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Developing Rations for Home Grown School Feeding

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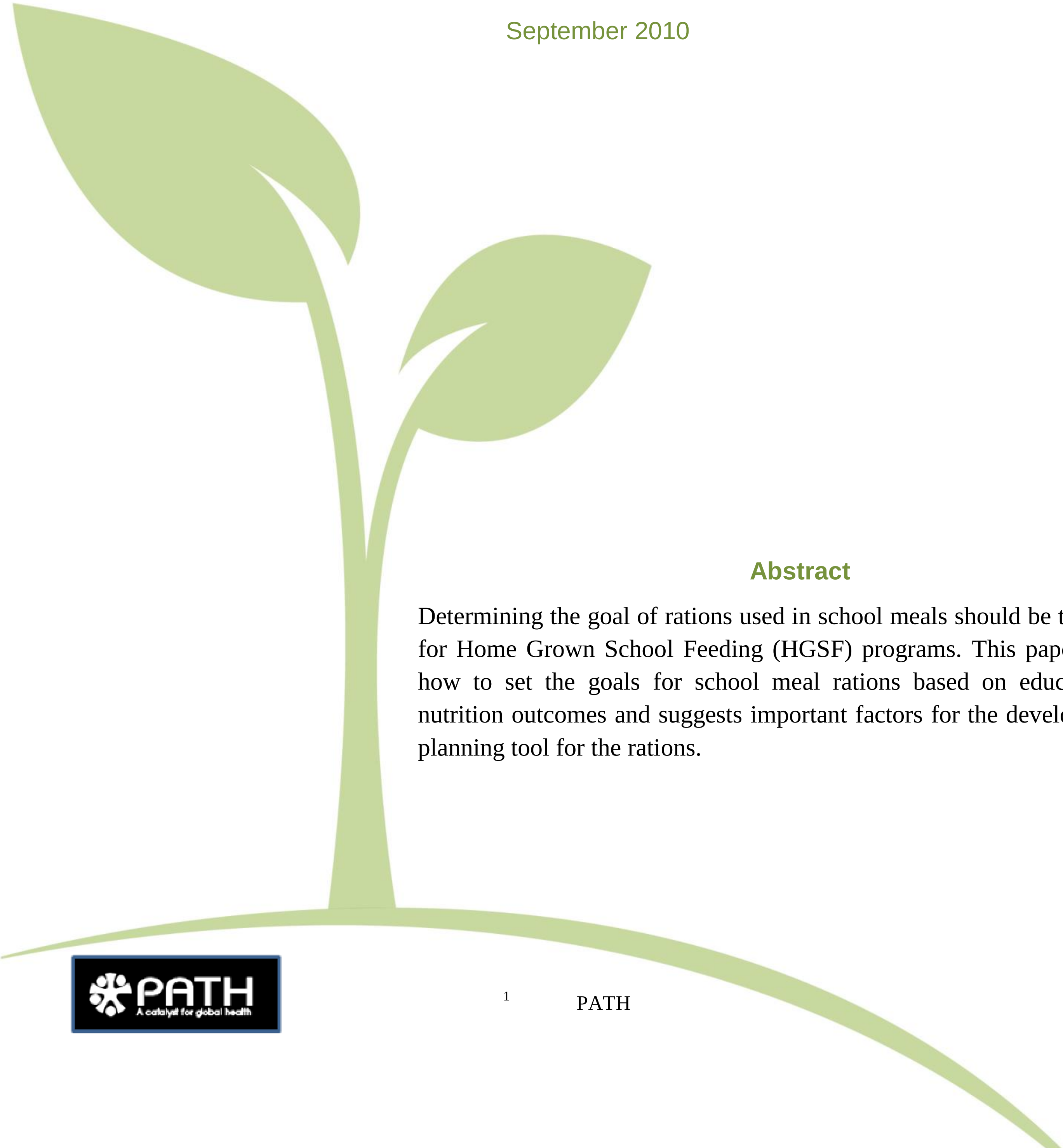

Abstract

Determining the goal of rations used in school meals should be the first step for Home Grown School Feeding (HGSF) programs. This paper discusses how to set the goals for school meal rations based on educational and nutrition outcomes and suggests important factors for the development of a planning tool for the rations.

