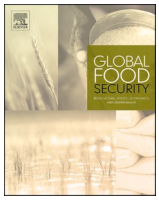
Global Food Security 45 (2025) 100838

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs



Subnational and lifecycle-specific estimates of diet costs support nutrition-sensitive policies and programmes

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

[a] Center for Development Research (ZEF), Bonn University, Bonn, Germany
[b] United Nations World Food Programme, Rome, Italy
[c] Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA

ARTICLE INFO

Keywords:
Diet cost
Cost of nutrient adequacy
Nutritional vulnerabilities
Food environment
Food system transformation
Fill the nutrient gap

ABSTRACT

National level estimates of diet costs are increasingly being published and serve to track global goals and compare costs across countries. Subnational level estimates, which can be aggregated to a national average, can be used to inform local policies and programmes. This study has two objectives: First, to assess whether national level diet costs from the Fill the Nutrient Gap (FNG) analysis are in line with national estimates from the Food Prices for Nutrition (FPN) Project and discuss methodological differences. Second, to review the added value of subnational and lifecycle-specific estimates from FNG to inform design of policies and programmes for improving nutrition of the most vulnerable groups. We examined the subnational estimates and national level averages of the cost of energy-sufficient and nutrient-adequate diets calculated in 26 FNG country analyses. We assessed the correlation with the corresponding national-level estimates for 2017 that were published in the FPN DataHub for energy-sufficient ($r = 0.79$, $p < 0.001$) and nutrient-adequate diets ($r = 0.61$, $p = 0.001$). For many countries, subnational variation of diet costs within the country was as large as variation across countries. Of individuals considered in the FNG approach, the cost of a nutrient-adequate diet was found to be highest for the adolescent girl. Subnational and lifecycle-specific estimates of the cost of nutrient needs from FNG analyses provided valuable additional information that has successfully informed policies and programmes in health, education and social protection sectors.

1. Introduction

1.1. Why measure the cost of diets

To achieve Sustainable Development Goal 2 of ending hunger and malnutrition in all its forms, individuals and households must have access to affordable and nutritious local foods. Measuring the cost of nutritious diets is a crucial step towards understanding local food environments and food systems. Data on the cost of diets can be tracked over time, used in anticipating shocks, modelling potential interventions, and, together with expenditure data, measuring the ability of households to afford them. This understanding is required for designing and implementing interventions that bring good nutrition within reach of even the most vulnerable.

There are a range of methods and metrics available to measure and monitor food prices and diet costs and affordability in low- and middle-income countries. Different metrics are designed and suited for specific purposes, each with its own strengths and limitations in terms of inputs requirements and application to dietary analysis.

1.2. Measuring and tracking food prices

National governments and international organizations use price indices to monitor price changes of specific baskets of food over time. For example, governments monitor inflation through the calculation of a Consumer Price Index (CPI), and the UN Food and Agriculture Organization (FAO) calculates a Food Price Index to track the weighted average of a basket of globally consumed agricultural commodities (FAO, 2021).

This article is part of a special issue entitled: Subnational diet cost & affordability published in Global Food Security.

* Corresponding author. Center for Development Research (ZEF), University of Bonn, Genscherallee 3, Bonn, 53113, Germany.
E-mail address: jklemm@uni-bonn.de (J. Klemm).

https://doi.org/10.1016/j.gfs.2025.100838
Received 15 January 2024; Received in revised form 12 February 2025; Accepted 14 February 2025
Available online 13 March 2025

The World Bank uses national price data for the calculation of purchasing power parity (PPP) exchange rates through the International Comparison Program (ICP) (ICP, 2018), which is a common source of food price data for comparison across countries. Food price data are also collected and used for early warning systems and for monitoring food insecurity, especially in rural settings, for example by the World Food Programme's (WFP) Research, Assessment and Monitoring (RAM) team, and the Famine Early Warning System Network (FEWS NET) (Bai et al., 2021a; USAID, 2022; WFP, 2022).

1.3. The cost of nutrient adequacy

Food price data can be used to calculate the cost of a diet that meets a defined threshold of adequacy. This adequacy threshold may refer to an energy-sufficient diet, a nutrient-adequate diet, or a healthy diet (Bai et al., 2021b; Herforth et al., 2020). While an energy-sufficient diet meets only an individual's energy requirements, a nutrient-adequate diet meets an individual's recommended intakes for essential macronutrients and micronutrients such as protein, fats, vitamins and minerals. A healthy diet, by comparison, is diverse and conforms to food-based dietary guidelines, which are intended to meet nutrient needs and reduce the risk of diet-induced non-communicable diseases (NCDs) (FAO and UNICEF, 2020).

