Integrating food poverty and minimum cost diet methods into a single framework: A case study using a Nepalese household expenditure survey

Perrine Geniez, Astrid Mathiassen, Saskia de Pee, Nils Grede, and Donald Rose

Abstract

**Background.** Current tools assessing affordability of nutritious diets are incomplete. “Food poverty” uses expenditure data to identify households unable to acquire a diet adequate in energy but does not consider other nutrients. The “minimum cost of a nutritious diet” method provides a threshold for purchasing a nutritious diet but must rely on other data to identify “nutrient-poor” households.

**Objective.** Integrating both methods into a single framework using a common data source, we sought to jointly estimate the proportions of a population that are food and nutrient poor.

**Methods.** Household expenditure data from the 2010/11 Nepal Living Standards Survey were used, focusing on representative samples of households from the mountain region ($n = 401$) and Kathmandu ($n = 857$). Food poverty thresholds were set at the cost for a low-income household to purchase a basket of foods providing adequate energy following the Cost of Basic Need method. Linear optimization was used to calculate a “nutrient poverty” threshold. Household expenditures were used to determine food and nutrient poverty rates.

**Results.** The food and nutrient poverty thresholds were $13,294$ and $18,628$ rupees/person/year, respectively, in the mountain region and $14,610$ and $22,945$ rupees/person/year, respectively, in Kathmandu. In the mountain region, $34\%$ of households were both food and nutrient poor and $24\%$ were just nutrient poor. In Kathmandu, the percentages were $7\%$ and $14\%$, respectively.

**Conclusions.** This approach, integrating two commonly used tools, provides a more nuanced interpretation of economic access to a nutritious diet and an opportunity to improve the design and targeting of nutrition and food security interventions.

**Key words:** Food poverty, household expenditure surveys, linear optimization, minimum cost of nutritious diet, Nepal, nutrient poverty

Introduction

Household expenditure surveys, such as those used in the World Bank’s Living Standard Measurement Study (LSMS), provide comprehensive information on socioeconomic conditions, food security, and poverty status. Analyses generated from them inform poverty reduction strategies and food security policies, leading to food assistance and other social protection programs [1–5]. Poverty measurements help analysts understand the extent to which households can afford enough food to satisfy their needs. Food poverty lines derived from these surveys are based on the average cost of a basket of food items consumed by low-income households, with quantities scaled to assure that energy requirements are met. However, because this benchmark is constructed to meet energy needs, it does not adequately reflect a household’s ability to meet its nutrient requirements beyond energy.

The Minimum Cost of a Nutritious Diet (CoD) is a method designed and used by Save the Children that can inform on the role of economic constraints as one of the key underlying causes of malnutrition. It is based on linear programming, a mathematical approach with a long history of application to human nutrition [6]. Recent uses by the World Food Programme provided insights on the household affordability of local diets. In Indonesia, it demonstrated how household affordability can improve based on different food-based strategies [7], while it illustrated the benefits of fortification...
for improving household access to a nutritious diet in Mozambique [8]. The CoD method calculates the minimum cost of a diet that would meet the nutrient requirements for a defined household, applying a linear optimization approach with food price data from a survey of local markets [9, 10]. The CoD results can be combined with data on household income or expenditures to estimate the percentage of households in nutrient poverty (i.e., unable to afford their nutrient requirements.) Unlike a food poverty line, which is constructed based on just energy needs, the CoD benchmark reflects a nutritious diet, based on more than a dozen nutrients. However, the approach does not include household data collection, so its value is limited by the availability of existing data on household income or expenditures. Moreover, the benchmark generated by the method is based on a market survey at one point in time and is therefore sensitive to seasonal variation in food prices.

Access to an appropriate diet that meets all nutrient needs is an important component of achieving food and nutrition security [11]. Information on a household’s economic access to such a diet could improve the understanding of the risk profile for developing undernutrition and is essential to supporting enhanced policy discussions of the Scaling Up Nutrition (SUN) Movement [12] and the post-2015 Sustainable Millennium Development Goals, which will succeed the Millennium Development Goals [13]. However, the tools described above are incomplete and as traditionally used alone, cannot estimate the prevalence of households not accessing their nutrient needs.