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[1] PATH

ACRONYMS/ABBREVIATIONS

DHS	Demographic and Health Survey
DRI	dietary reference intake
FAO	Food and Agriculture Organization (of the United Nations)
g	gram
HGSF	Home Grown School Feeding
mg	milligram
PDCAAS	protein digestibility corrected amino acid score
RAE	retinol activity equivalent
RDA	recommended daily allowance
μg	microgram
UNICEF	United Nations Children Fund
UNU	United Nations University
USDA	United States Department of Agriculture
WFP	World Food Programme
WHO	World Health Organization (of the United Nations)

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I. Background

The Partnership for Child Development, based at Imperial College, London, is leading the Home Grown School Feeding (HGSF) initiative in four countries (Ghana, Kenya, Mali, and Nigeria). The initiative includes a wide range of stakeholders, including Ministries of Agriculture, Education, and Health; smallholder farmers; and school children and their families. The goal of the HGSF initiative is to stimulate local agriculture production by making school feeding programs one market for locally grown commodities. Creating a link between local agriculture production and school feeding programs has the potential to improve the income and livelihoods of smallholder farmers and diversify the foods that school children consume.

Assessments in four countries (Ghana, Kenya, Mali, and Rwanda), conducted by the United States Department of Agriculture (USDA),[1] recommended that "menu, kilocalorie, and nutritional guidelines" be established by countries participating in the HGSF initiative. However, the need for these guidelines will depend on the objective of the ration itself, and determining the goal of the ration should be the first step for HGSF programs. Currently, World Food Programme (WFP) school feeding rations in low-income countries are driven by what is donated. The majority of these donations are staple foods common to the country or region. In Southern and Eastern Africa, for example, the rations provided by the WFP include maize meal, iodized salt used in cooking, and in some cases, oil. Legumes are added when they are available from donors. In a survey of school feeding sites in 2006 in Kenya, it was found that some schools asked parents to contribute legumes to add to the maize ration.[2] In some countries, the food staple is fortified with micronutrients, as in Malawi. In India, Ultra Rice®, fortified rice flour that is extruded to look like a granule of rice, is blended in some areas with the school rice ration provided by state governments to improve the iron status of school children.[3] Fortified biscuits and snacks have been used in both a research setting[4] and national programs.[5]

While staple foods have been shown to increase enrollment, attendance, and retention, there is less evidence they will improve the nutritional status of school children, although there is some conflicting information about this in the literature that will be discussed subsequently. In general, the returns for improving nutritional status have been disappointing because school feeding programs act more as an income transfer rather than augmenting the child's diet, and allow families to feed their school-going children less at home, often called "the substitution effect," and to spend the savings on food on other things. If the goal of the HGSF program is to also improve the nutritional status of school children by increasing energy intake, staples provided in school feeding programs will need to be additive to the child's diet, and complementary educational programs to reduce substitution will be needed. If the goal is to improve the micronutrient status of school children, other foods (e.g., nutrient-dense staples such as orange-fleshed sweet potatoes, fruits, vegetables, and animal products) will need to be part of the ration or the ration will need to be fortified with

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[1] United States Department of Agriculture (USDA), Foreign Agriculture Service, Office of Capacity Building and Development. Assessments of Local Production for School Feeding: Reports for Ghana (June 1-12, 2009), Kenya (June 19-July 1, 2009), Mali (April 26-May 8, 2009) and Rwanda (July 8-22, 2009).

[2] Galloway R. Cost analysis of school feeding programs in the Gambia and Kenya. Trip report to the World Bank. 2006.

[3] PATH. Ultra Rice Technology: An invisible bounty. http://www.path.org/projects/ultra_rice.php

[4] van Stuijvenberg ME, Kvalsvig JD, Faber M, Kruger M, Kenoyer DG, Spinnler Benadé AJ. Effect of iron-, iodine-, and ß-carotene-fortified biscuits on micronutrient status of primary school children: a randomized controlled trial. *American Journal of Clinical Nutrition.* 1999; 69:497-503.

