Prevalence of Undernourishment in Indian States

Explorations Based on NSS 68th Round Data

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Prevalence of undernourishment, a measure developed by the Food and Agriculture Organization, is a key indicator for global hunger and food insecurity targets. The FAO has developed a sound conceptual model for estimating the prevalence of dietary energy deficiency. However, the estimation methodology of the prevalence of undernourishment has been a subject of much debate. Important modifications are suggested in the estimation of the distribution of average calorie intake and average minimum dietary energy requirements. Using the latest available data and the revised methodology, it is shown that about 472 million people in India, a staggering 39% of the population, were undernourished in 2011–12.

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Calls to eradicate hunger—a condition where a person, given their physical condition, is unable to consume an adequate quantity of food for healthy living—have been articulated on the world stage since the World Food Summit of 1996. The Rome Declaration, adopted in the 1996 World Food Summit, pledged,

> Our political will and our common and national commitment to achieving food security for all and to an ongoing effort to eradicate hunger in all countries, with an immediate view to reducing the number of undernourished people to half their present level no later than 2015.

The World Food Summit, 2002, and the World Summit on Food Security, 2009, reaffirmed the global commitment to eradicate hunger. United Nations Secretary General Ban Ki-moon launched the Zero Hunger Challenge in 2012 with the aim of ending world hunger. Subsequently, ending hunger was adopted as Goal 2 of the 2030 Agenda for Sustainable Development.

While the policy ambition has been to eradicate hunger, measuring progress towards these goals using estimates of the number and proportion of people who are unable to get an adequate amount of food has not been easy. The main problem in estimating the proportion of people who are undernourished is that the energy requirements of individuals vary, based on their age, sex, body size, and level of physical activity. Pregnant and lactating women and children need additional food to support reproduction and growth. In addition, dietary energy requirements also vary according to the metabolic efficiency with which food is converted into energy, and how efficiently the body absorbs energy. Given these variations, it is methodologically incorrect to compare the dietary energy intake of an individual with an average dietary energy requirement in order to assess whether they are undernourished (Naiken 2002; Sukhatme 1961). This has led the scholarly work in this area to move to a probabilistic measurement of undernourishment rather than a simple headcount approach.[1]

Prevalence of undernourishment (PoU), a measure developed by the Food and Agriculture Organization (FAO), is the most widely used measure based on a probabilistic measurement of undernourishment. PoU was the officially recognised indicator for measuring progress on Target 1C of the Millennium Development Goals (MDG). It is also one of the two officially recognised indicators for measuring progress on Target 2.1 of the Sustainable Development Goals (SDGs).

Over the years, the FAO's methodology for estimating PoU has been subject to intense criticism. Much of this criticism, however, is misplaced as it arises from a lack of clarity on the exact methodology used to calculate the PoU and from a lack of access to all the data that FAO uses to estimate the PoU for each country. Some valid concerns have also been raised with respect to estimation of the distribution of calorie intake and the cut-off calorie requirement. The need to adapt the FAO methodology to estimate PoU at the subnational level, a requirement under the SDG monitoring framework, has also been pointed out.

In this paper, we introduce some important modifications to the FAO method and use it to estimate the PoU for India and Indian states. We also present a method for estimating PoU at the subnational level. We have made important improvements in estimation of calorie intake distribution and average minimum dietary energy requirement (MDER). These improvements address some of the most important criticisms of the FAO methodology.

The revised PoU estimates for India are considerably higher than the FAO's estimates for India, pointing to the possibility that the problem of hunger in India, and consequently, the world, may be much larger than it is currently estimated to be.

Estimation Methodology: The Overall Approach

This section briefly summarises the current approach used by FAO for estimating PoU, as described by Cafiero (2014), Cafiero et al (2014), and Wanner et al (2014). The FAO method is based on a statistical model designed to avoid bias by controlling for differences in dietary energy requirements due to age, sex, height (as a proxy for ideal body mass), and physical activity level (PAL). Since the dietary energy requirement of every individual cannot be reliably measured, it is not possible to estimate the PoU as a headcount ratio of persons for whom their dietary intake is lower than their dietary requirements. In view of this, the FAO uses a statistical model to estimate the probability distribution of dietary intake of an average individual. For this hypothetical average individual, a probability distribution comprising different levels of dietary energy requirements that are compatible with good health and normal physical activity is established. The PoU is estimated as the probability that the calorie intake for the representative average individual is below the MDER level (equation 1). MDER is the average of the minimum dietary energy requirements of individuals in the population.

$$\text{PoU} = \int_{x<MDER} f(x)dx \quad \dots (1)$$

For different groups of countries, the FAO currently uses the log normal distribution, the log skew normal distribution, or the skew normal distribution to model the probability distribution of average calorie intake. A major limitation in many countries is the unavailability of regular consumption surveys, because of which the coefficient of variation and skewness cannot be updated as regularly as is desirable.

Data

Ending hunger has remained a central concern in the discourse on development in post-independence India. Based on the pioneering work of V M Dandekar and Nilakanth Rath in the 1970s, measurement of calorie intake has been central to India's measurement of poverty.[2] Scholarly work on the use of calorie intake to measure poverty in India has also had a significant bearing on the international debate on measuring undernourishment.

The NSSO conducts large sample surveys of consumption and consumption expenditure on a quinquennial basis. The National Sample Survey Office (NSSO) conducted the last large-sample survey for 2011–12 as part of the 68th round surveys.[3]

These surveys provide detailed data on the consumption of all food and non-food items. The NSSO canvasses two types of survey schedules, which differ in terms of the reference period that is used for collecting information on different commodities. This paper is based on the Type-II schedule, which uses a 30-day reference period for the consumption of cereals and cereal substitutes, pulses, dairy products, salt, and sugar; a seven-day reference period for the consumption of all other food items; a seven-day reference period for paan, tobacco, and intoxicants; a 30-day reference period for fuel, other goods and services, rents and taxes; and 365 days for infrequently purchased items (like consumer durables).[4] The NSSO provides the nutrient content of a unit quantity of each food item (2014). We used these to compute the total calorie intake of a household.

Gaps in household consumption data: Two problems with the use of consumption data from household surveys for the purpose of estimating PoU need to be addressed.

First, as in most household surveys, information on food consumption is recorded in NSSO surveys for households as a whole. The FAO model, however, is based on an estimation of distribution of calorie intake of an average individual.[5] Computing the per capita calorie intake as a simple average across all members of a household results in a very significant averaging at the stage of computing per capita calorie intake itself, with all variations across age and sex being flattened. This is a serious problem, as coefficient of variation is a key parameter in the estimation of PoU.

In our view, rather than assuming that all individuals in a household consume equal calories irrespective of age and sex, it is better to assume that a household divides the total consumption broadly in the ratio of the minimum calorie requirements for different age and sex groups. This is equivalent to assuming that all members of a household equally under-consume or over-consume relative to their requirements. Even though this assumption does not capture intra-household variations in activity levels and discrimination in food allocation, it is better than assuming that all members of a household consume equal calories irrespective of their age and sex. To implement this idea, we estimated the minimum calorie requirement for median heights of men and women of different ages, and used these to estimate the ratio of the minimum calorie requirements of persons of a given age and sex to the calories required by an 18-year-old adult male. We took these ratios into account to apportion total household consumption among the members of each household.

