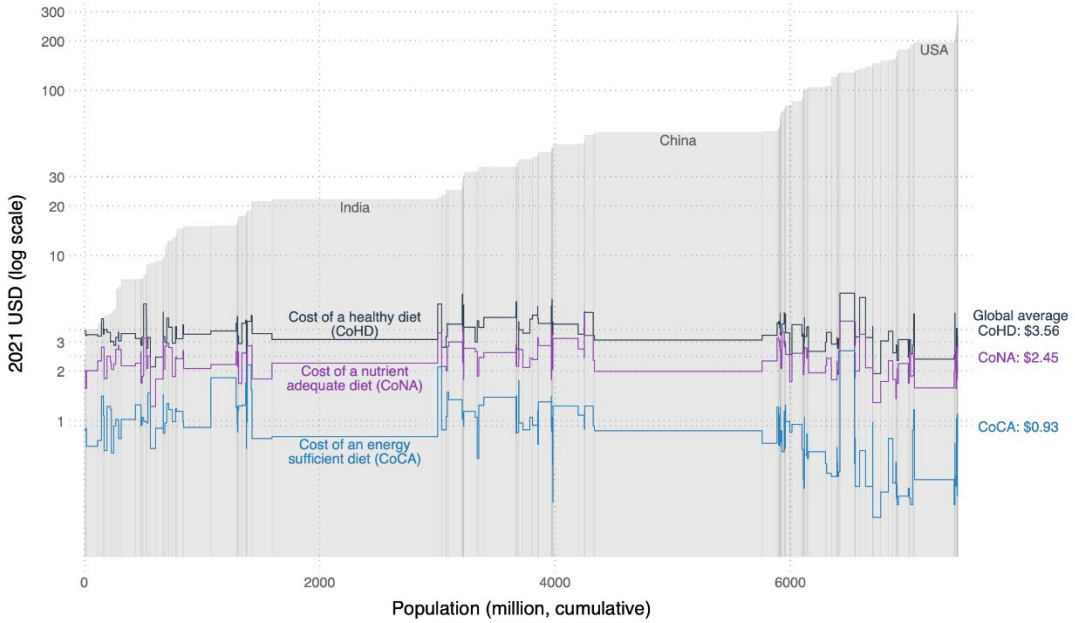
For CoAHD, the preferred approach to measuring income available for food is to infer the required level of nonfood spending from national governments' poverty lines, so as to align this new metric of food affordability with existing policies about other kinds of deprivation. This was done for the updated CoAHD results published in July 2024 using the World Bank's international poverty lines, which in turn are based on the national government poverty lines available in each income group observed to be around $2.15 for low-income countries, $3.65 for lower middle income, $6.85 for upper middle income, and $24.36 for high-income countries, all in PPP dollars per capita per day. The CoAHD method then uses the actual nonfood spending of people near that international poverty line, as estimated by the World Bank for each quintile of the population for each country, and subtracts that level of nonfood spending per day from total household income or expenditure to obtain income available for food (FAO, IFAD, UNICEF, WFP and WHO 2024; Bai et al. 2024b), leading to the results presented below.

3. Newly available data on the cost and affordability of a healthy diet in 2021

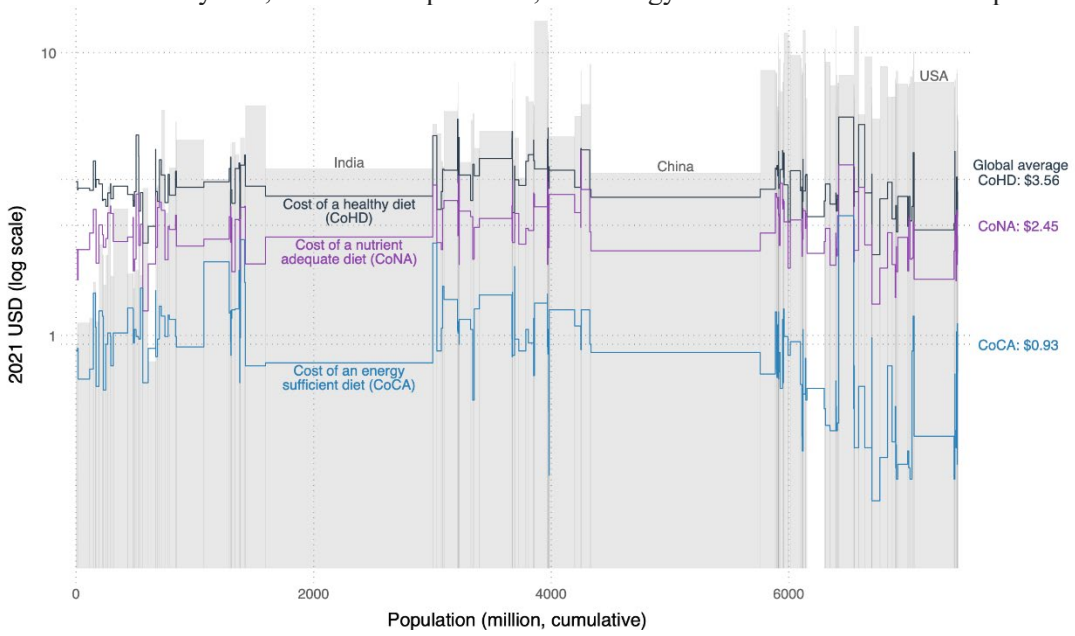
The global average CoHD in 2021 was $3.56 in U.S. dollars at purchasing power parity prices (PPP) per person per day. Consistent with previous rounds of data, newly released data show that the CoHD in 2021 is not systematically related to national income, as shown in the Pen's Parade plot in panel A of Figure 2. This figure is adapted from parade plots shown in Herforth et al (2025), extended to contrast CoHD with the\ somewhat lower level of cost for diets with just enough essential nutrients to stay within upper and lower bounds, known as the Cost of Nutrient Adequacy (CoNA), and the even lower threshold of diets that provide just enough dietary energy from starchy staples for short-term survival known as the Cost of Caloric Adequacy (CoCA). All of those diet costs can be compared to both national income and actual food spending (Figure 2, panel B).