Mathematical optimization using linear programming provides a tool to calculate the lowest possible cost of a diet that meets the requirements for nutrients of interest. Linear programming has long been used for the design of low-cost livestock feed, and while its potential for analysis of human nutrition was first described over six decades ago, its uptake in the field was initially limited by the computing resources required to solve the complex equations involved (Darmon et al., 2002; Smith, 1959). As computing power improved and specialized approaches were developed, linear programming has been increasingly used for analysing diet problems in human nutrition. While general computational software such as Microsoft Excel has been used in many applications, specialized software programs have also been developed and refined for this purpose (Deptford et al., 2017).

1.4. Study purpose

For this study, we focus on two different methodologies for estimating the lowest-cost diets meeting nutrient requirements based on local prices, building on different types of policy and program questions. The first is the method used in the Fill the Nutrient Gap (FNG) analysis, developed by the World Food Programme (Bose et al., 2019; World Food Programme, 2020). The second method was developed and scaled up by Tufts University and partners in several successive projects, most recently the Food Prices for Nutrition (FPN) project (Tufts University, 2022), published in the Food Prices for Nutrition DataHub (World Bank, 2023) and also the Food Systems Dashboard (Global Alliance for Improved Nutrition and Columbia Climate School, 2023). We consider this particular approach as reference for national estimates, because of its global scale, consistent methodology and wide use. Extensive technical descriptions of each methodology and the models underlying the estimates are not considered in this paper as they are available elsewhere (Bai et al., 2021b; Bose et al., 2019; Herforth et al., 2020; Wallingford et al., 2024).

This paper has two objectives: First, to discuss the (degree of) alignment of national-level estimates generated by the FNG with FPN estimates and their respective methodologies. Second, to highlight the relevance for improved decision making and program design of the additional information provided by subnational and lifecycle specific estimates as calculated by the FNG.

2. Methods and materials

2.1. Data sources

FNG estimates of diet cost come from 26 FNG country analyses carried out between 2015 and 2021. A table detailing all countries included in this analysis are reported in supplementary material Table S3Annex Table 3 The FNG analyses considered here used Cost of the Diet software, developed by Save the Children UK (Deptford et al., 2017). Detailed description of the FNG dataset, a full list of food price data sources, number of subnational assessments and year of analysis for each country arereported in the supplementary materials of Turowska et al. (2024). All cost estimates were standardized from local currency to 2020 USD purchasing-power parity (PPP) using World Bank conversion rates (see Turowska et al., 2024, and supplementary materials for more detail).

The data on the cost of energy-sufficient and nutrient-adequate diets from the FPN project were first published in the State of Food Security and Nutrition in the World (SOFI) 2020 and are now available at the Food Prices for Nutrition Data Hub (World Bank, 2023) as well as the Food Systems Dashboard (Global Alliance for Improved Nutrition and Columbia Climate School, 2023). For simplicity in this paper, we refer to these data as the "FPN estimates". The methodology used for the FPN estimates utilized 2017 national-level food price data from the World Bank's International Comparison Project for 170 countries to calculate the minimum cost of nutrient adequacy with linear programming (World Bank, 2023; Bai et al., 2021b; Herforth et al., 2020). Only the countries for which there are both FPN and FNG data were used in this analysis ($n = 25$ for energy sufficient diet, $n = 26$ for nutrient-adequate diet), and we adjusted the data to 2020 purchasing-power parity (PPP) for comparability, using World Bank conversion rates.

It should be noted that in addition to the above, the FPN is producing a Cost of a Healthy Diet (CoHD), which meets the requirements of food-based dietary guidelines for a single indicator individual (FAO and UNICEF, 2022; Herforth et al., 2022; Herforth et al., 2020). It is, however, not constrained to meet minimum nutrient requirements. This CoHD is tracked and reported annually by FAO. These estimates have also recently started to become available at subnational level for some countries (National Bureau of StatisticsNigeria, 2024; Alemayehu et al., 2023). CoHD was not calculated for the FNG analyses reported in this paper and is therefore not considered here. FNG analyses carried out in and after 2023 have also reported CoHD on subnational level. A recent study, building on the FPN approach, also estimates the variation in cost of a healthy diet across individuals, but is not directly comparable to the nutrient-adequate diet discussed here (Headey et al., 2023).

2.2. Overview of both methodologies

To adequately compare FNG and FPN estimates it is helpful to first provide an overview of the respective methodologies, as each approach is designed for a certain purpose and differences between the two estimates arising from differences in their construction are to be expected. We briefly outline the main differences and similarities between the two approaches, focussing on 1) methodology, such as nutrient reference intakes, target groups, included macro- and micronutrients or staple food selection and 2) data sources, such as food lists, price data and food composition tables.