Second, a typical problem in estimating calorie intake based on consumption surveys is that they do not take into account the consumption of meals (and snacks) that household members obtain in ready-to-eat forms (Cafiero et al 2014). These may include food purchased in restaurants and cafes, eaten as guests in other households, or obtained as part of school meals or other social protection programmes.[6] A methodologically related issue is the need to net out the food served by the household to non-householders or partakers.

In the context of the NSSO surveys on consumption, Minhas (1991), and more recently, Meenakshi and Viswanathan (2013) and Smith (2015), have argued that the data on calorie intake should be adjusted for food eaten away from home. Smith (2015) recently argued that the failure to account for the increasing incidence of meals eaten away from home contributes greatly to the discrepancy between trends in calorie intake and economic growth in India.

In most countries, consumption surveys collect data only on the expenditure on obtaining ready-to-eat meals outside of the home. In view of this limitation, in FAO's estimation of PoU, the contribution of food away from home to dietary energy intake is estimated by assuming that the implicit price of the calories in the food consumed away from home is equal to that of food prepared at home (Troubat 2016). This, however, is not a very satisfactory assumption, as the price of ready-to-eat food is likely different from (and most probably higher than) the price of home-cooked food.[7] The use of a fixed amount of calories (1,200 kcal per cooked meal), as suggested in NSSO (2014), is also inappropriate, and is likely to result in an overestimation of children's calorie intake.[8] The NSSO surveys are unique in their collection of data on meals obtained away from home and consumption by partakers, or non-householders fed in the home. In addition to information on the expenditure incurred on obtaining meals away from home, these surveys also collect information on the number of meals obtained outside.[9] We have used this information to substantially improve the method of incorporating the calorie intake associated with such consumption. Our method for intra-household apportioning of consumption, accounting for meals obtained away from home, and netting out the calories contained in food provided to partakers, involves the following steps:

(i) Computing a per day number of meals for each person: We used information on the number of meals eaten at home and outside by each member of the household for the last 30 days to compute the number of meals each person eats per day.[10]

(ii) Converting the number of meals to the number of standard meals per person: We used the ratio of calories required by persons of a given age and sex to the calories required by an 18-year-old male to convert the number of meals consumed at home and outside by each householder into the number of standard meals. For example, a two-year-old female child needs only 50% of the calories that an 18-year-old male requires. If a girl of this age ate two meals per day, the number of standard meals she consumed would be one per day.[11]

(iii) Calculating the average number of calories in a standard meal for each household: By adding the total number of standard meals eaten at home by householders and the number of meals given to partakers, we obtained the total number of standard meals that members of a household prepare and eat at home. We divided the total calorie intake of the household, computed from the nutrient content of the food acquired by the household (excluding ready-to-eat meals obtained and eaten outside), by the total number of standard meals cooked at home to arrive at the average calorific content of a standard meal of the household.

(iv) Computing the daily calorie intake of each member of a household: We multiplied the number of standard meals eaten at home and outside by a person by the average calorie content of a standard meal of the household to arrive at the daily calorie intake of one householder.

It is worth reiterating that this method of accounting for food away from home assumes that the standard meal of a particular household has the same calories irrespective of whether it is cooked at home and consumed by household members, cooked at home and consumed by partakers, or obtained and consumed by household members away from home.

Dealing with outliers: The mean, coefficient of variation, and skewness of per capita calorie intake are the three key distributional parameters used in the estimation of the PoU. The calculation of these parameters requires treating the data to identify and remove outliers. As suggested by Wanner et al (2014), we used the distribution of skewness in jackknife samples to identify outliers.[12]

Minimum Dietary Energy Requirement

MDER refers to the minimum dietary energy requirement that is compatible with good health for an average individual in the population. According to the FAO, MDER is

> estimated for each sex/age class of individuals based on the energy requirement (based on the basal metabolic rate) for the lowest acceptable body weight for that sex/age combination, adjusted for a minimal physical activity level compatible with a healthy life. Then a weighted average (the weights used are the proportions of the population in the corresponding sex/age groups) of the MDER of each sex/age class is computed. Finally, the extra energy required by pregnant women is added to the weighted average to derive the minimum dietary energy requirement of a representative individual of the population. (Cafiero et al 2014: 50)

More specifically, the FAO's computation of MDER involves the following three steps:

(i) In the first step, age-specific median heights for men and women are estimated for the population.

(ii) Then, using guidelines provided in FAO, WHO, and UNU (2001), the minimum dietary energy requirement associated with the median height for each year of age is estimated for men and women.

(iii) Finally, these age-specific minimum dietary energy requirements are averaged using population weights to obtain the MDER.

There have been two kinds of criticisms about the use of MDER as the cut-off for PoU. A number of scholars have criticised PoU for using MDER instead of the average dietary energy requirement as the cut-off, below which dietary intake is considered inadequate (Smith et al 2006). This criticism is based on an incorrect understanding of the statistical model underlying PoU. As Cafiero (2014) has explained, the use of the average dietary energy requirement will necessarily result in an overestimation of PoU.

The second criticism targets the use of dietary energy requirements corresponding to physical activity levels associated with a sedentary lifestyle (Lappé et al 2013; Pogge 2016). Given the lack of data on the distribution of physical activity levels in the population across different countries, the FAO's estimates do not account for variations in physical activity levels in the computation of average MDER, and instead, as a conservative approach, use physical activity levels associated with sedentary lifestyles.

In this paper, we show that the use of physical activity levels associated with sedentary lifestyles results in a substantial underestimation of PoU in India. An important contribution of the present paper is the extension of the FAO methodology to account for variations in physical activity levels while estimating the MDER, using data from a survey of occupations and employment. In this section, we provide a detailed description of our methodology for the estimation of MDER and present our estimates for India and Indian states.

Estimation of median heights: It may be noted that in the measurement of PoU, we estimated the minimum calorie requirements according to the median heights of persons of different ages and sex.[13]

There are two recent large-scale surveys that have collected data on population heights:

(i) Third National Family Health Survey (NFHS-III), 2005–06: The NFHS-III, conducted in all the states of India, measured heights for children aged zero to three years, men aged 13–54 years, and women aged 13–49 years. Using unit-level data from NFHS-III, we estimated the median height for men and women for each of the above age groups at the state level.

(ii) Survey of Diet and Nutritional Status of Rural Population, 2000–01, National Nutrition Monitoring Bureau (NNMB): During 2000–01, the NNMB conducted a survey on the nutritional status of the rural population in nine states of India—Andhra Pradesh, Gujarat, Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Maharashtra, Odisha, and West Bengal. Based on the survey, the NNMB provided median heights for single years of age between 0 and 17 years, and for the age groups 18–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, and above 75 years. There are separate estimates for each of the nine states and the pooled data.

In both surveys, there are significant gaps in the data on heights. While NFHS-III did not collect data on heights for persons of all ages, the NNMB survey covered only the rural populations of these nine states. Given these gaps, we decided to rely primarily on NFHS-III data for estimating median heights. We used estimates of year-on-year (or age group-to-age group) percentage change in median height from the NNMB survey to interpolate median heights for ages for which data were not available from the NFHS-III survey.[14]

The final estimates of median heights for each age for India as a whole can be found in Appendix Table A1 (p 45).