Figure 2. Cost of a healthy diet, nutrient adequate diet, and energy sufficient diet by country at each level of national income or food expenditure per capita per day in 2021

A. Cost of a healthy diet, nutrient adequate diet, and energy sufficient diet and GNI per capita per day



B. Cost of a healthy diet, nutrient adequate diet, and energy sufficient diet and food expenditure per capita per day

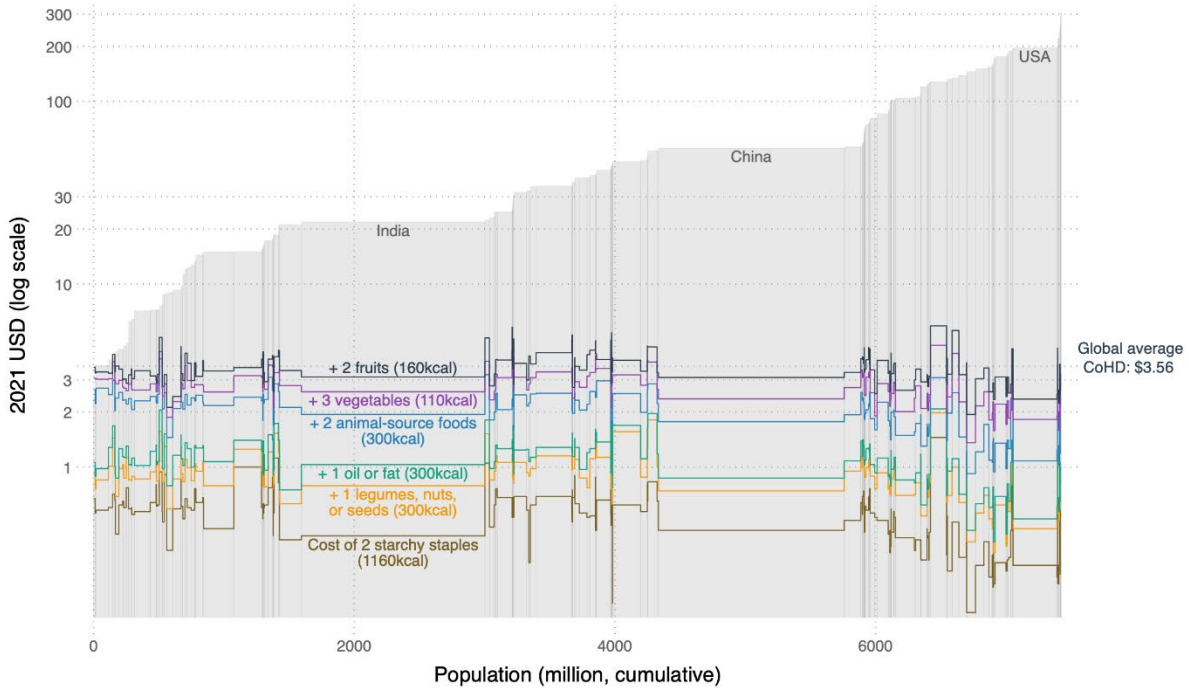


Note: Pen's Parade plots in panels A and B show the global population by country, represented by the width of each bar, in order of national income per person per day. Data shown in colored horizontal lines are estimates for 2021 of each country's Cost of a Healthy Diet (CoHD), Cost of a Nutrient Adequate (CoNA) diet, and Cost of a Calorie-Adequate (CoCA) diet, each in U.S. dollars at purchasing power parity prices, per person, per day, available from the World Bank Food Prices for Nutrition Database, version 3.0, at https://databank.worldbank.org/source/food-prices-for-nutrition. The height of each gray bar represents a country's national income per person per day (panel A) or food expenditure per person per day (panel B). National income data are available from the World Development Indicators, at https://databank.worldbank.org/source/world-development-indicators. Food expenditure data are from the International Comparison Program, and the missing data for Russia is in Panel B.