This paper describes an integrated approach in which the analysis of food poverty and nutrient poverty is conducted jointly using a single data source. The paper uses data from the 2010/11 Nepal Living Standards Survey, a type of household expenditure survey regularly available in many countries. The analysis provides estimates of the proportion of households unable to access their minimum energy and/or nutrient requirements, using benchmarks adjusted to account for seasonal variation in food prices. Such an analysis can provide more nuanced insights on the design and targeting of food and nutrition interventions than the use of either approach by itself.

Methods

The Nepal Living Standards Survey (NLSS-III) was conducted over a 12-month period from April 2010 to March 2011 by the Nepalese Central Bureau of Statistics [14]. The cross-sectional sample of NLSS-III is representative down to the area level. The analysis conducted here focuses on two areas that illustrate a range of socioeconomic contexts: the rural mountain region \((n = 401)\) and urban Kathmandu \((n = 857)\).

Central to our study on food and nutrient poverty is a comprehensive module on food consumption and expenditure, based on a 7-day recall of the household respondent. The quantities of 60 food items acquired and consumed were reported in local units, along with the monetary value of each. This applied to all foods consumed, whether they were acquired through own production, purchase, gifts, or food assistance. Quantities were converted to kilograms, and prices were calculated in Nepalese rupees per kilogram. (At the time of the survey, 1,000 Nepalese rupees were equivalent to 11.72 US dollars.) These prices were adjusted for seasonality, since interviews were conducted throughout the year. The median values of prices for each of the 60 items were used to represent area-specific food prices. Additional details regarding survey methods have been published previously [14, 15].

Food poverty line

Households that cannot afford a typical diet that is adequate in energy are in food poverty. The food poverty line used in this paper was based on the Cost of the Basic Needs (CBN) approach [16], as calculated by the Nepalese Central Bureau of Statistics [17]. This involves three main steps: estimation of a typical low-income food consumption pattern, adjusting the quantities in this pattern so that energy needs are met, and costing this out with specific area prices.

Step one began with estimating the average per capita quantity of each food item consumed by households in the second to the fifth decile of the income distribution. Low-income households were used in the calculation of this food basket since the basket should represent a basic diet among the poor [17]. The poorest, or the first decile of the income distribution, were excluded from the calculations of the poverty line, as their consumption patterns may represent extreme adaptations. A national average, rather than regional, food basket was used for calculation of the food poverty line, to ensure that the basket represented the same quality across the country.

In step two, the per capita quantities of foods in this basket were increased proportionally so that consumption would provide 2,220 kilocalories per day. This represented the average per capita energy requirement as prescribed by the Ministry of Agriculture [17]. No further nutritional consideration was made in the calculation of the food poverty line.

In step three, the per capita quantities of foods in the basket were multiplied by the area median prices and summed to get an overall cost of the food poverty line. Although the basket composing the food poverty line was the same nationwide, the food poverty lines differed by area (e.g., mountain region and Kathmandu), because of differences in food prices. Table 1 provides additional details on the food poverty method.
TABLE 1. Comparison of food poverty and Minimum Cost of a Nutritious Diet (CoD) methods of assessing dietary affordability

