Evans School of Public Affairs
UNIVERSITY OF WASHINGTON

Re-evaluating the Hunger Numbers

by Professor Marieka Klawitter and Joelle Cook
with assistance from Jessica Cagley and Georgine Yorgey

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The FAO currently offers the most widely used county-level estimates of the prevalence of hunger. Because collecting new survey data is expensive and not always viable, the FAO uses a methodology based on existing data to calculate the number of undernourished persons in each country. The methodology has several key assumptions, the first being that the probability density function of dietary energy consumption within a given country is lognormally distributed, with the parameters of μ_x and σ^2_x where:

- μ_x is the mean caloric intake per person, and is estimated by $\bar{x}$. The FAO calculates $\bar{x}$ by using the three-year mean of the per-person dietary energy supply (DES) which is derived from the Food Balance Sheet (FBS) available for each country. The FBS is an aggregation of food available in country, (production and imports minus exports and waste) which is then converted to energy values and divided by total population and by 365 days. The resulting DES is expressed by kcal/person/day.

  A second way to estimate the mean (one that is not used by FAO in its current estimates) is to use data from Household Budget Surveys (HBSs) which gather household-level consumption data, and calculate calories consumed based on survey responses regarding food consumption. This method would allow for more specific sub-regional levels of analysis but unfortunately, these surveys only take place every five to ten years; thus data are not readily available.

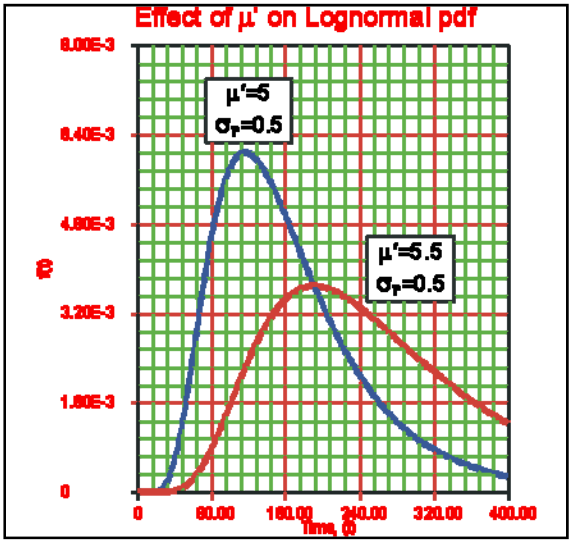
- σ^2_x is the variance of per-person caloric intake, estimated by the coefficient of variation CV(x) of household daily per person dietary energy consumption (σ_x / μ_x). CV(x) is formulated by: $CV(x) = \sqrt{CV^2(x \mid v) + CV^2(x \mid r)}$

  where $\mathrm{CV(x|v)}$ is variation of caloric intake due to household per person income and $\mathrm{CV(x|r)}$ is variation due to energy requirement. $\mathrm{CV(x|r)}$ is considered to be fixed at 0.20 and $\mathrm{CV(x|v)}$is estimated based on household survey data which is stratified by household income or expenditure class.

Once the dietary energy consumption distribution is calculated, a minimum dietary energy requirement or caloric cutoff point (CCOP) is estimated and persons below this point are deemed undernourished. The FAO derives the cutoff point by aggregating the sex-age energy requirements (as defined by WHO's weight-for-height Body Mass Index reference tables) weighted by the proportion of each sex and age group in the total population, and also considering pregnancy rates within countries.