2.2.1. Reference intakes

For nutrient-adequate diets the FNG uses the RNI, which meets the needs of 97.5% of a population (WHO/FAO, 2004), while the FPN uses the EAR as a nutrient target, which meets the needs of 50% of a population. If all other components of the estimate were the same (including

caloric targets), we would expect cost estimates using EAR to be lower than those using RNI. Notably, even in cases where the nutrient target has been set at the EAR, the RNI may be met as the cost-optimized solution may exceed some minimum nutrient constraints to satisfy all constraints. Sensitivity analysis carried out for the FPN showed relatively small differences in cost estimates between diets meeting EAR and diets meeting the recommended dietary allowance (RDA) from Institute of Medicine, (2006), which is conceptually analogous to the RNI (2.33 and 2.71, respectively, in 2017 USD PPP, in Herforth et al., 2020).

2.2.2. Target groups

Diet cost in the FNG are typically estimated for the following individuals, which represent a standardized household in the FNG: a breastfed child under two, a child aged 6–7 years, an adolescent girl aged 14–15 years, an adult woman who is breastfeeding and an adult man. These individuals are selected to capture the range of nutrient needs across the lifecycle and the average diet cost of these individuals provides the FNG per capita cost for an energy-sufficient and a nutrient-adequate diet at the subnational level. A national level average is then derived from the population-weighted average of subnational estimates.

The FPN methodology calculates the cost of meeting the median nutrient requirements for a non-pregnant, non-breastfeeding adult woman. This individual is selected because the nutritional needs fall approximately at the median of the population and because adult women are seen as nutritionally vulnerable (Bai et al., 2021b; Herforth et al., 2020). A recent study has also estimated the cost of nutrient-adequacy for individuals of other physiological groups, but results were not reported by country and are therefore unavailable for comparison (Bai et al., 2022).

The difference in target group selection is based on the different goals of the indicator. FNG estimates the minimum cost of a diet that meets the needs of nearly everyone and has a low risk of inadequacy for individuals, while FPN represents a minimum cost for the median nutrient needs of the population and compares food systems across countries.

2.2.3. Target micro- and macronutrients

Estimates from the FNG are based on a linear optimization model that includes minimum and maximum constraints for energy, protein, fat, and 13 micronutrients (Deptford et al., 2017). The minimum constraint for micronutrients is set to the recommended nutrient intake (RNI) for each physiological group, indicating that this level is met or exceeded in every calculation. Slightly varying levels are defined for protein (95th percentile of distribution of requirement per kg body weight) and fat (20 to 35% of energy intake, depending on age group) (Deptford et al., 2017). The target for energy is set to the estimated average requirement (EAR), the median for each physiological group, and this target is met exactly in each model, for both energy-sufficient and nutrient-adequate diets, i.e. energy levels in the calculation are always 100% of the reference value.

In the FPN estimates, energy-sufficient diet is calculated as the cost to meet energy requirements using the least-cost starchy staple available in the country. A nutrient-adequate diet is calculated as the least-cost diet that meets the levels recommended for the physiological group and stays within tolerable upper limits where applicable of 23 essential macro- and micronutrients while meeting the energy requirement exactly (Bai et al., 2021b).

2.2.4. Staple adjustments

The FNG model specifies a minimum constraint (equal to approximately 50% of energy) for the most commonly consumed local staple(s), in order to prevent selection of cheap sources of energy that are not commonly consumed. The staple foods are identified through review of food expenditure data and consultations with local stakeholders and may vary between subnational units. The FPN does not constrain the model to a specific food, but rather specifies that macronutrient intakes fall within the acceptable range set by the Institute of Medicine, thus the least-cost staple is often selected. For energy-sufficient diets, the FNG methodology calculates the lowest cost of meeting the energy requirement per individual, adhering to portion size constraints per food group (Deptford et al., 2017), while the FPN calculates the cost of meeting energy requirements using the least cost starchy staple for a country (Bai et al., 2021b).

2.2.5. Food lists and food prices

Choice of food lists, price data and food composition tables also affect diet cost estimates. Food lists used in FNGs (comprehensive overview by country in supplementary materials) are subnational and the source of food price data for each FNG varies by country; these include primary data collection carried out specifically for the FNG at local markets, preexisting government data (for example, data collected for calculation of the CPI), and data from household consumption and expenditure surveys (cf. supplementary materials Table S3.). In the FNG, primary data collection aims to be as comprehensive as possible, including those foods that are less common or only available locally, whereas the other two methods use closed food lists. The underlying food prices for the FNG have been collected in different years, therefore possibly introducing price variation due to availability and seasonality, which carries through despite PPP standardization. FPN uses national food prices collected with pre-set lists of foods which may miss foods that are only available regionally.