Age-specific MDER for men and women: We estimated age-specific MDER for men and women using the methods described by the FAO, WHO, and UNU (2001). They provide a range of body mass indices (BMI) compatible with a healthy lifestyle for each age. Since the objective is to obtain the minimum dietary requirement, we used the BMI corresponding to the fifth percentile for people above 10 years of age, as recommended by the FAO.

For people younger than 10 years of age, we used the BMI corresponding to the 50th percentile. For each age, we combined estimates of median height with the recommended minimum BMI to obtain the corresponding body weights.

We then used these weights to compute the total energy expenditure (TEE) for men and women of different ages. TEE refers to the average energy spent by an individual in a 24-hour period. Gender, age, body weight, and level of physical activity are the main determinants of TEE. In the case of children and adolescents, we make an allowance of 4.1 kcal/day for boys aged below one year, 4.4 kcal/day for girls below one year, and 2 kcal/day per gram of weight gain for children above one year to account for energy deposition in growing tissues.

Specific equations used for estimating age-specific energy requirements and estimates of age-specific energy requirements can be found in Appendix Tables A2 and A3 (p 45).

Classification across different categories of activity: In this paper, we improve upon the MDER estimate for India by incorporating information on occupations and activities from the NSSO's 68th Round Survey on Employment and Unemployment. The Government of India's Task Force on Projections of Minimum Needs and Effective Consumption Demand made a similar attempt at using data from the employment and unemployment surveys to assess the share of the population engaged in different levels of physical activity (Planning Commission 1979). More recently, Manna (2007) updated these data using the NSSO's 55th Round Survey on Employment and Unemployment for 1999–2000 to classify the population and estimate dietary energy requirements. Both the Planning Commission (1979) and Manna (2007) used the 1968 National Classification of Occupations (NCO) to identify occupations for the purpose of classification (see Manna 2007: Table 5).

In this paper, we improve upon the categorisation of activity levels by the Planning Commission (1979) and Manna (2007) in two important ways.

First, we use more recent data from the NSSO's 68th Round Survey on Employment and Unemployment, and the more detailed 2004 NCO, which is currently used in NSSO surveys to identify the occupations in the population (DGET 2004). Table 1 gives the list of NCO codes that have been assigned to different categories of physical activity levels.

A serious limitation of the classifications by the Planning Commission (1979) and Manna (2007) is their uniform categorisation of all non-workers under the "sedentary activity level." Recent NSSO surveys also provide information on the activities of women who are classified as non-workers and are reported

Table 1: Classification of Persons Engaged in Different Occupations across Categories of Physical Activity

Physical Activity Level (PAL) Category	NCO Codes
Sedentary	111–4, 121–3, 130, 211–3, 221–2,231, 241–2, 244–6, 312, 324, 341–4, 346, 348, 411–4, 419, 421–2, 515, 521–3
Moderate	214, 223, 232–3, 243, 311, 313–5, 321–3, 331–5, 347, 511–4, 516, 741, 743–4, 811–7, 821–9, 831–4
Heavy	611–5, 620, 711–4, 721–4, 731–4, 742, 911–6, 920, 93–3

Occupations as defined in the National Classification of Occupations, 2004.

to be primarily engaged in household work. Information on their participation in different household activities, like acquiring goods and providing services to other members of the household, can be used to classify them under different categories according to physical activity levels.

It is noteworthy that the definition of "economic activities" used in the Indian system of national accounts, and correspondingly, the classification of the population as workers and non-workers in employment statistics in India, is inconsistent with the UN System of National Accounts (SNA). In the Indian system of national accounts, household work is not considered an economic activity, and persons engaged in household work are classified as non-workers. As per the UN SNA, the activities through which households produce goods for their own use are considered economic activities. In contrast, the activities through which household members provide services for use within the household are not recognised as economic activities (United Nations Statistics Commission 1993, 2009).[15]

A substantial proportion of women engaged in household work do arduous, unpaid labour. Table 2, based on the NSSO's 68th Round Survey of Employment and Unemployment, shows that in 2011–12, 35% of women between 15 and 59 years of age were regularly engaged in acquiring food for their households; 32% were regularly engaged in collecting fuel and fodder; 30% regularly made fuel from animal waste; and 25% had to fetch water from outside the house because of the lack of water supply. Women engaged in household work were classified into categories according to physical activity levels, as specified in Table 3.

After classifying workers on the basis of their occupations and persons primarily engaged in housework on the basis of the nature of their activities, we still needed to categorise 55% of the population (Table 4). Of the remaining population, rural persons below the age of 60 years were classified as having a moderate physical activity level and the rest were classified as having a sedentary activity level.

Table 5 shows the proportion of men and women in rural and urban areas classified under different categories by physical activity levels.

Table 2: Proportion of Rural and Urban Women Aged 15–59 Years Principally Engaged in Housework Who Regularly Performed Activities of Economic Importance for Their Households (%)

S No	Activity	Rural	Urban	Total
1	Various activities to obtain, process, and preserve food	45	13	35
1.1	Maintenance of kitchen garden	24	8	19
1.2	Maintenance of household animal resources	22	2	16
1.3	Collection of food	19	2	14
1.4	Manually husking paddy	10	2	7
1.5	Manually grinding grain	9	3	7
1.6	Making gur	3	1	2
1.7	Preserving fish and meat	4	1	3
2	Obtaining fuel and fodder for household use	58	7	42
2.1	Collection of fuel and cattle feed	44	5	32
2.2	Drying animal dung to produce fuel	42	5	30
3	Fetching water from outside the household premises	31	10	25
4	Making or mending clothing	30	25	28
5	Making baskets and mats	5	2	4
6	Tutoring own children or other children for free	8	13	9

Table 3: Proposed Categorisation of the Physical Activity Levels of Women Regularly Engaged in Types of Household Work

Activity	Physical Activity Level
Various activities to obtain, process, and preserve food	Heavy
Free collection of fuel and cattle feed	Heavy
Drying animal dung to produce fuel	Heavy
Fetching water from outside the household premises	Heavy
Making baskets and mats	Heavy
Regular participation in other household work	Moderate

Table 4: Proportion of Sample Observations That Were Classified across PAL Categories on the Basis of Occupation Activities Done for the Household, and Size of the Residual Classified as Having Sedentary Activity Level (%)

Place of Residence	Sex	Classified on the Basis of Occupation	Classified on the Basis of Housework	Residual
Rural	Male	54	0	46
Rural	Female	24	20	56
Urban	Male	53	0	47
Urban	Female	15	9	76
Total	Female	20	16	64
Total	Persons	37	8	55

Table 5: Proportion of Rural and Urban Persons in India Classified under Categories of Physical Activity Level, by Sex (%)

PAL Category	Rural		Urban		Total	
	Male	Female	Male	Female	Male	Female
Sedentary	8	5	68	83	26	27
Moderate	48	54	14	5	38	40
Heavy	43	41	18	11	36	33
All	100	100	100	100	100	100

Source: NSSO 68th Round Employment and Unemployment Survey.

