Assessing the Quality of Food Aid Deliveries

Canadian International Development Agency

Agence canadienne de développement international

World Food Programme

A WFP project supported by the European Commission and Canada.

Colleen Doak,
Ludovic Subran,
Shanta Marapin,
& Maiza Campos Ponce

2 March 2008

Contact:
Colleen M. Doak, PhD
Assistant Professor
VU University Amsterdam
FALW, Department of Health Sciences
Nutrition and Health
De Boelelaan 1085
1081 HV Amsterdam
colleen.doak@falw.vu.nl
Phone: +31 20 598 3502
Fax: +31 20 598 6940

Acknowledgements

This paper was written as part of a WFP project, which was supported by the European Commission and Canada. We would also like to thank collaborators from the World Food Programme who contributed to the thinking and formulation of the measures shown here, including Vera Mayer, Pushpa Acharya, Edith Heines, Ester Fiorito, Simonetta Basile, MariaTeresa Silvi, Tina Van Den Briel, Cora Best, Lothar Kuijper and Michiel de Boer. Additionally we would like to thank the reviewers Stuart Clark, Max Merbis, Andrew Seal, Amélie Solal-Céligny, Iacopo Viciani and Patrick Webb. We would also like to give special thanks to Henk-Jan Brinkman for his detailed comments that have helped to improve the analysis and clarifications to the writing.

Table of Contents

Summary

This report was commissioned as a two month consultancy to develop a method of assessing the nutritional quality of food aid. In order to complete the project within the time frame, the indices created are based on the simplest hypothetical scenario. Namely, all indices are based on the minimal requirements estimated based on a reference individual for a population entirely dependent on food aid. These measures could be calculated for all kinds of food aid to be used as a reference point. The hypothetical scenario used here will not fit the context of programme or project food aid and may not fit all populations dependent on emergency food aid. Thus, the interpretation of results should be made in the context of local conditions, including external sources of food, existing supplementation programs, and the nutritional needs of a population where the food aid is delivered.

Nutritional requirements met by food aid are based on the estimated needs of the "reference individual" from a population dependent on emergency food aid. These measures are meant as a means of documenting the nutritional content of food aid, scaled to the amount of food aid delivered. Furthermore, per ton quality indices are also included for use in time trend comparisons, to document changes in the micronutrient quality of food aid, per ton. These indices identify nutritional imbalances in food aid deliveries. Using these measures to identify nutritional gaps requires validation using more direct measures. Furthermore conclusions are limited by the availability and quality of existing food composition tables.

The final score is based on the ratio of nutrient to energy requirements met. The indices developed, include intermediate indices such as the total nutrient requirements met and "per ton" quality indices. Together these provide a total picture of food aid. If the quality measures are used without consideration of the total quantity of food aid given, food aid donors might be encouraged to donate less in exchange for higher quality. The primary emphasis should be on maintaining the quantities. However, quality measures provide additional information about food aid that helps assess the balance of multiple nutrients in food aid deliveries. Further adaptation to these indices might be useful to apply these measures based on the actual conditions under which food aid is given and received. Methods developed here can best identify trends over time in food aid quality, as measured by the balance of multiple nutrients relative to energy.

1. Literature review

1.1 Documenting food aid deliveries

Food aid deliveries reached a record low of 5.9 million metric tons in 2007 (WFP, 2008). While the levels of donations have been steadily less since 1999 the need for food aid has increased related to an increase in natural disasters and additional pressures related to climate change, rising fuel prices, and increasing cost of cereal grains (WFP, 2007). The astronomical increase in food prices has been documented, with a 55% increase in the prices of wheat, a 70% increase in the price of maize, and a tripling in the price of rice in the one year period from May of 2007 to May of 2008 (Klotz et al, 2008). Related to household budgeting strategies, higher food prices may contribute to micronutrient malnutrition (Klotz et al, 2008). The concerns about micronutrient quality are not new. A number of researchers have called for a shift in paradigm to improve the (micronutrient) quality of food systems (Combs et al, 1997; Welch & Graham, 2004). A number of strategies have been proposed to improve the micronutrient quality in developing countries ranging from supplementing diets with meat (Allen, 2002; Tontisirin et al, 2002) to home gardens (Tontisirin et al, 2002) and the breeding bio-fortified staple plant foods. Specific to the food aid context, van den Briel et al (2007) have shown how local fortification of cereal grains can help to reduce iron and vitamin A deficiencies. Assessing the total macro and micronutrient requirements met by food aid, as well as the nutrient quality of food aid per ton, are both equally necessary given current trends.

1.2 The need to measure food aid deliveries in terms of nutrient quality

Food aid is currently assessed in terms of wheat equivalents or monetary values, with no evaluation of the nutrient quality of food aid. However, the importance of micronutrient quality is well established. In the 1980s, when world energy and protein production was sufficient to feed the world, emphasis shifted towards improving micronutrient quality (Welch, 1999). The focus on widespread nutritional deficiencies led to recommendations such as increasing the production of traditional crops which are higher in iron and other limiting nutrients (ibid). Currently, escalating cereal grain prices underscores the need for continued emphasis on energy sufficiency while also attending to widespread micronutrient deficiencies.

1.3 Nutrient quality and child growth and cognition

Clinical evidence shows a clear relationship between nutrition and optimal child growth. The relationship between energy intake and child growth in height is strong and consistent. Additionally, a number of specific micronutrients have also been related to improved child growth. In their recent chapter *A Multiple Micronutrient Malnutrition,* Ramakrishnan and Huffman (2008) describe the micronutrients most important to optimal child growth. Of the single micronutrients, zinc is most clearly related to improving height and weight in children (ibid). However, there is a recent focus on multiple rather than single micronutrient supplementation (ibid). Studies on foods have focused on animal products showing improvements in growth (Allen et al, 1992) although fortified foods have shown varying results (Ramakrishnan and Huffman, 2008).

1.4 Micronutrient quality and immune function

Although exact functions and mechanisms are not always known, it is clear that micronutrient deficiencies have a vital influence on the immune response. Deficiencies of iron, zinc, vitamin A and vitamin C are known to diminish immune function, which can lead to increased prevalence of and morbidity and mortality from infectious disease. In the year 2000, over 800,000 deaths were attributed to iron deficiency (Mathers et al., 2007). Malnutrition may also increase the severity of respiratory infection (Johnson et al., 1992). The prevalence of respiratory disease is higher in children with low Vitamin A and Zinc status (Sommer et al., 1984; Bloem et al., 1990; Bahl et al., 1998). Moreover zinc can prevent and palliate pneumonia (Bhutta et al., 1999, 2000). Lower respiratory infections caused 3.8 million deaths in 2002 (Mathers et al., 2007). A healthy immune system is vital to resistance against the gastrointestinal bacteria, viruses or parasites that cause diarrhoeal disease. Vitamin A and zinc are associated with higher morbidity and mortality due to diarrhoea (Mitra et al., 1998; Penny et al., 1998, Sommer et al., 1984; Black 2003).

The strong inter-relationship between nutrition and infectious disease was made apparent by the case of HIV/AIDS. In people living with HIV/AIDS, even in the absence of symptoms, energy needs increase by 10%. In the case of AIDS, the increased energy needs are 20-30% or more (WHO, 2003). Furthermore, a number of clinical studies have indicated increased needs for a number of micronutrients, particularly although not exclusively, anti-oxidants. While energy and micronutrient malnutrition influence HIV disease progression, HIV infection, in turn, can lead to symptoms that reduce intake, reduced uptake or increased excretion that can result in weight loss, micro-nutrition losses and ultimately nutritional deficiencies. Furthermore, higher intake of niacin, vitamins B_1, B_2, B_3 and C are associated with slower progression to AIDS. Exact mechanisms are not known but vitamin C, apart from enhancing the immune response, may also inhibit virus replication (Harakeh et al., 1990, 1995). Studies on the effect of zinc and iron on AIDS progression have provided conflicting results (Tang et al., 1993, & 1996, Graham et al., 1991, Clark & Semba., 2001, Traore & Meyer 2004). In the context of food aid, an HIV affected population will need a greater quantity as well as quality of food.

Malaria is the most important parasitic disease of human beings and currently accounts for approximately 2-3 million deaths a year (Guinovart et al., 2006). Nutrients strongly influence malaria morbidity and mortality and, in turn, malaria also has a profound effect on the hosts' nutritional status. For example, vitamin A and zinc are associated with a decrease in morbidity due to Malaria (Cuevas et al., 2005, Caulfield et al., 2004). A poor thiamine status has also been reported to be associated with a greater risk of severe malaria in simple clinical malaria (Krishna et al., 1999). The exact effect of iron deficiency is not completely understood, although iron deficiency anaemia has been identified as both a cause and a consequence of malaria (Richard et al., 2006; Nyakeriga et al., 2004).

2. Introduction

2.1 Nutritional guidelines in the emergency food aid context

Nutritional needs and guidelines for populations dependent on emergency food aid have been clearly identified by the World Food Programme (WFP) in two joint publications. These guidelines provide the basis upon which food quality can be assessed. In *Food and Nutrition Needs in Emergencies*, a joint publication between the WFP, United Nations High Commissioner for Refugees (UNHCR), United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), specific guidelines are given for the energy and macronutrient needs for populations entirely dependent on food aid. These guidelines are set based on activity levels usual in populations reliant on emergency food aid. The guidelines recommend food aid to provide, per person per day, 2100 kilocalories, 17 percent energy from fat and 10-12 percent of energy from protein. In a separate joint statement by the WHO, WFP & UNICEF (2002), 15 micronutrients are identified as most important to the context of emergency food aid. These 15 micronutrients are: vitamin A, vitamin D, vitamin E, vitamin C, thiamine, riboflavin, niacin, vitamin B6, vitamin B12, folic acid, iron, zinc, copper, selenium, and iodine. Food aid quality should be assessed based on how well food aid deliveries contribute to these 15 micronutrients as well as meeting needs for energy, protein and fat.

2.2 Food composition tables for assessing food aid deliveries

NutVal, an emergency food aid rationing software programme, was developed as a collaboration between the World Food Programme in Rome, Italy and the United Nations High Commissioner for Refugees (UNHCR) in Geneva, Switzerland. The NutVal programme was commissioned by WFP to help calculate the optimal combination of foods to best meet the nutritional requirements of individuals receiving emergency food aid (NutVal, 2008). The "minimal nutritional requirements" values of individuals receiving emergency food aid are based on a reference individual with a level of activity requiring 2100 kilocalories (WHO, 2000). Protein, fat and micronutrient values (UNHCR/UNICEF/WFP/WHO, 2002) are also based on the reference individual as used in the NutVal programme. The nutrient values are based on the food composition table used in the NutVal programme. Data Sources for Foods and Nutrients and links to details of the food composition tables can be found within version 2 of the NutVal 2006 programme (download available at http://www.NutVal.net/2008/05/download-page.html). Where database entries were inconsistent, the midpoint value was used. Specific conversions used for calculating niacin equivalents and international units of vitamin A are also described in the NutVal programme. Where micronutrient values are unknown they are left blank in the food composition table and are entered as 0 in the analysis here. Finally, the NutVal programme clarifies that nutrient values are based on raw portions of food; the actual nutritional values will vary by food preparation and cooking practices.

The WFP conducted an extensive comparison of food composition tables, with commodities relevant to food aid. Multiple food composition tables were compared and findings indicated that existing data food composition tables, including those in NutVal, are not yet sufficient. Therefore, a new food composition table was being constructed when this analysis was being done. Unfortunately, the improved food composition tables were not available to include in these results.

2.3 Food Labelling and Profiling

A system of scoring food aid is needed which includes the essential macronutrient (energy protein and fat) and micronutrient needs. Examples used for the scoring of whole foods, to summarize the information in a clear and systematic way, exist in the literature. Food labelling, as described by Drewnowski, was developed with the goal of guiding shoppers to make healthy choices (Drewnowski, 2005). One of the earliest such examples was the University of Michigan grocery shopping guide as a point-of-sale guidance system (Mercer et al, 1988). The “Choices” profiling system originates from the Unilever food labelling system and provides a logo for food products that fit set criteria (Ik Kies Bewust report 3.2, 2007). In the UK a system stoplight programme was developed (Snelling, 2007).

These food profiling systems evaluate foods based on population health concerns, largely focusing on overweight, obesity and chronic disease risks. However, micronutrient contribution is also considered. Because of the importance of milk to calcium, for example, the “Choices” system allows for more flexible standards regarding fat and saturated fat content for milk as compared to other foods.

