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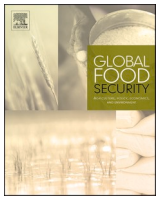

Analyzing diet cost and affordability: A dataset from Fill the Nutrient Gap analyses (2015–2021)☆

Zuzanna Turowska [a,*], Janosch Klemm [a,b], Saskia de Pee [a,c]

[a] World Food Programme, Via Cesare Giulio Viola, 68/70, 00148 Roma RM, Italy
[b] Center for Development Research, Bonn, Germany
[c] Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA

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ABSTRACT

Between 2015 and 2021, the World Food Programme (WFP) carried out "Fill the Nutrient Gap" (FNG) analyses in 37 countries. Apart from a few early FNG analyses, each analysis calculated the cost of energy-sufficient diets, staple-adjusted nutrient-adequate diets, and the non-affordability of the latter at the subnational level during a specific period decided by in-country stakeholders and data availability. In 2021–2022, all FNG output data were compiled into one dataset, which is provided as an online supplement to this paper. Here, we describe the parameters and data used in these FNG analyses and the process for standardizing diet costs for time (to January 2020) and in currency (PPP USD and MER USD). The objective of this paper was to provide the dataset utilized in the other papers in this GFS special issue on diet cost and affordability analyses conducted as part of FNG analyses by WFP and partners, and to provide a description of the considerations and methods employed for compiling this dataset.

1. Introduction

High cost of nutritious foods and limited household food budgets constitute barriers to accessing diverse, healthy diets which are fundamental to good nutrition, particularly in many low and low-middle income countries (FAO et al., 2020). While several studies on economic barriers to nutritious diets have emerged in recent years, most have focused on national level estimates of least cost nutrient-adequate diets (Hirvonen et al., 2020; Bai et al., 2021; Bai, Herforth and Masters 2022), often derived from similar data sources as the International Comparison Program (ICP) (Herforth et al., 2022; The World Bank, 2023). Few studies have focused on analyzing and consolidating subnational data estimates on the cost and affordability of diets, even though analyses tailored to country-specific population characteristics in terms of age and sex distribution, which determine nutrient needs, as well as sub-national food availability and prices as well as incomes, are better tailored for policy-making and programme design.

Between establishing the "Fill the Nutrient Gap" (FNG) analysis in 2015 (Bose et al., 2019) and 2021, the World Food Programme's (WFP) Nutrition division together with partners, including country governments, carried out FNG analyses in 37 countries to calculate the costs of energy-sufficient and nutrient-adequate diets and the percentage of households that were unable to afford each diet. These analyses were used to assess barriers to households' access to diverse diets that would meet their food and nutrition needs, review relevant policies and programmes within each country on how to better enable access to nutritious foods, and to develop recommendations to improve nutrition outcomes through food, health, social protection and education systems interventions.

The FNG analytical process produces two indicators, diet cost and non-affordability, which are standard among countries. It is not a survey which regularly produces intra-nationally and internationally comparable indicators like Minimum Dietary Diversity or Food Consumption Score, which are calculated, typically every few years, using primary data in assessments such as the Demographic and Health surveys (The DHS Program website), Multiple Indicator Cluster Surveys (UNICEF, 2024), Comprehensive Food Security and Vulnerability Assessments (WFP, 2009), or Food Security and Nutrition Monitoring Surveys (Bence and Chandra Babu, 2015). Each FNG was carried out as a stand-alone analysis relying as much as possible on secondary data. Although the motivations and priorities of each FNG analysis differed and were determined by contextual needs, all FNG analyses share a basic set of

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* Corresponding author.
E-mail address: Zuzanna.turowska@wfp.org (Z. Turowska).

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equivalent and comparable analytical diet cost and affordability indicators. The objective of this paper is to describe the methods used for compiling these indicators into one dataset, as it serves as the foundation for other analyses reported in the GFS special issue on FNG diet cost and affordability analyses. This paper describes the data sources used in each analysis, the process of data collation, and discusses considerations around selection of household size and currency.

2. Methods

2.1. The FNG framework

The conceptual principles and methodology of the FNG analyses have been previously described (Bose et al., 2019). The FNG methodological framework consists of a secondary literature review and a calculation of a least cost energy-sufficient diet and a least cost staple-adjusted nutrient-adequate diet for which Save the Children's Cost of the Diet optimization tool (Deptford et al., 2017) has been used. The FNG approach defines the 'energy-sufficient diet' as the lowest cost diet that meets an individual's or a household's caloric needs. The FNG defines the 'staple-adjusted nutrient-adequate diet' as the lowest cost nutritious diet that includes a typical staple food and excludes culturally inappropriate foods (e.g., pork in areas with a majority Muslim population). Staple adjustments were done to reflect the main source(s) of carbohydrates and energy in the local diet (i.e., the predominantly consumed staples were included, even if there were lower cost staples available). The staple-adjusted nutrient-adequate diet meets requirements for nutrients, including protein, nine vitamins and four minerals, without exceeding their upper limits where applicable, and does not exceed energy and fat requirements. To reasonably categorize these combinations as 'diets,' the optimization is carried out within defined constraints to prevent the inclusion of unrealistic types or amounts of individual foods or food groups.

Household-level estimates of the least cost energy-sufficient and staple-adjusted nutrient-adequate diets were compared against percentiles of food expenditure for a five-person household to estimate the percentage of households that would be unable to afford the energy-sufficient and the staple-adjusted nutrient-adequate diets. This is how non-affordability was defined. The dataset compiled for this paper only includes non-affordability for the staple-adjusted nutrient-adequate diet, as some of the early FNGs did not calculate non-affordability of energy-sufficient diets. Estimates for the costs of diets and for non-affordability of the staple-adjusted nutrient-adequate diet were first calculated at the subnational level. National level estimates for each indicator were calculated using population-weighted averages.

2.2. Dataset compilation

Forty FNG analyses across 37 countries (two each in Rwanda, Indonesia and Niger) were conducted between 2015 and 2021. The indicators of cost and non-affordability produced by these analyses have been included in the supplemental dataset and described in this paper. Each analysis was conducted for sub-national units, which were selected by country stakeholders. Each analysis in a subnational unit is referred to as an "assessment" in this paper, and all FNG assessments between 2015 and 2021 are included in the dataset. The dataset is comprised of two datasets and a sheet explaining variable names and coding structures. Dataset 1 includes all original estimates for the costs of energy-sufficient and staple-adjusted nutrient-adequate diets for each individual included in the modelled household for each assessment area from each FNG analysis. It includes information for each assessment, including the geographic location, when the analysis was carried out, when the data used for the analysis was collected, individuals included in the analysis, household size, urban/rural classification, and currency. Details on the methods utilized to standardize across currencies are described below in section 2.6. Dataset 2 includes non-affordability estimates for each assessment from each FNG analysis. Non-affordability estimates are represented at the household level. The two datasets can be merged.