MDER for an average person: Equation 2 gives the formula used to obtain MDER. To estimate the MDER for an average person, the total energy requirements corresponding to different age, sex, and physical activity status categories are averaged using the population share of each category as a weight. As recommended by the FAO, using crude birth rate as a weight, we include an additional allowance of 210 kcal per day to account for the energy requirements of pregnant and lactating women.

$$\mathrm{MDER} = \sum_{i} w_i \times \mathrm{TEE}_i + 210 \times \mathrm{cbr} \quad \ldots (2)$$

where

cbr = birth rate

w_i = population share of *i*th group of age, sex, and activity level

TEE_i = age, sex, and activity status-specific energy requirement

Table 6 shows two estimates of MDER. Column II of the table shows MDER estimates based on the assumption that all persons aged 18 years and above have a sedentary physical activity level. For India as a whole, this gives an MDER of 1,853 kcal per day, which is very close to the FAO's current MDER for India—1,791 kcal per day. The third column of the table shows MDER estimates after accounting for different activity levels.

Table 6: Statewise Estimates of MDER

State	MDER (PAL = 1.55)	Physical Activity Status- Adjusted MDER
Jammu and Kashmir	1,905	2,112
Himachal Pradesh	1,879	2,125
Uttarakhand	1,858	2,017
Punjab	1,887	2,043
Haryana	1,891	2,074
Uttar Pradesh	1,809	1,987
Rajasthan	1,858	2,058
Gujarat	1,859	2,037
Madhya Pradesh	1,865	2,081
Chhattisgarh	1,845	2,095
Maharashtra	1,871	2,015
Karnataka	1,890	2,061
Kerala	1,866	2,018
Tamil Nadu	1,869	2,027
Andhra Pradesh	1,854	2,045
Odisha	1,851	2,084
Jharkhand	1,824	2,029
West Bengal	1,862	2,060
Bihar	1,822	2,030
Assam	1,873	2,124
India (all states and UTs)	1,853	2,037

Source: NSSO 68th Round Consumption and Employment Surveys.

As the table illustrates, this yields considerably higher values of MDER. For India as a whole, the proposed MDER is 2,037 kcal per day, which is 184 kcal higher than the estimate based on sedentary PAL and is 246 kcal higher than the current MDER used by the FAO for India.

Mean, Coefficient of Variation, and Skewness

Mean, variance, and skewness of per capita intake are the three key parameters used to obtain the distribution of the per capita calorie intake of an average individual. In this section, we describe in detail the methodology used to calculate these parameters and present our estimates.

Average per capita calorie intake: The FAO estimates average per capita calorie intake using data on food supply from aggregate food balance sheets. A significant advantage of this approach is that it allows an annual estimation for a large number of countries. On the other hand, a limitation of this approach is that it cannot be used to estimate the POU at the subnational level because of a lack of input–output tables at the subnational level (Naiken 2002).

In India, the input–output tables record a higher level of average per capita consumption than the average (or total) level of consumption estimated from the household surveys. This discrepancy can stem from either an overestimation in the input–output tables (for example, because of a failure to account for food losses and waste and a lack of sufficient data on some sectors) or an underestimation in the household surveys (for example, because of incomplete coverage, under-reporting by households, or other sampling and non-sampling errors). In 1993, an expert group headed by D T Lakdawala noted that the growing discrepancy between estimates of per capita private household consumption from the input–output tables of National Accounts Statistics (NAS) and the household consumption surveys could not be attributed solely to problems in household surveys; it recommended that the practice of using average per capita consumption estimates from the national accounts for the estimation of the poverty headcount ratio be discontinued (D T Lakdawala Committee 1993).[16] Consequently, India stopped the practice of using aggregate input–output tables to calculate the average per capita consumption to estimate poverty. More recently, the Adhikari Committee has argued that both the household consumption surveys as well as the rates and ratios used to prepare input–output tables need to be improved to close the gap between the NSSO and NAS estimates (CSO 2015).

Smith et al (2006) show that there is no systematic pattern in the discrepancy between the estimates of mean per capita calorie intake from food balance sheets and household consumption surveys across countries. In some countries, food balance sheets underestimate the mean calorie intake because of an underestimation of food availability; in other countries, household expenditure surveys have a lower estimate of per capita dietary intake than the estimate from food balance sheets.

Given this background and the unavailability of aggregate input–output tables at the state level, we have estimated the average per capita per day calorie intake using the NSSO 68th Round Consumption Survey itself (Table 7). As per these data, average calorie intake for India was 2,135 kcal per capita per day.[17] It is noteworthy that this is 183 kcal per capita per day lower than the average per capita calorie intake based on food balance sheets (2,453 kcal per capita per day for 2011–13) (FAO 2017). Of 2,135 kcal per capita, 2,053 kcal per capita were from food prepared at home, while 82 kcal per capita were from ready-to-eat meals obtained away from home. According to state-level data, the highest average calorie intake was in Himachal Pradesh (2,504 kcal per capita per day), while the lowest average calorie intake was in Tamil Nadu (1,973 kcal per capita per day).

Table 7: Average per Capita per Day Intake of Calories by State, 2011–12

State	Mean
Jammu and Kashmir	2,409
Himachal Pradesh	2,504
Uttarakhand	2,428
Punjab	2,304
Haryana	2,349
Uttar Pradesh	2,114
Rajasthan	2,256
Gujarat	2,015
Madhya Pradesh	2,128
Chhattisgarh	2,098
Maharashtra	2,144
Karnataka	2,066
Kerala	2,032
Tamil Nadu	1,973
Andhra Pradesh	2,246
Odisha	2,138
Jharkhand	2,061
West Bengal	2,103
Bihar	2,168
Assam	2,063
India (all states and UTs)	2,135

Source: NSSO 68th Round Consumption Survey.

Coefficient of variation: Variations in actual calorie intake may be due to factors that determine a household's access to food (for example, income, prices, and physical access to markets), as well as those that determine individual's requirement of calories.

Cafiero et al (2014) argue that variability in "habitual" food consumption is expected to be lower than the variability in survey data on food consumption. They list several reasons to explain this. First, consumption surveys often capture the seasonality of consumption by surveying different households at different points of time during the reference year. Seasonal variations in consumption thus shows up as inter-household variability in consumption. Second, surveys are often designed to capture food acquisition rather than food consumption. Third, the occasional spurt in consumption caused by festivals and celebrations may add to variability in consumption. Finally, additional variability could be the result of incomplete information from some households.

Therefore, Cafiero et al (2014) and Wanner et al (2014) suggest that instead of directly using variability from food acquisition data, variation in "habitual" food consumption should be computed by estimating separately the variation in calorie intake due to variations in income, and the variation in calorie intake based on variations in requirements (see equation 3).

$$CV = \sqrt{(CV|y)^2 + (CV|r)^2} \quad \text{... (3)}$$

where

$CV|y$ is the coefficient of variation in calorie intake on account of income.

$CV|r$ is the coefficient of variation in calorie intake on account of variations in calorie requirements.

$CV|y$ is estimated as the coefficient of variation of predicted values of per capita calorie intake from the regression model specified by equation 4.

$$PPC_i = \beta_0 + \beta_1 \times \log(y_i) + \beta_2 \times M_{1,i} + \beta_3 \times M_{2,i} \ldots \beta_{12} \times M_{11,i} + \mu \quad \ldots (4)$$

where

PPC_i is the per capita calorie intake for the ith household

y_i is the income of the ith household

$M_{1,i}$ are dummies for months (j) of survey

However, this approach has two limitations.