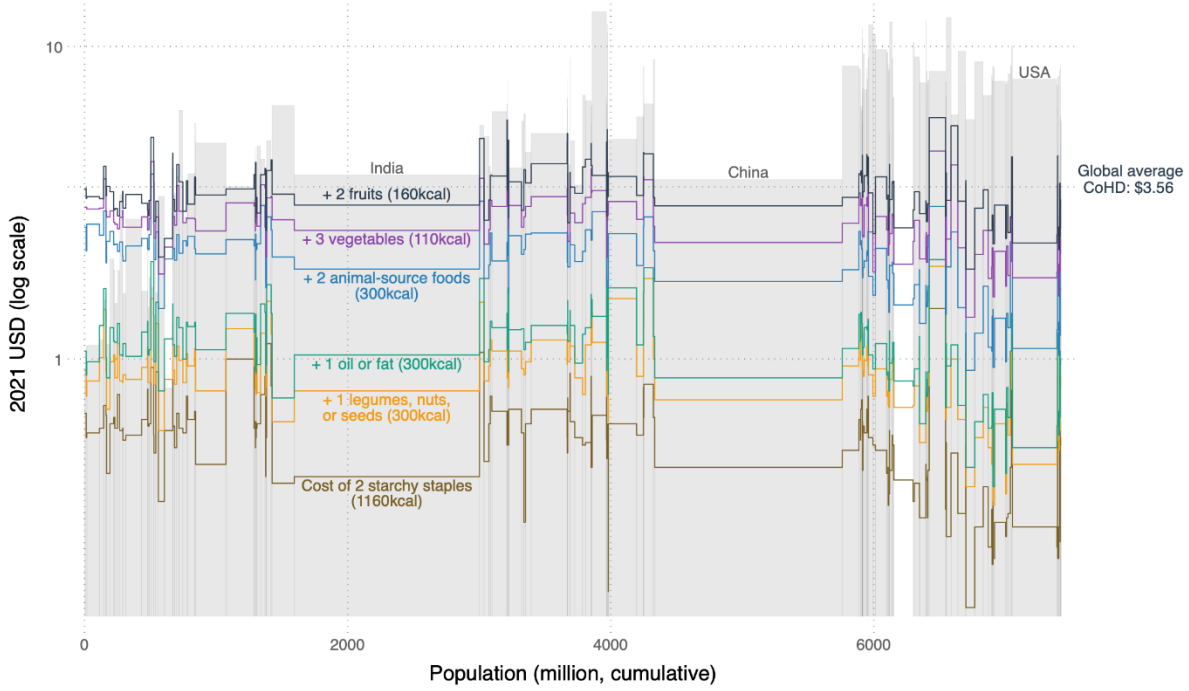
Figure 3 and appendix Figure A1 show how the six HDB food group costs sum to the CoHD within each country. Breaking the CoHD out into its HDB food group components shows that nutrient dense food groups like animal-source foods, vegetables, and fruits tend to make up the greatest shares of the CoHD, bringing the CoHD close to GNI per capita per day (Figure 3, panel A) and above average food expenditures per capita per day (Figure 3, panel B) for many of the poorest countries. On average globally, oils and fats are the least expensive food group, followed by legumes, nuts, and seeds, starchy staples, fruits, vegetables, then animal-source foods, though this ranking does not consistently hold within each country, showing how local agroecology and food system characteristics are reflected in HDB food group costs (Figure 3, panel C). Within food groups, the range of costs varies by income level and region, where, for example, the range of costs for the animal-source foods food group is much higher for low-income countries than for high-income countries, and the range of costs for the vegetables and fruits food groups are substantially lower for low-income countries than for high-income countries (Figure 4).

Figure 3. Healthy Diet Basket food group costs in least-cost healthy diets and Gross National Income or food expenditure per capita per day in 2021

