Food and Agriculture Organization of the United Nations

FAO Statistics Working Paper Series

Issue 24-44

METHODS FOR MONITORING THE AFFORDABILITY OF A HEALTHY DIET

FAO Statistics Working Paper Series / 24-44

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Yan Bai
World Bank, Washington, DC

Anna Herforth
Food Prices for Nutrition, Boston

Carlo Cafiero

Valentina Conti

Marko Olavi Rissanen
World Bank, Washington, DC

William A. Masters
Friedman School of Nutrition, Tufts University

José Rosero Moncayo

Food and Agriculture Organization of the United Nations
Rome, 2024

Required citation:
Bai, Y., Herforth, A., Cafiero, C., Conti, V., Rissanen, M.O., Masters, W.A. & Rosero Moncayo, J. 2024. *Methods for monitoring the affordability of a healthy diet*. FAO Statistics Working Paper Series, No. 24-44. Rome, FAO. https://doi.org/10.4060/cd3703en

ISBN 978-92-5-139470-0

Abstract

This study updates the methods for monitoring the affordability of a healthy diet, calculated semiannually by the Food and Agriculture Organization of the United Nations (FAO) and the World Bank. We first calculate the cost of a healthy diet (CoHD) in each country, which is the cost of purchasing the least expensive locally available foods to meet food-based dietary guidelines. By adding the CoHD to the cost of meeting a basket of basic non-food needs, a cost threshold is obtained that defines the minimum income level required to afford a healthy diet. This threshold is compared to national income distributions from the Poverty and Inequality (PIP) platform of the World Bank to determine the prevalence of unaffordability (PUA). The number of people unable to afford a healthy diet (NUA) is then computed by multiplying the PUA by the population size. The income required for non-food basic needs is in principle determined by the non-food portion of the poverty line. To facilitate global measurement and international comparison, we apply the World Bank's international poverty lines. We estimate the non-food portion by finding the average proportion of non-food expenditures among households of the income quintile closest to the international poverty line for each country's income classification (low-, lower-middle-, upper-middle- or high-income). The cost and affordability indicators were initially introduced in 2020 using the 2017 price data from the International Comparison Program (ICP), and further revised in 2022. Unlike the previous method to determine affordability, which required a uniform proportion of income to be reserved for food, the updated method identifies the cost of basic non-food needs and the CoHD separately and independently.

Applying this method to 2017 price data, it was found that between 2.78 and 3.11 billion people, with a midpoint of 2.96 billion, were unable to afford a healthy diet. This update generally decreases unaffordability estimates in low- and lower-middle-income countries but increases them in upper-middle- and high-income countries. It results in a lower PUA and NUA globally.

We identify clear advantages to the country group-specific approach for resetting baseline levels of unaffordability. This paper also addresses other critical data and methodological challenges for future improvements. First, ongoing research aims to identify more granular country-specific poverty lines, which would enable the estimation of the cost of non-food basic needs at the country level, moving beyond the income-group level. Second, as we took initial steps to account for cross-country heterogeneity in non-food essential costs, we also introduce a discussion on the importance of capturing the variability in access to a healthy diet and non-food basic needs in a country.

Contents

Acknowledgements

The authors gratefully acknowledge the many collaborators from FAO who provided insightful comments for this study, as well as collaborative discussions and inputs during the ongoing indicator computation work, especially Cindy Holleman (Agrifood Economics and Policy Division), Veronica Boero, Piero Conforti, Jean-Marie Munyeshyaka and Michele Vollaro (Statistics Division). The authors also thank colleagues at the Development Economics Vice Presidency (DEC) of the World Bank, especially Dean Jolliffe, Mizuki Yamanaka, Nishant Yonzan and Samuel Kofi Tetteh Baah for their valuable insights on data sources and method development.

The authors are also grateful to Olivier Lavagne d'Ortigue (FAO Statistics Division) for his editorial and layout support, as well as publishing coordination.

1 Introduction

A set of indicators measuring the cost of a healthy diet (CoHD) and the affordability of a healthy diet (PUA and NUA indicators), has been monitored since 2020 by the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Children's Fund (UNICEF), the World Food Programme (WFP) and the World Health Organization (WHO) in *The State of Food Security and Nutrition in the World* (SOFI). The set of indicators is published jointly in FAOSTAT (FAO, 2024) and the World Bank DataBank (World Bank, 2024c). It is updated twice a year, in July when the SOFI report is released and in December, reflecting the World Bank's data on countries' income distributions are updated in the fall. Variables capturing the same constructs, compiled using the same conceptual method, are used for within-country monitoring and policy analysis, as for example in Nigeria's monthly "Cost of a Healthy Diet" reports (National Bureau of Statistics, 2024).

Initially launched in 2020, the cost and affordability of a healthy diet (CoAHD) measure economic access to nutritious foods to meet dietary needs for an active and healthy life. The cost of a healthy diet is the cost of purchasing the least expensive locally available foods to meet requirements for energy and food-based dietary guidelines (FBDG) for a representative person within energy balance at 2 330 kcal/day. The cost of a healthy diet is converted to international dollars using purchasing power parity (PPP) and expressed in current PPP dollar/person/day. The original method for producing the CoHD (Herforth *et al.*, 2020) was revised in 2022 with the development of the healthy diet basket that serves as the global cost standard (derived from FBDG) for the CoHD (Herforth *et al.*, 2022).

A healthy diet is defined as unaffordable when income is lower than the CoHD after accounting for the cost of non-food basic needs. The affordability of a healthy diet is measured by the *prevalence* of unaffordability (PUA), and the *number* of people unable to afford a healthy diet (NUA). Operationally, the share of individuals unable to afford a healthy diet is obtained by comparing the sum of the CoHD and the cost of non-food basic needs with the distribution of disposable incomes in the population, derived from household per capita consumption expenditure or income distributions available in the Poverty and Inequality Platform (PIP) of the World Bank.

The PUA and NUA indicators, as previously used for global monitoring, specified that a healthy diet would be considered unaffordable when its daily cost exceeds a fixed percentage of total household expenditure (FAO, IFAD, UNICEF, WFP and WHO, 2020, 2021, 2022, 2023, 2024). The fixed threshold provided a simple, easily communicated benchmark, though it implied the unreasonable assumption that the cost of non-food goods and services would always be a fixed proportion (48 percent) of incomes, irrespective of the income level. As a result, the income available for food was likely assumed to be too high for relatively rich households and countries, and too low for relatively poor ones.

To compute the CoHD for global monitoring, the food price data source is the International Comparison Program (ICP), a global statistical initiative managed by the World Bank. The ICP provides data on purchasing power parity, internationally comparable price level indexes, real gross domestic product (GDP) and its expenditure components (World Bank, 2024b). Since 2020, the CoAHD indicators have relied on 2017 global price data, providing annual average, nationally representative prices for 680 foods and non-alcoholic beverages across 175 countries. For the years following 2017, the CoHD was estimated based on food inflation data in each country (Bai, Conti *et. al.*, 2024). In May 2024, the global price data

for 2021 became available, covering 735 foods and non-alcoholic beverages in 173 countries. These latest data include more food items and, most importantly, cover a greater variety of locally representative nutritious foods, such as dark green leafy vegetables, thereby improving the precision of CoAHD indicators.