First, disregarding the impact of various other factors on access to food—for example, differences in consumer prices (which may vary across different consumers because of market imperfections) and physical access to markets and discrimination (for example, intra-household discrimination in food given to girls and boys)—introduces a negative bias in the *CV* of habitual consumption.

Second, this approach assumes that income and determinants of calorie requirement are orthogonal to each other. This assumption works in the theoretical framework discussed by Cafiero et al (2014) because the variance in BMI is independent of income, and in the absence of any data, only a normative distribution is assumed to account for variations in physical activity levels. However, the assumption breaks down if physical activity levels are related to levels of income. In such a case, the decomposition of the *CV* of habitual calorie intake would have to account for the covariance between income and physical activity levels. Given that this covariance between income and physical activity levels is expected to be negative, using PAL-adjusted calorie requirements without accounting for this covariance is likely to inflate the estimate of the coefficient of variation.

Table 8 shows empirical and model-based estimates of the coefficient of variation for India as a whole. We made both empirical and model-based estimates after the treatment of data. Table 9 presents the results of the regression model used for the estimation of $CV|y$. Since NSSO surveys do not collect data on income, we used the total monthly per capita expenditure of households as a proxy for income in this regression model. It is worth noting that both the empirical and model-based estimates of *CV* are very close, and they are higher than the FAO's current estimate for India (0.25). The model-based estimate is marginally higher than the empirical estimate. This is because of the high variance in calorie requirements. Table 10 presents empirical and model-based estimates of the coefficient of variation at the state level. It shows that in most states, the model-based estimate of *CV* is higher than the empirical estimate. It is clear that the use of PAL-adjusted calorie requirements, without accounting for the negative covariance between income and physical activity levels, inflates the estimate of the coefficient of variation of habitual calorie intake.

Table 8: Model-based and Empirical Estimates of the Coefficient of Variation of per Capita per Day Intake of Calories, India, 2011–12

	Coefficient of Variation
CV | y	0.1193
CV | r	0.2717
Model-based CV	0.2967
Empirical CV	0.2938

Source: NSSO 68th Round Consumption and Employment Surveys.

Table 9: Regression of per Capita Calorie Intake with Monthly per Capita Consumer Expenditure

	Dependent Variable: Per Capita Calorie Intake
log(mpce)	450.565 t = 299.721***
Constant	–3,182.511 t = –175.814***
Month dummies	Yes
Observations	459,860
R^2	0.165
Adjusted R^2	0.165
Residual std. error	27,945.350 (df = 459847)
F statistic	7,561.759*** (df = 12; 459847)

* p<0.1; ** p<0.05; *** p<0.01

Given these limitations of the model for the estimation of *CV*, and given that the empirical and model-based estimates are very close, we chose to use the empirical estimate of *CV* to estimate the POU.

Table 10: Empirical and Model-based Estimates of the Coefficient of Variation of per Capita per Day Intake of Calories by State, 2011–12

State	Empirical CV	Model-based CV
Jammu and Kashmir	0.2728	0.2882
Himachal Pradesh	0.2628	0.2736
Uttarakhand	0.2637	0.2687
Punjab	0.2864	0.3142
Haryana	0.3042	0.3245
Uttar Pradesh	0.2926	0.3175
Rajasthan	0.2911	0.3090
Gujarat	0.2872	0.3210
Madhya Pradesh	0.3006	0.3144
Chhattisgarh	0.2953	0.2996
Maharashtra	0.2922	0.2996
Karnataka	0.2984	0.3023
Kerala	0.3219	0.3022
Tamil Nadu	0.3059	0.3060
Andhra Pradesh	0.2738	0.2926
Odisha	0.2804	0.2843
Jharkhand	0.2972	0.3113
West Bengal	0.2851	0.2879
Bihar	0.2808	0.3142
Assam	0.2691	0.2860
India (all states and UTs)	0.2938	0.2967

Source: NSSO 68th Round Consumption and Employment Surveys.

Skewness: Table 11 presents the estimates for the skewness of the distribution of per capita calorie intake. As expected, the skewness is positive for all states. For India as a whole, skewness was estimated at 0.5282, which was only marginally lower than the FAO's current estimate for India (0.55). Of all the states, skewness in the distribution was estimated to be highest for Bihar (0.5282) and lowest for Himachal Pradesh (0.139).

Table 11: Skewness of per Capita Calorie Intake by State, 2011–12

State	Skewness
Jammu and Kashmir	0.3139
Himachal Pradesh	0.1390
Uttarakhand	0.3641
Punjab	0.3759
Haryana	0.5095
Uttar Pradesh	0.5260
Rajasthan	0.4552
Gujarat	0.5699
Madhya Pradesh	0.5873
Chhattisgarh	0.5564
Maharashtra	0.6031
Karnataka	0.5512
Kerala	0.5393
Tamil Nadu	0.5257
Andhra Pradesh	0.3998
Odisha	0.2753
Jharkhand	0.4942
West Bengal	0.4953
Bihar	0.6226
Assam	0.5240
India (all states and UTs)	0.5282

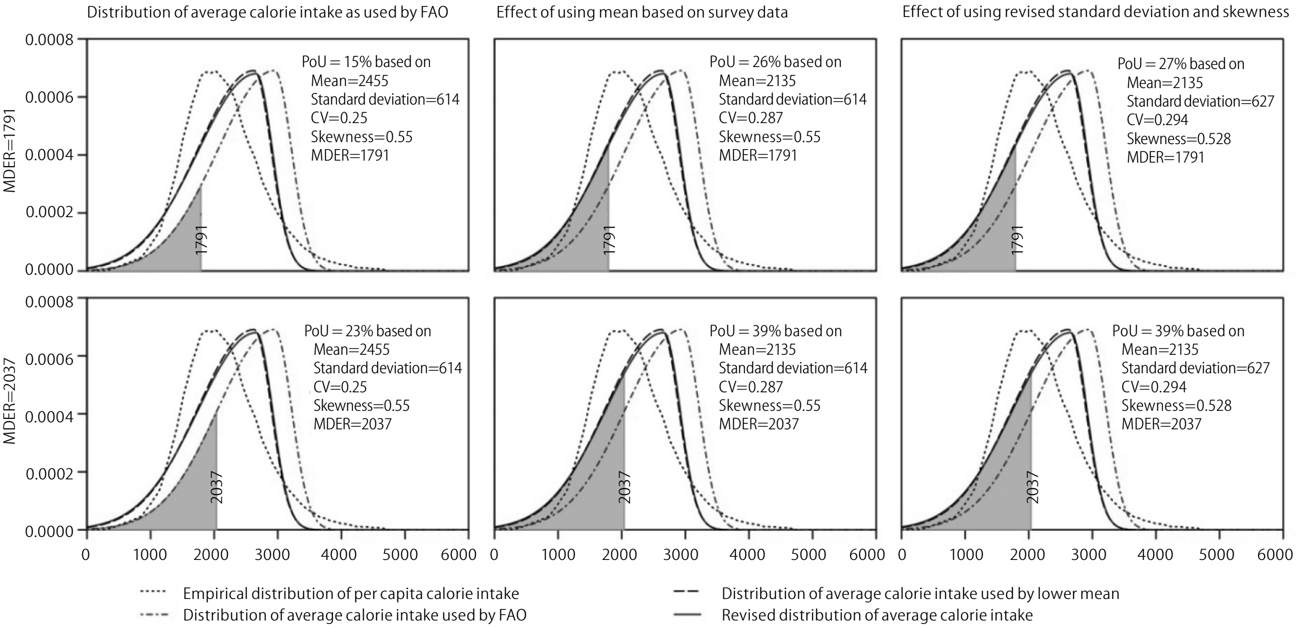
Source: NSSO 68th Round Consumption Survey.