While labelling and logo approaches are focused on assisting shoppers in making healthy choices, they provide useful methods that can be adapted to the emergency food aid context. Namely, the score should be evidence-based, focusing on the priority nutritional concerns for the target population e.g. food aid recipients, and should evaluate foods in a manner that is sensitive to the context of how a food aid is delivered.

2.4 Existing Food Quality Scores

A number of diet quality indexes have been developed (Kant, 1996). Most useful to developing a score for assessing food quality based on the above 18 nutrients is a method developed by Madden and Yoder (1972). This method assesses foods based on the ratio of a given nutrient contained in a food relative to the recommended daily allowance (RDA) for that nutrient. The ratio for individual nutrients provides useful, easily interpreted, information. A summary score for the food can be used by taking the mean of the nutrient specific ratios, a scoring system described as a mean adequacy ratio (MAR), a concept that allows for assessing foods based on their mean contribution to nutrient requirement recommendations. A second approach, also helpful to the food aid perspective, was developed by Lachance (1986). This method is the Calories for Nutrient Score (CNF) which averages, over a number of nutrients, the energy density of a food over the mean percentage daily value for 100 grams of a food.

Drawing on the methods above, we create a new index for scoring food aid deliveries, scaled to metric tons and based on the nutrient recommendations for the emergency food aid context.

The methods above provide two key concepts that are critical in developing a score for the emergency food context. First, the score should assess the nutrients most important to the population based on the needs of populations receiving food aid as identified by the “minimal requirements”. Second, the score should help to assess whether food aid provides a balance of all nutrients. Finally, energy density based approaches can help to identify whether emergency food aid provides a balance of minimal requirements for multiple nutrients (protein, fat, trace minerals and vitamins) in proportion to the energy requirements contributed.

2.5 Optimization modelling

Darmon, Ferguson and Briend (2002) developed a modelling approach to calculate the optimal nutrient density of a population’s diet. They used linear programming to identify the constraints in meeting nutritional recommendations in a population's diet. Darmon et al (2002) used food consumption data collected during 2 seasons from rural Malawian children aged 3–6 years. Using modelling techniques they were able to identify when locally available foods were not sufficient to meet needs. More specifically, they were able to identify that in the non-harvest season, nutritional adequacy was impaired by the low availability of riboflavin- and zinc-rich animal or vegetable foods and by the high phytate content of other foods. Aspects of the Darmon et al (2002) approach are also utilized here. In this case the available food is emergency food aid and the nutritional recommendations are replaced by the estimated requirements of a reference individual. Like Darmon et al (2002), we assess gaps between recommended intakes and food available using a nutrient density approach.

2.6 Donor and recipient countries

The World Food Programme maintains a comprehensive database covering world-wide food aid flows, allowing for the monitoring of food aid allocations and management. This system, called the International Food Aid Information System (INTERFAIS), provides a source of information that enables measurement of food aid flows and assessments of food aid quality with 20 years of data available. INTERFAIS reports “deliveries,” defined as food aid that actually reaches the recipient country. According to a 2007 WFP report, 83 countries or territories received 6.7 million tons of food aid in 2006 (Interfais report WFP, 2007). Food aid falls under three main categories defined as follows: 1. Emergency food aid is destined for victims of natural or man-made disasters; 2. Project food aid aims at supporting poverty-reduction and disaster prevention activities; 3. Programme food aid is usually supplied bilaterally from one government to another as a resource transfer for balance-of-payments or budgetary support. These three types of categories differ in their objectives. The emergency food aid context, as used here, is the only food aid category in which a recipient population might be entirely dependent on the food aid provided. Furthermore, project and programme food aid may not have, as a principle aim, the goal of improving nutritional status per se. In project food aid, for example, deliveries may be used as incentives whereas programme food aid may be sold.

Combining all food aid together, nearly half of the recipient countries (n=40) were from sub-Saharan Africa. The top two countries receiving food aid in 2006 were Ethiopia (12%) and the Sudan (9%). While populations dependent on emergency food aid may also have other sources of food, populations receiving emergency food aid are closer to the simple hypothetical scenario used here. Thus, emergency food aid is the basis for illustrating the proposed methodology. For Ethiopia 91% of food aid deliveries were categorized as Emergency Food Aid and in the Sudan nearly all (99%) of the deliveries received fit the category of emergency food aid (WFP, 2007). Overall, the USA contributed 49% to emergency food aid and the EU 24% in 2007 (WFP, 2007). Thus, the food aid deliveries given to Ethiopia and the Sudan as recipient countries and the USA and EC as donor countries are used to illustrate the methods developed.

3. Aims and Objectives

Previously, food aid been measured in wheat equivalents, based on metric tons, or in monetary value, such as in US dollars or Euros (see internal WFP document*, A proposal to develop Nutritional Measure of Food Aid Flows*). However, in the current environment of inflation and food shortages, it is important to have alternative methods of assessing both the quality and quantity of food given and received. Furthermore, wheat equivalents or monetary values do not assess nutritional quality of the food supply. Maintaining the necessary balance of energy, protein, fat and micronutrients requires a tool for measuring both the energy sufficiency as well as nutritional quality of emergency food aid. There is a clear need for a tool that can be used to report food aid quality and monitor changes over time. Comparisons from year to year are challenging given the fluctuations in food aid quantities given in response to famine. Furthermore, converting food aid into grain equivalents does not adequately account for differences in the nutritional value of foods. Identifying nutritional imbalances in food aid deliveries may help to identify specific nutrients that are in short supply. This information can be used to stimulate donations that would redress imbalances between food aid deliveries and nutritional requirements.

An instrument for assessing food aid quality will be developed using, as examples, the food aid flows to Ethiopia and Sudan. Separate analysis will compare the quality of emergency food aid deliveries donated by the USA and EU. The overall aim of this project is to creating a measure that is suitable as a tool for monitoring, reporting and advocacy. This aim is met through a summary score that measures the quality of food aid comparing nutrient contributions relative to energy. A further objective is to provide additional measures that quantify and qualify the nutritional value of food aid they provide over time. Together these indices provide a total picture of the nutritional value of food aid.

4. Methodology

The first two sections below describe the reference individual and minimal requirements for selected nutrients, as this information is the basis of all indicators used for the final score. The initial indicator is a measure of the total number of reference individuals whose minimal requirements would be met by the food aid. The second is a per ton quality indicator. This indicator measures the number of hypothetical individual requirements met, annually, per ton for each of the nutrients. This information can be provided for a single commodity or for a food delivery. Next, two summary scores of nutrient density are created. The main summary score used to measure the quality of food aid provides a scaled mean of the nutrients relative to energy. An additional summary score is described in text at the end of the Methodology section. This score is supplementary to the main score and simply counts how many nutrients are provided at levels equal to or exceeding energy.

4.1 Minimal requirements and the reference individual

The calculation for the number of hypothetical individual requirements (HIR) is based on 1) the nutritional requirements estimated for individuals receiving emergency food aid and 2) the nutritional content of food aid. Values have been determined both for the average requirements of individuals dependent on food aid as well as the nutrient composition of foods, which is based on NutVal. For the purposes of our scores, the minimal requirements for populations dependent on emergency food aid are defined by the World Food Programme. These values are based on the needs of the population served by the food aid deliveries. Calculations based on minimal requirements are a point of reference for all indices. The methods developed here focus on identifying deficiencies. Excesses of nutrients are not addressed.

4.2 The nutrients to be included

WFP (2002) includes specific energy recommendations as well as for protein, fat and 15 micronutrients including vitamin A, vitamin D, vitamin E, vitamin C, thiamine, riboflavin, niacin, vitamin B6, vitamin B12, folic acid, iron, zinc, copper, selenium, and iodine. The ideal nutrient quality score would have included all of these nutrients. Because of the limited number of micronutrients available from NutVal we are not able to include vitamin D, vitamin E, vitamin B6, vitamin B12, folic acid, zinc, copper, or selenium in our indices. The remaining seven micronutrients together with protein, energy and fat are shown in Table 1. Because this analysis is based on food aid given annually, the minimal requirements are converted from daily into annual measures. The annual requirements for the ten nutrients shown in **Table 1** are the basis for evaluating the requirements met per ton of food aid.

Table 1. Daily and annual minimal requirements for the reference individual

Minimal require-ments	Energy	Protein	Fat	Iron	Iodine	Vitamin A	Thiamine	Ribo-flavin	Niacin	Vit-amin C
Daily Require-ments	2100 kcal	52.5 g	40 g	41 mg	150 µg	500 µg	0.9 mg	1.4 mg	12 mg	28 mg
Yearly Require-ments	766,500 kcal	19,163 g	14,600 g	14,965 mg	54,750 µg	182,500 µg	329 mg	511 mg	4,380 mg	10,220 mg

4.3 Commodity contribution divided by nutrient requirement

All assessments will be based on the nutrient contents of foods relative to "minimal requirements" per year as defined in **Table 1** above. These values are used to determine the denominator to calculate the total nutrient requirements in a ton of commodity. The formula for this calculation, given below as CR_{ij}, is equal to the total nutrient requirements provided in a ton of commodity. For every nutrient *j*, the nutrient content per metric ton of food commodity *i* is divided by the yearly minimal requirement for a reference individual for each nutrient. The values for r_j are given in **Table 1** above as "daily requirements" in the first row. The values for R_j, the yearly hypothetical individual requirement for each nutrient, are provided in the second row (**Table 1**).

n_{ij}: Content of nutrient *j* in food commodity *i*, per 100 g.

$N_{ij} = n_{ij} \cdot 10000$: Content of nutrient *j* in food commodity *i*, per 1 metric tonne.

r_j: Daily hypothetical individual minimal requirement per nutrient *j*

$R_j = r_j \cdot 365$: Yearly hypothetical individual minimal requirement per nutrient *j*

$$CR_{ij} = \frac{n_{ij} \cdot 10000}{r_j \cdot 365} = \frac{N_{ij}}{R_j}$$

4.4 Assessing donations given to and received by Ethiopia and Sudan

The number of hypothetical individual requirements values will be used to assess the nutritional values of food aid, both in terms of quantity and quality. All analysis is based on the HIRt for each nutrient. The basis of this calculation is the minimal requirements met values for nutrients as defined by the World Food Programme, based on the "hypothetical individual" requiring 2100 kilocalories. The hypothetical individual requirements for each nutrient are used to create scores for each food commodity based on the balance of nutrients relative to energy. The methods developed here will be illustrated using the actual food aid deliveries to Ethiopia and Sudan. The quantity and quality of the portions of contributions to Ethiopia and Sudan given by the two main donors, the United States and the European

Commission, will also be assessed separately. Specific quantity and quality indicators for assessing food aid are described in detail below.

4.5 Intermediary indicators and the final score used to assess food aid quality

Below are calculations for the measures for the nutritional value of food aid. The notations that are the basis of the formulas are given below. The final scores are based on a total number of *I* food commodities, for *J* macro and micronutrients. The content of nutrient *j* for commodity *i* is described as n_{ij} per 100 grams and N_{ij} per metric tons. The hypothetical individual minimal requirement per nutrient *i* is described as r_i for the daily requirement and R_i as the annual requirement. Q_i is the total food aid quantity for a given commodity, with total food aid quantities summarized as Q. The proportional contribution of a given commodity to a given food aid delivery is described as d_i with all values of d_i adding to 1.

I : Total number of food commodities, where commodities are: *i = (1, 2, 3, … , I).*

J : Total number of macro and micronutrients (10), where nutrients are: *j = (1,2,3,… ,J)* [i.e. j=1 energy, j=2 fat, j=3 protein, …, j=10 vitamin C].

n_{ij} : Content of nutrient *j* in food commodity *i*, per 100 g.

$N_{ij} = n_{ij} \cdot 1000($: Content of nutrient *j* in food commodity *i*, per 1 MT.

r_i : Daily hypothetical individual minimal requirement per nutrient *i*

$R_i = r_i \cdot 365$: Yearly hypothetical individual minimal requirement per nutrient *i*

Q_i : Total food aid quantities in MT of i^{th} commodity.

$Q = \sum_{i=1}^{I} Q_i$: Total food aid quantities in MT.