2.3. Data sources

Depending on the context, analyses used retail food price data from data collections done specifically for the purpose of the FNG using either WFP or local third-party enumerators (n = 16) or leveraged existing data sources (n = 24). Retail food price data included both bulk products if available in markets, as well as small quantities, such as those purchased for fresh foods or condiments. Primary data collection was carried out directly by WFP staff or by trained third-party enumerators using an exhaustive food list. In countries where high-quality food price data already existed, the use of those secondary data were preferred. Secondary sources included data collected by national bureaus of statistics to calculate the Consumer Price Index (CPI), other government market monitoring data and food prices derived from household consumption and expenditure surveys. In the case of using secondary data, we had limited control over the food list, geographic scope and regularity of collection. Results based on both primary and secondary food prices data sources may not be representative if food price data were not available in all assessment areas, or some markets could not be reached, thereby biasing national level estimates. Secondary sources for food prices were not assumed to include an exhaustive list of all foods available throughout a country's food environment, i.e., not each food available in the market is documented. In analyses where WFP conducted primary market price data collection, we assumed food lists were exhaustive. Incomplete food lists may bias cost estimates upwards as they may result in fewer food items from which a diet's cost can be calculated.

FNG analyses used only secondary data for estimating expenditure percentiles for the non-affordability calculation. If available, standardized and regularly conducted surveys like the World Bank's Living Standards Measurement Survey or Household Income and Expenditure Survey were selected. In countries where these data did not exist, other data sources were used, like a food security survey in Afghanistan or a resilience survey in Cambodia. Expenditure data were cleaned by removing outliers of household size. Decisions on what size household constituted an outlier were often decided with inputs from stakeholders, as household sizes can be large in some contexts where multiple generations and extended families live together. Expenditure was calculated as an estimate of food expenditure per capita, then multiplied by the number of members of the modelled household in each assessment area to allow for the calculation of non-affordability. Often expenditure survey data did not align with the time period during which food prices were collected. In these instances, expenditure data were adjusted using inflation rates to align with the food price time period. A table of the data sources used for both the price and expenditure data for each FNG analysis is provided in the Supplementary data Table 1.

2.4. Unit of analysis

2.4.1. Household size and composition

The number and type of individuals included in the FNG modelled household differed among some countries, and within some countries among assessment areas (Supplementary data Table 2). The majority of FNG analyses (n = 25) used a five-person modelled household composed of a breastfed child under two, a school-age child, an adolescent girl, a breastfeeding woman, and an adult man (referred to as the 'standard household'). Stakeholders in four analyses chose to construct households with fewer than five people, while stakeholders in ten analyses chose to include households of more than five people to better reflect average national household size. The additional individuals (i.e., in households with more than five people) differed among countries and, in the case of Ghana, Pakistan, Laos, and Madagascar, also among

Table 1
Average per capita energy and micronutrient requirements by modelled household composition used across FNG assessments.

		Analysis or assessment area	Household size	Calories	Protein (g)	Vitamin A (RAE µg)	Vitamin C (mg)	Vitamin B1 (mg)	Vitamin B2 (mg)	Niacin (mg)	Vitamin B6 (mg)	Pantothenic Acid (mg)	Folic Acid (µg)	Vitamin B12 (µg)	Calcium (mg)	Absorbed Iron (µg)	Magnesium (mg)	Zinc (Low Biovailability) (mg)
Standard five-person household	Breastfeeding woman, adult man, adolescent girl, school-aged child, and breast0fed child under two years	Bangladesh, Burundi, Cambodia, Ecuador, El Salvador, Ethiopian Public Health Institute and WFP (2022), Kyrgyz Republic, Laos, Lesotho, Mozambique, Myanmar, Nepal Pakistan, Philippines, Rwanda, Sri Lanka, Tanzania, Timor Leste, Uganda, Zambia	5	2093	35	510	38	0.9	0.9	12	1.0	4.4	310	1.9	880	1.7	177	12
One additional person	+ Child aged 4–5 years	Mali, Mauritania, Democratic Republic of Congo	6	1961	32	500	37	0.9	0.9	11	0.9	4.2	292	1.8	833	1.5	160	11
	+ Child aged 10–11 years	Pakistan (Balochistan)	6	2091	35	525	38	0.9	0.9	13	1.	4.5	325	2.0	950	1.7	185	11
	+ Elderly man	Tajikistan	6	2119	36	525	39	1.0	1.0	13	1.1	4.5	325	2.0	950	1.7	185	12
	+ Elderly woman	Laos (Oudomaxai)	6	2086	36	525	39	0.9	0.9	12	1.1	4.5	325	2.0	950	1.6	179	12
Two additional people	+ Child aged 10–11 years and child aged 4–5 years	Guinea Bissau	7	1978	32	514	37	0.9	0.9	12	1.0	4.3	307	1.8	900	1.5	170	12
	+ Child aged 10–11 years and elderly woman	Laos (Xekong), Afghanistan, Niger I, Niger II	7	2085	35	536	39	1.0	1.0	13	1.1	4.6	336	2.0	1000	1.6	186	12
Three additional people	+ Child aged 10–11 years, child aged 9–10 years and child aged 12–13 years	Pakistan (KP)	8	2109	34	531	38	1.0	1.0	13	1.1	4.5	331	2.0	963	1.6	180	12

Table 2
Comparison of average cost per five-person household per day by exchange rate for global regions (not weighted for population size).

	Cost of the staple-adjusted nutrient-adequate diet (USD)			
	Market exchange rate (MER USD, 2020)		Purchasing power parity (PPP USD, 2020)	
Region (n refers to number of country analyses)	Five-person household	Per capita	Five-person household	Per capita
East Asia and Pacific (n = 6)	4.11	0.82	11.57	2.31
Europe and Central Asia (n = 2)	4.38	0.88	17.49	3.50
Latin America and Caribbean (n = 4)	8.72	1.74	18.10	3.62
South Asia (n = 5)	3.08	0.62	10.76	2.15
Sub-Saharan Africa (n = 16)	2.73	0.55	7.13	1.43

assessments within the country. In Afghanistan and Burkina Faso, for example, analyses had six-person modelled households. In both countries, the standard household was used, and an additional member added – an additional school-age child in Afghanistan and an elderly woman in Burkina Faso.