[5] Ahmed AU, del Ninno C. Food for education program in Bangladesh: an evaluation of its impact on educational attainment and food security. Food Consumption and Nutrition Division, IFPRI. Washington, DC: IFPRI; 2002.

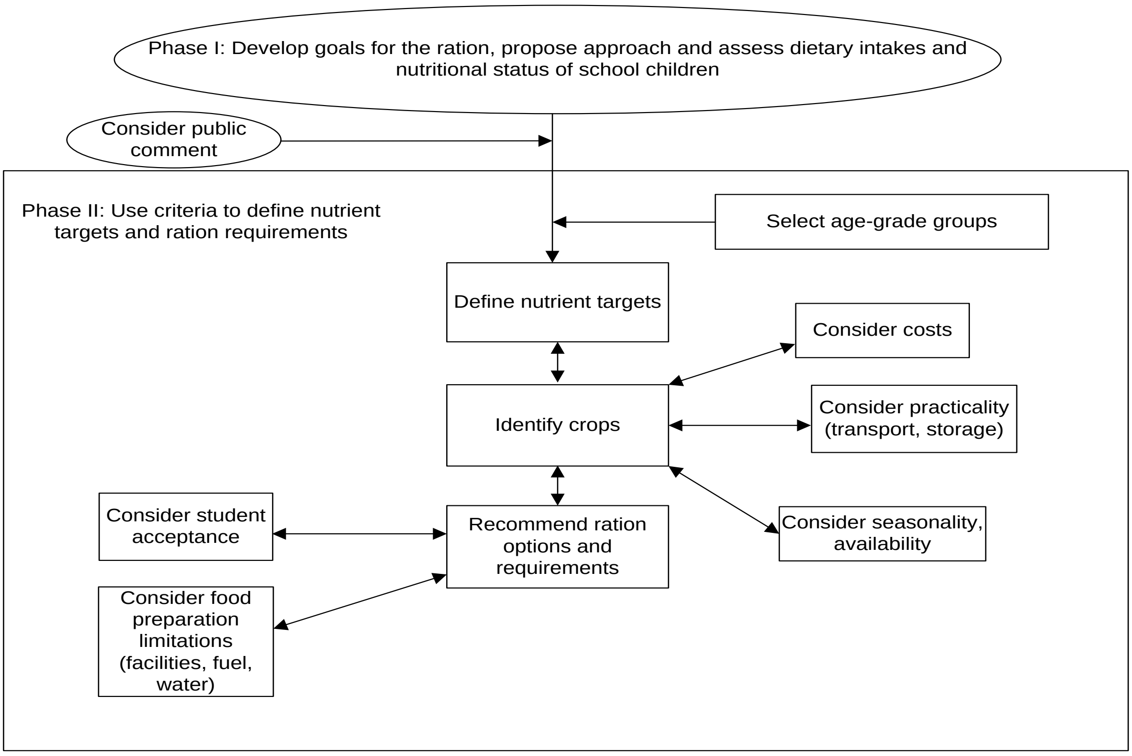
micronutrients in school feeding programs. Improving the nutritional status of school children, particularly improving intake of some of the micronutrients, such as iron and iodine, will lead to improved cognitive function as well as improving enrollment, attendance, and retention. To do this, planning with farmers will be needed to assess what is currently being grown and the types of foods they need to produce in the future that meet educational and nutritional goals of the HGSF programs.

This paper discusses how to set the goals for rations based on educational and nutrition outcomes and suggests important factors for the development of a planning tool for the rations.

II. Where to Start? A Framework for Developing Food Rations for Home Grown School Feeding Programs

A. The Proposed Framework and Choosing Objectives and Goals

A proposed framework or pathway, adapted from the model for school feeding programs in the United States, for developing rations for HGSF programs is shown in **Figure 1.**



Adapted from School Meals: Building Blocks for Healthy Children, NAS, 2010

Figure 1: Proposed framework for developing Home Grown School Feeding rations.