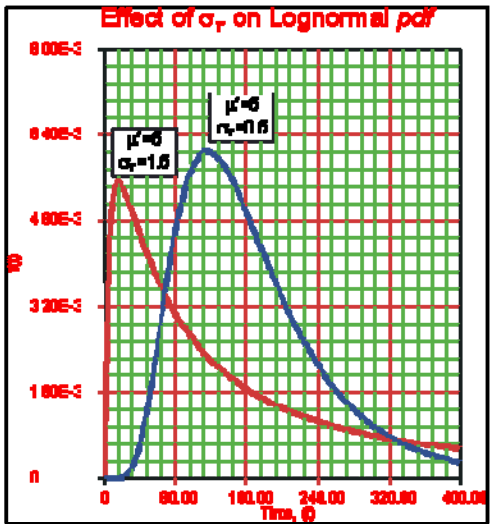
Using the above parameters yields an estimate of the proportion of undernourished in a given country, from which the number of undernourished can be calculated. The lognormal distribution is sensitive to changes in the estimate of the mean of the distribution (from updated data from FBSs) and changes in the CV(x). Because the CV(x) is calculated based on income stratifications, the FAO methodology is also sensitive to changes in income reflected in national surveys. Changes to either parameter estimate will change the estimated proportion of persons under the cutoff point.

Figure 1



Source: www.weibull.com

Figure 2



A lognormal distribution is similar to a normal distribution, but has two key differences: 1) the lognormal curve always begins at zero, and 2) the lognormal distribution is skewed to the right. The distribution becomes more skewed with an increase in either μ_x or σ^2_x, while holding the other constant.

Figure 1 shows that increasing the mean shifts the peak to the right and flattens out the distribution. In Figure 2, an increase in the variance from 0.5 to 1.5 shifts the peak towards zero while pulling the tail further out. We can imagine a hypothetical fixed cutoff point in each of the figures, and see the differences in the area under the two curves below the hypothetical cutoff point, which shows how changes in parameters affect estimates of the prevalence of hunger.

This means that for a given cutoff point, an increase in μ_x would decrease the proportion of the distribution below the cutoff point, and thus lead us to conclude that the prevalence of hunger in a given country has decreased. Similarly, a decrease in σ^2_x as estimated by the CV(x), would lead to a decrease in the proportion of the distribution under the cutoff point, because the curve peaks further from zero.

Critiques of FAO Methodology

Lognormal distribution

We found no authors who questioned the assumption of a lognormal distribution of per person dietary energy consumption, nor did we find any authors who made a rigorous argument defending this foundational assumption, although Aduayom and Smith (2002) reported that household expenditure survey data from three countries supported the assumption of lognormal distribution. More generally, Svedberg (1999) notes that the use of probability functions to estimate numbers of undernourished is highly sensitive to slight alterations in already uncertain parameters. He thus questions the prevalence of undernutrition reported by the FAO.

Caloric Availability

In its current estimates, the FAO relies exclusively on Dietary Energy Supply (DES) estimates calculated from Food Balance Sheets (FBS) from individual countries to estimate the mean of the distribution of caloric intake. A criticism of this approach is that FBSs measure availability of food at a macro-level, but do not reflect actual availability or distribution at the household level. Smith (1998) advocates switching to estimates based on household survey data, instead of the FBSs claiming that the survey data is much more readily available than in the past, and more accurately reflects the availability of food at the micro-level.

Svedberg posits that food availability is actually underestimated throughout the world, due in large part to subsistence farming outputs that do not get reported in official statistics worldwide. This underestimation of food availability leads to a systematic overestimation of the prevalence of undernutrition. He does, however, note that there are no data available to help test his assumption, and no reliable method for checking the consistency of the alleged biases.

Calorie Cutoff Point Estimation

Gabbert and Weikard (2001) argue that the FAO estimates incorrectly classify people as either undernourished or not. This classification problem is due in part to the fact that the FAO uses a standardized method to calculate the cutoff point, and this method incorrectly assumes that dietary energy requirements are the same for all people within a sex and age class. The authors therefore re-estimate the calorie cutoff point by correcting for the fact that dietary energy requirements vary between people. Their results suggest that the FAO's estimates are biased, although the direction of the bias varies by country.

Svedberg questions the supposition that the basal metabolic rate[1] (BMR) per kilogram of body weight is 1) constant across countries, and 2) is of equal size for people of a given age and sex in all populations. Although part one is ambiguous and cannot be disproved, Svedberg cites studies from the 1990s that show lower BMRs for those living in the tropics compared to those living in "northern" countries. Because the FAO uses BMRs from northern populations as reference points in their estimates, it is likely that the cutoff points as they are currently estimated are too high. Similarly, physical activity levels are applied uniformly across all countries, and do not take into account variation in job activities and work productivity across countries.