To estimate PUA and NUA indicators, income distributions for each country are sourced from the PIP. These distributions are used to inform poverty estimates published by the World Bank every year, typically meant to represent the national distributions of disposable incomes directly derived from household consumption and expenditure survey data, or modelled by the World Bank Poverty Data group for years when no survey data are available.

In 2024, several updates were made to the CoHD, PUA and NUA estimates. This paper discusses the revised method of determining affordability, primarily based on an improved method for estimating the cost of non-food basic needs. A companion paper (Bai *et al.*, 2024) discusses the updates of CoHD based on new data. In this study, we also compare the available data on food expenditure shares from national accounts, CPI weights and household survey data compiled by the World Bank. Finally, we outline future research directions for a further refinement of the methodology to estimate affordability.

2 Methods and data for computing affordability

In each country, the proportion and number of people unable to afford a healthy diet is based on income distributions from nationally representative household surveys, assembled by the PIP. The PIP updates these income distributions in March and September each year, while the SOFI report is published in July. For this reason, global CoAHD data are published based on new CoHD results simultaneously by FAO and the World Bank each July, followed by updated affordability numbers each December.

Establishing whether an individual can afford a healthy diet requires comparing the CoHD to income available for food, after accounting for the cost of non-food basic needs. Thus, a method is needed to estimate the cost of non-food basic needs. Previously, normative non-food expenses were estimated as a fixed proportion of income, based on the observed expenditure shares of food vs non-food among the poor in low-income countries. The initial affordability method, introduced in 2020 based on household survey data, showed that low-income people spent 63 percent of their income on food in low-income countries (FAO, IFAD, UNICEF, WFP and WHO, 2020, 2021). The survey data, however, was over a decade old, so for global monitoring, the revised affordability method introduced in 2022 switched to the best available data source at that time, which was the national accounts data compiled by ICP for PPP estimation (World Bank, 2024a). These data showed that the average share of household income spent on food in low-income countries was 52 percent. Therefore, the affordability used for global monitoring specified that a healthy diet would be considered unaffordable when its cost per day exceeded 52 percent of total income (FAO, IFAD, UNICEF, WFP and WHO, 2022, 2023).

This uniform global proportional approach provided a simple, easily communicated benchmark using readily available and routinely updated national accounts data from the ICP. However, people in higher-income settings, including within a country, devote a larger share of expenditure to non-food expenses (such as housing and energy, transportation, clothing, education and health care): this established regularity in economic analysis is known as Engel's law (Masters and Finaret, 2024). Therefore, the use of a uniform global proportion likely underestimates the share of income that should be reserved for non-food expenses by the rich, and overestimates it for the poor, and, as a result, underestimates unaffordability for lower-income people in middle- and high-income countries and overestimates unaffordability for lower-income people in low-income countries. The second issue with using a fixed *proportion* of income that must be reserved for non-food basic needs is that the *amount* covaries with the CoHD. If the CoHD rises, then the amount reserved for non-food needs also rises proportionally. The costs for basic non-food needs should not be tied to the CoHD.

Therefore, a fixed cost of basic non-food needs needed to be identified for each country. We did not seek to define basic needs for non-food; rather, we relied on existing definitions used in poverty measurement. To this end, the most relevant definition of the cost of non-food basic needs is the non-food component of each country's national poverty line. We see three barriers to applying this method: firstly, there is no global database of national poverty lines; secondly, the methodology for defining poverty lines varies across countries; and thirdly, not all countries publish separate food and non-food components of the lines. As the second-best approximation, we refer to the international poverty lines as articulated by the World Bank for low-income (USD 2.15), lower-middle-income (USD 3.65), upper-middle-income (USD 6.85), and

high-income countries (USD 24.36) (Jolliffe *et al.*, 2022).[1] These lines are not decomposed into food and non-food. To separate the non-food component of the World Bank poverty line, we identify the proportion of expenditures on non-food vs food among low-income consumers by considering the countries that belong to each country income group, and multiply this proportion by the international poverty line, thus obtaining a fixed amount that can be considered an estimate of the cost of basic non-food needs.

To obtain the non-food expenditure share of low-income consumers, we use data from recent household budget surveys conducted by national statistical organizations, compiled and analysed by the World Bank Development Data Group (Mahler *et al.*, 2022). These provide detailed actual consumption per person and expenditure shares by quintile of each country's income distribution for a total of 71 countries, including 24 low-income, 21 lower-middle-income, 22 upper-middle-income, and 4 high-income countries. The median survey year is 2016, with most data spanning an interquartile range from 2014 to 2018; only four of the 71 countries were surveyed before 2010.

To obtain non-food requirements for people in income quintiles around the poverty line, the data can be summarized with the following equation, for country *i* in income group *j*:[2]

$$IncomeThreshold_i = CoHD_i + (IntlPovLine_j \times NonfoodExpShareLowIncome_j)$$

We use three income groups with different expenditure shares: low-income countries, lower-middle-income countries, and the combined group of upper-middle-income and high-income countries (which we merge because the World Bank data on high-income countries include only four nationally representative surveys). To identify the quintile of the income distribution that is closer to the assumed poverty line, we refer to the data presented in Table 1, showing the observed level of income or expenditure (denoted "mean daily welfare") from the PIP's compilation of household surveys for 71 countries. This table shows that the average for those quintiles is close to, but below, the international poverty lines for countries in each income group, leading to choosing the second income quintile in low- and lower-middle-income countries and the lowest-income quintile in upper-middle-income countries, as the reference group.

Table 1. International poverty lines and observed average income or expenditure for the first two quintiles of national populations in each income group (2017 PPP dollars)

		Observed average income or expenditure (mean daily welfare)	
Income group	International poverty line	First quintile	Second quintile
Low income	2.15	1.20	**2.00**
Lower-middle income	3.65	1.92	**3.24**
Upper-middle income	6.85	**5.16**	8.96

Note: Bold values indicate the quintiles whose income or expenditure is closest to the international poverty line for each income group.
Source: Authors' own elaboration.

[1] As an alternative, we also applied country-specific societal poverty lines (SPL) lines (Jolliffe *et al.*, 2022; Mahler *et al.*, 2022; Tetteh Baah *et al.*, 2024). These are obtained from the observation that governments' own national poverty lines, when converted from local currency to PPP terms, have a horizontal floor around an extreme poverty line and then rise at a slope that is half of the population's median income (Jolliffe and Prydz, 2021). The most recently observed relationship is the SPL formula of a floor at 2.15 in 2017 USD PPP terms, or a country-specific level above that of USD PPP 1.15 plus 0.5 times the country's median income or expenditure (Tetteh Baah *et al.*, 2024). For details, please refer to the Appendix.

[2] We use three income groups for expenditure share estimates but four groups for international poverty lines.