Phase 1 should consist of defining the goal of the ration and proposing the approach for meeting the goal. Most all Ministries of Education want to improve educational outcomes through school feeding programs. If the goal is also nutrition-related, ideally the type of ration should be based on the nutritional status and dietary intakes and needs of school children, but this may not be known. In most developing countries, there are no national surveys on the nutritional status of school-aged children or children attending school. There is even less information about what school-aged children are consuming. Collecting this information could be part of this phase and would be useful in establishing a baseline on the nutritional status of children and their dietary intakes and designing the ration. However, these surveys are often costly and are not a prerequisite for ration development and program implementation.

In most developing countries, Demographic and Health Surveys (DHS) collect nutritional status data and qualitative information on dietary intake for children less than five years of age. This information is disaggregated by age group and nutritional status, and qualitative dietary information for five-year-old children is available. Thus DHS information for children four to five years old can be used as a proxy for the nutritional status and dietary intake (qualitative) of children around the time they are entering school.

For HGSF programs, the objective or objectives will vary by country. Three goals for HGSF programs that have been recommended and are positioned in the Comprehensive Africa Agriculture Development Programme, led by the New Partnership for Africa's Development, include: (1) improving availability of staples and other crops through increased production of these foods or increased income of smallholder farmers to purchase them; (2) improving access to a diverse diet; and (3) improving utilization to ensure the provision of a diverse diet to all vulnerable groups including school children. For HGSF programs, these goals are in addition to those to improve educational outcomes (increase enrollment, attendance, and retention).

B. Evidence of the Benefits of School Feeding

In general, there are three documented and potential benefits from existing school feeding that can be used in setting the goals for the program related specifically to school children.

1) Improve enrollment, attendance, and retention. It is well documented that providing meals at school increases enrollment, attendance, and retention rates in developing countries. A review[6] of WFP-supported school feeding programs in 32 countries in sub-Saharan Africa found enrollment increased 28% for girls and 22 percent for boys during the first year of the program. For girls, the increase in enrollment was as much as 46% when take-home rations were combined with on-site feeding. These programs provided a staple food, and in most cases oil and legumes were part of the ration for school meals. A systematic review by Kristjansson and others[7] of school feeding outcomes found that the greatest benefit from school feeding was for attendance, which increased by 4-6 days per child per year. In most of the studies reviewed, animal products were part of the school meal.

2) Alleviate short-term hunger. Because many school children in developing countries do not eat breakfast, another goal for many school feeding programs is to provide breakfast to alleviate short-term hunger. The logic is that feeding children breakfast will improve their attention span and ability to learn, although this has not been evaluated in school feeding programs. There have been controlled studies in which cognitive outcomes (i.e., verbal fluency but not test scores) have improved when undernourished children are fed breakfast consisting of animal products.[8] A problem with providing a school breakfast to children is getting the food cooked early enough. Meeting this goal is easier when snack foods, which are already prepared, like biscuits, are served for breakfast.

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[6] Gelli A, Meir U, Espejo F. Does provision of food in school increase girls' enrollment? Evidence from schools in Sub-Saharan Africa. *Food and Nutrition Bulletin.* 2007; 28(2): 149-55.

[7] Kristjansson E, Robinson V, Petticrew M, et al. School feeding for improving the physical and psychosocial health of disadvantaged elementary school children. *Cochrane Database of Systematic Reviews*. 2007; (1) CD004676.

[8] Chandler AMK, Walker SP, Connolly K, Grantham-McGregor SM. School breakfast improves verbal fluency in undernourished Jamaican children. *Journal of Nutrition.* 1995; 125:894-900.

3) Improve the nutritional status of schoolchildren. While it seems logical that school feeding programs improve the nutritional status of school children, this claim has been debated. There are studies that have shown increased dietary intake for school children served a school meal, but not all studies have reported on dietary intake at home to determine if food intake is decreased or maintained at home.[9] When this has been investigated, the net increase in energy provided to children is less than half of that provided by the school meal.[10] In a national survey of the health and nutritional status of school-aged children in Malawi, it was found that over 80% of parents reported that children received less food at home when they received a meal at school.[11] In an analysis from a school feeding program in the Philippines, less substitution effect was detected, although the sample was urban and the dietary intake benefits of school feeding were not as pronounced in poorer households.[12] This substitution effect probably affects the impact that school feeding has on nutritional outcomes. The Kristjansson review found school feeding had an effect on weight gain overall but only a small effect on height, using controlled, before and after methodology, although all the studies where an effect was seen were conducted in India, a country where malnutrition is more prevalent than in the rest of the world. On the other hand, the studies considered also may not have been long enough to observe a change in height.