$d_i = Q_i / Q$: Share in 1 ton of commodity *i* in selected *K* food aid deliveries in percentage.

$$\sum_{i=1}^{I} d_i = 1$$

$\mathbf{HIRt_j}$ – per total food aid delivery

The next formula **$\mathbf{HIRt_j}$** provides the total hypothetical individual requirements met by multiplying, for each commodity, CR_{ij} times the total food aid quantities of commodity *Qi* in metric tons. The results are summed for all commodities in a delivery. There are 10 **$\mathbf{HIRt_j}$** scores, one for each nutrient. The formula for $HIRt_j$ is given below with the formula for CR_{ij}, which is the sum of the total requirements met for nutrient *j* for each commodity *i* times the metric tons of commodity *i*. The formula is described again in **Table 2**, in words, using the actual values for the annual requirements (R_j).

$$HIRt_j = \sum_{i=1}^{I} CR_{ij} \cdot Q_i$$

$$\text{where } CR_{ij} = \frac{n_{ij} \cdot 10000}{r_j \cdot 365} = \frac{N_{ij}}{R_j}$$

$\mathbf{HIR_j}$ - per 1 ton

The formula $\mathbf{HIR_j}$ provides the hypothetical individual requirements per ton of food, which is the total hypothetical individual requirements ($\mathbf{HIRt_j}$) divided by the total tons of food aid in a delivery. There are ten HIRi scores, one for each nutrient.

$$HIR_j = \sum_{i=1}^{I} CR_{ij} \cdot d_i = \sum_{i=1}^{I} CR_{ij} \cdot \frac{Q_i}{Q} = \frac{HIRt_j}{Q}$$

HIRs – per 1 ton (Final Score)

The formula **HIRs** provides a score for the hypothetical individual requirements. This score is a ratio of the HIR_j for a given nutrient j, compared to HIR_1, the HIR value for energy. The scores are capped at 1 for each nutrient and divided by the number of nutrients (J), providing a scaled mean. The final result is expressed as a percentage, with a score of 100% indicating nutrient HIRs values being in balance with energy.

$$HIRs = \frac{\sum_{j=1}^{J} \min\left[\frac{\sum_{i=1}^{I} CR_{ij} \cdot d_i}{\sum_{i=1}^{I} CR_{i1} \cdot d_i}, 1\right]}{J} = \frac{\sum_{j=1}^{J} \min\left[\frac{HIR_j}{HIR_1}, 1\right]}{J}$$

where j=1 refers to Energy

The first is a quantity measure, used to assess the total nutritional contribution of food aid given and received by Ethiopia and the Sudan. The total HIR value of a food aid package converts tons of food aid into **total** number of Hypothetical individual Requirements met (HIRt). HIRt will be calculated for Ethiopia and the Sudan, separately. Furthermore, from the total donations given to Ethiopia and Sudan, the HIRt from the donations given by the United States and the European Commission will also be calculated separately. The HIRt values will be calculated separately per nutrient, comparison of differences for HIRt values per nutrient providing information about the balance of nutritional requirements. HIRt provides a measure that includes the full scale of a donation of food aid, and should be interpreted as a quantity measure, providing a measure of the scale (size) of the delivery. The interpretation of HIRt is based on the total hypothetical individuals whose requirements could be met.

Table 2: The formulas for Total Hypothetical Individual Requirements (HIRt) values per 100 grams and per ton per year

HIRT Nutrient	**Formula per 100 grams**	**Formula per ton annual**
HIRt Energy	**Energy** $_{\text{100g food commodity}}$/2100 kilocalories	Energy $_{\text{ton food commodity}}$/766,500 kcal
HIRt Fat	Grams fat $_{\text{100g food commodity}}$/40 grams	Grams fat $_{\text{ton food commodity}}$/14,600 grams
HIRt protein	Grams protein $_{\text{100g food commodity}}$/52.5 grams	Grams protein $_{\text{ton food commodity}}$/19,163 grams
HIRt iron	Milligrams iron $_{\text{100g food commodity}}$/41 milligrams	Milligrams iron $_{\text{ton food commodity}}$/14,965 milligrams
HIRt iodine	Micrograms iodine $_{\text{100g food commodity}}$/150 micrograms	Micrograms iodine $_{\text{ton food commodity}}$/54,750 micrograms
HIRt vitamin A	Micrograms vitamin A $_{\text{100g food commodity}}$/500 micrograms	Micrograms vitamin A $_{\text{ton food commodity}}$/182,500 micrograms
HIRt thiamine	Milligrams thiamine $_{\text{100g food commodity}}$/0.9 milligrams	Milligrams thiamine $_{\text{ton food commodity}}$/329 milligrams
HIRt riboflavin	Milligrams riboflavin $_{\text{100g food commodity}}$/1.4 milligrams	Milligrams riboflavin $_{\text{ton food commodity}}$/511 milligrams
HIRt niacin	Milligrams niacin $_{\text{100g food commodity}}$/12 milligrams	Milligrams niacin $_{\text{ton food commodity}}$/4,380 milligrams
HIRt vitamin C	Milligrams vitamin C $_{\text{100g food commodity}}$/28 milligrams	Milligrams vitamin C $_{\text{ton food commodity}}$/10,220 milligrams

4.6 Reporting the per ton indicators of food aid

The $\mathbf{HIR_j}$ (per metric ton) values will be reported in a summary document, per nutrient, in a Table showing the HIR values per ton of food aid, per commodity, and for a total food aid delivery package. Results can be interpreted as the total number of reference individual whose requirements are met for each nutrient. This value is calculated for the total annual delivery or for the food aid delivery contributed by the United States or the European Commission. For the total delivery package, the results of the ten nutrients will be further described using spider web graphs and a bar chart showing the number of (hypothetical) adults whose requirements can be met for a year by an adjusted average ton of food aid delivery. A spider web graph will be used to provide a pictorial overview showing the relative balance of the 10 $\mathbf{HIR_j}$ values. spider-web graphs are shown below to illustrate the nutrients that are most deficient. Attention will be given to nutrients with HIR values of less than 40% proportionate to the energy HIR.

4.7 Counting the nutrients in balance with energy (HIRc)

A score not described in the formulas is an additional measure, HIRc. This score is a simple counting that assesses the number of nutrients whose HIR values are equal to or exceeding energy HIR. A nutrient is counted as in balance with energy if the HIR value of a nutrient is equal to or exceeds the HIR for energy. A perfect score of 10 would indicate all 10 nutrients have HIR values equal to or exceeding energy. In other words, a HIRc score of 10 indicates that where the reference individual's needs for energy are met, all other nutrient requirements of the reference individual are also met. HIRc is used for scoring a full delivery rather than individual commodities. For example, iodized salt or micronutrient supplements are not scored using HIRc as these commodities do not provide energy. However, the micronutrient contributions of iodized salt and micronutrient supplements are an important component of the HIRc score for a full delivery. Thus, non-energy containing commodities *are* included in HIRc assessment of the food aid delivery. This score shows how many nutrients are in balance with energy requirements, based on the reference individual. It provides an additional context for understanding the HIRs score.

5. Results

The results for the proposed methodology are illustrated using the emergency food aid for 2006 for the two largest donors (the EC and the US) and the two largest recipients (Ethiopia and the Sudan).

5.1 Ethiopia: Tons emergency food aid donations by source

Table 3 shows the amounts in tons of emergency food aid donated to Ethiopia, in total, and by the USA and EC. **Figure 1** shows 70% of all emergency food aid to Ethiopia comes from the USA, with 15% coming from the EC and 15% from other donor countries. **Figure 2** further shows that most of the emergency food aid donated to Ethiopia, in tons, is mainly from wheat (53%) maize (17%) and corn soy blend (8%) which together contribute to 78% of the contribution to Ethiopia.

Table 3: Emergency food aid to Ethiopia by Commodity in Tons

commodity	Metric tons From USA	Metric tons From EC	Total tons	Commodity in Proportion to Total Tons (%)
BEANS	-	-	3111	0.5%
CER & GRAINS	-	-	170	0.0%
CORN SOY BLD	45558	-	56208	8.5%
EDIBLE FAT	-	15	15	0.0%
FAFFA	-	5479	22189	3.4%
H.R.W.WHT	41995	-	41995	6.3%
IODISED SALT	-	-	150	0.0%
LENTILS	23749	-	23949	3.6%
MAIZE	2417	40700	109630	16.6%
PEAS	2650	-	2650	0.4%
RICE	5460	-	5460	0.8%
SOFT WHEAT	17450	-	17450	2.6%
SORGHUM	-	-	1088	0.2%
SOYA FLOUR	-	788	788	0.1%
SOYA OIL	-	-	45	0.0%
SUGAR	-	-	138	0.0%
VEG OIL	11159	-	13945	2.1%
WHEAT	268350	45962	347610	52.5%
WHEAT FLOUR	-	-	2693	0.4%
WHEAT SOYA BLD	3496	-	3496	0.5%
WHOLE PEAS	1130	-	1130	0.2%
YEL SPL PEAS	4286	-	7821	1.2%
Total Delivery	**427701**	**92943**	**661729**	100.0%