Coefficient of Variation Estimate

Gabbot and Wiekard note that because household survey data are not available for many countries, the CV(x) values are extrapolated in many cases. The authors also find it problematic that the FAO does not make available the raw data used in their calculations of CV(x) of per capita caloric intake, and only report that values are typically between 0.2 and 0.35. It is, however, impossible to further investigate their numbers without access to the raw data.

Recalling that $CV(x) = \sqrt{CV^2(x \mid v) + CV^2(x \mid r)}$ Svedberg (2002) claims that the FAO overestimates the interhousehold variability in per capita calorie availability ($\mathrm{CV(x|v)}$), and underestimates the variability in per capita calorie requirement ($\mathrm{CV(x|r)}$), leading to incorrect values for CV(x). .

Also, using stratified income categories to estimate the coefficient of variation for the entire population could underestimate variation by ignoring additional factors such as geographic distribution of food or differences by social or cultural groups such as castes.

A Summary of Other Critiques

Gabbert and Weikard point out that the FAO methodology consistently miscounts by including some groups who are not undernourished (e.g., those with low caloric needs), while excluding some who are actually undernourished (e.g., those with very high caloric needs). The FAO assumes that these two types of misclassification errors net to zero, meaning that the number of false positives and the number of false negatives cancel each other out, and the resulting estimate is unbiased.

Gabbert and Weikard, however, point out that the cancelling-out of the classification errors depends on the location of the cutoff point. They further point out that under the assumption of a lognormal distribution, it is unlikely that the errors will net to zero, thus leaving us with biased estimates of the prevalence of hunger. To show this, they re-estimate the prevalence of hunger in 86 countries using their corrected methodology, and find that the FAOs estimates are underestimated in 59 of the countries, and overestimated in the remaining 27 countries.

[1] The basal metabolic rate is the amount of energy expended while at rest in a neutrally temperate environment.

Svedberg (2002) contends that there are fundamental flaws in the FAO's parameter estimates. He maintains that the FAO has consistently ignored evidence that per household calorie requirements vary depending on the makeup of the household. Additionally, the methodology yields implausibly low caloric intake values in the lower portion of the distribution, and it is unlikely that individuals could survive on such low caloric intake. After re-estimating values for the 3 parameters he questions (minimum per capita caloric requirement, interhoushold variability in per capita calorie availability, and the variability in per capita calorie requirement), Svedberg concludes that the FAO has actually overestimated the prevalence of hunger worldwide.

All authors point out that the FAO's methodology is based heavily on parameters estimated from imperfect data. Of course, the question on the table is whether better estimates could be had using different methodologies, or relying on data that either are or could be available in a cost-effective manner.

Recommendations for Future Research

There are many opportunities to expand the current literature, as much of the literature we found was published before the early 2000s. The key questions appear to be whether the FAO methodology creates valid and reliable estimates of the number of undernourished people over time and across counties. Helpful further research includes new estimates of parameters of the caloric intake distribution, new information on the shape of the intake distribution, and information on the distribution of caloric needs within and across counties. More specifically:

1. It would be useful to have a more systematic comparison of FAO hunger estimates to anthropometric research results available at the country level, in order to answer questions about the validity of the methodology.

2. A more in-depth look at the correlation between household level data and DES estimates derived from the Food Balance Sheets could be undertaken to see if they do, if fact, correlate. As Smith mentions, household level data is available to estimate parameters, as well as to estimate levels of undernourishment within their sample.

3. More in-depth research into alternative methods of calculating the prevalence of hunger could be valuable. Svedberg contends that the current FAO model is inherently biased and the development community should move towards the joint-distribution model laid out in his 2002 paper. This would require the collection of more complete and reliable data on the key parameters in the joint-distribution model.

4. Additional research testing the assumption of the log-normal distribution could shed light on the validity and importance of that assumption to the estimates of hunger.

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