Most of the rations in these studies included some food of animal origin, which is not usually available in most school feeding programs, although some HGSF programs are currently including animal products in their rations. Other approaches for improving the nutrient intake of school children have been to fortify school rations with micronutrients to improve the quality of the diet. Many of the micronutrients, like iron and zinc, are not available in the diets of and foods available or affordable to most households in developing countries. Centrally processed foods are usually the easiest to fortify although there have been pilot programs on community-based fortification.[13] [14]

Micronutrient deficiencies in school children affect their health and performance in school. Even in the United States, iron deficiency anemia is associated with lower performance in math.[15] A study in Malawi found that a program to treat school children for malaria

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[9] Kristjansson et al., 2007.

[10] Ibid.

[11] Banda TE, Bobrow R, Galloway R. National school health and nutrition baseline survey. Ministry of Education and Vocational Training, Ministry of Health, National Statistical Office. Malawi. 2007.

[12] Jacoby HG. Is there an intrahousehold ‘flypaper effect’ ? Evidence from a school feeding programme. *The Economic Journal.* 2002; 112: 196-221.

[13] Berti P, Mildon A, Siekmans K, et al. An adequacy evaluation of a 10-year, four-year nutrition and health programme. *International Journal of Epidemiology*. 2010; 39:613-629.

[14] Other interventions such as deworming and micronutrient supplementation also will improve the nutritional status of school children. These interventions will increase the nutritional impact of school feeding programs and have been shown to improve the nutritional status of children in the absence of school feeding.

[15] Lozoff B, Jimenez E, Hagen J, Mollen E, Wolf A. Poorer behavioral and developmental outcome more than 10 years alter treatment for iron deficiency in infancy. *Pediatrics*. 2000; 105:1-11.

decreased mortality. The program was also giving twice-yearly vitamin A supplements which may also have contributed to the decrease in mortality,[16] as it does in children less than five years of age,[17] although the contribution of vitamin A toward decreasing mortality is not addressed in the study.

The nutritional status of developing children, particularly in fetal development and between birth and two years of age, also has an effect on the performance of the education sector. There is evidence that stunting in children less than two years of age, when most of childhood stunting occurs, delays enrollment in school. In Zimbabwe,[18] using econometric modeling, stunting in preschool children was found to delay enrollment by six months and decrease the grades completed by 0.85 grades. This may be because children who are short are often deemed as too young by their parents to attend school and are enrolled when they are older and taller.

A recent analysis[19] using data from five developing countries found that an increase in birth weight of 0.5 kg (one standard deviation) increased length of schooling by 0.21 years and decreased risk of grade failure by 8%. Weight gain in children less than two years of age of 0.7 kg (one standard deviation) increased length of schooling by 0.43 years and decreased risk of failure by 12%. This effect was even greater when children were born in the lowest third for weight. For these children, 0.7 kg more weight gain (one standard deviation) between birth and two years was associated with 0.52 years more of schooling compared with 0.30 years for children who were in the upper third for birth weight with the same weight gain between birth and two years. Weight gain between 24 to 48 months had a weak or no relationship with educational outcomes, suggesting the benefits only came from programs that improved weight gain during fetal development and before two years of age. Stunting at two years of age had the largest effect on the length of schooling, increasing older age enrollment, decreasing time in school by 0.9 years, and increasing the risk of failing at least one grade in school by 16%.

As mentioned earlier, there is evidence that stunting occurring during fetal development and between birth and two years of age cannot be reversed later in life.[20] The progression of stunting in children less than five years of age in developing countries shows that the prevalence of stunting levels off after 18 to 24 months and stays constant between three and

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[16] Pasha O, Del Rosso J, Mukaka M, Marsh D. The effect of providing fansidar (sulfadoxine-pyrimethamine) in schools on mortality in school-age children in Malawi. *The Lancet*. 2003; 15:361(9357):577-8.