Figure 1: USA and EC contributions to Ethiopia

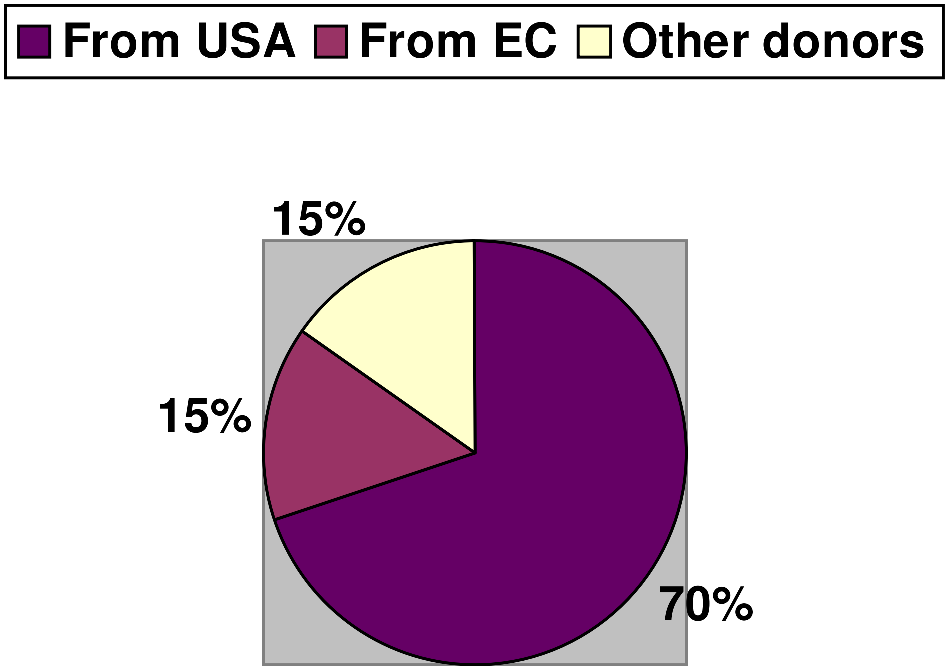


Figure 2: Composition of Emergency Food Aid to Ethiopia by Commodity

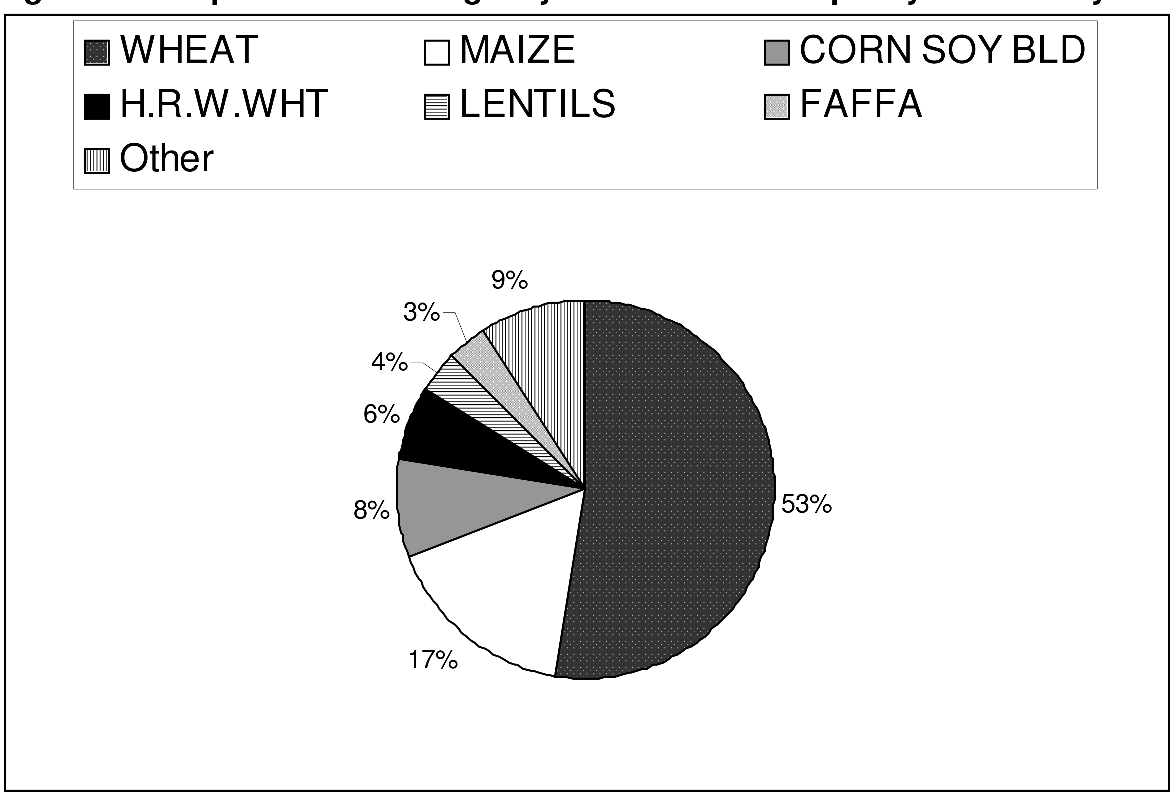


Table 4: HIRt for Ethiopia

	HIRT									
	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLVIN	NIACIN	VIT. C
USA contribution	1,959,448	2,933,721	1,356,428	1,634,885	495,896	**177,130**	4,447,081	1,080,634	7,847,573	2,073,561
EC contribution	417,499	564,564	198,703	289,035	0	315,211	931,396	270,255	1,206,592	160,832
Total Contribution	3,044,680	4,393,288	2,105,672	2,484,138	**694,366**	1,025,457	6,847,781	1,923,073	10,551,690	3,164,348

5.2 Ethiopia: Total Number of Hypothetical individual Requirements Met (HIRt)

Table 4 shows the total number of persons whose minimal energy requirements could potentially be met based on the 2100 kilocalories of energy (HIRt). The US contribution provides energy to meet the minimal needs of nearly 2 million reference individuals for a year, the EC contribution provides energy requirements for 417,000 reference individuals for a year and the total deliveries to Ethiopia meets the energy needs for just over 3 million reference individuals for a year. However, comparing across nutrients indicates there is imbalance in the nutrients provided by deliveries. Namely, HIRt values for the total contribution exceeds energy by more than double for thiamine and niacin whereas HIRt values for iodine is less than a quarter and vitamin A is only about a third of the energy HIRt. The US contribution to Ethiopia is limited by the contribution of vitamin A to the total deliveries, with the vitamin A (as measured in retinal equivalents) of the total contribution meeting the minimal needs of only 177,130 reference individuals for a year. Food composition tables do not include iodine for the commodities donated by the EC and therefore these results are inconclusive. Of the total contribution, the limiting micronutrient is iodine, with iodine values sufficient only to meet the minimal requirements of 694,366 per year. This finding may be related, in part, to poor data for the EC contribution.

Table 5: Annual HIR per metric ton of food aid to Ethiopia

	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLVIN	NIACIN	VIT. C
From USA	4.6	6.9	3.2	3.8	1.2	0.4	10.4	2.5	18.3	4.8
From EC	4.5	6.1	2.1	3.1	0	3.4	10.0	2.9	13.0	1.7
Total Delivery	4.6	6.6	3.2	3.8	1.0	1.5	10.3	2.9	15.9	4.8

5.3 Ethiopia: Annual HIR per metric ton of food aid

Table 5 shows that a representative average ton of food deliveries to Ethiopia provide energy to support 4.5 (EC contribution) or 4.6 reference individuals for one year (US contribution and total contribution). While the energy contribution values are very similar comparing donor and recipient contributions, other nutrients differ markedly. In the US contribution, the nutrient values are at or equal the HIR values for energy for 5 nutrients (energy, protein, thiamine, niacin and vitamin C). The results for the EC contribution are similar, but with 4 nutrients (energy, protein, thiamine, and niacin) meeting or exceeding energy contributions, as illustrated further in **Figure 3B.** The final row of **Table 5** and **Figure 3C** show the total deliveries, which is similar to the contribution from the USA, with the same nutrients meeting or exceeding the energy contribution and also similar HIR values for each of the nutrients. Using the scoring method of counting the number of nutrients that meet exceed the energy requirements (HIRc), the USA contribution scores a 5 on a 10 point scale, the EC contribution a 4 while total deliveries for Ethiopia are scored as a 5 altogether.

Figure 3A: HIRc for US contribution to Ethiopia: 5 nutrients meet minimal requirements at or equal the value of energy (including energy)

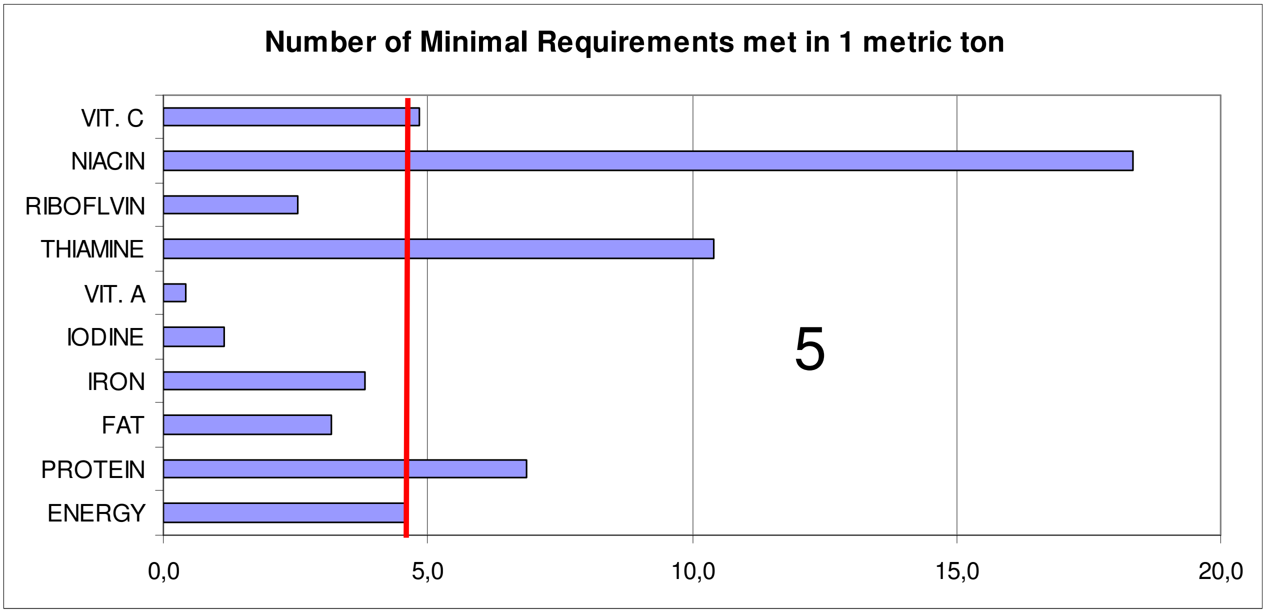


Figure 3B: HIRc for EC contribution to Ethiopia: 4 nutrients meet minimal requirements at or equal the value of energy (including energy)

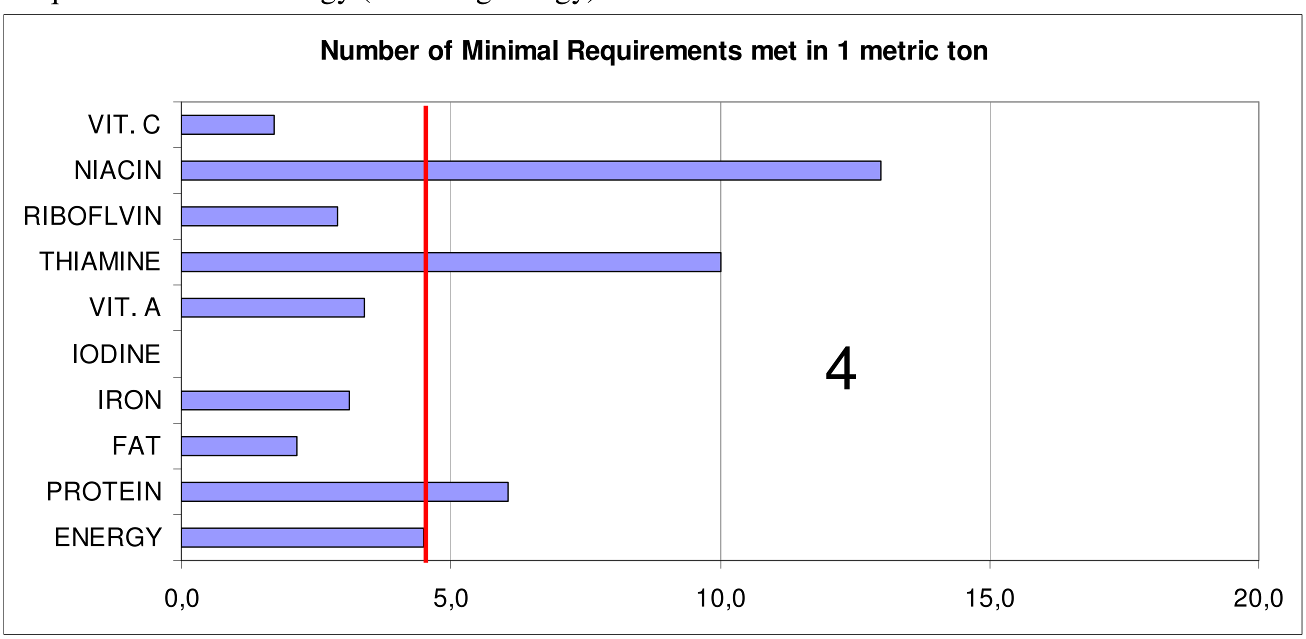


Figure 3C: HIRc for total to Ethiopia: Five nutrients meet minimal requirements at or equal the value of energy (including energy)

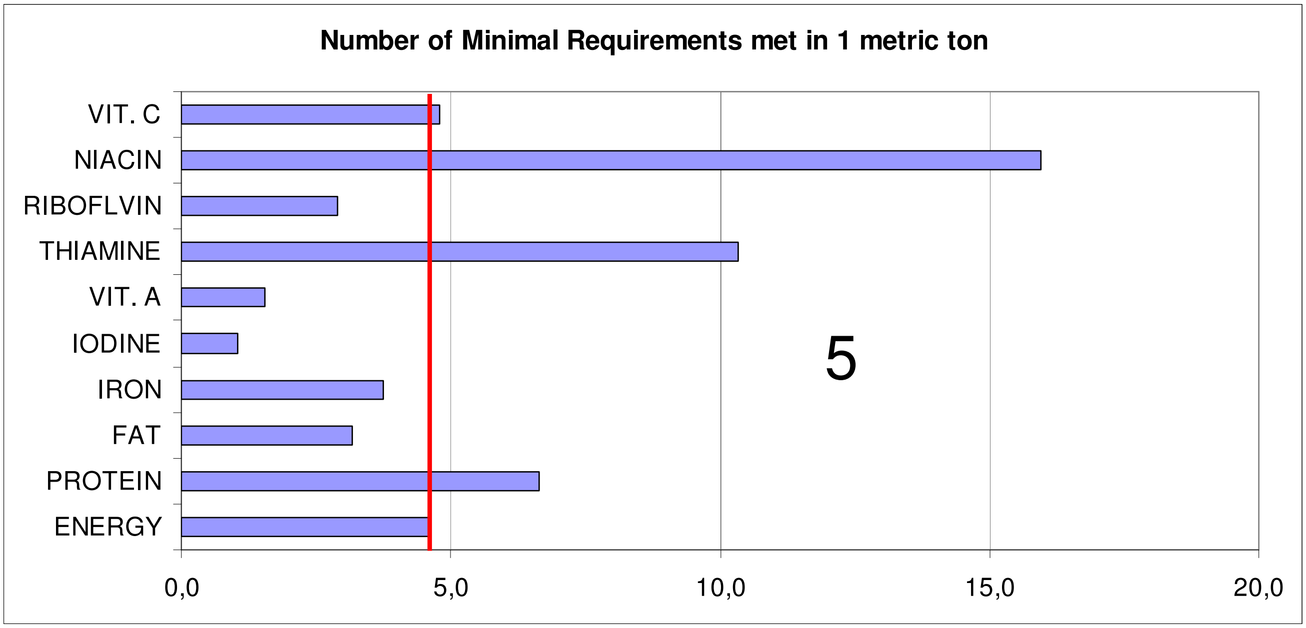


Table 6: Annual HIR per metric ton of food aid and HIR score (HIRs) for Ethiopia

	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLVIN	NIACIN	VIT. C	HIRS= AVERAGE
From USA	100%	100%	69%	83%	25%	9%	100%	55%	100%	100%	74%
From EC	100%	100%	48%	69%	0%	75%	100%	65%	100%	39%	70%
Total Delivery	100%	100%	69%	82%	23%	34%	100%	63%	100%	100%	77%

5.4 Ethiopia quality of donations: Annual HIR per metric ton of food aid and HIR score (HIRS)

Table 6 shows the HIR values expressed as a percentage of the HIR energy with all values exceeding the energy contribution capped at 100%. The HIR score "HIRs" is the average of the ten nutrients HIR values expressed as a percentage of HIR for energy. The HIR score of the USA contribution is 74% of the energy contribution. The average HIR value (HIRs) for the EC contribution is 74% of the energy contribution. The average for the total contribution of emergency food aid (HIRs) to Ethiopia overall is 77% of the HIR contribution for energy. Given the variability of the HIR values for individual nutrients, spider-web graphs are shown below to compare the nutrient HIR values. The nutrients with HIR values of less than 40% proportionate to the energy contribution are identified as nutrients needing particular attention. The USA contribution is thus particularly short in vitamin A and iodine relative to energy, the EC contribution is short in vitamin C and iodine relative to energy, and the total Ethiopia delivery is short in vitamin A and iodine relative to energy.