In the selection of household members, the Cost of the Diet Software allows for selection based on sex, age, body weight, activity level, and reproductive status (pregnancy or lactation). Some analyses had the same household composition (i.e., the five-person household) but differing characteristics for the individuals. For example, stakeholders in Zambia chose to include a standard household in which the adult man is specified to be 30–59 years old, 55 kg, and moderately active, while stakeholders in the Nepal analysis chose the same but specified that the adult man weighed 50 kg. Detailed descriptions on the sex, age, body weight, activity level for each household individual are included in the supplemental dataset.

2.4.2. *Considerations for per capita calculations*

The FNG methodology does not calculate the cost of diets for a reference individual, i.e., an adult woman, not pregnant not breastfeeding, or a 'standardized individual' reflecting a population's average energy and nutrient requirements, such as the Sphere reference recommended content of per capita food rations (Sphere Association 2018). Rather, the method calculates the cost of diets for a household, summing individual-specific optimizations in household sized clusters of four to eight people, depending on context. In an FNG analysis, a per capita cost of diet is therefore the household's total cost divided by the number of household members. This is different from a per capita value that represents a reference individual. Per capita cost estimates based on the standardized household differ from those for larger households, and the magnitude of the difference is determined by the energy and nutrient needs of the additional individual(s). The majority of FNG analyses used the standard five-person household previously described. In order to assess whether average needs increase or decrease upon adding further household members to the standardized household, Table 1 shows the average per capita energy and micronutrient needs, in a standardized five-person household as compared to those in non-standard FNG households used in various analyses. The table indicates that, averaged, per capita requirements stay within a narrow range. For example, across all modelled household compositions the minimum per capita energy requirement was 1961 kcal/person/day, while the maximum was 2119 kcal/person/day. The largest percent difference between micronutrient needs per capita was observed for calcium (14%), absorbed iron (12%), vitamin B_1 (11%) and vitamin B_2 (11%) between standard and one of the non-standard households shown in Table 1.

Fig. 1 shows national averages for the per capita costs of nutrient-adequate diets pre and post household standardization for countries which did not have a five-person standard household in their original FNG analysis. The standardized household was constructed using the two-tier codification system embedded in the dataset and described in Supplementary data Table 3, tier 2. Supplementary data Table 3 shows which age- and weight-specific individuals were assigned to which standard individual, meaning that in one household, the child under 2 may be represented by a child 9–11 months old, while in another, this individual may be represented by a child 12–23 months old.

The choice of additional individuals beyond the five-person standardized household can reduce or increase cost compared to the standard household, depending on which individual(s) were added. In Mauritania, for example, the sixth individual was a child aged 10–11 years, whose cost of the nutrient-adequate diet is comparatively less

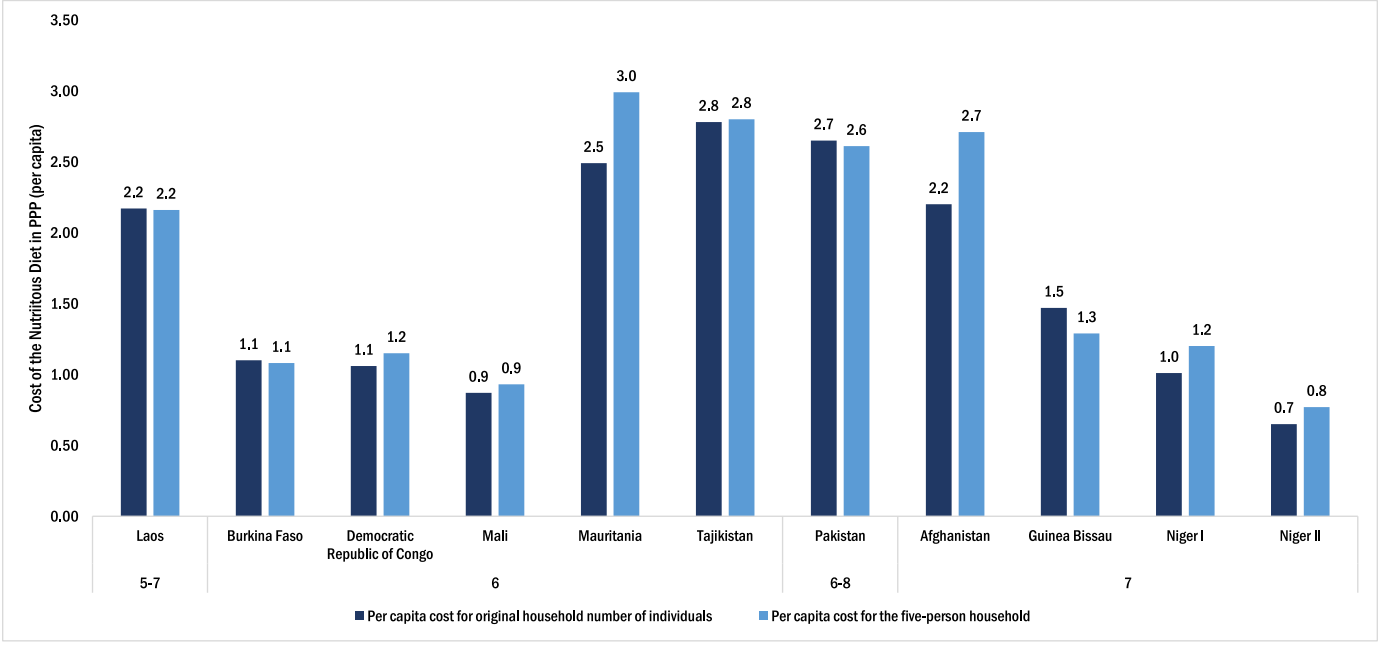

Fig. 1. Per capita daily cost (PPP) of the nutrient-adequate diet, calculated as the average from the specific household size and composition, for FNGs with more than the typical five members.

than that of an adult man. The per capita cost based on that six-person household was therefore less than the per capita cost of the standardized household. The supplementary dataset retains all original household members included in the analysis to enable users to select a standardized household only if it suits their analysis purposes.

Users of the supplementary dataset who wish to convert FNG modelled household members into per capita estimates should consider how the household composition can affect per capita estimates. The combination of individuals included in the modelled household make it so that the household has higher nutrient-density needs on average than a typical adult man. If we were to convert each individual into Adult Male Equivalent (AME) using energy requirements, the AME individual we construct has the same nutrient density needs as the household-derived per capita average (i.e., higher than for an adult man). Since high individual costs are mostly driven by heightened nutrient density needs, the average per capita AME cost estimated using the energy conversion would be slightly higher than if we were truly using an adult man.