[17] Rice AL, West KP Jr., Black RE. Vitamin A deficiency. In: *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Risk Factors.* Ezzati M, Lopez AD, Rodgers A, Murray CJL, eds., Vol. 1. Geneva: World Health Organization; 2004.

[18] Alderman H, Hoddinott J, Riley B. Long term consequences of early childhood malnutrition. *Oxford Economic Papers.* 2006; 58(3): 450-474.

[19] Martorell R, Horta BL, Adair LS, et al. Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low- and middle-income countries. *Journal of Nutrition.* 2010; 140:348-354.

[20] Martorell R, Khan LK, Schroeder DG. Reversibility of stunting: epidemiological findings in children from developing countries. *European Journal of Clinical Nutrition*. 1994; 48: Suppl 1:S45-57.

five years of age. Iron deficiency in children less than two years of age leads to cognitive damage that persists in later in life.[21] Many early childhood development and preschool programs have, unfortunately, focused on older children (3-5 years old) instead of under-twos even though the latter age group is most important to child development and improving educational outcomes during primary school and beyond.

While the nutritional status of children less than two years of age is an important determinant of performance in school, it needs to be remembered that growth continues during the school years and ensuring and maximizing growth during these periods will contribute to overall growth. Children in the United States have three growth spurts for height—before 2 years of age, 8-10 years of age, and adolescence.[22] There is wide variation in when these occur in individual children, and it is unknown if school-age children in developing countries follow the same patterns, although there is sufficient evidence that under-two growth patterns are comparable between Western and developing-country children in well-nourished and healthy children. It is therefore probable that well-nourished and healthy school-age children in developing countries differ little in their patterns of growth compared with children from Western countries. A working group of experts "observed differences in linear growth across ethnic groups reflect true differences in genetic potential rather than environment influenced" and called for developing growth standards for older children based on careful modeling of existing studies.[23]

C. Ration Considerations

After determining the goal of the ration, **Phase 2** (Figure 1, proposed framework) will determine the nutrients needed to meet the goals and the foods and crops needed to provide the nutrients. The quantity of these crops and foods will be determined based on the number of children by age group.

A number of other factors also determine what crops and foods can be used for these programs:

- The prices and costs of the foods.
- How easy the foods are to transport and store.
- The availability of staple and nutrient-rich foods by season.
- Differences in food contamination and safety (e.g., some crops have a greater risk of being infected with aflatoxin than others).
- What and how much farmers are willing to grow/produce.
- The confidence farmers have in markets or how their risks of production or market failure can be mitigated.
- How much of what they grow farmers are willing to consume and sell.
- The food processing requirements for crop foods (locally, regionally, or centrally).
- The behaviors of school children (e.g., what they like and will eat).
- Food preparation limitations based on available facilities, fuel, cooking utensils, and water.

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[21] Lozoff et al.,2000.

[22] U.S. National Center for Health Statistics.

[23] Butte NF, Garza C, de Onis M. Evaluation of the feasibility of international growth standards for school-aged children and adolescents. *Journal of Nutrition.* 2007; 137:153-157.

Prices will determine what foods school feeding programs can purchase. Increasing prices of commodities will benefit farmer income but may limit what school feeding programs can buy and may compromise variety, quality, and quantity. On the other hand, low prices will be a disincentive to farmers producing foods. Market regulation should control some of this but will not control for all of it. An analysis of the Ghana school feeding program found that prices for six items used in the program increased by 53% over a three-year period,[24] although these increases were not because of the Ghana school feeding program. Planning between farmers and schools will be needed to strike the balance so that food production supplies affordable foods for schools and at the same time increases incomes for farmers. Creating demand for nutrient-rich foods for farm households would encourage them to grow enough of these foods so they can consume them at home and sell the excess to schools.