Figure 4A: The USA contribution to Ethiopia is short in vitamin A and iodine

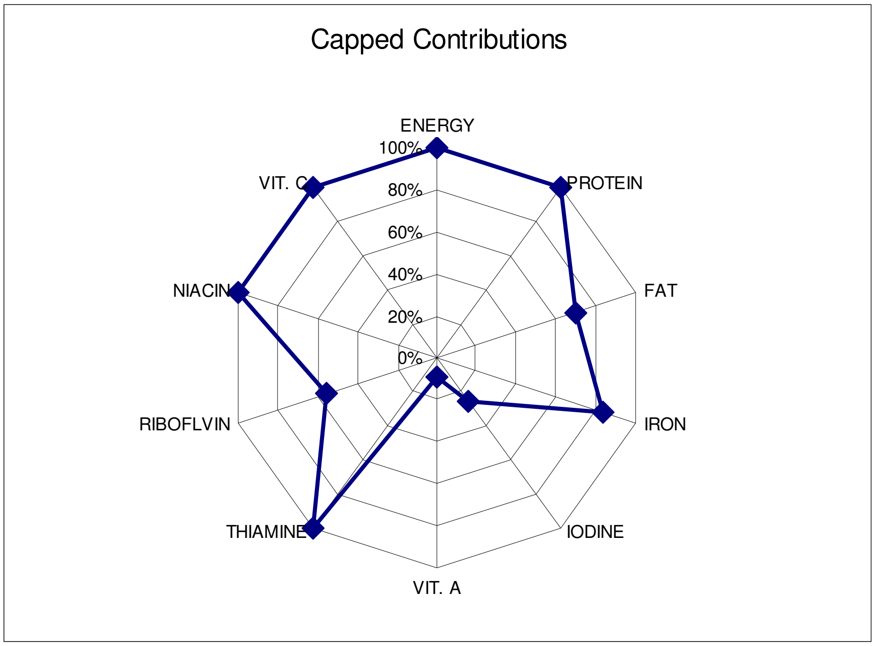


Figure 4B: The EC contribution to Ethiopia is most short in vitamin C and iodine

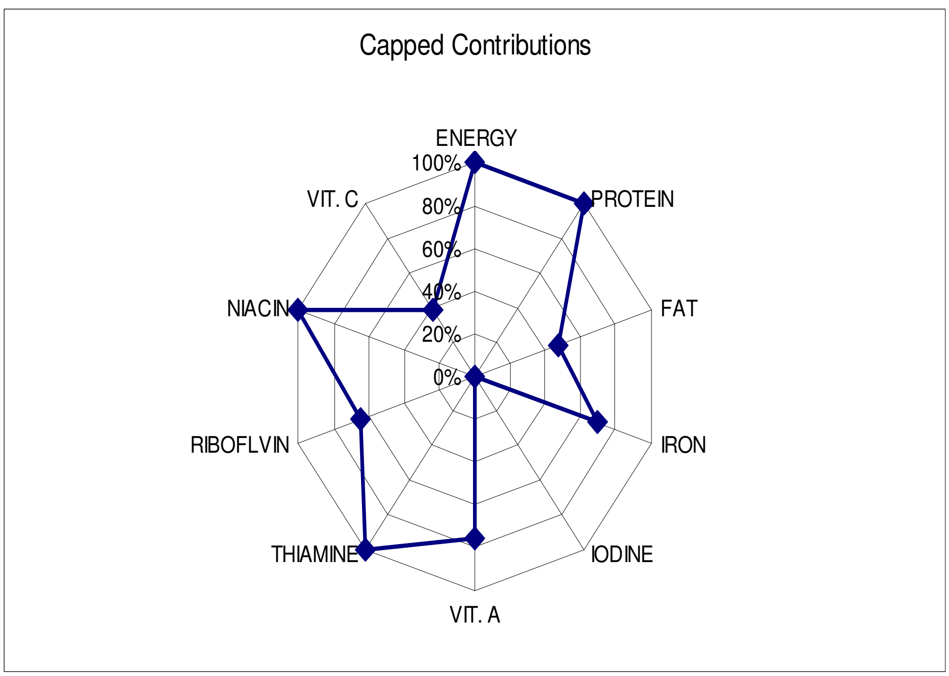
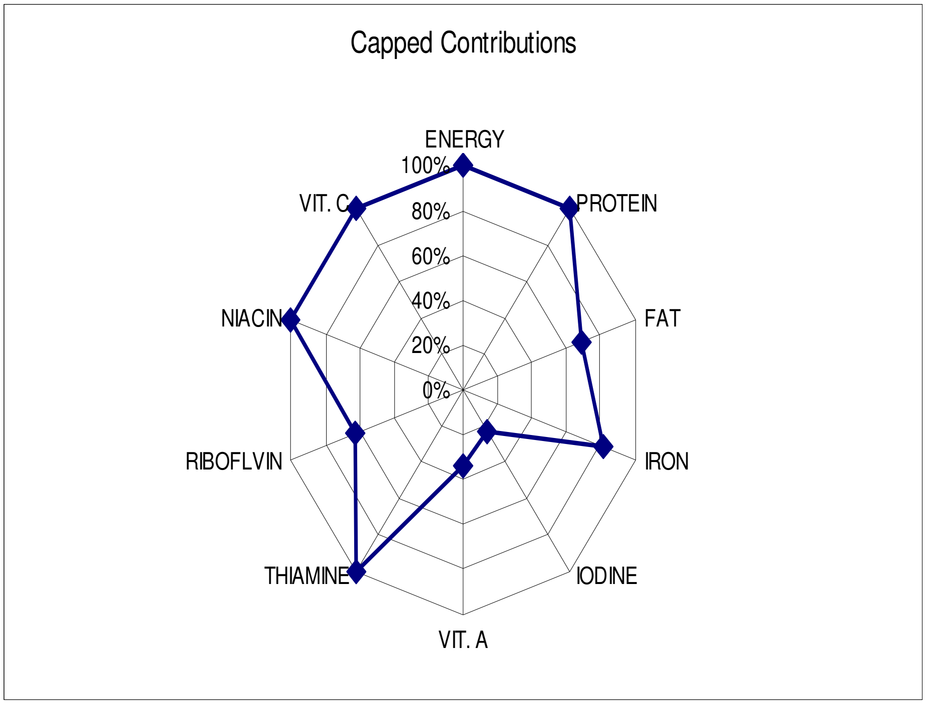


Figure 4C: Emergency Food Aid Deliveries to Ethiopia are most short in vitamin A and iodine



5.5 The Sudan: Tons emergency food aid donations by source

Table 7 shows the amounts in tons of emergency food aid donated to the Sudan, by the USA and EC and the total contribution. **Figure 5** shows 82% of all emergency food aid to Ethiopia comes from the USA, with 12% coming from the EC and 6% from other donor countries. **Figure 6** further shows that the emergency food aid donated to Ethiopia, in tons, are mainly from sorghum (55%), wheat (26%), lentils (5%), vegetable oil (4%) and corn soy blend (4%) which together contribute to 96% of the contribution to Sudan.

Table 7: Emergency food aid to the Sudan by Commodity in Metric Tons

Commodity	Metric tons From USA	Metric tons From EC	Total Metric tons	Commodity as % Metric Tons
BEANS	-	3300	4290	0.7%
BISCUITS	-	-	1	0.0%
CORN SOY BLD	12215	6540	23610	4.0%
DRY WHO MILK	-	-	5	0.0%
GROUND NUTS	-	536	3049	0.5%
IODISED SALT	80	6312	6452	1.1%
LENTILS	29328	1685	31038	5.3%
MAIZE	-	-	10	0.0%
MILK	-	-	0	0.0%
NUTS	-	-	35	0.0%
SALT			561	0.1%
SORGHUM	284131	30161	320073	54.6%
SOYA OIL	-	-	28	0.0%
SUGAR	326	14352	18685	3.2%
VEG OIL	15747	6842	24304	4.1%
WHEAT	136990	-	151691	25.9%
YEL SPL PEAS	-	810	2110	0.4%
Total Delivery	**478,816**	**70,538**	**585943**	**100%**