<table>
<thead>
<tr>
<th>Feature</th>
<th>Food poverty</th>
<th>CoD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>Benchmark to assess the affordability of energy-adequate diets. Percentage of population that cannot afford such diets</td>
<td>Benchmark to assess the affordability of nutritious diets</td>
</tr>
<tr>
<td>Specific outputs</td>
<td>Area-specific thresholds indicating the cost to purchase a typical low-income diet that is adequate in energy. Prevalence of food-poor households, i.e., indicating they cannot afford a diet that provides them with enough energy</td>
<td>Area-specific thresholds indicating the minimum cost to purchase foods that meet needs for energy and nutrients. Does not identify the prevalence of households that cannot afford this, because the method does not collect expenditure data</td>
</tr>
<tr>
<td>Most common current use</td>
<td>As an input to calculate poverty rates, or as a stand-alone food security assessment tool</td>
<td>As a tool for nutrition advocacy and policy, or as a stand-alone nutrition assessment tool</td>
</tr>
<tr>
<td>Typical users</td>
<td>Economists, country statistical offices, and international agencies that assess poverty</td>
<td>Nutritionists, country health ministries, and international agencies that promote improved nutrition</td>
</tr>
<tr>
<td>Data required</td>
<td>Household expenditures on specific foods and other goods, and the value of food and other goods that are produced at home. Household size. Energy needs of a representative person</td>
<td>Area food prices, energy and nutrient needs of individuals that form a model household</td>
</tr>
<tr>
<td>Source of primary data</td>
<td>Household expenditure survey, which collects price as well as expenditure data</td>
<td>Local food market survey, also known as a “light market survey”</td>
</tr>
<tr>
<td>Time frame for data collection</td>
<td>Interviewing staggered throughout a calendar year</td>
<td>Market survey conducted at a particular moment in time</td>
</tr>
<tr>
<td>Analytical techniques</td>
<td>Typical diet determined from taking median quantities of foods consumed by low-income households. Quantities are scaled up in fixed proportion to ensure typical energy needs are met. Median area-level costs of these food quantities are summed to provide food poverty threshold</td>
<td>Linear programming with the objective of minimizing the total cost of a diet, subject to nutrient requirements and food prices</td>
</tr>
<tr>
<td>Advantages</td>
<td>Based on data collected routinely throughout the world. Benchmark is based on actual household consumption patterns. Uses the same data source to provide prevalence rates of those affected</td>
<td>Light market surveys are quick and inexpensive. Benchmark cost is provided for a nutritious diet</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Does not explicitly address nutrients. Those not in food poverty may have diets that do not meet nutritional needs</td>
<td>The “optimized” diet is theoretical and not based on local food habits. Nutrient poverty thresholds may underestimate cost of a nutritious local diet</td>
</tr>
</tbody>
</table>

**Nutrient poverty line**

Households that cannot afford a minimum-cost diet adequate in energy and other nutrients are in nutrient poverty. Calculation of the nutrient poverty line was based on a linear optimization technique using Save the Children’s Minimum Cost of a Nutritious Diet (CoD) tool [9]. This is implemented with linear programming using a solver function, or specific tool, of Microsoft Excel 2003. This allows the analyst to find the minimum cost of providing a nutritionally adequate diet, given the prices of locally available foods. In linear programming language, the objective function is to minimize the cost of the diet, and the constraint set is based on the nutrient requirements of a predefined household. The algorithm generates a hypothetical diet using a combination of local foods that meet the energy and nutrient requirements of all members of this household at the lowest possible cost. The calculations involved three main steps: listing local foods available at sampled markets and obtaining data on their price, selecting nutrient requirements for a representative individual or household, and using this information with software that calculated the minimum cost of a nutritious diet, based on available foods and their nutrient contents at existing market prices.

The typical approach to obtaining local food prices is through a light market survey [9]. This is a quick...
survey that collects prices on all foods available at a specific point in time in five or six markets in a given area. However, to develop an integrated approach, this study used food prices taken from the NLSS-III. As discussed previously, these prices were seasonally adjusted, which is an important methodological advantage over the snapshot of prices collected through the typical CoD approach. The nutrient content of food items is derived from the World Food Composition Database, which is incorporated into the CoD software [9]. Nutrient bioavailability is taken into account for iron and calcium by expressing their contents in absorbed amounts, which vary among food sources, and expressing requirements as absorbed amounts. Food items from the NLSS-III were matched to the closest equivalent items in this database.