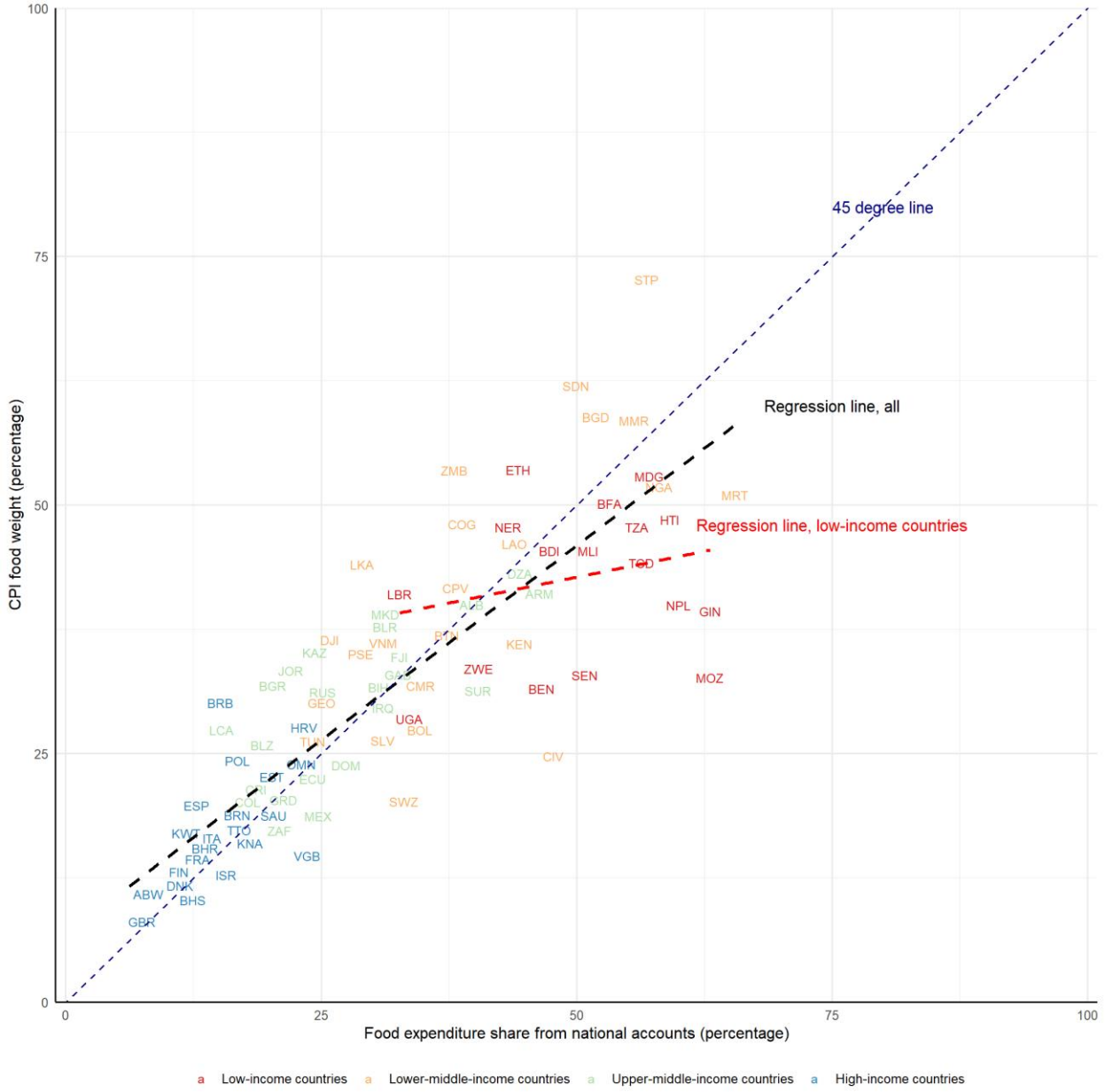
We compared these household survey data with two other data sources for the share of expenditures on food vs non-food at the national level: (1) national accounts expenditure data and (2) national averages from the expenditure weights on food and non-alcoholic beverages in each country's consumer price index (CPI). The national accounts expenditure data and the CPI expenditure weights on food represent the entire population as in the existing affordability thresholds using the low-income countries' average. Using survey-based data on income and expenditure shares has the advantage of taking into account within-country group variation, allowing a focus on lower-income consumers.

The food expenditure share data from national accounts are available through the ICP data publications in each ICP cycle. Each country officially reports the food and non-food expenditure weights with CPI data to the International Monetary Fund (IMF) and other international agencies. These data are updated periodically based on nationally representative household surveys. For the base year of CoAHD data in 2017, these expenditure weights are available for 152 countries (IMF, 2024). Like national accounts, the CPI weights used for inflation data are based partly on United Nations Statistical Commission standards. However, countries differ in how and when their CPI weights are updated.

2.1 Comparison of data for food and non-food shares

The first question concerns data sources for national average food expenditure shares, comparing 2017 ICP national accounts to the 2017 CPI food weights compiled by the IMF and the Organisation for Economic Co-operation and Development (OECD). Figure 1 reveals their similarities and differences across the 138 countries reporting both data. The two variables are intended to measure the same thing and might fall along the 45-degree line, but differences in measurement lead to a Pearson correlation coefficient of 0.87. Differences are greater for the low-income countries, for which the Pearson coefficient is 0.22 and not statistically different from zero (p-value < 0.32). The coefficients for other country income groups are similar and associated with income, at 0.71, 0.78, and 0.79 for lower-middle-, upper-middle-, and high-income countries, respectively (all p-values < 0.01).

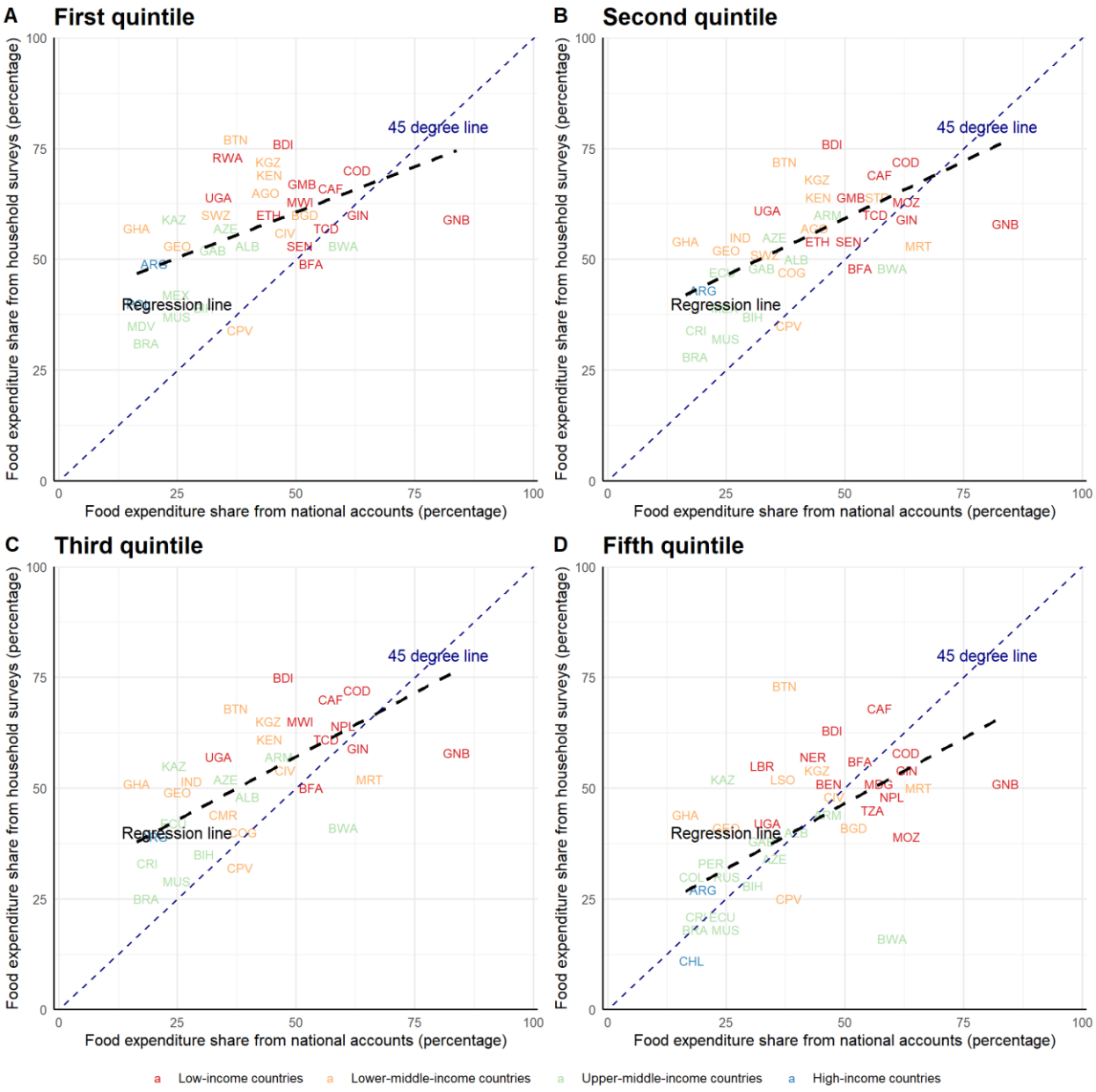
Figure 1. Food expenditure shares from national accounts vs CPI weights, 2017