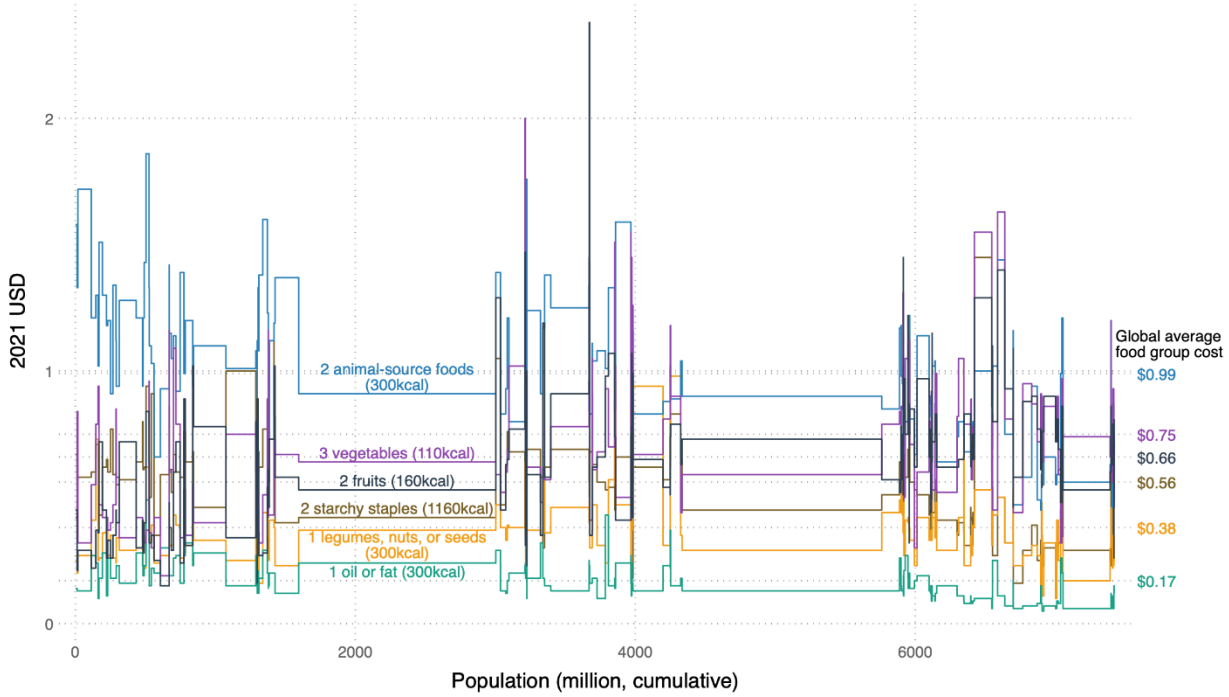
A. Healthy Diet Basket food group costs in least-cost healthy diets and GNI per capita per day



B. Healthy Diet Basket food group costs in least-cost healthy diets and food expenditure per capita per day



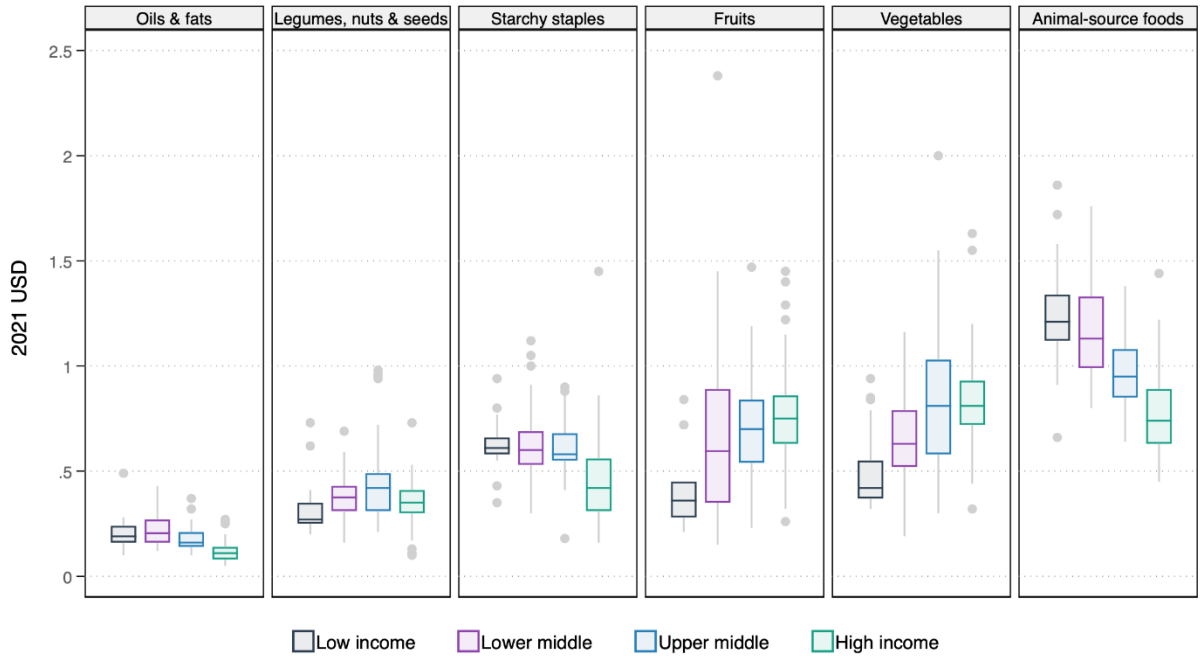
C. Healthy Diet Basket food group costs in least-cost healthy diets