In this study, the predefined model household was defined as consisting of one breastfed child 12 to 24 months of age, one child aged 11 or 12 years, one child aged 16 or 17 years, one moderately active adult man aged 30 to 59 years weighing 50 kg, and one moderately active and lactating adult woman aged 30 to 59 years weighing 45 kg. The requirements of these individual members were summed to get household totals for energy, protein, fat, and 13 additional nutrients: iodine, calcium, magnesium, iron, zinc, folic acid, and vitamins A, C, B₁, B₂, B₆, B₉, and B₁₂. The nutrient requirements were based on the World Health Organization/Food and Agriculture Organization (WHO/FAO) recommendations for specific age, sex, and physiological condition [9].

The linear optimization tool used for this analysis was the Excel-based software developed by Save the Children UK [9]. The objective of this program is to calculate the minimum cost of a nutritious diet, subject to the prices and nutrient contents of local foods, and expressing requirements as absorbed amounts. The same model household was used for the calculations in both geographic areas, but the food prices were different. Thus, the nutrient poverty lines, like the food poverty lines, are area-specific. Table 1 provides additional information on the CoD method.

Calculation of food and nutrient poverty rates

A household was assessed as food poor if its per capita food expenditures were below the food poverty line, which is also expressed in annual per capita terms. Similarly, a household was assessed as nutrient poor if its food expenditures were below the nutrient poverty line. Food expenditures were derived for all households in the NLSS-III and were based on total household expenditures on all goods, adjusted for basic nonfood necessities [17, 18], as described below. Total household expenditures included the monetary values of all purchases, as well as all items consumed or used from a household’s own production. It also included the values of gifts and in-kind wages, if they were eaten or used during the reference period, and estimates of the use value of assets and housing.

All normative poverty standards include information on necessities other than food, such as housing, clothing, and healthcare. Since we are focused here on food and nutrient poverty, these nonfood necessities need to be netted out of our analysis. Previous CoD analyses have handled this by adopting an extreme assumption, namely, that the poor can spend at most 70% of their income on food; thus 30% was subtracted from the income measure to get the amount available for food [19]. Here we have taken a more nuanced approach favored by most poverty analysts. For households that are not in poverty, we have subtracted the cost of basic nonfood necessities, referred to as the nonfood poverty line, from total expenditures. This gives a monetary measure of the resources available for food beyond the basic requirements for nonfood necessities. For simplicity of expression, this is referred to as food expenditures. The nonfood poverty line is calculated by the Nepalese Central Bureau of Statistics following the Cost of Basic Needs approach [17]. Households below the poverty line are not able to meet both food and nonfood needs and are already limited to meet needs; therefore, for these households, the resources available for food were their actual food expenditures.

Results

Using the techniques described above, the food poverty line for the mountain region was calculated as 13,294 rupees/person/year and the nutrient poverty line was calculated as 18,628 rupees/person/year. To demonstrate the magnitude of the population falling below and above these lines, Figure 1 displays a distribution of household food expenditures, with expenditures on the y-axis, the number of households on the x-axis, and both poverty lines indicated horizontally. In the mountain region, 42% of households had food expenditures above the nutrient poverty line, while 58% were below it. The latter group, which was unable to afford a diet that would meet their nutrient needs, can be further subdivided into two groups: those with spending above the food poverty line, comprising 24% of the households, and those with spending below the food poverty line, comprising 34% of the region’s households. The latter group was the worst off, being unable to afford a nutritious diet or even one that would meet their caloric requirements. The middle group—24% of households in the mountain region—did not

* It is the average amount spent on nonfood items by households with food expenditures near the food poverty line, which is considered a bare minimum, as households only meeting the minimum food standard are also likely to meet only the minimum nonfood needs.
FIG. 1. Prevalence of food-poor and nutrient-poor households and distribution of per capita household food expenditures in mountain region, Nepal. 1,000 Nepalese rupees = US$11.72

FIG. 2. Prevalence of food-poor and nutrient-poor households and distribution of per capita household food expenditures in urban Kathmandu, Nepal. 1,000 Nepalese rupees = US$11.72
face affordability constraints in meeting their caloric needs but did face such a constraint in accessing a nutritious diet.