2.2.6. Food composition information

The FNG uses a combination of food composition tables (FCTs), including the USDA standard reference database (USDA, 2013) as well as region-specific FCTs for West Africa (FAO, 2019) and in few cases country-specific information to approximate regional varieties for East Africa and Asia (FAO/Government of Kenya, 2018; Institute of Nutrition and Food Science, 2013; Lukmanji et al., 2008). FPN also uses USDA, region-specific FCT from West Africa and South Asia and a FCT including fish and shellfish composition information (Bai et al., 2021b).

2.3. Analytical approach for comparison

We estimated the correlation between the FNG and FPN estimates, the variation within subnational FNG estimates and variation in diet cost across the lifecycle. These characterizations inform the discussion of the use case of subnational findings and individual-level estimates in the programme and policy context.

We used Spearman's rank correlation coefficient to calculate the correlation between measures of the cost of energy sufficiency and nutrient adequacy of the two methods. Next, we visualized the FPN estimate (national) within the range of subnational FNG estimates by country for both the energy-sufficient and nutrient-adequate diets. We calculated summary statistics of energy-sufficient and nutrient-adequate diet by country and different individuals. We plotted and reported histograms and density plots for both estimates by country (supplementary materials Figure S1 and S2).

3. Results

Table 1 presents the national estimates of the cost of energy-sufficient and nutrient-adequate diets using the FPN and FNG methods, for countries discussed here.

Table 1
Average cost for FPN and FNG estimates of energy-sufficient and nutrient adequate diets by country.

Country	FPN Estimates for Cost of … (in 2020 USD PPP)		FNG Estimates for Cost of … (in 2020 USD PPP)	
	Energy-Sufficient Diet	*Nutrient Adequate Diet*	*Energy-Sufficient Diet*	*Nutrient Adequate Diet*
Bangladesh	0.69	1.75	0.60	1.31
Burkina Faso	0.45	2.16	0.51	1.08
Burundi	0.60	1.31	0.61	1.16
Cambodia	1.11	2.79	0.64	2.19
Cameroon	0.60	1.79	0.62	1.11
Democratic Republic of the Congo	0.31	1.16	0.38	1.15
Dominican Republic	1.27	2.71	0.94	3.98
Ecuador	1.35	2.39	1.08	3.52
Ethiopia	0.66	2.24	0.54	2.16
Guinea Bissau	0.85	2.17	0.93	1.59
Indonesia	1.14	2.89	0.54	1.43
Kyrgyz Republic	0.99	2.36	0.99	4.20
Lesotho	0.70	2.46	0.65	2.53
Mali	0.60	1.70	0.42	0.93
Mauritania	0.89	2.53	1.05	2.45
Mozambique	0.40	1.88	0.27	1.08
Myanmar	0.91	2.37	1.13	2.51
Nepal	1.06	2.45	0.84	2.03
Pakistan	0.87	2.01	0.99	2.63
Philippines	1.29	2.71	1.23	2.35
Rwanda	0.46	1.32	0.53	1.17
Sri Lanka	1.05	2.18	0.97	2.17
Tajikistan	1.13	2.72	NA	2.80
Tanzania	0.58	1.73	0.62	1.47
Uganda	0.50	1.65	0.33	2.11
Zambia	0.63	2.23	0.45	1.13

3.1. Correlation between FNG and FPN national level estimates

Fig. 1 shows the relationship between the FNG estimates and the FPN estimates of the energy-sufficient and nutrient-adequate diets for all countries included in the analysis. The correlation coefficient (Spearman's rank) for the two measures of the cost of an energy-sufficient diet is 0.79 ($p < 0.001$, Fig. 1a), while the correlation coefficient for the cost of a nutrient-adequate diet is 0.61 ($p < 0.001$, Fig. 1b). Median estimates for the energy sufficient-diet are 0.78 and 0.62 USD PPP, and for nutrient-adequate diet are 2.21 and 2.07 USD PPP for the FPN and FNG methodologies, respectively.

3.2. In-country variation

Fig. 2 shows the range of subnational FNG estimates and population-weighted national FNG average for the cost of the energy-adequate and the nutrient-adequate diets. The number and range of subnational estimates (smaller dots) varies across countries and for some was as large as the variation across countries (also see Table 4, S2 in supplementary materials). The visualization also displays where the FPN estimate falls along the overall distribution of subnational FNG estimates and in relation to the FNG weighted national estimate.