Note: Each country is represented by its three-letter ISO code. The 45-degree line indicates where the food expenditure share equals the CPI weight. Guinea-Bissau and Botswana are outliers excluded from the analysis.
Source: Authors' own elaboration.

From Figure 1, we conclude that national accounts and CPI weights are not aligned for low-income countries. We then turn to household survey data, examining the correlation between food expenditure shares from national accounts and food expenditure shares by quintile of income distribution, in the 69 countries for which both national accounts and survey data are available. Figure 2 shows the scatterplots and the resulting regression line for the first, second, third, and fifth quintiles. For the lowest-income consumers in each country (Q1), we observe a positive correlation coefficient (0.56, $p < 0.01$), with higher coefficients for Q2, Q3, and Q5 (0.64, 0.68, and 0.64, respectively, all $p < 0.01$).

Figure 2. Food expenditure shares from national accounts vs average shares by quintile of income in each country from household surveys, 2017



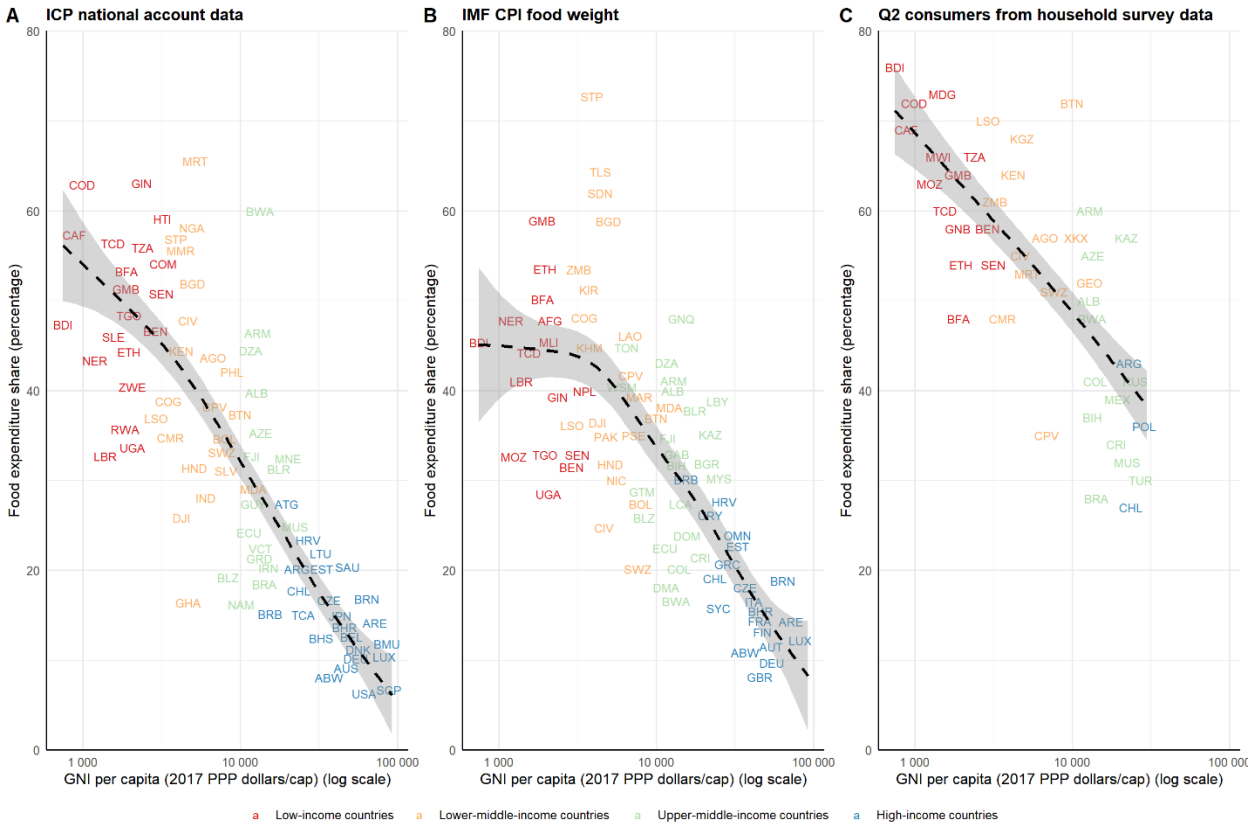
Source: Authors' own elaboration.

Figure 2 reflects Engel's law: households in lower quintiles have higher food expenditure shares than households in higher-income quintiles. The 45-degree line represents a perfect alignment between national accounts and household survey data. From Figure 2, regression lines show that each quintile's average food expenditure shares in the survey data have less variance and are typically higher than the whole country's food expenditure shares in national accounts.

A further test of how the three sources of data on food expenditure compare to each other and Engel's law is provided in Figure 3, showing food expenditure share against the gross national income (GNI) per capita for 2017. The three scatterplots show the relationship using ICP national accounts, CPI expenditure

weights, and Q2 households from survey data. In each case, a higher GNI per capita is associated with lower food expenditure shares, but levels are higher, and the variance around the mean at each income level is smaller for the survey data among Q2 households.