The results for Kathmandu are presented in figure 2. The food and nutrient poverty lines were calculated to be 14,610 and 22,945 rupees/person/year, respectively. The two poverty lines divide the population into three groups: 7% of households were both food and nutrient poor, 14% were not food poor but were nutrient poor, and 79% were neither food nor nutrient poor.

**Discussion**

This paper demonstrates an approach to integrating two tools for assessing the affordability of diets into a single framework and using household expenditure survey data as the source of both food prices and household expenditure data. One tool, food poverty, has been traditionally used as an input to poverty studies by analysts concerned with a household’s ability to meet basic needs for an energy-adequate diet. A second tool, the Minimum Cost of a Nutritious Diet (CoD), has been used by nutrition planners concerned with the affordability of diets that are adequate from a nutrient perspective. Using them together allows comparison of a household’s total expenditure with two different thresholds—a food poverty line and a nutrient poverty line—and provides a detailed view of household economic access to an adequate nutritious diet.

The analysis, which was conducted for two geographic areas of Nepal—the mountain region and Kathmandu—used data from a large household expenditure survey. Use of the two poverty lines, which were calculated separately for each region, enabled segmentation of each region’s population into three groups of households (see figs. 1 and 2). Affordability constraints are much more a concern in the mountain region, where 58% of households could not afford a nutritious diet, compared with 21% in Kathmandu.

These results also point out the magnitude of the potential error in exclusive reliance on an energy-based food poverty indicator. For example, in the mountain region, using just food poverty, we found that 34% of households had a problem with access. However, setting the poverty threshold by considering a full range of nutrients (i.e., using the nutrient poverty line) indicates that 58% of households had a problem with access, which is 1.7 times the estimate based on considering only energy needs. Although the access problem was not as severe in Kathmandu, the relative error from using only the food poverty indicator was greater. Fully three times as many households had a problem with access according to the nutrient poverty line, as opposed to the food poverty line (21% and 7%, respectively).

![Figure 3](image_url)

**FIG. 3.** Categorization and risk profile of population groups based on analysis of food and nutrient poverty lines: Example of mountain region, Nepal. 1,000 Nepalese rupees = US$11.72
Another advantage of this approach, particularly in comparison with the traditional CoD methodology, is that the analysis uses household expenditure data collected throughout the year. Rather than being based on a snapshot of food prices, the nutrient poverty line calculated here is based on temporally adjusted food prices. In the context of high food price volatility, this methodological strength is important for a robust policy application.

A more refined approach to nutrition policy-making is an important benefit of our approach. This can be seen in the framework laid out in figure 3, which categorizes groups based on their household expenditures and their diet affordability. A key point here is that this categorization has implications for dietary intake. Group A, with spending above both the nutrient and the food poverty lines, can afford a nutritious diet. However, group B is likely to have a diet deficient in micronutrients, while group C is likely to be deficient in both micro- and macronutrients. Different policy interventions can be targeted to each group (table 2). For those with sufficient ability to buy a nutritious diet, interventions could be focused on education and behavior change to assure that nutritious choices are made. Those in nutrient poverty will require some sort of micronutrient intervention and/or income assistance (group B). Those in group C will need interventions that provide nutrient-dense food and/or income assistance. On an emergency basis, this might take the form of food assistance, whereas a long-run solution might favor asset-building or social protection schemes. Note that these recommendations are suggestive, and there will be some overlap in intervention needs across the different groups. For example, group C would also likely benefit from micronutrient supplementation, and all groups might benefit from nutrition education.