3.3. Lifecycle variation in diet cost

Fig. 3 displays summary statistics by individual household member for the FNG cost estimates of energy-sufficient and nutrient-adequate diets across countries. For an energy-sufficient diet, the costs were around one dollar (2020 USD PPP) for the adolescent girl (0.84; 95% CI 0.82–0.86), adult man (0.96; 95% CI 0.94–0.98) and breastfeeding woman: 0.98 (95% CI 0.96–1.00). The nutrient-adequate diet cost (in 2020 USD PPP) for the adolescent girl, the adult man and the breastfeeding woman were 3.57 (95% CI 3.45–3.68), 2.16 (95% CI 2.10–2.21), and 2.92 (95% CI 2.85–2.99) respectively. Fig. 3 also shows that the highest range of cost of nutrient-adequate diet across subnational areas was for the adolescent girl (see supplementary materials Table 1 for mean and standard deviation by individual).

4. Discussion of findings and policy and programme relevance

In this study we found a strong correlation between the FNG and FPN estimates for the cost of an energy-sufficient diet, and a moderate correlation for the cost of nutrient adequate diet. Our graphs show wide distribution of subnational cost for several countries. We add to existing evidence that the cost of a nutrient-adequate diet for individuals differs quite significantly across the lifecycle, both in terms of the absolute estimate as well as the variation in cost observed.

Estimates for energy-sufficient diet costs were generally relatively close and follow a linear pattern, with small variation along the trendline. FNG estimates of nutrient-adequate diets were higher for countries above the median, and FPN estimates were higher for countries below

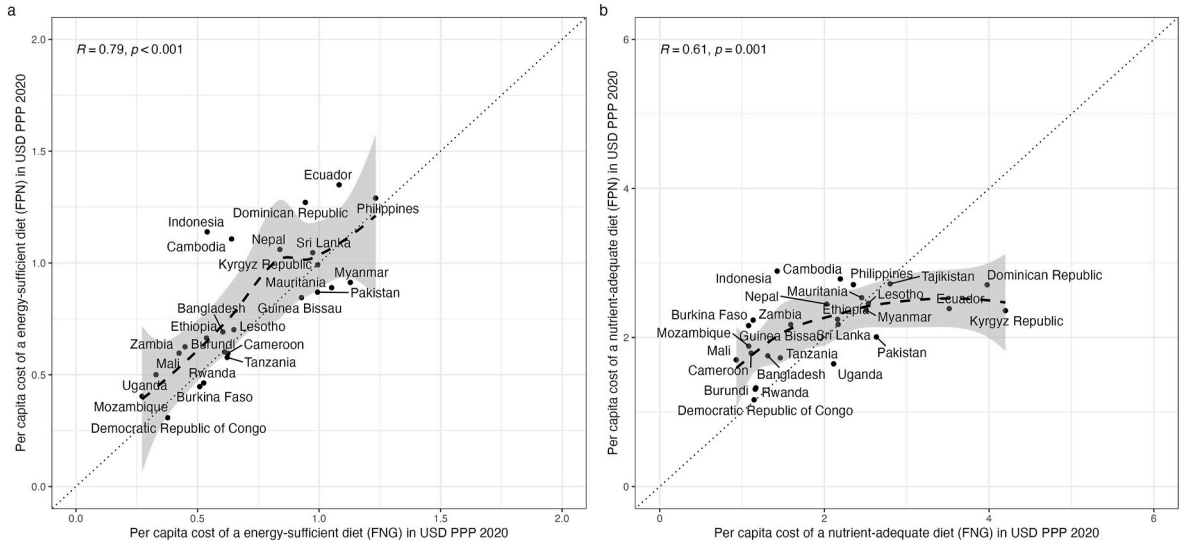


Fig. 1. a–b: Correlation between national-level FNG and FPN estimates for energy-sufficient and nutrient-adequate diet cost.
Note, Note: FNG – Fill the Nutrient Gap, FPN – Food Prices for Nutrition, USD PPP – United Stated Dollar Purchasing Power Parity adjusted