Figure 5: USA and EC contributions to the Sudan

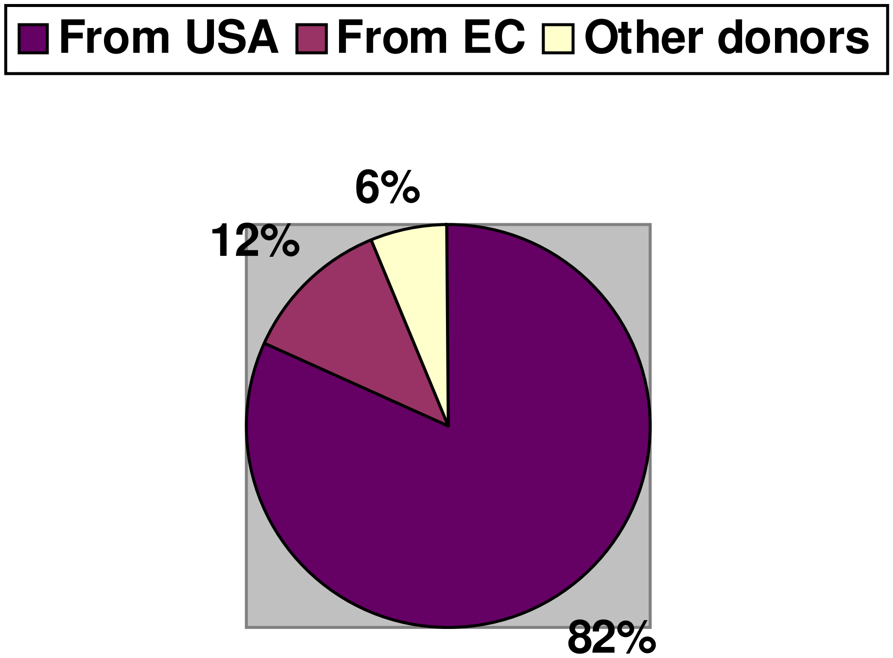


Figure 6: Composition of Emergency Food Aid to the Sudan by Commodity

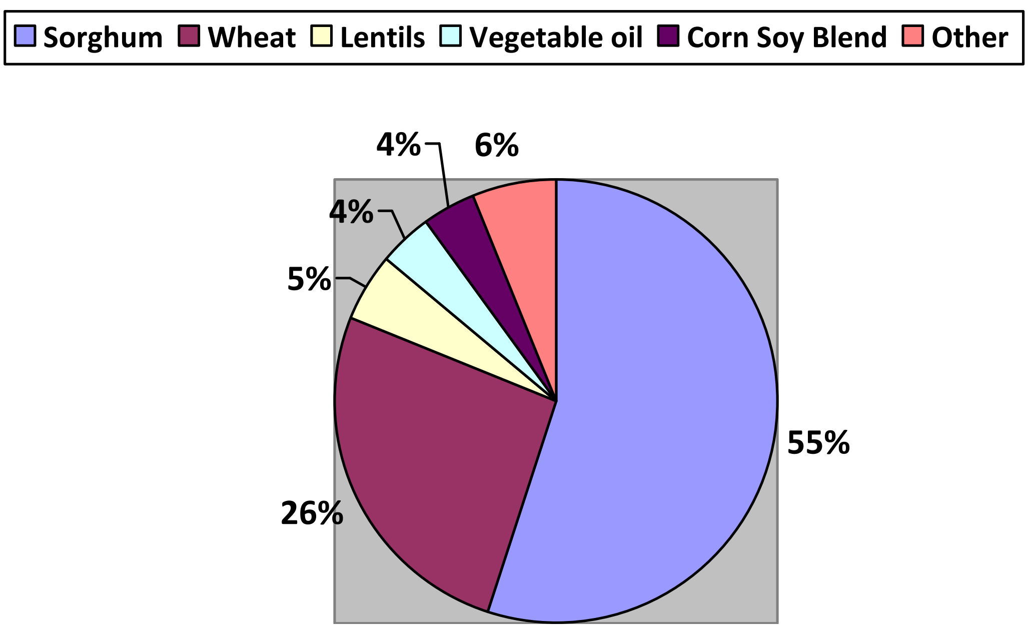


Table 8: HIRT: Total nutritional value of food aid to the Sudan

	HIRT									
	ENERGY	**PROTEIN**	**FAT**	**IRON**	**IODINE**	**VIT. A**	**THIAMINE**	**RIBOFLVIN**	**NIACIN**	**VIT. C**
USA contribution	2,146,210	2,926,066	1,872,895	1,539,767	202,418	**11,540**	4,817,438	1,279,923	6,659,244	650,258
EC contribution	347,620	307,688	582,727	199,413	3,542,303	**8,565**	520,249	175,716	537,438	283,433
Total Contribution	2,736,403	3,468,450	2,712,530	1,869,874	3,840,828	**28,221**	5,703,056	1,554,348	7,749,106	1,131,031

5.6 The Sudan: Number of Hypothetical individual Requirements Met (HIRT)

The first column of **Table 8** shows the total number of reference individuals whose minimal energy requirements could potentially be met for a year based on a daily requirement of 2100 kilocalories. The US contribution provides energy to meet the minimal needs of over 2.1 million reference individuals for a year, the EC contribution provides energy requirements for 347,620 reference individuals for a year and the total contribution to the Sudan can meet energy needs for just over 2.7 million reference individuals for a year. However, comparing values across nutrients indicates imbalance in nutrients. Namely, for the total contribution HIRt values for thiamine and niacin exceeds energy by more than double whereas HIRt values for vitamin A is only about 1% of the energy HIRt. All contributions to the Sudan are limited by the relatively low contribution of vitamin A (as measured in retinal equivalents). The US contribution meets all nutritional requirements for 11,540 reference individuals, with vitamin A being the limiting nutrient. Vitamin A is the limiting nutrient for the EC contribution also, meeting the needs of 8,564 reference individuals. The total emergency food aid deliveries to Sudan limited by vitamin A contributions and meets the minimal requirements of only 28,221 reference individuals for a year.

Table 9: Annual HIR per metric ton of food aid to the Sudan

	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLVIN	NIACIN	VIT. C
From USA	4.5	6.1	3.9	3.2	0.4	0.0	10.1	2.7	13.9	1.4
From EC	4.9	4.4	8.3	2.8	50.2	0.1	7.4	2.5	7.6	4.0
Total Delivery	4.7	5.9	4.6	3.2	6.6	0.0	9.7	2.7	13.2	1.9

5.7 The Sudan: Annual HIR per metric ton of food aid

Table 9 shows that the USA contribution provides, per average ton of food deliveries, energy requirements to meet the needs of 4.5 reference individuals. The EC contribution contributes energy to meet the needs of 4.9 reference individuals for one year. The total delivery meets the needs of 4.7 reference individuals for one year. These results are similar to the results for Ethiopia but with a somewhat higher energy contribution especially from the EC donations. As with the results from Ethiopia, the Sudan results show a wider range of values from the other 9 nutrients. In the US contribution, as shown in **Figure 7A,** the nutrient values are at or equal the HIR values for energy for 4 nutrients (energy, protein, thiamine, and niacin). The results for the EC contribution are similar, but with 5 nutrients (energy, fat, iodine, thiamine, and niacin) meeting or exceeding energy contributions, as illustrated in **Figure 7B.** The final row of **Table 9** and **Figure 7C** shows that the deficiencies in iodine from the USA contribution are offset by the high iodine HIR values of the EC contribution resulting in a total HIR iodine value of 6.6 adult requirements met for a year per metric ton of emergency food aid. Thus, the total score count shows an average ton of emergency food aid delivered to the Sudan providing 5 nutrients (energy, protein, iodine, thiamine and niacin) in proportion to or exceeding the HIR values for energy. Using the scoring method of counting the number of nutrients that meet or exceed the energy requirements, the USA contribution scores a 4 on a 10 point scale, the EC contribution a 5 and the total deliveries to Sudan as a 5.

Figure 7A: HIRc for US contribution to the Sudan: 5 nutrients meet minimal requirements at or equal the value of energy (including energy)

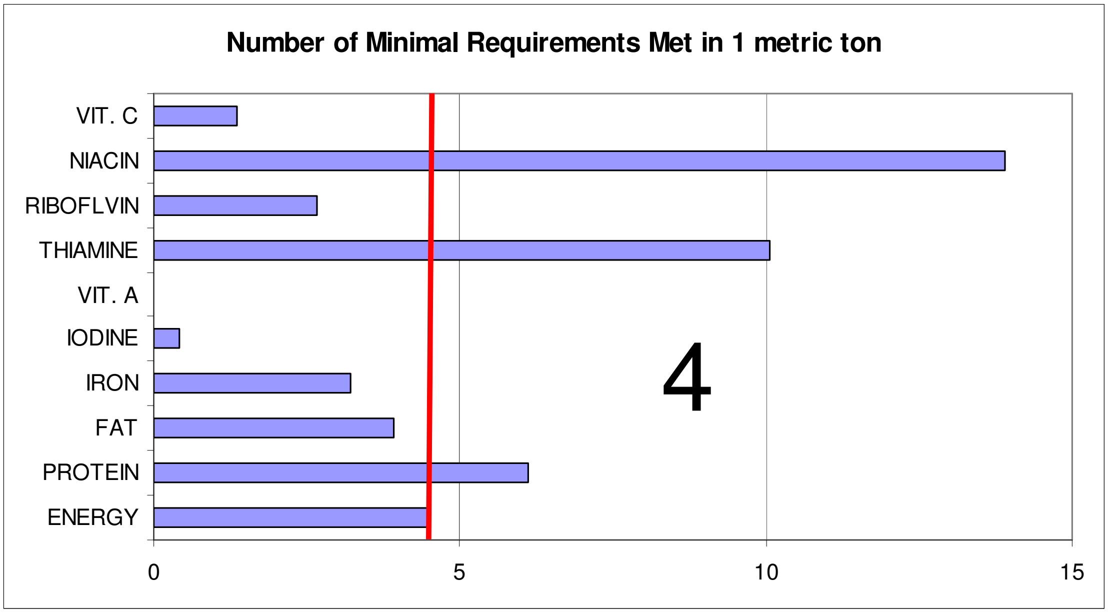


Figure 7B: HIRc for EC contribution to the Sudan: 5 nutrients meet minimal requirements at or equal the value of energy (including energy)

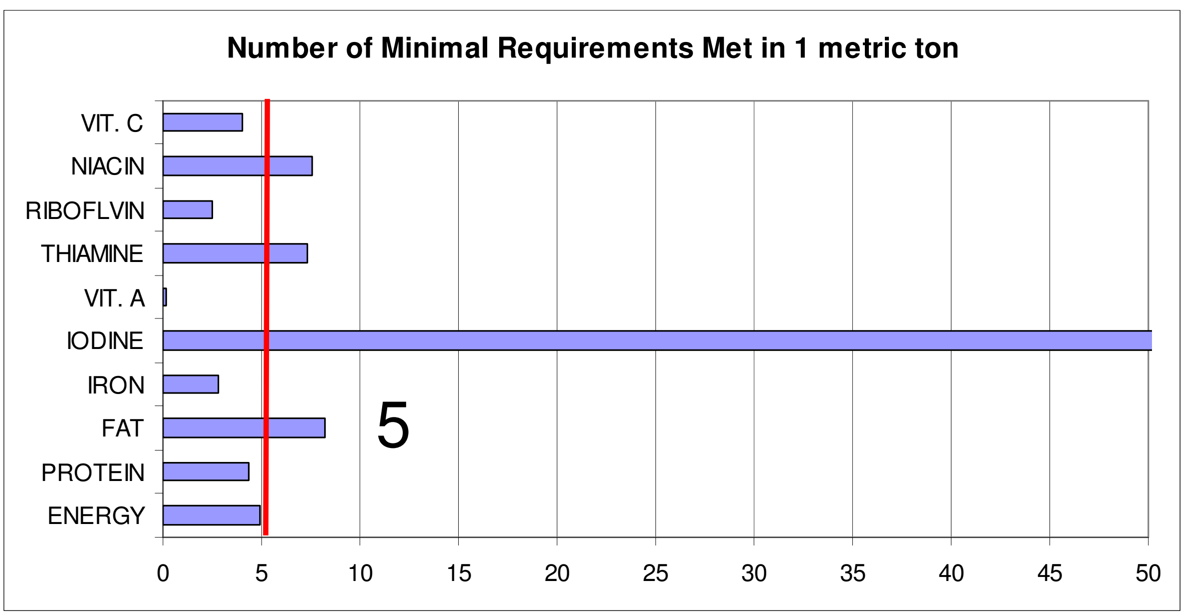


Figure 7C: HIRc for total to the Sudan: Five nutrients meet minimal requirements at or equal the value of energy (including energy)

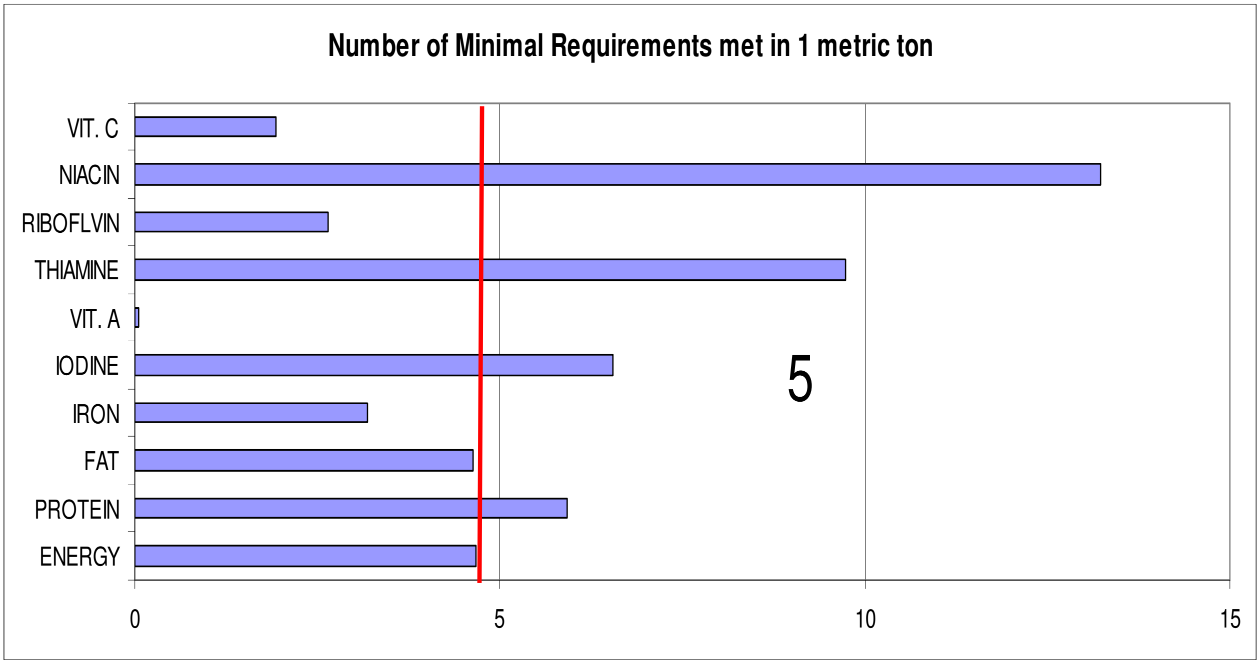


Table 10: The Sudan Annual HIR per metric ton of food aid and HIR score (HIRs)