Figure 3. Food expenditure share vs GNI per capita, 2017



Note: Panel A shows the national accounts data for all 171 countries recorded by ICP, panel B shows the CPI weights on food and non-alcoholic beverages for 150 countries reporting to the IMF and OECD, and panel C shows the food expenditure share for second-quintile households in the 71 nationally representative household surveys compiled by the World Bank. The pattern for first-quintile consumers is similar but not shown. Smoothed means at each income level are shown using generalized additive models with 95 percent confidence intervals. For panel B, China, Macao SAR is excluded from the analysis as an outlier.
Source: Authors' own elaboration.

Figure 3 confirms that household survey data for low-income quintiles generally reveal a higher share of income spent on food than national accounts or CPI food weights, with less variance around the pattern associated with the GNI per person.

Because the total expenditure data used to measure affordability also comes from household surveys, using the same data source for food expenditure shares is warranted. It reflects the actual share of households' self-reported income that they spend on food, which is higher and varies less than the share in national accounts, as shown in Figure 2.

Table 2 shows food and non-food expenditure shares for each quintile of households by country income group, as well as each category's mean and interquartile ranges (IQR) of food and non-food shares. The first two rows of Table 2, showing Q1 and Q2 households in each group of countries, provide the

expenditure share data for our proposed country-specific affordability thresholds. Low-income country households in the first four quintiles show expenditure shares on food that are higher than the previously used 52 percent threshold, or very close to it for Q5 households.

Table 2. Average food and non-food expenditure shares by consumer quintile and country income group, derived from household surveys

Consumer quintile	Low income		Lower-middle income		Upper-middle income and high income	
	Mean	Interquartile range	Mean	Interquartile range	Mean	Interquartile range
Food expenditure share						
Q1	63	60–67	60	56–64	**46**	39–53
Q2	**63**	59–68	**56**	52–61	42	36–48
Q3	62	58–66	**52**	47–56	39	33–44
Q4	59	55–64	49	43–53	35	30–41
Q5	51	47–55	43	35–49	27	21–33
Non-food expenditure share						
Q1	37	33–40	40	36–44	**54**	47–61
Q2	**37**	32–41	**44**	39–48	58	52–64
Q3	38	34–42	48	44–53	61	57–67
Q4	41	37–45	51	47–57	65	59–70
Q5	49	45–53	58	51–65	73	68–79

Note: The data are shown for the 71 countries with household survey data compiled by the World Bank. Bold numbers correspond to the quintiles used for the fixed non-food share method, which is Q2 for low- and lower-middle-income countries and Q1 for upper-middle- and high-income countries. The underlined number shows that the current 52 percent food expenditure share derived from national accounts of low-income countries matches the mean food expenditure share for Q3 consumers in household surveys from lower-middle-income countries.
Source: Authors' own elaboration.

The new method using country group-specific fixed non-food spending is based on the expenditure shares in Table 2, multiplied by the international poverty lines shown in Table 1, leading to the results shown in Table 3. These non-food expenditures provide a proxy for the non-food poverty line, or the cost of non-food basic needs. The sum of CoHD and the fixed amounts shown in Table 3 establish the level of income needed to afford a healthy diet. The IQR establishes a range around the required income level to determine a range of PUA.

Table 3. Fixed non-food expenses by income classification

	Mean non-food expenditure share (percent)		International poverty line (2017 PPP dollars)	Mean non-food expenditure (2017 PPP dollars)	
	Value	IQR	Value	Value	IQR
Low income	0.37	0.32–0.41	2.15	0.80	0.69–0.88
Lower-middle income	0.44	0.39–0.48	3.65	1.61	1.42–1.75
Upper-middle income	0.54	0.47–0.61	6.85	3.70	3.22–4.18
High income	0.54	0.47–0.61	24.36	13.20	11.4–14.9

Note: The non-food expenditure shares for upper-middle-income and high-income countries are based on 22 and 4 observations, respectively.
Source: Authors' own elaboration.

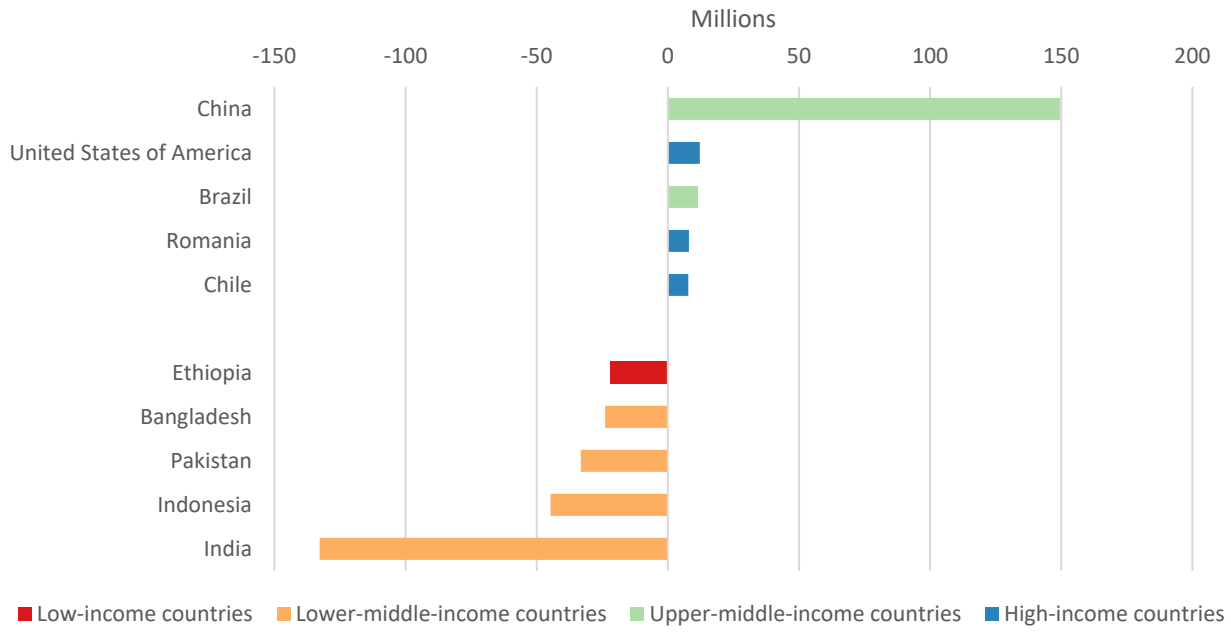
As shown in Table 3, the fixed country-group level of non-food spending required when determining household income available for food is larger in higher-income countries. However, this level would be the same for all countries in the same income group. An important aspect of this approach is the discontinuity between countries near the boundaries between income groups. All low-income countries would have non-food requirements estimated at USD 0.80 (IQR 0.69–0.88), even at the top of their income range, while a country whose income is just higher enough to be classified as lower-middle income would have non-food requirements estimated at USD 1.61 (IQR 1.42–1.75), and similarly at the boundary of the upper-middle-income and high-income groups.

3 Effects of updated methods and data on results

The CoAHD results with the new affordability method differ from the previous ones. The updated affordability method based on the 2017 price data leads to a lower number of people unable to afford a healthy diet, shown in Figure 4. Using the IQR ranges of non-food expenditure shares, the world total is 2.88 billion for 2017, with a lower bound of 2.72 billion and an upper bound of 3.02 billion using the country income-group-specific fixed non-food method, compared to the baseline figure of 3.12 billion (FAO, IFAD, UNICEF, WFP and WHO, 2023).