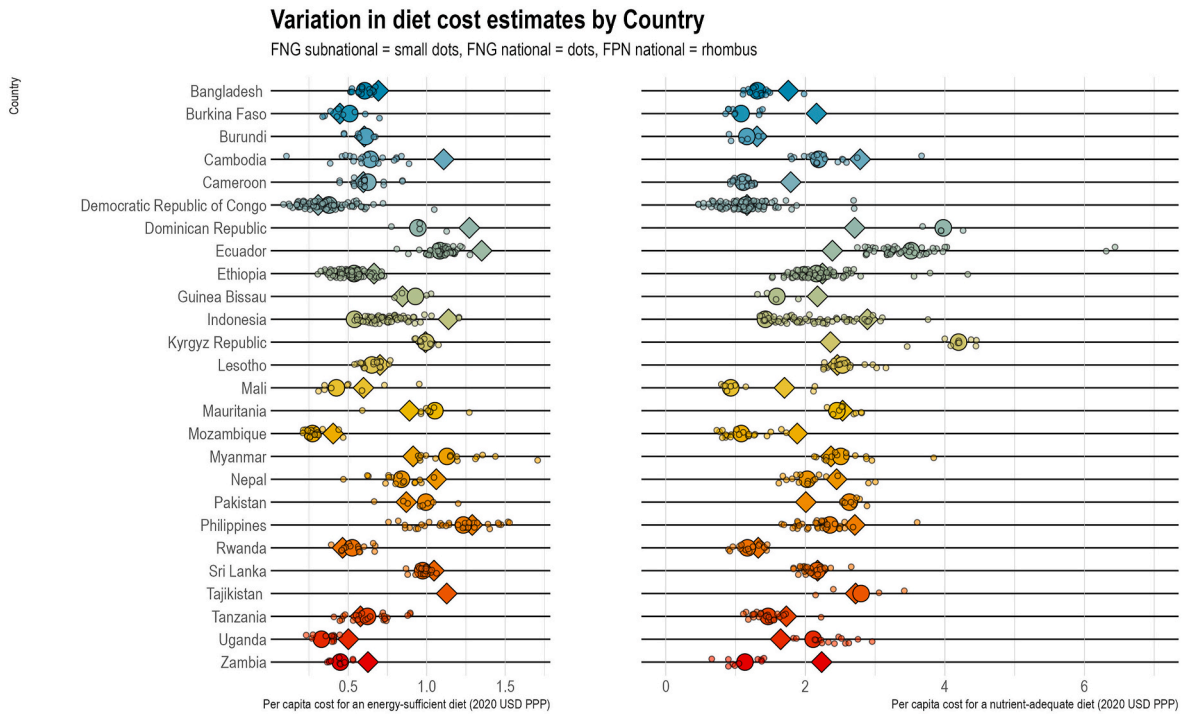


Fig. 2. Subnational and National cost estimates from FNG (circle) and FPN (rhombus).
Note: FNG – Fill the Nutrient Gap, FPN – Food Prices for Nutrition, USD PPP – United Stated Dollar Purchasing Power Parity adjusted. National level FNG estimates are population-weighted averages of the subnational estimates.

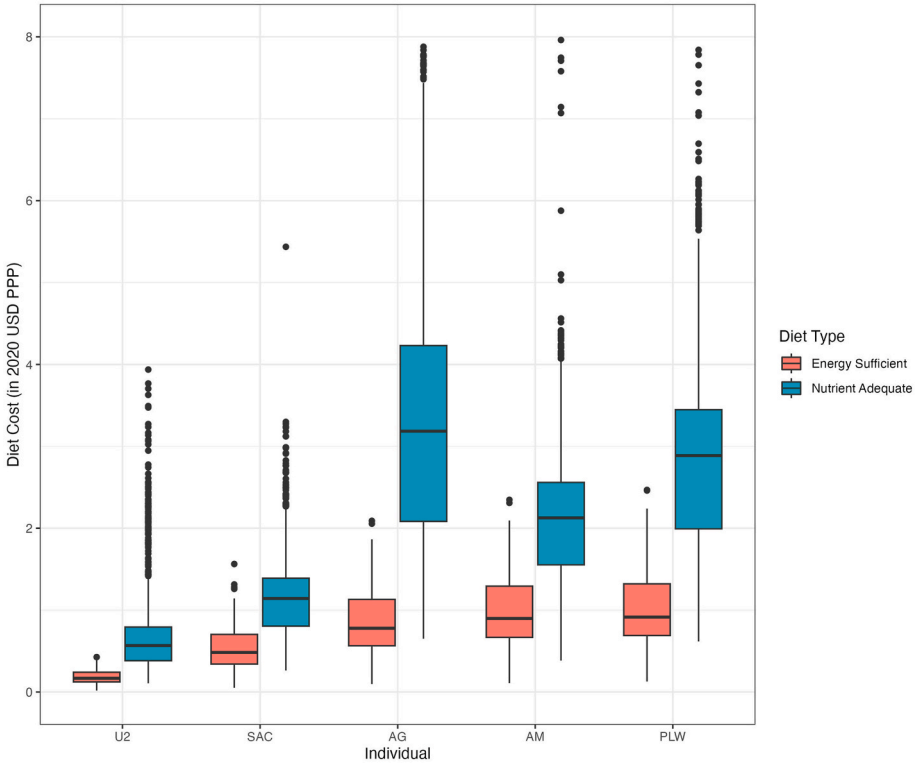


Fig. 3. Box and whisker plot of the estimated diet cost by FNG individual.
U2 – Child 6–23 months of age, SAC – School Aged Child (6–7 years), AG – Adolescent Girl (14–15 years), AM – Adult Man, moderately active, 30–59 years, PLW – Breastfeeding Woman, moderately active, 30–59 years.