In the dataset, results may be missing for certain individuals if the Cost of the Diet software was unable to calculate the cost for the individual, i.e., where the software was unable to find a combination of foods that met nutrient requirements given predetermined, individual-specific standard portion sizes (e.g., the 12–23 month old child in Somalia and Lesotho).

2.5. Seasonality

Country stakeholders and the availability of price data determined the number of seasons that were included in the FNG analysis. The dataset includes cost of the energy-sufficient and staple-adjusted nutrient-adequate diet for each individual for all seasons included in each assessment. Table 4 in the supplementary data shows the number of seasons included in each analysis.

Food price and expenditure data can constrict how representative estimates are across seasons. Expenditure surveys are often expensive and time-consuming, and therefore it is rare for them to be conducted annually or year-around. Food price data is typically more available for more seasons or months (for example, if collected monthly to estimate CPI). Given these constraints, FNG cost and non-affordability estimates only provide a snapshot of the time of analysis and do not systematically account for seasonality. This limitation has potential to provide lower- or higher-than-average costs, depending on the season from which the price and expenditure data were taken. When possible and applicable, food price data were collected during periods with lower availability and higher prices, so as to derive estimates for cost and non-affordability for periods with a greater likelihood of food or nutrition insecurity.

2.6. Currency and inflation adjustments

Each FNG analysis was conducted in the currency relevant to the country and was done for one or several specific moments in time. Because many contexts where FNGs were conducted have experienced large fluctuations in the value of the currency, the dataset includes the original cost of the energy-sufficient and the staple-adjusted nutrient-adequate diet per individual in local currency as well as USD January 2020 values. We included both Market Exchange Rates (MER) (World Food Programme 2021) and Purchasing Power Parity (PPP) (The World Bank Group, 2021) conversions to capture the cost of diets in nominal USD values (using MER) and in values adjusted for differences in country price levels (using PPP) (IMF, 2007). To align diet costs from different years and different currencies, adjustments of both currency and time period were required, meaning that each diet cost was converted to same currency (USD) and inflation-adjusted up to the same moment in time (January 2020) based on a three step methodology described in Dhaliwal et al. (2013). For both MER and PPP adjustments, data in local currency for the time point as used in the original analysis was first merged to conversion data by country, month, and year to convert costs into USD and then adjusted for inflation. Table 2 summarizes the cost of the staple-adjusted nutrient-adequate diet for the standardized household by region in both USD MER and USD PPP. The data shown is Table 2 is summarized from the 33 of the 40 countries for which it was possible to estimate a national average cost for the standardized five-person FNG household.

Fig. 2 shows a side-by-side comparison of cost estimates in PPP and MER. The PPP adjustment increased the USD value of the staple-adjusted nutrient-adequate diet by between 1.84 (Ecuador) and 4.65 (Afghanistan) times the value in exchange rate-adjusted USD values, highlighting that FNG diet cost data outputs can differ widely based on the conversion method used. Users should consider what currency conversion rates to use for making comparisons. MERs indicate the individual currency market relationship between a given country and the US at the point in time to which the conversion applies, while PPP exchange rates capture the differences between the cost of a basket of goods and services between a given country and the US (Organization for Economic Co-operation and Development, 2021). Time specificity of either method may be relevant when considering which conversion method to use as MER is aligned by month and year to cost data, while PPP is measured and aligned annually to cost data.

2.7. Geography

The geographic scope of each FNG analysis was determined by the geographic delineation in the food price and expenditure data, as well as the needs of stakeholders. If stakeholders planned to use the analysis for policymaking, for example, they could choose to use administrative units, like regions, provinces, or woredas. In cases where the FNG was used for humanitarian programming, stakeholders could instead choose to use livelihood zones or areas classified as refugee camps. Where data allowed, estimates for cost, non-affordability, or both could be disaggregated by urban and rural zones. Supplementary data Table 5 shows which analyses included urban and rural assessments (n = 13). In Cameroon and Zambia, only non-affordability was disaggregated because expenditure data were available for urban and rural areas, but food price data were only available for each subnational unit without disaggregation.

The supplementary dataset maintains all original geographic delineations included in each analysis. The number of geographic assessment areas is determined by the available data, meaning there is sizeable variation among the analyses. Results for cost and non-affordability do not always align geographically. In Zambia, for example, diet costs were calculated at the regional level, but non-affordability was calculated at the regional level with urban and rural divisions. In the Sahel, diet costs and affordability were calculated by livelihood zones (FEWSNET 2023; Hobbs et al., 2023), posing challenges in aligning with other subnational indicators, which are often calculated by administrative area.

A key feature of this dataset is that it allows users to identify disparities in cost and affordability between subnational areas. Fig. 3 shows the subnational variation in cost of energy-sufficient diets, Fig. 4 for