	ENERGY	PROTEIN	FAT	IRON	IODINE	VIT. A	THIAMINE	RIBOFLVIN	NIACIN	VIT. C	HIRs= AVERAGE
From USA	100%	100%	87%	72%	9%	1%	100%	60%	100%	30%	66%
From EC	100%	89%	100%	57%	100%	2%	100%	51%	100%	82%	78%
Total Delivery	100%	100%	99%	68%	100%	1%	100%	57%	100%	41%	77%

5.8 The Sudan quality of donations: Annual HIR per metric ton of food aid and HIR score (HIRS)

Table 6 shows the HIR values expressed as a percentage of the HIR energy and capped at 100%. The final column shows the HIR score (HIRs) which is the average of the ten nutrient/energy HIR scores, as a percentage. The USA contribution shows HIRs as 66% of the energy HIR. The average HIR value (HIRs) for the EC contribution is 78% of the energy HIR value, and the average HIR value for the total contribution to Sudan is 77% of the HIR for energy, the same score as for Ethiopia. The total score shows only part of the picture, as specific nutrient percentages vary widely. These differences, shown in **Table 10,** are further illustrated in the spider-web graphs below. In the USA deliveries, the reference individual requirements met for iodine, vitamin A and vitamin C are less than 40% of the energy HIR (**Figure 8A)**, with the lowest value being for Vitamin A (at 1% of the HIR for energy). In the EC contribution (**Figure 8B)** and for the total Sudan delivery (**Figure 8C**) vitamin A is also identified as having the lowest contribution to nutritional requirements, relative to energy. Vitamin A HIR values provide requirements for only 1-2% relative to the energy needs met.

Figure 8A: USA contribution to the Sudan is short in vitamin C, vitamin A and iodine

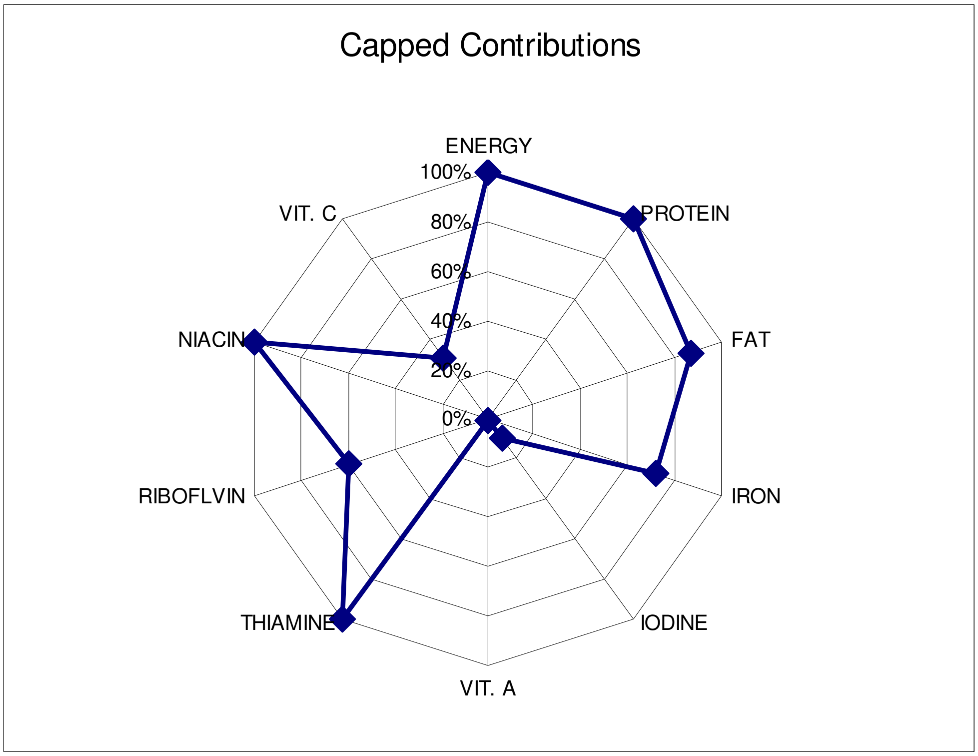


Figure 8B: EC contribution to the Sudan is short in vitamin A

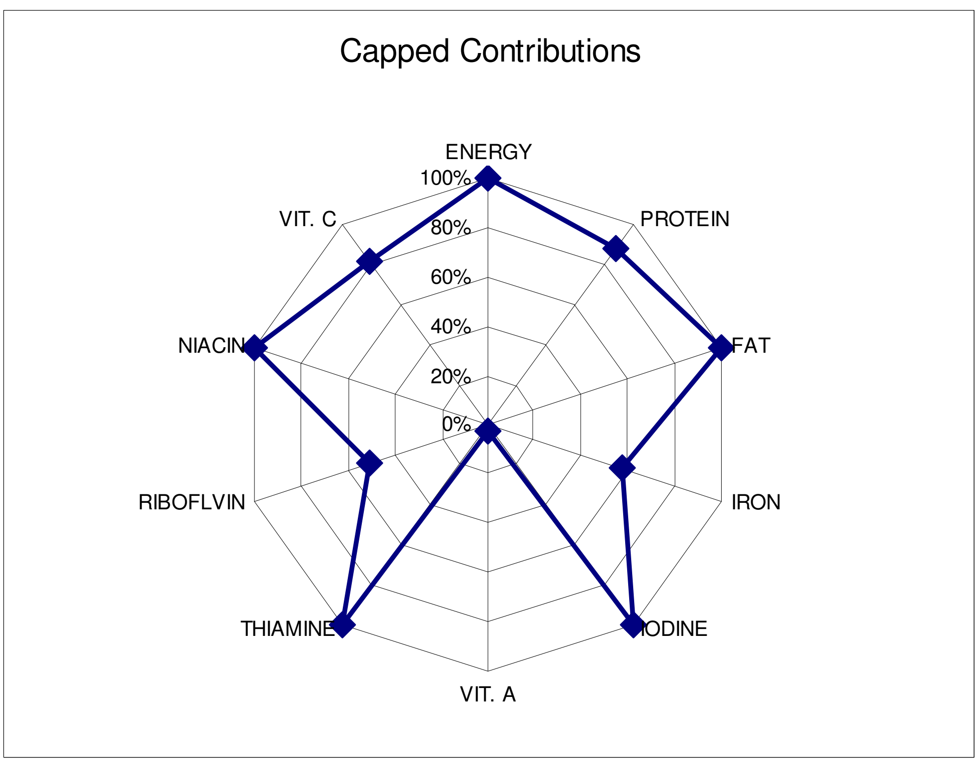
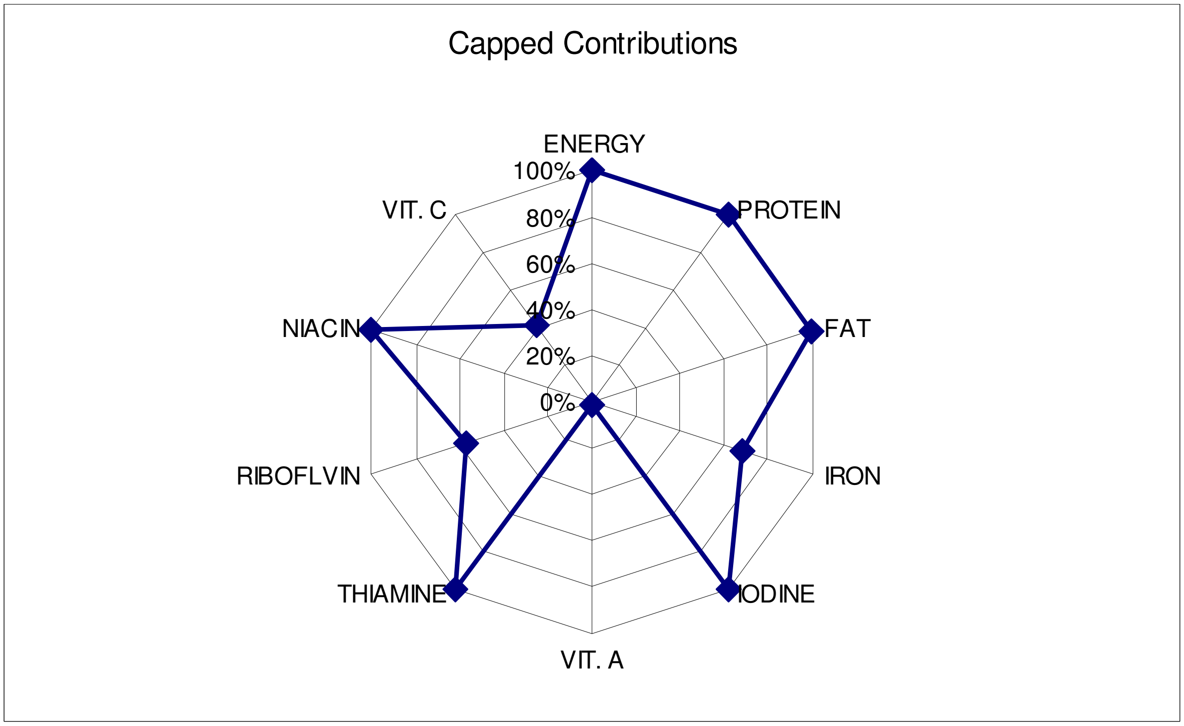


Figure 8C: Emergency food aid contributions to the Sudan are short in vitamin A



6. Discussion

6.1 Limitations

These calculations are based on the assumption that the ‘minimal requirements’ of populations in the emergency food aid is uniform across different settings. The validity of these measures is limited by whether the energy needs of the population reflect the 2100 kcal diet. Furthermore, the micronutrient density of pregnant women and children are known to be higher. Thus, these assumptions may over or underestimate the micronutrient quality of food aid relative to needs depending on the age demographics of the population, the endemic infectious diseases present that may influence nutrient density needs, behaviours, beliefs, and practices related to food culture or other conditions that may increase needs or reduce uptake of nutrients. In addition to potential underlying population differences, another limitation to comparisons between countries relates to the differences in the quality of the preferred staple foods. While donating a higher quality food may increase the quality score of the contribution, if that higher quality food is not accepted locally and if it does not fit in with local food practices, such foods may not be consumed. Thus, any changes to donations should be made with local food culture and preferences in mind. It is important to emphasize that the purpose of this analysis is not to make comparisons of donation quality between recipient countries but to give information to donors on what will improve the nutritional balance of the total donation. In particular, it is important to identify likely nutritional deficiencies and to use these methods to compare food aid deliveries over time.

The HIRt scores show the number of reference individuals whose requirements could be met for each of the 10 nutrients included in this analysis. A limitation of this analysis is the absence of food composition data on all micronutrients that have been identified as important. Furthermore, while this analysis allows for a calculation of the potential to meet the needs for a specific number of reference individuals, the analysis is only used as a tool for evaluating and scoring deliveries. The goal of the measures developed and presented here is not to present individual level information, but rather evaluation of food deliveries that are provided and distributed at the national level. While the methodology is based on the assumption that nutritionally balanced food deliveries would allow for an optimal balance of all nutrients in the food distributed to individuals, this project cannot assess the distribution of nutrients or foods to individuals. Analysis is not based on foods as cooked, or commodities as given to individuals, but as an assessment of food aid provided at the national level. These results are not intended to quantify the number of individuals whose nutritional needs are actually met by food aid but. Instead, these indices use the reference individual as a point of comparison that can be used to monitor both the quantity and nutritional quality of deliveries over time.

6.2 Application of quality indicators in the broader context.

The methodology used in this analysis is applied specifically to the conditions of the emergency food aid context. However, the index counts the number of hypothetical individual requirements met for macro and micronutrients providing information about both the quantity and quality of food aid. In the context of an emergency where beneficiaries have limited or no access to other food sources, the hypothetical reference individual is closer to the needs of beneficiaries. Outside of the emergency food aid context, the objectives of food aid, through programmes or projects, differ. To the extent that aims of programmes and projects can be translated into meeting the needs of specific micro- or macro-nutrient requirements for a specific number of people, these indices could be adapted. The hypothetical reference individual can be replaced with a sum of the actual nutritional needs in the population. All scores could be revised to sum the nutritional requirements needed and how well these are fulfilled by food aid donations provided. Even outside of the emergency food aid context, where programme and project aims can be translated into nutrient requirements these scores can be applied. Thus, nutritional contribution of the food aid deliveries can be compared to the nutritional requirements needed to meet the aims of projects/programmes. Instead of comparing the total HIR values relative to energy, the comparison would be the HIR values required to meet the programme and project objectives. However, it is important to note that these scores cannot be used where the goals of programmes and projects cannot be translated into nutritional requirements.