The differences are more prominent in the most populous countries, starting with China, an upper-middle-income country, and India, a lower-middle-income country. For India, where the new method implies a lower cost of non-food basic needs, the number of people unable to afford a healthy diet is reduced by 133 million. Similar reductions are observed in other lower-middle- and low-income countries, notably Indonesia, Pakistan, Bangladesh and Ethiopia. These downward revisions are offset by upward revisions in upper-middle- and high-income countries where the new methods reflect higher non-food costs, primarily in China (CHN), where the new method leads to an increase of 150 million people. Other countries with notable upward revisions include the United States of America and Brazil.

Figure 4. Revision in the number of people unable to afford a healthy diet, top and bottom countries, 2017

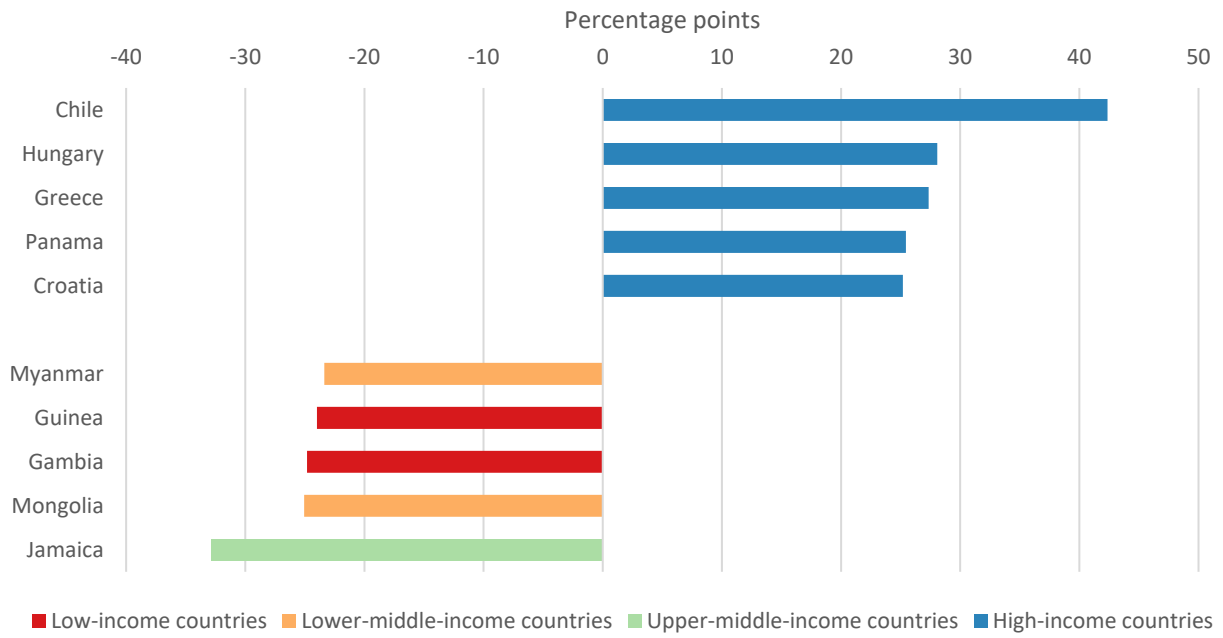


Source: Authors' own elaboration.

Revisions in the prevalence of unaffordability (PUA) are shown in Figure 5. Again, as expected, the new methods lead to upward revisions for upper-middle-income and especially high-income countries due to more extensive non-food requirements, and downward revisions for lower-middle- and low-income countries with smaller estimated non-food requirements. Countries with large proportional changes often have relatively small total populations, which limits their effect on the global total, such as reductions for the Gambia where the PUA is revised downwards by 25 percentage points. Countries with relatively high levels of CoHD also see notable downward revisions, such as Jamaica by 33 percentage points. Due to

large populations in lower-income countries where non-food requirements are revised downwards, the revised global prevalence of unaffordability is 41.3 percent (IQR: 38.8–43.4 percent), which is lower than the one previously estimated at 43.8 percent.

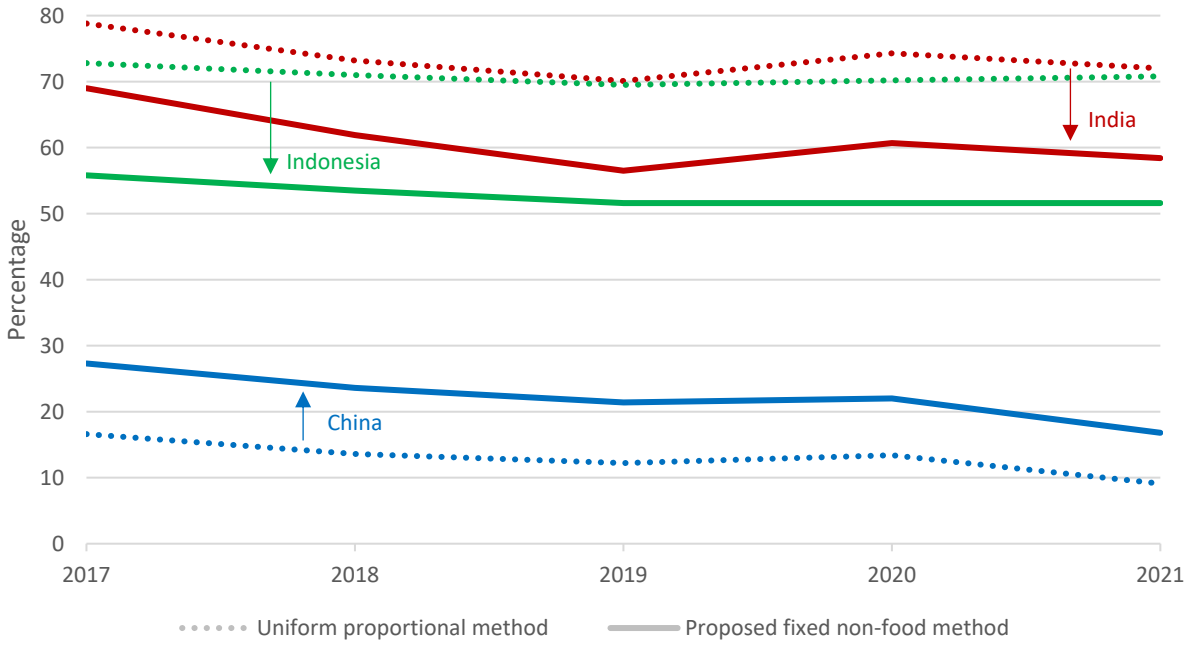
Figure 5. Revision in the percentage of the population unable to afford a healthy diet, top and bottom countries, 2017



Source: Authors' own elaboration.

A final step in this analysis is to consider changes over time in the three most populous countries affecting global results, notably China, India and Indonesia. Figure 6 compares the previous data with results using the fixed non-food method, and shows the expected downward revision based on smaller non-food needs than previously estimated for India and Indonesia and upward revision based on larger non-food needs than previously estimated for China. Trends in all three countries are unaffected: Indonesia shows progress from 2017 to 2019 that has stalled since the COVID-19 pandemic in 2020; India shows even more progress from 2017 to 2019 that reversed at the onset of the COVID-19 pandemic in 2020 but has since resumed its decline in 2021; and China shows a similar pattern of improvement that paused in 2020 but resumed in 2021.