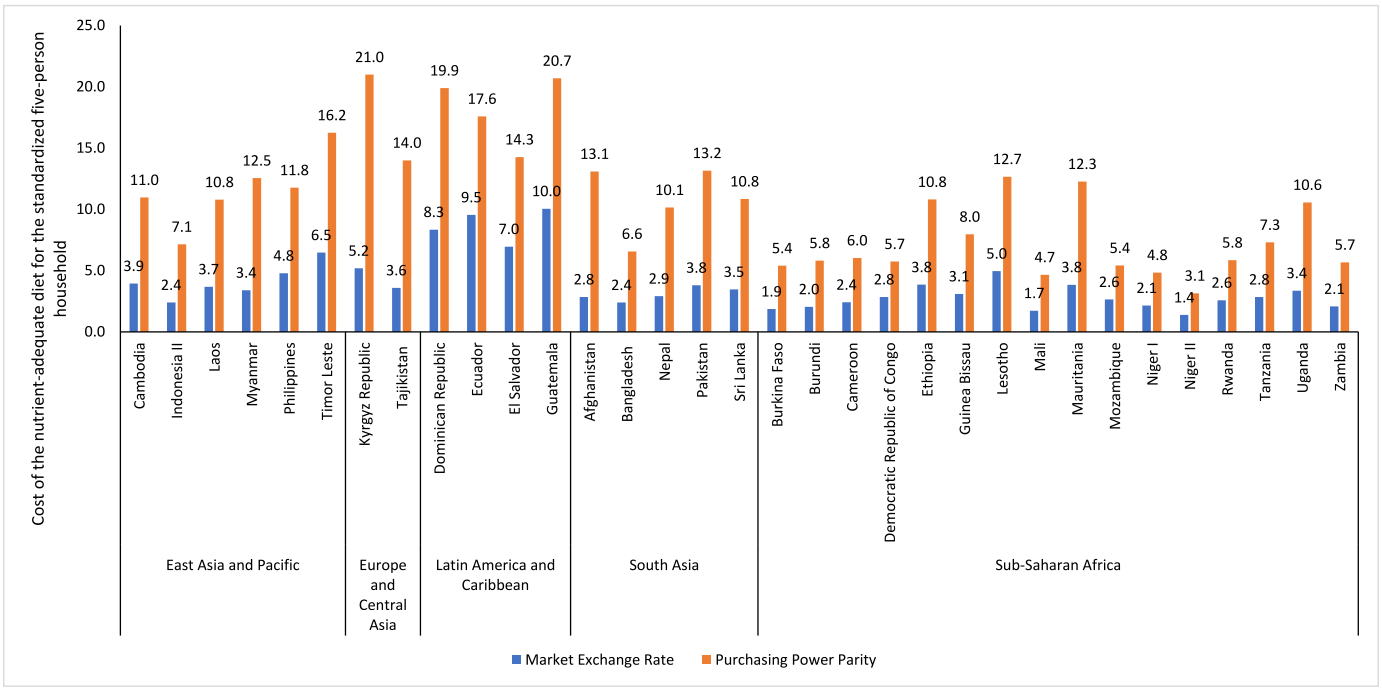

Fig. 2. Daily cost of the staple adjusted nutrient-adequate diet for the standardized household in USD 2020 b y different source of currency exchange (exchange rate and PPP).
All figures do not include Madagascar because we were unable to calculate a national average due to missing weights; Indonesia I, Armenia, and Ghana because these analyses use a 4-person household; Rwanda and Kenya refugee analyses were excluded because they are not country-level analyses; and Somalia was excluded because the World Bank does not provide a PPP adjustment value.

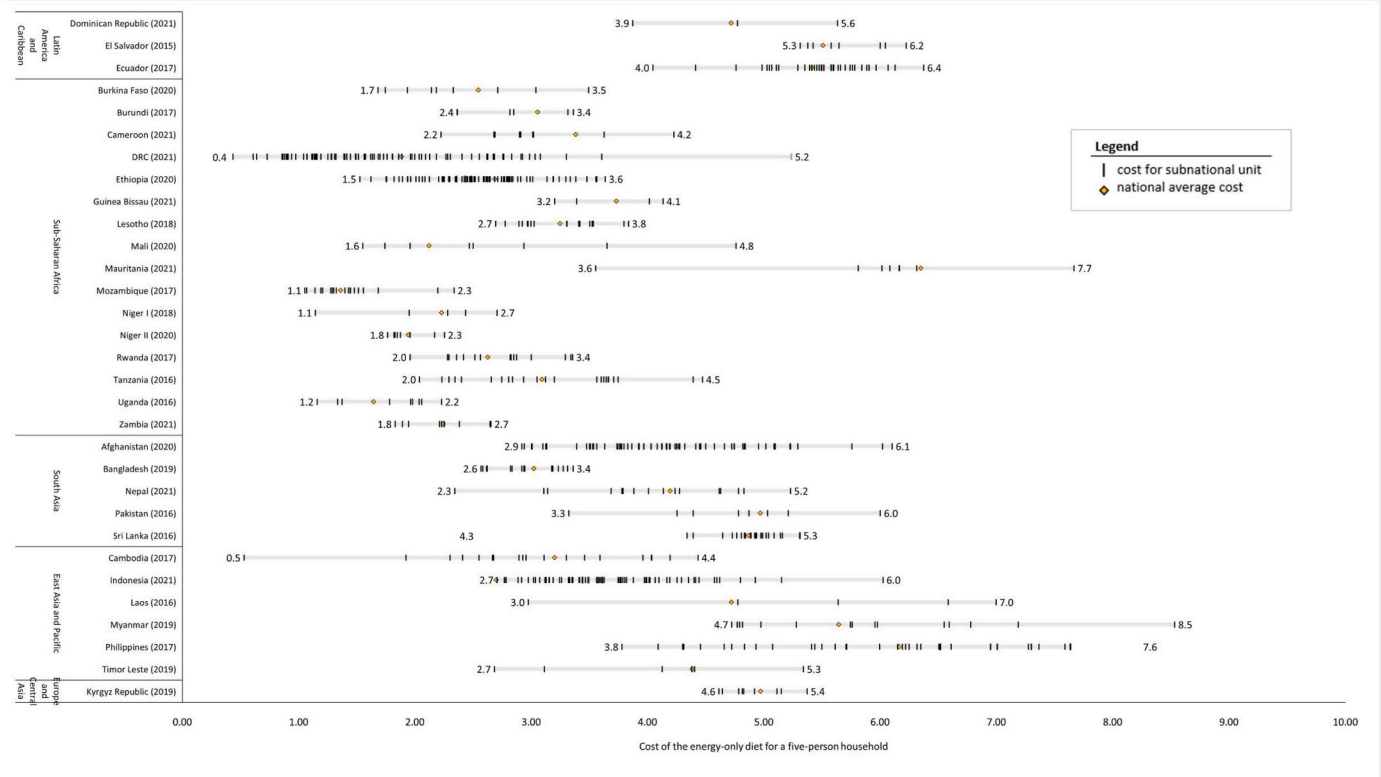

Fig. 3. Range of cost of the energy-sufficient diet by country in PPP USD converted values, per 5 person household per day.
Fig. 3 also excludes Guatemala and Tajikistan because the cost of energy-sufficient diets was not calculated in these analyses.