Prevalence of Undernourishment

Based on the revised estimates of the distributional parameters and physical activity status-adjusted MDER, we estimate the POU in India to be at 39% (Figure 1, p 42). This estimate is much higher than the current POU estimate for India of 15%. As per our estimate, as many as 472 million people in India have a lower dietary intake than the minimum level compatible with good health.

Figure 1 shows the effect of revising the distribution of average calorie intake and MDER on the estimate of POU. The estimate of average calorie intake based on the NSSO data, 2,135 kcal per day, is 320 kcal less than the estimate used by FAO,

Figure 1: Change in the Estimate of PoU Because of Updates in the Mean, Other Distributional Parameters, and MDER



which is based on data from food balance sheets. The lower mean calorie intake, with no other change in parameter estimates, shifts the distribution to the left, and raises the PoU by about 11 percentage points. Our estimate of standard deviation is slightly higher, and our estimate of skewness is marginally lower than the FAO estimate. Introducing these changes only marginally affects the estimate of PoU. Accounting for variations in physical activity status shifts the MDER to the right, resulting in the most substantial increase in PoU estimates—in the range of 8–13 percentage points.

Table 12 shows the final figures for PoU and the estimated number of undernourished persons across different states in India. As per these estimates, about 472 million people in India are undernourished and unable to meet the MDER for good health. As per these estimates, Assam, Tamil Nadu, and Gujarat stand out, with the highest level of PoU. In all these states, more than 45% of the population is undernourished. In absolute numbers, Uttar Pradesh alone has 74 million undernourished people. Of the 21 states whose PoU we have estimated, Uttarakhand, at 24%, has the lowest.

It would be useful to examine the relationship between state-level estimates of PoU and state-level estimates of poverty and nutritional outcomes. This is a task in itself, and needs to be executed with some attention to detail. A quick scrutiny suggests that while there is a broad correspondence between state ranks in terms of PoU, poverty, and nutritional outcomes, there are also some significant divergences. For example, Kerala and Tamil Nadu, two states with relatively low rates of poverty (measured as a headcount ratio) and child stunting, have high PoU estimates. Gujarat, a state with low levels of poverty, has high PoU and child stunting. On the other hand, while the poverty headcount ratio and rate of child stunting in Uttar Pradesh are higher than the all-India level, its PoU turns out to be lower. There can be many reasons for these divergences. The determinants of undernourishment are somewhat different from those of poverty and various nutritional outcomes. There may also be state-specific limitations on data (for example, literature on Kerala points out that NSS surveys in the state under-record the consumption of fish and tapioca, food obtained as part of wages, and out-of-home consumption). A meticulous exploration can help throw light on the limitations of these estimations as well as state-specific gaps in the prevalence of hunger and malnutrition.

Table 12: PoU and Estimated Number of Undernourished People by State, India, 2011–12

State	PoU (%)	Number Undernourished (Millions)
Jammu and Kashmir	29	3.6
Himachal Pradesh	25	1.7
Uttarakhand	24	2.4
Punjab	31	8.6
Haryana	31	7.9
Uttar Pradesh	37	73.9
Rajasthan	34	23.3
Gujarat	46	27.8
Madhya Pradesh	42	30.5
Chhattisgarh	44	11.2
Maharashtra	38	42.7
Karnataka	44	26.9
Kerala	44	14.7
Tamil Nadu	47	33.9
Andhra Pradesh	33	27.9
Odisha	40	16.8
Jharkhand	42	13.9
West Bengal	41	37.4
Bihar	37	38.5
Assam	48	15.0
India (all states and UTs)	39	472.2

Source: NSSO 68th Round Consumption and Employment Surveys.

Concluding Observations

PoU has been used as a measure to track global progress towards the World Food Summit targets and the MDG Target 1C. Under the new 2030 Agenda for Sustainable Development, PoU is one of the core indicators for monitoring progress towards meeting Goal 2, which is to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture." This requires that countries regularly estimate the PoU at national and subnational levels.

The FAO publishes national and global estimates of PoU annually in the *State of the Food Insecurity in the World* reports. With the largest number of undernourished people in any country, estimates of PoU for India are crucial not only to correctly prioritise national food security policies, but also to assess progress towards the global ambition of ending hunger.

This paper makes some important improvements to the methodology of estimating PoU, and using the latest available data, shows that the problem of undernourishment in India is more severe than it is currently thought to be.

We introduce two specific improvements in the computation of distributional parameters using data from the consumption survey. First, we take into account the age and sex of household members to apportion household-level calorie intake between members of the household. In other words, rather than assuming that all members of a household consume calories equally irrespective of their age and sex, we assume that all members equally under-consume or over-consume relative to their requirement. Second, we use information on the number of meals consumed by each member outside the home to account for calorie intake through food consumed away from home. Our method assumes that the calorie content of a meal eaten outside is equal to that of a meal consumed at home. This is an improvement on the current global practice of estimating the calories of food consumed away from home by assuming that the cost of calories of food prepared at home is the same as that of food obtained outside the home.

For India as a whole, our estimate of average per capita calorie intake is lower (2,135 kcal per day) than the estimates for India used in the *State of Food Insecurity in the World 2015* report (2,455 kcal per day) (FAO 2015). While FAO uses food balance sheets to estimate average per capita calorie intake, our estimate comes from household survey data. Our estimate of the coefficient of variation (0.294) of the distribution of average per capita calorie intake, based on the latest NSSO survey, is marginally higher than the FAO estimate of 0.25 (2015). Our estimate of skewness (0.528) of the distribution of average per capita calorie intake—0.528—is almost equal to that of the FAO—0.55 (2015). The paper also presents separate estimates of these parameters for Indian states.

Applying the MDER threshold used in the SOFI 2015 Report (1,791 kcal per day) to the revised distribution of average per capita calorie intake gives us a PoU 12 percentage points higher than that of the SOFI 2015 Report.

The FAO's MDER threshold takes into account the age and sex of the population. Given the difficulties in obtaining comparable data from most countries, however, a limitation of global PoU estimates is the failure of the FAO estimation of MDER to account for employment-related variations in activity levels. In their absence, the global estimates use an MDER threshold based on the requirements associated with the lowest category of physical activity level for adult men and women of different ages.

The NSSO Surveys on Employment and Unemployment in India provide detailed statistics on the population's participation in different economic and non-economic activities. This paper updates the classification of the Planning Commission (1979) and Manna (2007) using the 2004 National Classification of Occupations and the 68th Round Survey of Employment and Unemployment. We also used information on the economic and non-economic activities of women engaged in household work to classify them across different categories of physical activity level.