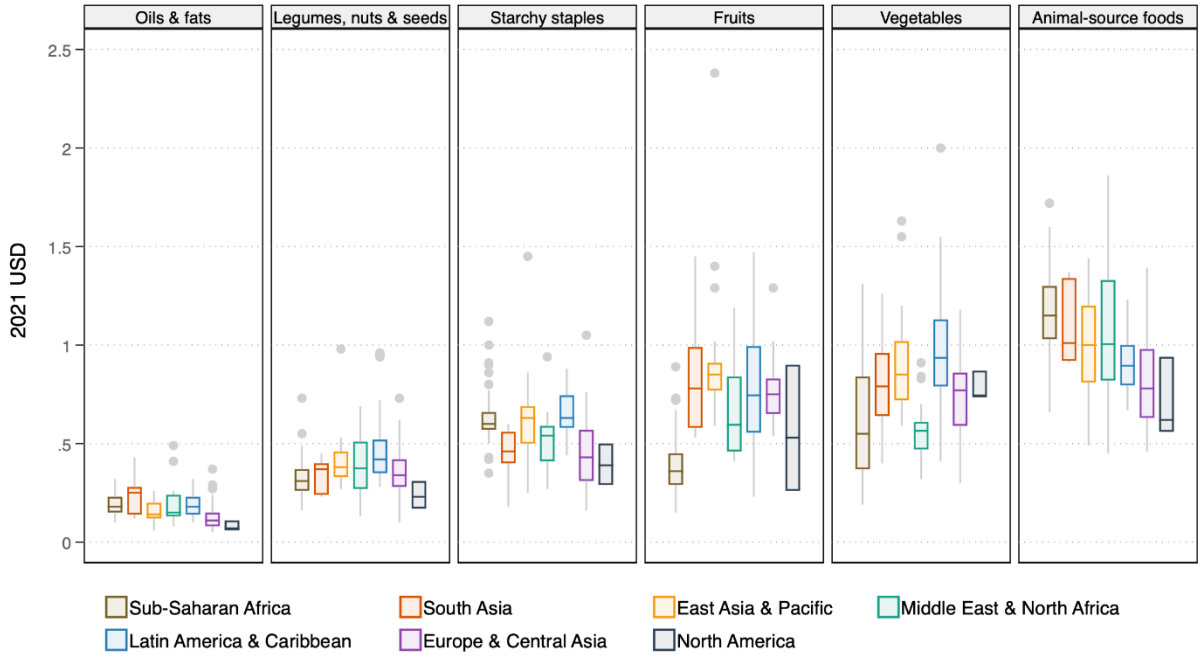
Note: Pen's Parade plots in panels A-C show the global population by country, represented by the width of each bar, in order of national income per person per day. Data shown in colored horizontal lines in panels A and B represent the cumulative Healthy Diet Basket food group costs in each country's least-cost healthy diet in 2021 in U.S. dollars at purchasing power parity prices per person per day, beginning with the cost of starchy staples in brown, then adding on the cost of legumes, nuts and seeds in orange, oils and fats in green, animal-source foods in blue, vegetables in purple, and fruits in black to reach each country's Cost of a Healthy Diet (CoHD) in red, available from the World Bank Food Prices for Nutrition Database, version 3.0, at https://databank.worldbank.org/source/food-prices-for-nutrition. The height of each light gray bar represents a country's national income per person per day (panel A) or food expenditure per person per day (panel B). National income data are available from the World Development Indicators, at https://databank.worldbank.org/source/world-development-indicators. Food expenditure data are from the International Comparison Program, and the missing data for Russia is in Panel B. Panel C shows costs for each Healthy Diet Basket food group in each country, as well as global average food group costs.

Figure 4. Range of costs per day by Healthy Diet Basket food group in each World Bank income category, 2021

A. Range of costs per day by Healthy Diet Basket food group in each World Bank income category



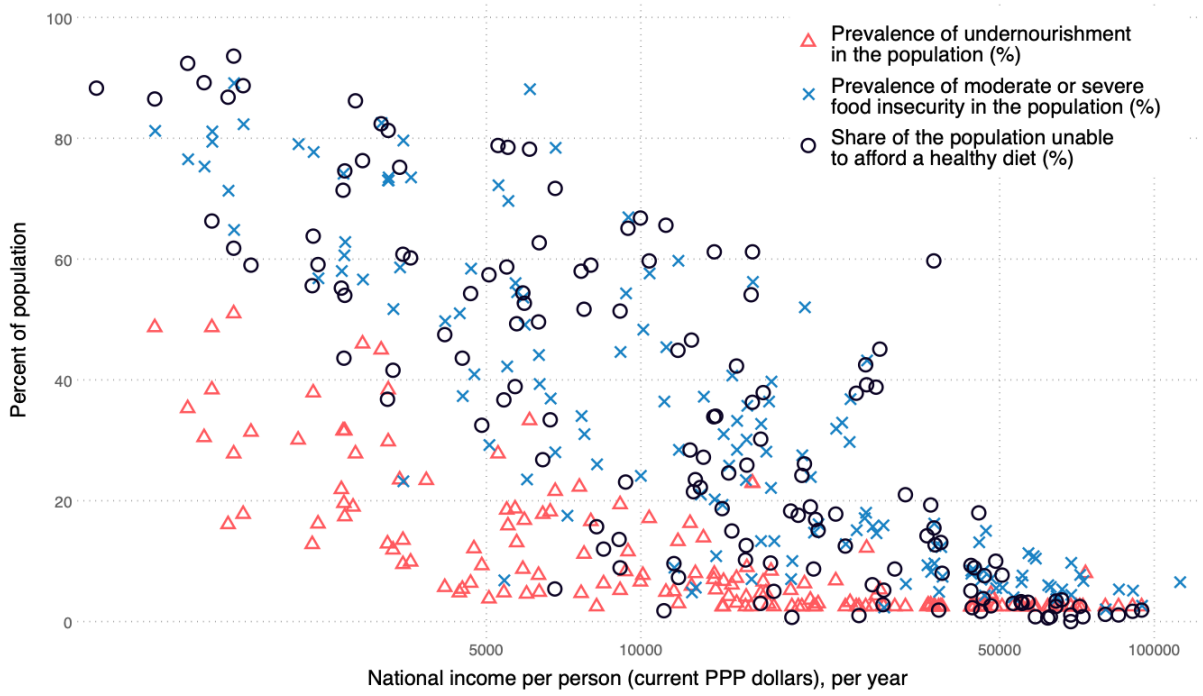
B. Range of costs per day by Healthy Diet Basket food group in each region