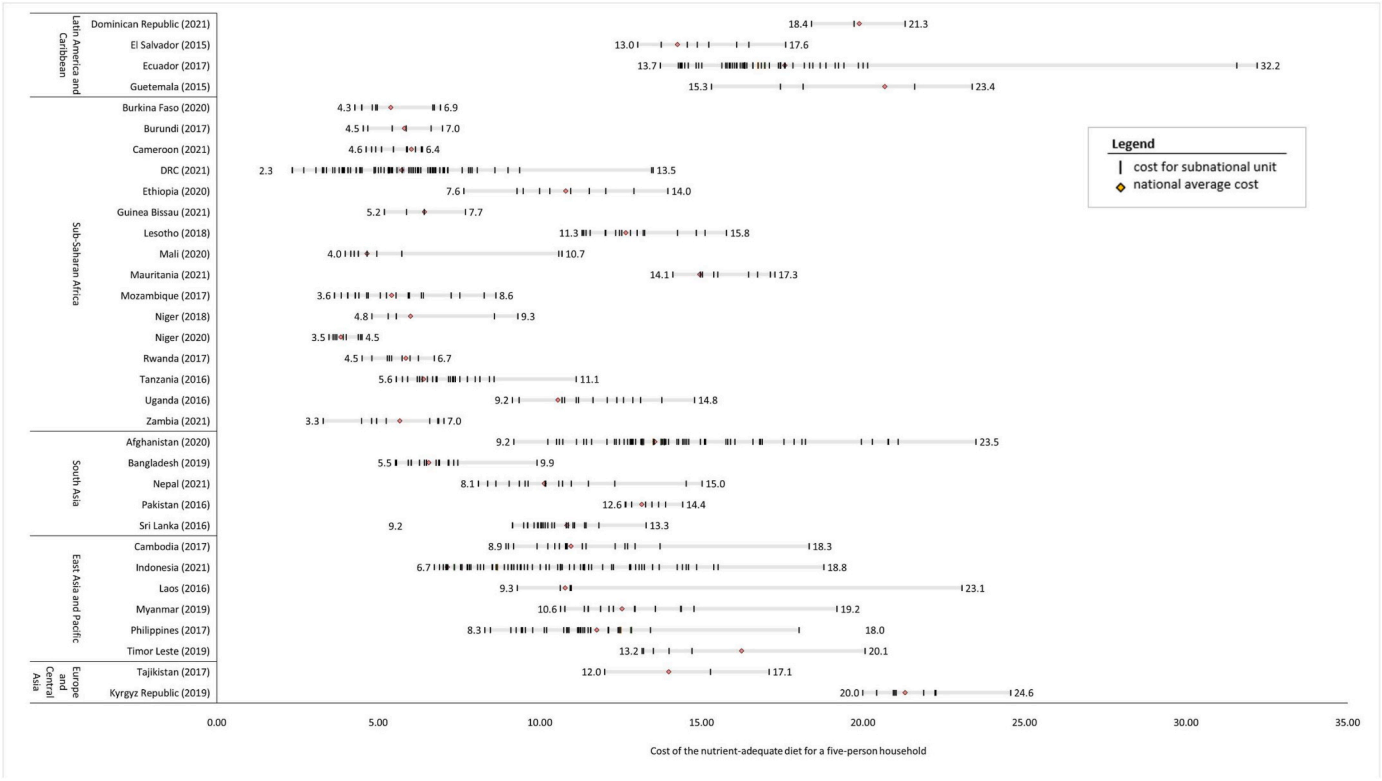

Fig. 4. Range of cost of the nutrient-adequate diet by country in PPP USD converted values, per 5 person household per day.

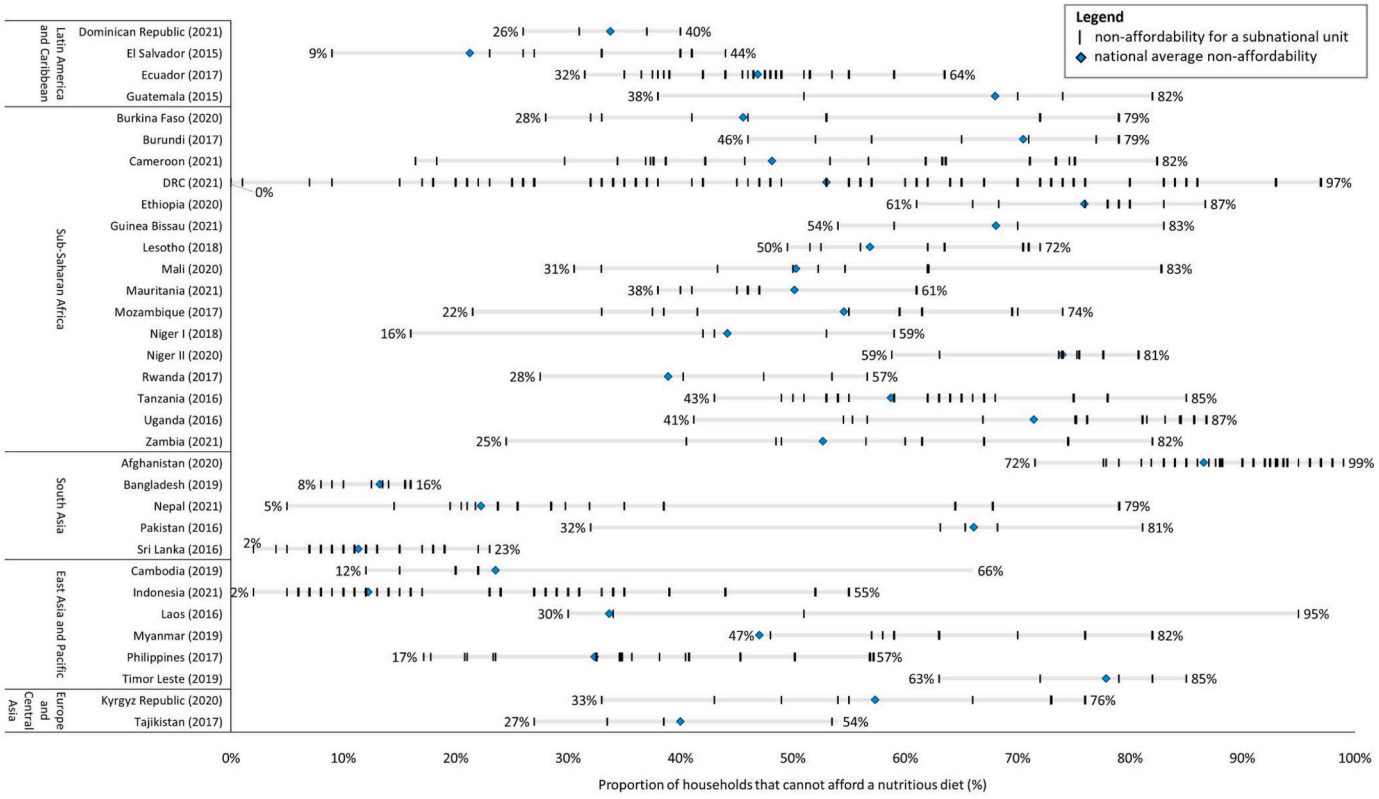

Fig. 5. Range of non-affordability of the nutrient-adequate diet by country.

staple-adjusted nutrient-adequate diets, and Fig. 5 for non-affordability of staple-adjusted nutrient-adequate diets. The number of countries included in each figure vary depending on available data. The household sizes for Figs. 3 and 4 have been standardized to five-people, using the method described in section 2.4.2, to allow for cross-country comparison.