The paper derived estimates of age- and sex-specific median heights for India and Indian states using data from the NFHS-III and a survey conducted by the NNMB. We then used these to estimate age, sex, and physical activity level-specific MDER using the methodology recommended by the FAO. The MDER is then calculated as an average of these minimum dietary energy requirements, using population weights of age, sex, and physical activity categories estimated using the NSSO Employment and Unemployment Survey. We found the physical activity status-adjusted MDER for India as a whole to be 2,037 kcal per day. The use of this estimate of the MDER results in an increase of about 12 percentage points in the PoU.

Our estimates show that about 39% of the Indian population—a staggering 472 million people—are undernourished and unable to meet MDER. These estimates suggest that the problem of undernourishment in India is rather serious. With the global ambition set to end hunger on the face of the earth, this calls for a much higher level of public action and expenditure.

NOTES

1 There is a large body of literature, spanning from over six decades, that discusses the measurement of undernourishment. It is beyond the scope of this paper to present an exhaustive review of this debate. However, FAO (2002) and Osmani (1992) provide an overview of this debate.

2 There have been several revisions to the method of measuring poverty in India over the last four decades. Although the poverty line is no longer based solely on the measurement of the consumption expenditure required to meet a normative dietary energy intake, food consumption remains the most important element in determining the poverty line.

3 NSSO surveys in relatively small states (in particular, the North Eastern states other than Assam) and many union territories have been fraught with problems of small sample sizes and poor administering (Sarma and Mehta 2011). Given that these states and union territories together account for only 3% of the Indian population, we do not present separate results for them. Estimates for India as a whole, however, account for all states and union territories.

4 The Type-I schedule uses a reference period of 365 days for infrequently purchased items and a reference period of the past 30 days for all food items, fuel, and other miscellaneous goods and services.

5 Svedberg's criticism of the FAO methodology (1999/2000/2002) is based on the questionable premise that PoU measures dietary inadequacy at the level of households. Although consumption surveys typically collect data on food consumption for households as a whole, the model used for the estimation of PoU uses distributions of dietary intake and requirement for an average individual in the population.

6 Such meals are mostly obtained and eaten outside of the home. Regardless of where they are eaten, all meals acquired outside are treated uniformly.

7 The price difference between purchased and home-cooked food may also vary—households from different socio-economic strata are likely to eat in a variety of establishments, with vast disparities in meal price.

8 School meals are the most important meals that children consume away from home. In India, the norms of the Midday Meal Scheme mandate the provision of meals containing 450 kcal to children in primary schools (up to Grade 5), and 700 kcal to children in upper-primary schools (up to Grade 8).

9 The instruction manual of the 68th round survey explains that "meals taken outside" refers to meals that are served outside the home, irrespective of where the meal is actually consumed. The survey asked two sets of questions about such meals. First, it collected basic information on each member of the household separately. There were questions about the number of free cooked meals received, meals purchased, and meals consumed at home over the last 30 days. In this block, no information was collected on snacks consumed away from home. Additionally, for information on the food consumption of the household as a whole, respondents were asked about the total number of cooked meals that

they had purchased, number of cooked meals received for free at the workplace, and number of cooked meals received as assistance. We collected this information with reference to the last seven days in the Type-II schedule used in this paper. For cooked snacks, the survey collected information only on the total expenditure by members of the household over the last seven days. The question on the number of meals served to partakers was part of the block of introductory information to the household, and referred to the last 30 days.

10 Information on the number of meals eaten was unavailable for 1.15% of the sample. Of those for whom information was provided, 47% consumed a total of two meals per day. For the 1.15% for whom information was missing, we assumed the consumption of two meals at home per day and no ready-to-eat meals obtained outside the home. It may also be noted that the data on the number of meals consumed away from home at the level of individual householders were not always consistent with the information on the household as a whole. In 38% of households, the total number of away-from-home-meals reported for the household as a whole was greater than the sum of away-from-home-meals recorded against each householder. We made a pro rata increase in the number of outside meals consumed by each member to account for this gap. For a few households (0.3% of the sample), information was available on outside meals consumed for the household, but not for its individual members. In such cases, outside meals were apportioned across members in the same ratio as their consumption of standard home-cooked meals.

11 We used energy requirements of adults with sedentary physical activity levels to compute these rations.

12 Wanner et al (2014) recommend removing observations whose exclusion makes the skewness swing beyond (Q1–5×IQR, Q3+5×IQR). In the data from the 68th Round Survey of the NSSO, the IQR of skewness from jackknife samples was very small (0.00000198). In view of this, we used (Q1–10×IQR, Q3+10×IQR) as limits of jackknife skewness to drop outliers—3.2% persons—from the sample. We also dropped an additional 0.95% persons from the sample who, after apportioning, we found had been allocated more than thrice the requirement.

13 This is notably different from the Indian Council of Medical Research's practice of using 95th centile heights to estimate energy requirements. For adult men and women, the difference in median height and 95th centile height is about 10 centimetres. This is an important source of difference between the average MDER used to calculate the PoU and the ICMR recommendation of dietary energy intake (National Nutrition Monitoring Bureau 2009).

14 We used state-level estimates from the NNMB survey for the nine states that it covered. For the other states, we used estimates of pooled data from the NNMB survey for interpolation and extrapolation. For union territories, which were not covered by either survey, we used estimates from neighbouring states.

15 See Rawal and Saha (2015) for a detailed discussion.

16 Interestingly, both V M Dandekar and P V Sukhatme were members of this committee. Dandekar (along with Nilakanth Rath and P D Ojha) produced the seminal work that laid the foundation of the calorie-intake-based measurement of poverty in India. Sukhatme, a staunch critic of the Dandekar–Rath methodology, consistently argued that the measurement of inadequacy of calorie intake must account for variations in calorie requirements.

17 Of this, about 81 kcal per day, or 3.8% of average calorie intake, came from meals obtained outside the home.

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Appendix Table A1: Estimates of Median Heights (Centimetres) of Persons of Different Ages (Male and Female), India, 2005–06

Age	Male	Female	Age	Male	Female	Age	Male	Female
0	70	68	20	165	152	40	164	152
1	84	82	21	165	152	41	164	152
2	90	89	22	165	152	42	164	152
3	97	96	23	165	152	43	164	152
4	99	98	24	164	152	44	164	152
5	112	112	25	165	152	45	164	151
6	117	117	26	165	152	46	164	151
7	123	124	27	165	152	47	164	152
8	129	130	28	165	152	48	164	151
9	134	135	29	164	152	49	164	151
10	138	139	30	165	152	50	164	151
11	142	143	31	165	152	51	164	151
12	146	148	32	165	152	52	163	151
13	159	151	33	164	152	53	164	151
14	161	152	34	164	152	54	164	151
15	163	152	35	165	152	55–64	163	148
16	164	152	36	165	152	65–74	162	146
17	165	152	37	164	152	>=75	161	142
18	166	152	38	165	152			
19	165	152	39	164	152			

Estimation of Age-Specific Dietary Energy Requirements for Men and Women

Equations used for estimating dietary energy requirements used by the FAO to estimate dietary energy requirements were compiled by Filippo Gheri and Carlo Cafiero:

For children younger than one year of age (for countries with high child undernutrition and infection)

$$\text{TEE} = (-99.4 + 88.6 \times \text{Kg}) + 2 \times \text{Gain} \times \text{ERwg} \quad \text{... (B1)}$$

For children aged between one and 1.9 years (for countries with high child undernutrition and infection)

$$\text{TEE} = \begin{cases} 0.93(310.2 + 63.3 \times \text{Kg} - 0.263 \times \text{Kg}^2 + 2 \times \text{Gain} \times \text{ERwg (if Male)} \\ 0.93(263.4 + 65.3 \times \text{Kg} - 0.454 \times \text{Kg}^2) + 2 \times \text{Gain} \times \text{ERwg (if Female)} \end{cases} \quad \text{... (B2)}$$

For children aged between two and 9.9 years

$$\text{TEE} = \begin{cases} (310.2 + 63.3 \times \text{Kg} - 0.263 \times \text{Kg}^2) + \text{Gain} \times \text{ERwg (if Male)} \\ (263.4 + 65.3 \times \text{Kg} - 0.454 \times \text{Kg}^2) + \text{Gain} \times \text{ERwg (if Female)} \end{cases} \quad \text{... (B3)}$$

For persons aged between 10 and 17.9 years (PAL taken as 0.85)

$$\text{TEE} = \begin{cases} 0.85(310.2 + 63.3 \times \text{Kg} - 0.263 \times \text{Kg}^2) + \text{Gain} \times \text{ERwg (if Male)} \\ 0.85(263.4 + 65.3 \times \text{Kg} - 0.454 \times \text{Kg}^2) + \text{Gain} \times \text{ERwg (if Female)} \end{cases} \quad \text{... (B4)}$$

For persons aged between 18 and 29.9 years

$$\text{TEE} = \begin{cases} \text{PAL} \times (692.2 + 15.057 \times \text{Kg}) \text{ (if Male)} \\ \text{PAL} \times (692.2 + 15.057 \times \text{Kg}) \text{ (if Female)} \end{cases} \quad \text{... (B5)}$$

For persons aged between 30 and 59.9 years

$$\text{TEE} = \begin{cases} \text{PAL} \times (873.1 + 11.472 \times \text{Kg}) \text{ (if Male)} \\ \text{PAL} \times (845.6 + 8.126 \times \text{Kg}) \text{ (if Female)} \end{cases} \quad \text{... (B6)}$$

For persons aged 60 years and above

$$\text{TEE} = \begin{cases} \text{PAL} \times (587.7 + 11.711 \times \text{Kg}) \text{ (if Male)} \\ \text{PAL} \times (658.5 + 9.082 \times \text{Kg}) \text{(if Female)} \end{cases} \quad \text{... (B7)}$$

where

TEE = Total energy expenditure (kcal)
PAL = Physical activity level
Kg = Weight in kilograms *(BMI × Height²)*
Gain = Weight gain for age (grams/day)
ERwg = Energy required per gram of weight gain (kcal)

Table A2: Minimum Requirement of Calories for Children Aged Less than 18 Years (Kcal per Day)

Age (Years)	Boys Weight	Boys Calorie	Girls Weight	Girls Calorie
0	9	795	8	736
1	11	963	11	883
2	13	1,111	12	1,024
3	15	1,205	14	1,120
4	15	1,235	15	1,151
5	19	1,456	19	1,390
6	21	1,578	21	1,480
7	24	1,714	24	1,609
8	26	1,844	27	1,748
9	29	1,982	30	1,870
10	27	1,621	27	1,512
11	29	1,714	30	1,596
12	32	1,838	33	1,716
13	40	2,119	36	1,790
14	42	2,223	37	1,834
15	45	2,309	38	1,861
16	47	2,386	39	1,878
17	48	2,438	39	1,889

Table A3: Minimum Requirement of Calories for Persons Aged 18 Years and Above (Kcal per Day)

Age (Years)	Men Weight	Men Calorie Requirement Sedentary	Moderate	Heavy	Women Weight	Women Calorie Requirement Sedentary	Moderate	Heavy
18	50	2,234	2,666	3,171	40	1,666	1,989	2,365
19	50	2,233	2,666	3,170	40	1,668	1,991	2,367
20	51	2,264	2,703	3,214	40	1,679	2,004	2,383
21	51	2,260	2,697	3,208	40	1,680	2,005	2,385
22	51	2,259	2,696	3,206	40	1,678	2,002	2,381
23	51	2,259	2,696	3,206	40	1,675	2,000	2,378
24	50	2,251	2,687	3,195	40	1,677	2,001	2,380
25	51	2,259	2,696	3,206	40	1,677	2,001	2,380
26	51	2,261	2,699	3,210	40	1,679	2,004	2,383
27	51	2,254	2,691	3,200	40	1,674	1,998	2,376
28	51	2,259	2,696	3,206	40	1,674	1,998	2,376
29	50	2,250	2,685	3,193	40	1,678	2,002	2,381
30	51	2,258	2,695	3,205	40	1,816	2,168	2,578
31	51	2,253	2,689	3,198	40	1,817	2,169	2,579
32	51	2,258	2,695	3,205	40	1,817	2,169	2,579
33	50	2,251	2,687	3,195	40	1,815	2,166	2,576
34	50	2,247	2,682	3,189	40	1,814	2,165	2,574
35	51	2,252	2,688	3,197	40	1,816	2,168	2,578
36	51	2,257	2,693	3,203	40	1,816	2,168	2,578
37	50	2,251	2,687	3,195	40	1,814	2,166	2,575
38	51	2,252	2,688	3,197	40	1,814	2,165	2,574

Age (Years)	Men Weight	Men Calorie Requirement Sedentary	Moderate	Heavy	Women Weight	Women Calorie Requirement Sedentary	Moderate	Heavy
39	50	2,246	2,680	3,187	40	1,814	2,165	2,574
40	50	2,249	2,684	3,192	40	1,815	2,166	2,576
41	50	2,249	2,684	3,192	40	1,815	2,166	2,576
42	50	2,246	2,680	3,187	40	1,816	2,168	2,578
43	50	2,251	2,687	3,195	40	1,813	2,164	2,573
44	50	2,240	2,674	3,180	40	1,814	2,165	2,574
45	50	2,242	2,676	3,183	40	1,810	2,161	2,570
46	50	2,251	2,687	3,195	40	1,811	2,162	2,571
47	50	2,245	2,679	3,186	40	1,814	2,165	2,574
48	50	2,242	2,676	3,183	40	1,812	2,162	2,572
49	50	2,240	2,674	3,180	40	1,812	2,162	2,572
50	50	2,246	2,680	3,187	40	1,812	2,162	2,572
51	50	2,248	2,683	3,191	40	1,812	2,162	2,572
52	50	2,237	2,670	3,175	40	1,812	2,162	2,572
53	50	2,246	2,680	3,187	40	1,812	2,162	2,572
54	50	2,246	2,680	3,187	40	1,812	2,162	2,572
55–60	50	2,235	2,667	3,172	38	1,791	2,138	2,542
60–65	50	1,811	2,161	2,570	38	1,558	1,859	2,211
65–74	49	1,797	2,145	2,551	37	1,544	1,843	2,192
>=75	48	1,786	2,132	2,535	35	1,513	1,805	2,147