Note: Data shown are FAO and World Bank estimates for the Cost of a Healthy Diet (CoHD) in 2021, using U.S. dollars at purchasing power parity prices, available from the World Bank Food Prices for Nutrition Database, version 3.0, at https://databank.worldbank.org/source/food-prices-for-nutrition, or on FAOSTAT, at https://www.fao.org/faostat/en/#data/CAHD.

Using the updated affordability threshold that incorporates the nonfood expenditure of people near the international poverty line for each of the World Bank's country income categories, the least-cost locally available healthy diet was unaffordable for approximately 2.8 billion people in 2021, which is about 36% of the world population. Each country's number and prevalence of unaffordability, known as NUA and PUA in official statistics (FAO 2024), differs from earlier FAO metrics of food security in systematic ways. As with the PoU and the FIES, there is lower prevalence of unaffordability in higher-income countries, but the new indicator spans a wider range from over 95% to near zero. CoAHD estimates for unaffordability of a healthy diet are much higher than measured undernourishment (PoU) in low- and middle-income countries, and somewhat higher than measured food insecurity (FIES) most low-income countries, but is almost zero at the highest income levels which is well below PoU or FIES in those countries (Figure 5).

Figure 5. Prevalence of undernourishment, experience of food insecurity, and unaffordability of a healthy diet in 2021



Note: Data shown are estimates for 2021 of the percent of the population within each country unable to afford a healthy diet, downloaded from the World Bank Food Prices for Nutrition Database, version 3.0, at https://databank.worldbank.org/source/food-prices-for-nutrition, and two FAO indicators, prevalence of undernourishment and experience of moderate or severe food insecurity, downloaded from FAOSTAT at https://www.fao.org/faostat. National income data were downloaded from the World Development Indicators at https://databank.worldbank.org/source/world-development-indicators.

4. Limitations of the CoAHD approach to measuring food security

The CoAHD approach was developed in the late 2010s in response to demand for improved food system metrics (Herforth 2015), to complement the many other indicators of food and nutrition security available at that time (Lele et al. 2016). It measures access to healthy diets in two steps, focusing first on food environments using cost per day for the least expensive locally available options in a healthy diet (CoHD), and then calculating affordability of that

benchmark diet using income available for food. The available data used to compute both diet costs and affordability have multiple limitations. Each variable used to compute these metrics is subject to measurement error, but we do not yet have a way to compute confidence intervals. Data sources may also introduce systematic biases, but we do not have a gold standard against which to compare each approach.

To describe the limitations of currently used techniques for measuring this new construct, it is helpful to list the variables and parameters used to compute CoAHD so as to consider how each might be improved in the future:

1) Food availability and price for global monitoring is now based on ICP data collection protocols, while other studies use each country's own consumer price index or a market information system. Increasing the frequency and extent of price reporting in standardized formats would help ensure that availability and price data accurately reflect the food environment at each location, and ensuring that these data come from the markets most often used by low-income people would help track their food access as shown for example by Headey (2024).
2) The edible fraction, energy content and food group classification of each item is obtained through the closest match between item descriptions in each price list and all available food composition tables. Published item descriptions are sometimes insufficient to identify the product's food composition, for example due to ambiguity about the product's likely moisture content. Using pooled food composition data as in the software toolkit provided by Food Prices for Nutrition (2024) can be helpful, but more precise item descriptions in price datasets would be helpful, and changing food environments call

for increased frequency and extent of food composition measurement and reporting through channels such as FAO (2024c).