Lastly, the dataset includes population weights. Population weights were calculated at the time of analysis and the sources of population weights are provided in the FNG report of each specific analysis. Weights should reflect relative population size and hence ideally require census data. However, in many cases, census data were not available so other sources of information were used, such as the United Nation Populations Fund projections or WFP estimates. Countries for which the assessment areas did not cover the entire country (i.e., not all of a country's sub-national units were included in the analysis), population weights were recalibrated based on the populations of the subnational units for which FNG analyses calculated cost and affordability.

3. Conclusion

This paper focuses on presenting and discussing a comprehensive dataset that has been compiled using the outputs of the Fill the Nutrient Gap (FNG) analyses conducted by WFP and its partners between 2015 and 2021. This dataset enables a deeper understanding of regional disparities in diet costs and non-affordability, which can inform targeted interventions and policies from multiple sectors and at the subnational level. Methodologically, we highlight several novelties to having this data compiled into one dataset, such as the standardization of diet costs across different currencies and time periods for sex- and age-specific individuals.

Indicators are useful to policymakers when they allow for decision-making around targeting and prioritization. National-level food insecurity and nutrition indicators lack the granularity required for such decisions. As shown in Figs. 4 and 5, cost and non-affordability of the nutrient-adequate diet showed sizeable variation within a country. Twenty-one of the 33 countries presented in Fig. 5 had a range of non-affordability greater than 30 percentage points, indicating the importance of subnational food price and expenditure monitoring to capture that variation. As countries face constrained resources post-COVID-19, geographic targeting has become especially critical for policy-making and programming. The granularity of the data available in the supplementary dataset supports policy-makers and programme designers in answering questions on who best to target with what interventions, and where.

The dataset also allows users to compare costs of diets to other types of economic indicators, including poverty lines, which are set at the national level. Poverty lines set at the national level can hide regional disparities and misrepresent areas where costs of basic needs are significantly higher than the national poverty line. The use of RNI as nutrition targets for the optimization renders the cost of the staple-adjusted nutrient-adequate diet at the household level often well above the World Bank Poverty lines of PPP dollars 2.15 (extreme poverty line) and 3.65 (lower-middle-income) per person per day, which capture not only food but also nonfood needs such as housing, healthcare, energy and other necessities. The World Bank calculates poverty lines through a consumption-based approach in which it calculates a standard basket of food and nonfood goods in 28 low-income countries and converts the cost of those baskets to US dollars using PPP. As opposed to FNG calculations for diet costs, poverty lines do not explicitly consider the specific micronutrient needs of individuals, nor do they take into account specific nutritional vulnerabilities of individuals (Jolliffe et al.). It is important not to conflate the interpretation between the percentage of people below a poverty line and non-affordability, as FNGs compare diet costs to actual food expenditure. A deep-dive on the use of Poverty Lines vis-à-vis cost of diet metrics is presented in another paper in this special issue (Balagamwala & Kuri et al., 2024). The relevance of FNG subnational-level estimates in country-level decision making is also further discussed by other papers (Hobbs et al., 2023) and other papers in this supplement (Klemm et al., 2023; Shepperdley et al., 2024).

Other publications which include diet cost estimation, such as the 2021, 2022, and 2023 State of Food Security and Nutrition in the World (SOFI) reports (Herforth et al., 2022), the FAOSTAT (Herforth et al., 2023), or the calculations for the cost of the Planetary Health Diet developed by the EAT-Lancet Commission on Food, Planet, Health (Hirvonen et al., 2020), provide national level estimates for diets based on dietary guidelines, meaning that they are not linearly optimized. The 2020 SOFI report included estimates for optimized nutrient-adequate diets, also calculated only at the national level, but this indicator has been excluded in more recent reports. The global calculations of least cost nutrient-adequate diets in Bai et al. (2022) were carried out for 20 unique individuals, but also only for the national level. The cost metrics made available in the supplementary dataset are most similar to those published by Bai and Masters (2019), which calculated least cost diets for 23 individuals of differing sex, age and reproductive status, but only for Malawi. To our knowledge, no comprehensive analysis has ever been published for a range of individuals at the sub-national level for a large number of countries. While not globally comprehensive, this dataset is a first step in establishing a repository for sex- and age-specific data on the cost and non-affordability of diets and creates a singular place to update these estimates.

Table 1 in the supplementary data shows the range of data sources used in FNG analyses, many of which are CPI or other secondary data routinely collected by government partners. Regular and accessible subnational CPI data enable localized analysis on access to diets and to nutritious foods. Other studies, such as the 2022 paper by Bai et al. on the connection between COVID-19 caseloads and food prices leveraged available CPI data, and made important contributions to our understanding of how external events are related to prices of nutritious foods.

We acknowledge that relying on secondary data might expose the analysis to biases that were inherent to the food price data collection, as described in the section on data sources. Costs of diets are typically lower in areas with longer food lists, because the optimization software has a greater of number of foods to choose from. Nonetheless, cost and affordability can be important indicators for measuring or monitoring food and nutrition security. We echo previous calls (de et al., 2022) to continue expanding governmental food retail price and on household expenditure data collection at the subnational level. We further recommend continuing to develop capacities of government institutions to regularly monitor cost and non-affordability, as has already been done in Ethiopia and Sri Lanka (Ethiopian Public Health Institute and WFP, 2022; Hector Kobbekaduwa Agrarian Research and Training Institute, Ministry of Health, Department of Census and Statistics and WFP, 2022).

The present paper and the supplementary dataset are tools to advance our understanding of diet costs and non-affordability. While health-based drivers of malnutrition indicators such as anaemia or vaccination rates are, in most contexts, regularly monitored at the sub-national level, a gap exists for monitoring drivers of poor diets that underly malnutrition, including at the sub-national level. As FNGs continue, and in many countries start for a second round, WFP will regularly update and publish outputs of these studies to support a more holistic analysis of nutrition challenges at sub-national levels, thereby enabling more practical policymaking across sectors for better nutrition in low and low-middle income contexts.

Data access

The dataset is accessible online as a supplement to this paper.

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CRediT authorship contribution statement

Zuzanna Turowska: Writing – review & editing, Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **Janosch Klemm:** Writing – review & editing, Visualization, Methodology, Data curation, Conceptualization. **Saskia de Pee:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The dataset described in this paper is available in the Supplementary materials.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2024.100798.