the median estimated cost. This was likely due to a larger variation in the FNG cost estimates. National FPN estimates for the nutrient-adequate diet ranged from 1.16 (Democratic Republic of the Congo) to 2.89 (Indonesia), and FNG estimates ranged from 0.93 (Mali) to 4.2 (Kyrgyz Republic). Noticeable differences between FNG and FPN cost of nutrient-adequate diets estimates occur in some countries, such as

Cambodia, Dominican Republic, Indonesia, Kyrgyz Republic and Zambia (cf. Tbl 1 and Fig. 2). This may have been due to the differences in the underlying data sources, e.g. longer or shorter food lists. A shorter food list could lead to higher cost estimates if less expensive food sources of nutrients are not included. The FNG captures larger individual and geographic variation, by including different target groups (which leads to a lower aggregated per capita kcal value for the household, compared to the FPN) to derive the per capita cost estimate and using subnational food prices. The inclusion of individuals with relatively high nutritional needs in areas with limited diversity of food and/or areas where diet cost deviate substantially from the national average may also explain some of the differences between national FNG and FPN estimates. This feature of the FNG makes it particularly suitable for capturing the national situation in terms of subnational variation and lifecycle specific vulnerabilities.

Our findings of intra-country subnational variation of diet cost support evidence from several other studies that emphasize geographic differences and vulnerabilities within countries. A study analyzing the cost of the EAT Lancet recommended diet in different rural districts in India reported a range of 3–5 USD per person per day, indicating high subnational variation (Gupta et al., 2021). In a state-level analysis of Nigeria, researchers documented high variation of cost of a healthy diet and reported association with food systems performance (Mekonnen et al., 2023). Highlighting subnational variation has also increasingly been facilitated through better data availability, with the first subnational Food Systems Dashboard launched in Nigeria in 2023 (The Global Alliance for Improved Nutrition (GAIN) and Columbia Climate School, 2023).

Measuring and understanding subnational variation in the cost of diets and their affordability can be helpful for planning interventions to reach economically or nutritionally vulnerable or otherwise remote areas, which is how FNG uses the cost and affordability metrics (Bose et al., 2021; Knight et al., 2024; Shepperdley et al., 2024; WFP, 2019a). Examples of this come from recent evaluations on the FNG, where situation assessment and policy and programme reviews have benefited from subnational granularity. In Myanmar, subnational level diet cost data was used to inform programmes in social protection (region--specific food baskets and local safety nets), school feeding, disaster risk reduction and welfare as well as the roll-out of a National Nutrition Policy from the Federal to the State level. In the example of Myanmar in 2018, the translation of the nutrition policy from a national to the regional level was supported by the identification of specific interventions relevant to the policy and programme context (Knight et al., 2024). In the Philippines, the FNG highlighted the gap in being able to afford a nutrient-adequate diet (affordability gap) after accounting for region-specific minimum wage levels and social-protection transfers (WFP, 2018). This has been used to inform the Philippine Plan of Action for Nutrition (PPAN) 2022–2028 and the recently launched Food Stamp Programme (Walang The Republic of Indonesia, 2020 Gutom) (WFP, 2025c). Similarly, in Indonesia, significant geographic disparities were identified across regions (WFP, 2025b) and interventions modelled to reduce the cost of nutritious diets focussed on improvements that would be feasible for different types of subnational areas. The FNG provided further evidence to support the implementation of rice fortification in the social safety net (SEMBAKO), which had already been featured in the National Medium Term National Development Plan (RPJMN, 2020–2024). Subnational estimates for diet cost were used to inform the process of modelling region-specific food baskets in Ecuador for the *Misión Ternura* programme (WFP, 2025a) and to inform a new regional school feeding strategy in Sri Lanka (Knight et al., 2024).