Figure 6. Share of the population unable to afford a healthy diet (PUA) before and after the change of method for China, India and Indonesia



Source: Authors' own elaboration.

All of the data shown in this analysis use the ICP item prices for 2017, so changes over time in Figure 6 depend only on the country's overall food CPI used to estimate diet costs between 2017 and 2022 (Bai *et al.*, 2024), and their income distributions as estimated by the PIP.

4 Further research for improving methods

4.1 Methods for country-specific non-food costs

To solve the discontinuity issue between countries near the boundaries between income groups, we may also apply the country-specific and yearly variant societal poverty lines to compute socially determined non-food expenditure requirements in each country, instead of the international poverty line levels. Therefore, the income threshold needed to afford a healthy diet for a country *i* in year *t* is the total of the cost of a healthy diet in country *i* and year *t* plus the societal poverty line of this country in the same year multiplied by the non-food expenditure share of people in the income quintile around its societal poverty line, which is expressed in the equation below:

$$IncomeThreshold_{i,t} = COHD_{i,t} + (SocPovLine_{i,t} \times NonfoodShareAtSocPovLine_{i,t}) \quad (1)$$

While this approach marginally changes the global estimate compared to the method discussed in this paper, leading to a total number of people unable to afford a healthy diet of 2.86 billion (IQR: 2.71–3.01 billion), it may make the estimates even more country-specific and time-dependent on changes in per capita income. This method could also provide an improved harmonization basis for the increasing national monitoring efforts, as country-specific societal poverty lines have shown great alignment with harmonized national poverty lines estimated by the World Bank (Jolliffe *et al.*, 2022).

4.2 Moving beyond the average cost threshold for unbiased estimates of the prevalence of unaffordability

As discussed in previous sections, the percentages and number of people unable to afford a healthy diet are estimated by comparing income distributions with the sum of the CoHD and the cost of non-food basic needs derived from household survey data and international poverty lines. In principle, as prevailing prices for both food and non-food goods and services vary by location, the ideal unit of analysis is the largest possible (usually subnational) area where the cost thresholds can be deemed equal for all the residing population.

Formally, the prevalence of unaffordability in an area s (PUA_s) can be estimated as:

$$PUA_s = \int_{-\infty}^{r_s=c_s+n_s} f^s(x)dx, \quad (2)$$

where r_s represents the income threshold needed to afford a healthy diet, composed of the sum of the cost of a healthy diet (c_s) and the cost of non-food essential needs (n_s), and where $f^s(x)$ is the distribution of incomes among residents of the area considered. Then, the number of people unable to afford a healthy diet is simply computed as the product between the PUA_s and the population size N_s:

$$NUA_s = PUA_s \times N_s \quad (3)$$

Then, national estimates of NUA can be obtained by summing NUA_s over all relevant areas s, and PUA as the ratio between NUA and the national population size:

$$NUA = \sum_s NUA_s\,; \tag{4}$$

$$PUA = \frac{NUA}{\sum_s N_s} \tag{5}$$

In practice, the assessment can often be done only for the entire national population or at the level of subnational geographic areas (such as urban vs rural, or administrative area units) that are larger than the ideal. This is because either the income distributions or the average costs – or both – are only available at that level. In such cases, one may still conduct the assessment using the formula in Equation 2, with reference to the *national* income distribution, $f(x)$, and the *national average* threshold $\bar{r}$, as follows:

$$PUA = \int_{-\infty}^{\bar{r}} f(x)\,dx \tag{6}$$

This represents the assumption behind the current estimates of affordability. However, the formula in Equation 6 will only yield an unbiased estimate of the true PUA if the distribution of the subnational area level values of r is statistically independent of the distribution of incomes across the same subnational areas. In all other cases, the threshold as used in Equation 6 will generate a bias.

If there is a systematic relation between income levels and the sum of the cost of a healthy diet plus the cost of non-food essential needs, using the average $\bar{r}$ as a threshold (as in Equation 6), will over- or underestimate the true prevalence of unaffordability (PUA), depending on whether the relation is positive or negative and whether the average falls above or below the modal income. This is because using the average threshold instead of the appropriate differing thresholds when a correlation exists between incomes and costs across the different locations in a country will induce misclassifications in each of the areas that will not cancel out in the aggregate. In these models, where the issue boils down to evaluating areas under a probability density function, the probability of misclassifying units at the two opposite sides of the threshold is not equal, except if the threshold happens to be in a region where the probability density function is flat. When the true thresholds are located in areas of the distributions where the income probability density functions are increasing, using the average as a threshold will lead to an overestimation of the PUA, if average incomes and food and essential needs costs are positively correlated, and to an underestimation in the (less likely) opposite case. To provide an example of biased estimates of unaffordability, Figure 7 shows income distributions for two hypothetical subnational geographic regions in a country, one where incomes are systematically higher and the other where they are systematically lower. The figure shows why errors in estimating the PUA, using an average as a threshold, do not cancel out if the correct values to use as thresholds are correlated with incomes.

Given that the existence and the sign of the spatial correlation between incomes and the appropriate cost thresholds are empirical questions, research is ongoing on a large number of datasets from recent household surveys to determine the best approach to adjust the threshold and correct for the potential bias that is affecting the current estimates. From an empirical point of view, due to the lack of universal data on the cost of r and income x for each individual in a population, a feasible solution is to model the PUA probabilistically, that is as the probability that a randomly sampled unit from the population is found to be unable to afford a healthy diet. Such a model can be defined in terms of the probability distribution of total disposable incomes $f(x)$ and of the range of the cost of r in a population. By extension of

arguments presented by Naiken (2007), and recognizing that a statistically significant positive correlation was found between x and r in 44 household surveys analysed, an unbiased estimate of PUA could be obtained as:

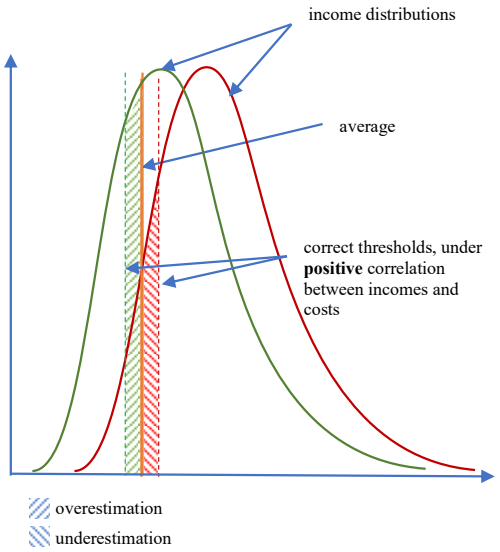
$$PUA = \int_{-\infty}^{r_L} f(x)dx \text{ if } \rho_{x,r} > 0 \quad (7)$$

where $\rho_{x,r}$ is the correlation between x and r in the population and r_L the lower bound of the distribution of r in the population. From an operational point of view, the use of household survey data allows to calculate the cost of c, n and r at the disaggregated level for subnational units of a country. This approach enables the calculation of the coefficient of variation (CV) for the cost of r within a country, and to test the correlation between the estimated average cost threshold r and the total consumption expenditures x, used as a proxy for total disposable income. If the correlation is positive, the lower bound of the distribution r_L, instead of the average cost of r, should be used as a threshold against which income distributions are contrasted to determine the prevalence of people unable to afford a healthy diet in a country.