6.3 Using HIR to identify gaps and needs

The results show that these indicators provide practical information identifying nutrients that are not in balance with energy. The indicators used here help to identify macronutrient or micronutrient imbalance in the commodities as given. The first measures shows the number of reference individuals whose requirements could be met, per nutrient, by the total package under the assumption that the nutrients are equally distributed in packages across the population. Identifying imbalances may help to reduce nutritional deficiencies if the imbalance can be avoided through provision of supplements or by encouraging local foods that are rich in the nutrients not covered by the food aid deliveries. Thus, these indices scoring food aid deliveries could aid in planning.

The numbers here do not represent the actual number of individuals whose needs are met but rather the number of reference individuals whose minimal requirements are met. These calculations do not reflect feasible, or even necessarily optimal, food aid distribution strategies. This analysis provides ‘hypothetical’ numbers of reference individual requirements met, with the simplifying assumption that nutrients are distributed equally. Theoretically, if the nutritional quality were proportionate in the total food delivery, in a manner than could be easily partitioned into food aid packages, a perfectly balanced delivery could provide food packages with 100% of the minimal requirements for all nutrients. However, in reality nutrients are distributed in foods with unequal concentrations of macro and micronutrients. Thus, even a perfectly nutritionally balanced donation of food aid delivery may not translate directly into nutrient requirements being met. Further analysis is needed to assess the relationship between a high score for food aid deliveries to the nutritional needs of individuals in recipient countries with direct assessments of the quality of food aid provided. More importantly, it is essential to evaluate whether improvements to the micronutrient quality of deliveries also translate into improvements in the micronutrient quality of food aid, as distributed and as consumed, by individuals.

In spite of the limitations, these results together can be used to illustrate existing imbalances in food deliveries. Most importantly, are the requirements met also for protein, fat and micronutrients proportional to energy? In both Ethiopia and in the Sudan, one ton of food aid provides the energy needs for 4.6 or 4.7 reference individuals per year respectively. From that same annual ton of food aid, an even greater number of minimal requirements are met for protein, niacin and thiamine. However, while protein, niacin and thiamine are abundant, these findings show a deficit compared to energy for 5 of the ten nutrients. Furthermore, it is notable that food aid deliveries to both countries provide fewer minimal requirements for vitamin A, riboflavin and iron in comparison to energy. Although the USA deliveries to the Sudan, making up 82% of the total contribution, are short in iodine, the contribution of iodized salt by the EC fills the gap. These results illustrate the importance of iodized salt to potentially improving the quality of emergency food aid deliveries to Ethiopia.

7. References

Allen LH. To what extent can food-based approaches improve micronutrient status? J Nutr. 2002 Mar; 132(3):495S-499S.

Armelagos, G, Goodman A, Jacobs K. The origins of agriculture: Population growth during a period of declining health. Population and Environment 13(1): 9-22, 1991.

Bahl R, Bhandari N, Hambidge KM, Bhan MK. Plasma zinc as a predictor of diarrheal and respiratory morbidity in children in an urban slum setting. Am J Clin Nutr. 1998 Aug;68 (2 Suppl):414S-417S.

Bhutta ZA, Black RE, Brown KH, Gardner JM, Gore S, Hidayat A, Khatun F, Martorell R, Ninh NX, Penny ME, Rosado JL, Roy SK, Ruel M, Sazawal S, Shankar A. Prevention of diarrhea and pneumonia by zinc supplementation in children in developing countries: pooled analysis of randomized controlled trials. Zinc Investigators' Collaborative Group. J Pediatr. 1999 Dec;135(6):689-97.

Bhutta ZA, Bird SM, Black RE, Brown KH, Gardner JM, Hidayat A, Khatun F, Martorell R, Ninh NX, Penny ME, Rosado JL, Roy SK, Ruel M, Sazawal S, Shankar A. Therapeutic effects of oral zinc in acute and persistent diarrhea in children in developing countries: pooled analysis of randomized controlled trials.
Am J Clin Nutr. 2000 Dec;72(6):1516-22.

Black, R. Zinc Deficiency, Infectious Disease and Mortality in the
Developing World J Nutr. 2003 May;133(5 Suppl 1):1485S-9S.

Bloem MW, Wedel M, Egger RJ, Speek AJ, Schrijver J, Saowakontha S, Schreurs WH. Mild vitamin A deficiency and risk of respiratory tract diseases and diarrhea in preschool and school children in northeastern Thailand. Am J Epidemiol. 1990 Feb;131(2):332-9.

van den Briel T, Cheung E, Zewari J, Khan R. Fortifying food in the field to boost nutrition: case studies from Afghanistan, Angola, and Zambia. Food Nutr Bull. 2007 Sep;28(3):353-64

Caulfield LE, Richard SA, Black RE. Undernutrition as an underlying cause of malaria morbidity and mortality in children less than five years old. Am J Trop Med Hyg. 2004 Aug;71(2 Suppl):55-63.

Clark TD, Semba RD.Iron supplementation during human immunodeficiency virus infection: a double-edged sword? Med Hypotheses. 2001 Oct;57(4):476-9.

Combs GF Jr, Duxbury JM, Welch RM. Food systems for improved health: linking agricultural production and human nutrition. Eur J Clin Nutr. 1997 Nov;51 Suppl 4:S32-3.

Cordain L, Eaton SB, Sebastian A, Mann N, Lindeberg S, Watkins BA, O'Keefe JH, Brand-Miller J. Origins and evolution of the Western diet: health implications for the 21st century.

Am J Clin Nutr. 2005 Feb;81(2):341-54.

Cuevas LE, Koyanagi A. Zinc and infection: a review.Ann Trop Paediatr. 2005 Sep;25(3):149-60

Darmon N, Ferguson E, Briend A**.** Linear and nonlinear programming to optimize the nutrient density of a population's diet: an example based on diets of preschool children in rural Malawi Am J Clin Nutr 2002 75: 245-253.

Drewnowski, A. Concept of a nutritious food: toward a nutrient density score. Am J Clin Nutr. 2005 Oct;82(4):721-32

FAO. 'Nutrient Composition of Selected Foods' Annex No. 3. FAO Food and Nutrition Paper 23: Management of Group Feeding Programmes, Rome, 1982.

Graham NM, Sorensen D, Odaka N, Brookmeyer R, Chan D, Willett WC, Morris JS, Saah AJ.Relationship of serum copper and zinc levels to HIV-1 seropositivity and progression to AIDS.J Acquir Immune Defic Syndr. 1991;4(10):976-80.

Guinovart C, Navia MM, Tanner M, Alonso PL.Malaria: burden of disease.
Curr Mol Med. 2006 Mar;6(2):137-40.

Harakeh S, Niedzwiecki A, Jariwalla RJ.Mechanistic aspects of ascorbate inhibition of human immunodeficiency virus. Chem Biol Interact. 1994 Jun;91(2-3):207-15.

Harakeh S, Jariwalla RJ.Ascorbate effect on cytokine stimulation of HIV production. Nutrition. 1995 Sep-Oct;11(5 Suppl):684-7

Johnson WB, Aderele WI, Gbadero DA.Host factors and acute lower respiratory infections in pre-school children. J Trop Pediatr. 1992 Jun;38(3):132-6.

Klotz, Christine, Saskia de Pee1, Andrew Thorne-Lyman, Klaus Kraemer, Martin Bloem. February 2008. “Nutrition in the Perfect Storm: Why Micronutrient Malnutrition will be a Widespread Health Consequence of High Food Prices.” Sight and Life, Magazine Issue 2/2008.

Mathers CD, Ezzati M, Lopez AD.Measuring the burden of neglected tropical diseases: the global burden of disease framework.PLoS Negl Trop Dis. 2007 Nov 7;1(2):e114

Mitra AK, Alvarez JO, Wahed MA, Fuchs GJ, Stephensen CB. Predictors of serum retinol in children with shigellosis. Am J Clin Nutr. 1998 Nov;68(5):1088-94.

Penny ME, Lanata CF. Zinc in the management of diarrhea in young children.
N Engl J Med. 1995 Sep 28;333(13):873-4.

Proc Nutr Soc. 2002 May;61(2):243-50 Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world.

The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Foods, UK. 'The Composition of Foods' McCance and Widdowson, Fifth Edition, 1991

Semba RD, Miotti PG, Chiphangwi JD, Liomba G, Yang LP, Saah AJ, Dallabetta GA, Hoover DR.Infant mortality and maternal vitamin A deficiency during human immunodeficiency virus infection. Clin Infect Dis. 1995 Oct;21(4):966-72.

Tontisirin K, Nantel G, Bhattacharjee L. Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. Proc Nutr Soc. 2002 May;61(2):243-50.

Welch RM, Graham RD. Breeding for micronutrients in staple food crops from a human nutrition perspective. J Exp Bot. 2004 Feb;55(396):353-64.

Welch RM. Breeding strategies for biofortified staple plant foods to reduce micronutrient malnutrition globally. J Nutr. 2002 Mar;132(3):495S-499S.

Krishna S, Taylor AM, Supanaranond W, Pukrittayakamee S, ter Kuile F, Tawfiq KM, Holloway PA, White NJ. Thiamine deficiency and malaria in adults from southeast Asia. Lancet. 1999 Feb 13;353(9152):546-9.

Nyakeriga AM, Troye-Blomberg M, Chemtai AK, Marsh K, Williams TN.
Malaria and nutritional status in children living on the coast of Kenya.
Am J Clin Nutr. 2004 Dec;80(6):1604-10.

NutVal programme. The planning, calculation and monitoring application for general food aid rations. Accessed 23 November, 2008. http://www.NutVal.net/2008/05/download-page.html

Richard SA, Zavaleta N, Caulfield LE, Black RE, Witzig RS, Shankar AH.
Zinc and iron supplementation and malaria, diarrhea, and respiratory infections in children in the Peruvian Amazon. Am J Trop Med Hyg. 2006 Jul;75(1):126-32.

Sommer A., Katz J., Tarwotjo I., Increased rsik of respiratory disease and diarrhea in children with preexisting mild vitamin A deficiency. Am. J. Clinical Nutr.1984;40;1090-1095

Tang AM, Graham NM, Saah AJ. Effects of micronutrient intake on survival in human immunodeficiency virus type 1 infection.Am J Epidemiol. 1996 Jun 15;143(12):1244-56.

Tang AM, Graham NM, Kirby AJ, McCall LD, Willett WC, Saah AJ.Dietary micronutrient intake and risk of progression to acquired immunodeficiency syndrome (AIDS) in human immunodeficiency virus type 1 (HIV-1)-infected homosexual men.Am J Epidemiol. 1993 Dec 1;138(11):937-51.

Traoré HN, Meyer D.The effect of iron overload on in vitro HIV-1 infection.

J Clin Virol. 2004 Dec;31 Suppl 1:S92-8.

USAID. USAID Commodities Reference Guide.
(http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/)

'USDA National Nutrient Database for Standard Reference, Releases 15 -18' U.S. Department of Agriculture, Agricultural Research Service. Nutrient Data Laboratory Home Page, (http://www.ars.usda.gov/main/site_main.htm?modecode=12354500)

UNHCR, UNICEF, WFP, WHO. Food and Nutrition Needs in Emergencies. 2002.

World Health Organization, World Food Programme, and Unicef. 2002. Preventing and controlling micronutrient deficiencies in populations affected by an emergency: Multivitamin and mineral supplements for pregnant and lactating women, and for children aged 6 to 59 months. Joint statement by the Wealth Organization, the World Food Programme and the United Nations Children's Fund.

World Food Programme*, 2006 Food Aid Flows*. 2007. World Food Programme. Rome, Italy.

World Food Programme*, 2007 Food Aid Flows*. 2008. World Food Programme. Rome, Italy.

World Food Programme. Food and Nutrition Handbook. 2002.

World Health Organization. Nutrient requirements for people living with HIV/AIDS *Report of a technical consultation* World Health organization. Geneva WHO consultation report. (http://www.who.int/nutrition/publications/Content_nutrient_requirements.pdf).