3) The definition of food groups and the balance between them needed for a healthy diet is obtained from national dietary guidelines, using the commonalities among them to construct the global reference Healthy Diet Basket. This process involves some inherent ambiguity, for example regarding whether a product such the breaded fish balls shown in the least-cost diets for China and Viet Nam (Figure 1) actually provide the nutritional value expected of items in the animal source food category. Variation in the nutritional profile of items within each food group is somewhat addressed by requiring two or three different items, but those can potentially be from the same species as in the inclusion of both refined wheat and whole wheat for Pakistan (Figure 1). We expect dietary guidelines to evolve with additional evidence about the food attributes needed for lifelong health, leading to improved food composition data about those attributes and also more use of updated dietary guidelines as in Ethiopia (EPHI 2025). We also expect some applications of the CoAHD approach to use customized nutritional requirements for specific age-sex categories or other demographic groups, and potentially adjusting the total amount of food required from the needs of a representative woman at 2,330 kcal/day to more precise estimates that vary with a person's height, weight, physical activity and other attributes (Bai et al. 2022).

4) The conversion of local currency prices from nominal to real terms involves adjusting for inflation over time and differences in purchasing power between locations. The price indexes used for these conversions may not reflect the time and place where food price

and income data were collected, calling for increased attention to price measurement in both nominal and real terms (Latino, Holleman and Cafiero, 2024).

5) Any comparison of diet costs to income available for food depends on both total income and required nonfood spending. In some settings it is preferable to report diet costs without calculating affordability, as done in Nigeria (NBS 2024) where those data are then used directly in policy debates such as around minimum wages as reported by Muhammad (2024). In other cases, it may be preferable to use ratio indicators, such as comparing diet costs to daily wages as in Headey et al. (2024). Where an estimate of the number and proportion of people who cannot afford a healthy diet is needed, methods are likely to be updated periodically based on improved data about income and nonfood spending as done in Bai et al. (2024b).

5. Conclusions

Updated global monitoring data for diet costs, using 2021 ICP food prices instead of 2017 prices, and number of people who cannot afford that cost, using new thresholds based on non-food requirements that are lower in low-income countries and higher in middle-income countries than those used for previous analyses, show that healthy diets remain unaffordable for just under three billion people in the world in 2021. Where healthy diets are affordable, the least-cost items needed for health are often displaced by more expensive items, as revealed by average food expenditures that far surpass the CoHD in many upper-middle- and high-income countries. These new data also show how nutrient-rich food groups, like fruits, vegetables, and animal-source foods tend to be more costly than the remaining HDB food groups (starchy staples, legumes, nuts and seeds, and oils and fats), and that, while the CoHD shows no relationship with

country income level, the range of costs within HDB food groups varies across income groups, in ways that differ across food groups. These cost data by HDB food group are currently only available for the year 2021, corresponding to the most recent year for which ICP food price data are available. Future work could develop methodology and expand food price data collection to allow for annual estimates of the food group costs that make up the CoHD.

Measuring access to foods needed for health, as captured by the CoAHD suite of indicators, complements ongoing use of other food security metrics such as PoU and FIES. Identifying the least-cost food items needed for health, and the number of people unable to afford even these least-cost items in each place and time, reveals where improvements in agriculture and food distribution may be needed to lower diet costs, improvements in livelihoods and social protection systems may be needed to raise incomes available for food, and actions to address the drivers of food choice beyond prices and income may be needed to improve diet quality. Continued global monitoring of the cost and affordability of healthy diets remains critical for guiding policy and intervention to improve global food security and move food systems towards achieving universal access to healthy diets.