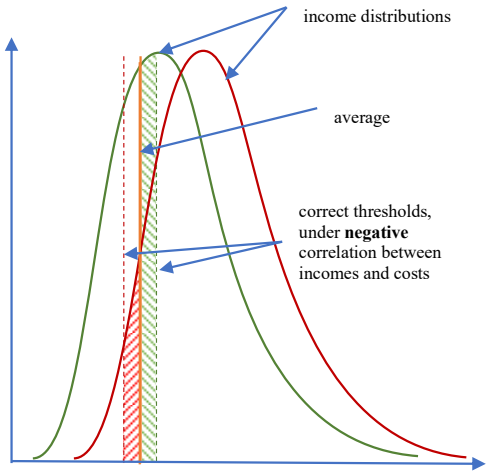
Figure 7. Overestimation and underestimation of the PUA when using the average as a threshold if incomes are correlated with costs

Panel A: the total cost of essential needs + healthy diet is **below** the disposable income's modal value

Panel A1: positive correlation

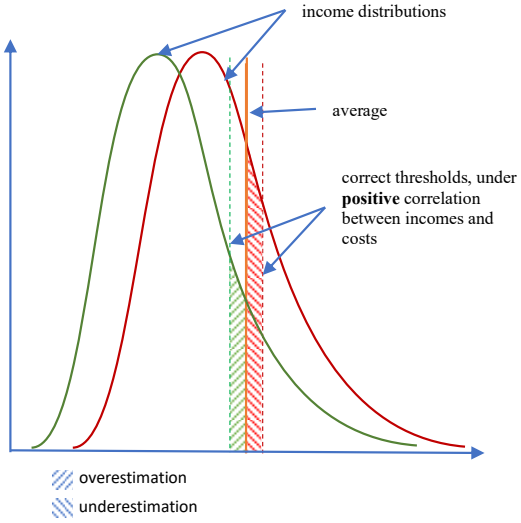


Panel A2: negative correlation

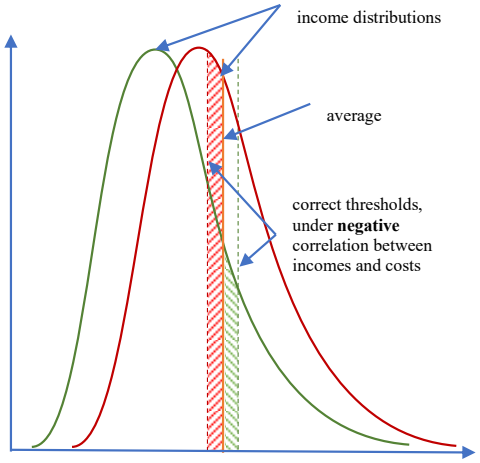


Panel B: the total cost of essential needs + healthy diet is **above** the disposable income's modal value

Panel B1: positive correlation



Panel B2: negative correlation



Source: Authors' (FAO) own elaboration.

5 Discussion and conclusion

For the newly released cost of a healthy diet estimates in July 2024, diet costs and unaffordability levels are recalculated using the updated method and the new ICP price data for 2021 (Bai *et al.*, 2024). Country-specific data on the availability and the price of internationally comparable foods, combined with the income-group-specific estimates of non-food costs obtained using the new method proposed in this paper, will provide a clearer picture and a promising new baseline for the global monitoring of the cost and affordability of a healthy diet. This method improves PUA and NUA estimates compared with the previous one.

The purpose of the cost and affordability of a healthy diet is to measure economic access to adequate food (sufficient, safe nutritious food to meet dietary needs for an active and healthy life). Since its introduction in July 2020 and its revision for global monitoring in July 2022, the cost and affordability of a healthy diet has attracted a high level of interest. The CoHD has been adopted by some national governments for their own within-country monitoring and used by a variety of policy analysts to guide decision-making. When the least-cost option for a healthy diet is unaffordable, two primary factors could contribute: either high costs for the most affordable healthy options, or insufficient income available for food, keeping the lowest-cost healthy diet out of reach. Conversely, when a healthy diet is affordable, a different pathway may influence dietary choices: the displacement of locally available, low-cost healthy options by other foods. A high CoHD points to the need for improved production and distribution to lower supply costs, while insufficient incomes available for food point to opportunities for social protection and nutrition assistance, and situations where healthy diets are affordable but displaced by unhealthy diets reveal the need for interventions relating to other aspects of food environments affecting food choice and other barriers to healthy eating such as time use and meal preparation costs.

Economic indicators, such as inflation or national income, are periodically updated to use new data sources and better inform decision-making. In the case of the affordability of a healthy diet, the dataset of household survey data facilitated an improvement in the methodology. As shown in Table 2, the 52 percent share available for food (derived from national accounts in low-income countries) is the average food expenditure share for third-quintile households in lower-middle-income countries (derived from newly available household survey data). However, people at local poverty lines in low-income countries spend a higher proportion on food, and people at local poverty lines in upper-middle-income and high-income countries spend a lower proportion on food.

To address the need for more granular and country-specific affordability thresholds, this paper highlighted unexplained variation in the CPI weights, especially for low-income countries. This variation is potentially due to different methods and long lags used to compute and update national CPIs. National accounts data align more closely with household survey data, particularly for wealthier quintiles in each country, as analysed by the World Bank's new compilation of household survey data. The main advantage of using survey-based data on income and expenditure shares is to take account of within-country variation by quintile of each country's income distribution in the 71 countries, extrapolated to the 166 countries for which a median income estimate is available. The survey data also reveal that the lower quintiles of each national income distribution provide the most relevant expenditure shares for affordability analyses.

The frequency of updates of the household survey database could be considered: currently, it does not have a regular update schedule and is updated on an as-needed basis. A commitment to update it on a

regular basis is needed not only for the affordability of a healthy diet, but for many other purposes, as advised by the relevant Statistical Performance Indicators framework of the World Bank on the CPI (Ketema *et al.*, 2021).

The proposed method for global monitoring can also be harmonized with country studies of affordability, where countries may use the non-food portion of national poverty lines or similar approaches to define non-food requirements added to the CoHD when estimating the income threshold required for the affordability of a healthy diet. Many countries are starting to monitor the CoHD, and may choose to add affordability aligned with the global method (Nigeria National Bureau of Statistics, 2024; Alemayehu *et al.*, 2023; Herforth *et al.*, 2024).

The new affordability method described in this paper provides a valuable advance for the global monitoring of the cost and affordability of a healthy diet. From the initial method introduced in 2020 (Herforth *et al.*, 2020) to the healthy diet basket approach introduced in 2022 (Herforth *et al.*, 2022) and now the inclusion of the cost of basic non-food needs in 2024, this food access indicator has developed and matured rapidly. We continuously pursue other methodological improvements, taking into account what is possible with existing data for global application, and anticipate further improvements in the future.

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Contact:

Statistics Division – Economic and Social Development
FAO-statistics@fao.org
www.fao.org/statistics/resources/en

Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-139470-0

CD3703EN/1/12.24