References

Bai, Yan, Masters, William, 2019. Heterogeneity in the cost of nutrient adequacy by age, sex, pregnancy or lactation status and other influences on individual requirements in Malawi. Curr. Dev. Nutr. 3 (Suppl. ment) https://doi.org/10.1093/cdn/nzz034.OR21-04-19.

Bai, Yan, Alemu, Robel, Block, Steven A., Headey, Derek, Masters, William A., 2021. Cost and affordability of nutritious diets at retail prices : evidence from 177 countries. Food Pol. 99 https://doi.org/10.1016/j.foodpol.2020.101983.

Bai, Yan, Herforth, Anna, Masters, William A., 2022. Global variation in the cost of a nutrient-adequate diet by population group: an observational study. Lancet Planet. Health 6 (1), e19–e28. https://doi.org/10.1016/S2542-5196(21)00285-0.

Bence, Brian, Chandra Babu, Suresh, 2015. Food security and nutrition monitoring: a survey. https://www.researchgate.net/publication/283311254_Food_security_and_nutrition_monitoring_a_survey.

Bose, Indira, Baldi, Giulia, Kiess, Lynnda, Pee, Saskia de, 2019. The 'Fill the nutrient gap' analysis: an approach to strengthen nutrition situation analysis and decision making towards multisectoral policies and systems change. Matern. Child Nutr. 15 (3), 1–11. https://doi.org/10.1111/mcn.12793.

de, Pee, Saskia, Zuzanna Turowska, 2022. Retail prices track food and nutrition security. Nature Food 3, 306–307. https://doi.org/10.1038/s43016-022-00515-w.

Deptford, Amy, Allieri, Tommy, Childs, Rachel, Damu, Claudia, Ferguson, Elaine, Hilton, Jennie, Paul, Parham, et al., 2017. Cost of the diet: a method and software to calculate the lowest cost of meeting recommended intakes of energy and nutrients from local foods. BMC Nutrition 3 (1), 1–17. https://doi.org/10.1186/s40795-017-0136-4.

Dhaliwal, Iqbal, Duflo, Esther, Glennerster, Rachel, Tulloch, Caitlin, 2013. "Comparative cost-effectiveness analysis to inform policy in developing countries: a general framework with applications for education." education policy in developing countries. https://doi.org/10.7208/9780226078854-008.

Ethiopian Public Health Institute and WFP, 2022. Cost and Affordability of Nutritious Diets Bulletin.

FAO, IFAD, UNICEF, WFP, WHO, 2020. The State of Food Security and Nutrition in the World 2020. FAO, Rome.

FEWSNET, 2023. Livelihood zones. https://fews.net/data/livelihood-zones.

Herforth, Anna, Venkat, Aishwarya, Yan, Bai, Costlow, Leah, Holleman, Cindy, Masters, William A., 2022. Methods and options to monitor the cost and affordability of a healthy diet globally. Background paper for the State of Food Security and Nutrition in the World 2022. In: FAO Agricultural Development Economics Working Paper 22-03. FAO, Rome.

Hector Kobbekaduwa Agrarian Research and Training Institute, Ministry of Health, Department of Census and Statistics and WFP, 2022. Minimum Cost of the Nutritious Diet and Affordability Analysis Bulletin.

Herforth, Anna, Holleman, Cindy, Bai, Yan, Masters, William A., 2023. The Cost and Affordability of a Healthy Diet (CoAHD) Indicators: Methods and Data Sources: Metadata for FAOSTAT. FAO, Rome, Italy. https://www.fao.org/faostat/en/#data/CAHD.

Hirvonen, Kalle, Bai, Yan, Headey, Derek, Masters, William A., 2020. Affordability of the EAT-Lancet reference diet: a global analysis. Lancet Global Health 8 (1), e59–e66. https://doi.org/10.1016/S2214-109X(19)30447-4. Epub 2019 Nov 7. Erratum in: Lancet Glob Health. 2020 Dec;8(12):e1472. PMID: 31708415; PMCID: PMC7024996.

Hobbs, Nora, Hug, Julia, Pee, Saskia de, 2023. High non-affordability of diets and malnutrition in africa's drylands: systems analysis to guide action. Food Nutr. Bull. 44 (2_Suppl. l), S45–S57. https://doi.org/10.1177/03795721231178065.

International Monetary Fund, 2007. "PPP versus the market: which weight matters?" Finance & development, 44 (1). https://www.imf.org/external/pubs/ft/fandd/2007/03/basics.htm.

Jolliffe, Dean, Daniel Gerszon Mahler, Christoph Lakner, Aziz Atamanov, Samuel Kofi Baah-Tetteh. "Assessing the Impact of the 2017 PPPs on the International Poverty Line and Global Poverty (English)." Policy Research working paper,no. WPS 9941, Paper is funded by the Knowledge for Change Program (KCP) Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/353811645450974574/Assessing-the-Impact-of-the-2017-PPPs-on-the-International-Poverty-Line-and-Global-Poverty.

Klemm, Janosch, Turowska, Zuzanna, Sclama, Gregory, Pee, Saskia de, 2023. What we learn from subnational and lifecycle-specific estimates of the cost of nutrient-adequacy compared to national estimates for an indicator individual. Global Food Secur. (forthcoming).

Organization for Economic Co-operation and Development, 2021. Prices and purchasing power parities (PPP), 2021. https://www.oecd-ilibrary.org/finance-and-investment/conversion-rates/indicator-group/english_067eb6ec-en.

Sphere Association, 2018. The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response. Fourth edition, Geneva, Switzerland. www.spherestandards.org/handbook.

The DHS Program website. "The DHS Methodology." Funded by USAID. http://www.dhsprogram.com.

The World Bank Group, 2021. DataBank. World development indicators. https://databank.worldbank.org/source/world-development-indicators/preview/on.

The World Bank, 2023. International Comparison Program: a worldwide statistical initiative to collect comparative price data and detailed GDP expenditures to produce purchasing power parities (PPPs) for the world's economies. https://www.worldbank.org/en/programs/icp.

UNICEF, 2024. Multiple indicator cluster surveys. https://mics.unicef.org/.

World Food Programme, 2009. Comprehensive food security & vulnerability analysis guidelines. In: https://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp203208.pdf.

World Food Programme, 2021. Macroeconomics: exchange rates, 2021. https://dataviz.vam.wfp.org/economic_explorer/macro-economics/exchange_rate.