The adolescent girl and breastfeeding woman require a higher density of micronutrients (per unit of energy), which come from foods that are often costly to obtain in local markets (Bose et al., 2019; Turowska et al., 2021). This physiological requirement increases the diet costs of these vulnerable groups (Bai et al., 2022). For example, compared to an adult man, an adolescent girl requires 3 times more iron per kilocalorie, and a breastfeeding woman requires approximately 2.5 times more (FAO/WHO/UNU, 2002; WHO/FAO, 2004). As iron with high bioavailability is typically found in animal-source foods which are more expensive than plant sources of iron, these individuals are at increased nutritional risk for deficiencies of iron and other micronutrients that follow a similar pattern. It has been established that it is often more expensive to meet the nutrient requirements of females rather than males of the same age, and for adolescents and pregnant and breastfeeding women, especially when adjusting for cost per kilocalorie (Bai et al., 2022). Our results broadly align with these observations. Furthermore, the inclusion of the adolescent girl (whose diet costs are greater than the average) in the FNG calculations may partially explain why the FNG and FPN estimates were less-correlated for the nutrient-adequate diet than for the energy-sufficient diet. This also indicates where an FNG analysis can be useful to unpack individual costs and identify bottlenecks for adequate nutrition.

Lifecycle-specific estimates from the FNG also emphasize vulnerabilities that sectors can cater to, such as health, education or social protection. For example, the high cost of the adolescent girl was used to advocate for the provision of micronutrient supplementation in school programmes (WFP 2018; WFP 2019b). Additionally, the highlighted vulnerabilities of young children and pregnant women have informed the inclusion of targeted nutrition-sensitive transfers in social assistance programmes, such as in the Benazir Nashonuma programme in Pakistan (Balagamwala and Kuri et al., 2024).

Our analysis has the following limitations. First, the countries included here are not representative of a larger region or other typology, and the findings therefore may not be generalizable beyond these countries. Second, the observed variation in cost does not necessarily allow conclusion on variation of affordability of the diet. For example, income and expenditure levels also vary across a country, which would impact purchasing power and have implications for the affordability of diets. Third, in our visualization we present the cost of subnational areas, but do not include population figures. Therefore, this shows the variation without attributing weight to more or less populated areas. Lastly, inflation adjustment of diet costs to 2020 USD PPP was done using food CPI, which may also not always reflect true price changes of the underlying commodities, especially if locally available foods are not captured in the surveys used for CPIs. It is therefore possible that the true diet cost are higher or lower than the standardized estimates reported here.

5. Conclusion

This paper demonstrates that national estimates of the cost of energy-sufficient and nutrient-adequate diets from FNG and FPN methods are correlated, indicating they are aligned in capturing the underlying phenomenon. We also document the strength of subnational and individual estimates in characterizing vulnerable areas and population groups that are not captured by a single national-level indicator. Measuring diet costs at subnational level allows food system actors and policymakers to better understand the potential of food systems to deliver healthy diets, to measure affordability of diets and to identify vulnerabilities, in particular as in-country variation can be as high as across countries.

The variation in nutritional vulnerability documented in this paper is a clear call to action to pay close attention to the most deprived within low- and middle-income countries, who may face elevated barriers to appropriate dietary intake, a major cause of poor nutrition and health. Monitoring and understanding diet cost at the individual and subnational levels is essential for delivering nutritious and healthy diets for all.

CRediT authorship contribution statement

Janosch Klemm: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation,

Conceptualization. **Zuzanna Turowska:** Writing – original draft, Data curation, Conceptualization. **Gregory Sclama:** Writing – review & editing, Writing – original draft, Conceptualization. **Saskia de Pee:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Funding & role of funding organization

Fill the Nutrient Gap (FNG) analyses are funded by different organizations, which are acknowledged and declared in country specific reports. UN World Food Programme country offices, the German Federal Ministry for Economic Cooperation and Development (BMZ) and the United States Agency for International Development (USAID) have funded multiple FNG analyses of which data were used for the analysis reported in this paper. None of these funders have had a role in the design, data collation and analysis reported in this paper, or in the decision to publish. The preparation of this manuscript and its open-access publication has been made possible by BMZ (grant numbers: 700022554 and 70002255).

Declaration of competing interest

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

Acknowledgements

The authors would like to acknowledge government partners, staff members in WFP Country Offices, and all national stakeholders for their leadership, contributions, and extensive support for each FNG analysis. We would like to thank the donors that enabled WFP Country Offices to carry out the FNG. We are grateful to colleagues from the Systems Analysis for Nutrition team at WFP Headquarters for their efforts in providing the data which makes up the FNGSTAT, inputs during the standardization process, and ideas for this paper. Many thanks to Alex Brito, Christopher Coffey, Julia Hug and Sabrina Kuri for their review of the manuscript and to Jane Badham for her support on the messaging. Thank you to two anonymous reviewers for their helpful feedback and comments.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2025.100838.

Data availability

Data will be made available on request.

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