Table 2. Diet affordability analysis can inform nutrition policy-making

<table>
<thead>
<tr>
<th>Variable</th>
<th>Household group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Household expenditures</td>
<td>Above nutrient poverty line</td>
</tr>
<tr>
<td>Diet affordability</td>
<td>Can afford nutritious diet</td>
</tr>
<tr>
<td>Implications for dietary intake</td>
<td>More likely to have nutritious diet</td>
</tr>
<tr>
<td>Type of policy interventiona</td>
<td>Nutrition information</td>
</tr>
<tr>
<td>Examples of intervention</td>
<td>Nutrition education campaign</td>
</tr>
</tbody>
</table>

Note that the policy interventions suggested here would be most typically needed by the specified household group under which they are listed. However, there may be overlap in needs. For example, group C households would also benefit from micronutrient supplementation, and both group B and C households might benefit from nutrition education.
needs within a household, there are limitations in the way household composition is taken into account when identifying the prevalence of food poverty and nutrient poverty. The food poverty line, based on the Cost of the Basic Needs (CBN), is expressed per capita, even though the cost would depend on energy requirements and thus would vary by factors such as age and sex. This per capita approach has implications in estimating the prevalence between urban and rural areas, since, on average, there are more children per household in rural than in urban areas. However, we have chosen this approach to be consistent with the approach taken in the official poverty calculation by the Nepalese Central Bureau of Statistics. Also, food and nutrient poverty lines are likely to be most useful as a policy tool to justify poverty reduction programs, so they need to look at populations rather than individual households.

The nutrient line is also expressed as a per capita cost, based on the per person cost of achieving nutrient adequacy, given a predefined household of five members. A more accurate estimate of nutrient poverty would come from calculating nutrient poverty lines that are specific to the age and sex composition of each household. This is not feasible, given the current version of Save the Children’s tool, but it may be possible in the future with a newer version. We are unable to estimate the degree or direction of bias that this “fixed” household approach introduces. However, the overall bias, if it exists, will be reduced by the fact that the underestimate of nutrient poverty for households with higher needs will be offset by the overestimate of those with lower needs.

Although additional research could explore some of the issues discussed above, it remains clear that adding a nutrient poverty line to existing poverty lines has significant potential for enabling policy makers to better recognize, assess, and address problems of food insufficiency, poor dietary diversity, and resulting undernutrition. Two types of audience might be particularly interested in this approach: poverty analysts and policy makers, and nutritionists and nutrition programmers.

For poverty analysts, the exclusive focus on energy as a means of normalizing typical diets does not address the gaps in consumption of micronutrients that are seen in these diets, even when they are consumed in sufficient quantities. The results from this study encourage poverty analysts to work more closely with the nutrition community to better target interventions to address diet quality as well as quantity issues.

For those focused on nutrition programming, the framework and approach described here enhances the stand-alone CoD approach by providing an integrated source of prevalence data on the percentage of households likely to have different types of nutrition problems. This is useful for advocacy purposes to increase existing program resources, as well as for better targeting of existing resources by using specific interventions for particular population groups. This approach also provides the ability to understand which nutrients are limiting with respect to the cost optimization. Because of low availability, high cost, or high relative need, some nutrients drive up the cost of nutritious diets. By understanding which ones these are, planners could target interventions to increase their availability (e.g., using food fortification and diversification for the general population, or micronutrient powders for young children) and thereby make nutritious diets more accessible.

In the current global context, there is an unprecedented commitment to achieving nutrition security for all [21]. To do this, we need an evidence base broader than ever before, allowing us to better understand the crucial role played by nutrient deficiencies in causing undernutrition. We need to be able to estimate the cost of a diet that meets nutrient needs as well as a household’s ability to afford such a diet.

Adding a nutrient poverty line to existing food poverty lines can help do this and seems particularly pertinent at a time when more and more countries are participating in the SUN movement. SUN countries are mobilizing a wide range of disciplines and actors and are revising and updating nutrition policies, with an increasing focus on preventing undernutrition. However, adequate nutrient intake at an individual level cannot be guaranteed unless households have the economic means to meet their needs. So it is crucial to be able to quantify the extent of constraints to access faced by households. The approach described in this article, which can be easily applied to many of the widely available household expenditure surveys, can provide this information.

Acknowledgments

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References

1. Rose D, Charlton KE. Quantitative indicators from a food expenditure survey can be used to target the food insecure in South Africa. J Nutr 2002;132:3235–43.