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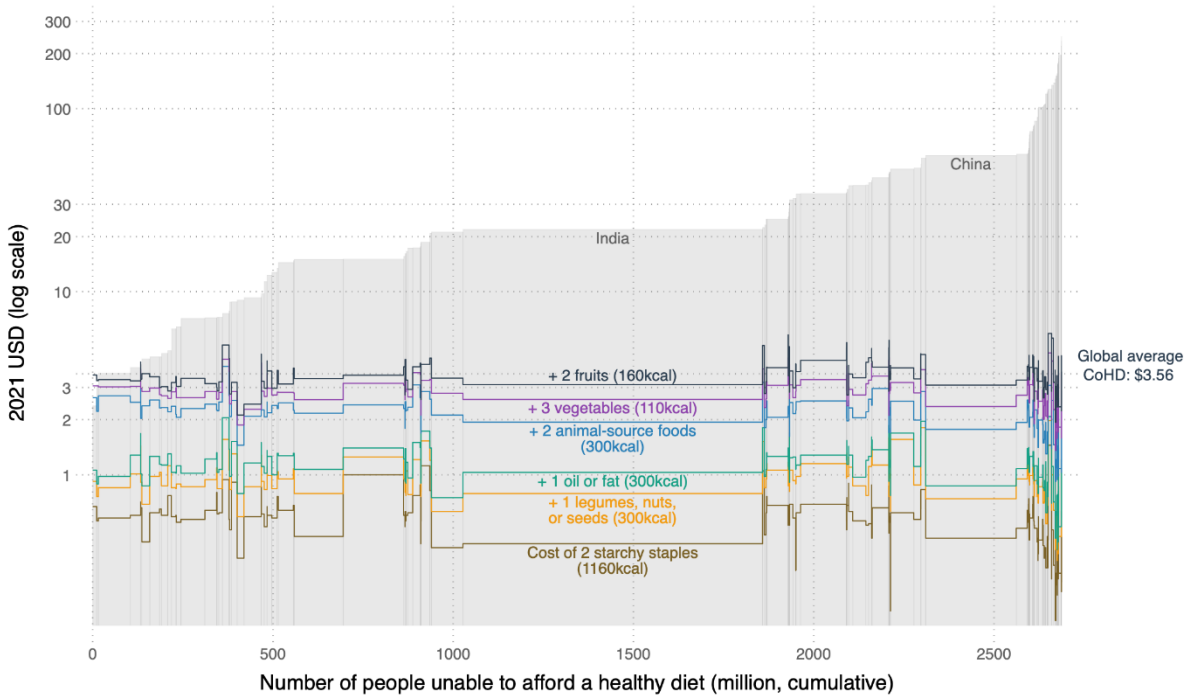
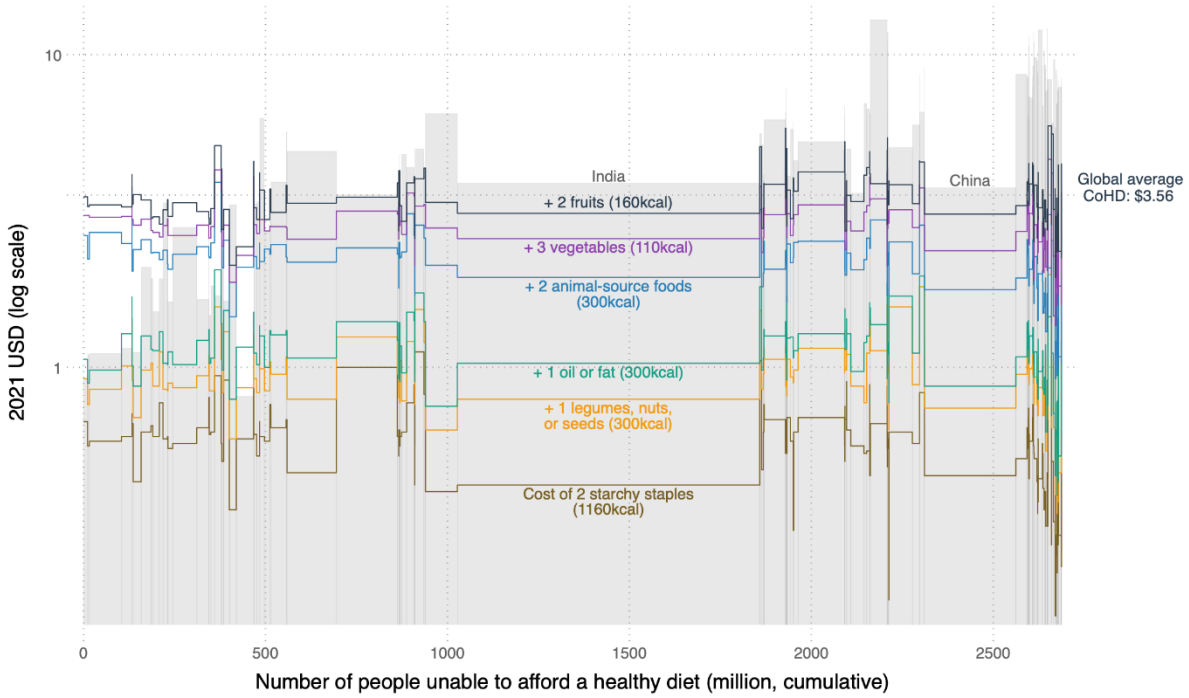
Appendix

Figure A1. Healthy Diet Basket food group costs in least-cost healthy diets, Gross National Income or food expenditure per capita per day, and the number of people unable to afford a healthy diet in 2021

A. Healthy Diet Basket food group costs in least-cost healthy diets, GNI per capita per day, and the number of people unable to afford a healthy diet



B. Healthy Diet Basket food group costs in least-cost healthy diets, food expenditure per capita per day, and the number of people unable to afford a healthy diet



Note: Pen's Parade plots in panels A and B show the number of people unable to afford a healthy diet by country, represented by the width of each bar, in order of national income per person per day. Data shown in colored horizontal lines in panels A and B represent the cumulative Healthy Diet Basket food group costs in each country's least-cost healthy diet in 2021 in U.S. dollars at purchasing power parity prices per person per day, beginning with the cost of starchy staples as the lowest line in brown, then adding on the cost of legumes, nuts and seeds in orange, oils and fats in green, animal-source foods in blue, vegetables in purple, and fruits in black, to reach each country's Cost of a Healthy Diet (CoHD) in red, available from the World Bank Food Prices for Nutrition Database, version 3.0, at https://databank.worldbank.org/source/food-prices-for-nutrition. The height of each gray bar represents a country's national income per person per day (panel A) or food expenditure per person per day (panel B). National income data are available from the World Development Indicators, at https://databank.worldbank.org/source/world-development-indicators.