In fact, the objectives of school feeding should be established by country. If improving enrollment and attendance and decreasing drop-out rates are the goals, then buying staple crops from farmers for school meals would be the most cost-effective in meeting those goals. If improving the dietary diversity of the diets of school children and farm families is a major goal, then a combination of foods may be identified for farmers to grow and sell to schools to provide a more diverse ration. If improving certain types of achievement scores are designed, then focusing on one or two foods that supply key nutrients will be the most important. **Table 1** shows some of the evidence for nutrients related to educational outcomes and foods that provide these nutrients.

Table 1: School outcomes, nutrients and foods providing the nutrients

School outcome of interest	Nutrient	Foods with nutrients
Enrollment	Energy	Staple foods
Attendance	Energy Vitamin A or foods with vitamin A activity (better health) Vitamin C (better health) Zinc (better health)	Staple foods Animal foods; green, orange, and yellow fruits and vegetables Fruit and vegetables Oysters, liver, other meat, seeds, peanuts, nuts, legumes
Attention span	Energy, iron	Staple foods for energy; animal flesh foods and legumes for iron
Improve math learning	Iron	Animal foods; legumes
Adequate weight	Energy Iron and zinc	Staple foods Oysters, animal foods, seeds, peanuts, nuts, legumes

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[24] Lopatka J, Topel J, de Vasconcellos P. Food staples in the Ghana school feeding program: analysis of markets, value chains, and menus. UC Berkeley Haas School of Business. International Business Development Program; 2008.

Improve development	Essential fatty acids*	Some plant oils
General learning, IQ	Essential fatty acids Iron Iodine	Some plant oils Animal foods; legumes Iodized salt

* Has been shown in younger children. See Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin A, Briend A, Dewey KG. Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: effects on growth and motor development. *American Journal of Clinical Nutrition.* 2007; 86:412-20.

Both food staples and other foods such as legumes, fruits, vegetables, oils, and animal products offer challenges for transport, storage, cost, seasonality, food preparation, and student acceptance. Staple foods will present less of a challenge for student acceptability than other foods. Qualitative research to determine what students like to eat and will eat is recommended to identify the best foods for school children. It is a risk to HGSF programs to encourage farmers to produce foods which children reject. Promotion of a more diverse diet nationally may help create demand in school-age children for different foods they do not normally eat. Deciding on the amounts of these foods will depend on the age groups of children served by the program, which should also be considered when identifying the target nutrients and crops.

III. Designing the Ration

A PowerPoint presentation for the HGSF initiative showed graphics depicting how the nutrition requirements for energy, protein, vitamins A and C, iron, zinc, and iodine of children 7-10 years old could be met using different foods. These nutrients were chosen as those that might have the largest effect on school outcomes but additional vitamins and minerals and fatty acids could also be added to the list. The graphics created for this presentation will be referred to as the “illustrative model.” It was later proposed to use this idea to develop a planning tool, similar, but more “user-friendly” than other available nutrition linear program planning tools. This section discusses the assumptions made for the illustrative model and makes recommendations for developing the planning tool.

A. The Nutritional Requirements of School Children

If improving nutrition is a goal for the ration, then determining the important nutrients and the proportion of daily requirements for those nutrients that the ration will meet is the first step.

Table 2 shows the most recent United States Recommended Dietary Allowances (1989) for energy, protein, vitamins A and C, iron and zinc for children 7-10 years of age. It also shows the more recent Dietary Reference Intakes (DRI), which gives values for children 4-8 years old and 9-13 years old.

Table 2: Recommended (Daily) Dietary Allowance for selected nutrients for children 7-10 years old in the United States and Dietary Reference Intakes for selected nutrients for children 4-8 and 9-13 years old in the United States)

	Energy (kcal)	Protein (gm)	Vitamin A (µg RE)	Vitamin C (mg)	Iron (mg)	Zinc (mg)	Iodine (µg)
7-10 yrs*	2,000**	28	700	45	10	10	120
4-8 yrs***	1,800 (4-6 yrs) 2,000 (7-10 yrs) 2,500 (11-14 yrs)	19	400	25	10	5	90
9-13 yrs***		34	600	45	8	8	120

*US RDA, 10th Edition, 1989. National Research Council.
**For U.S. children with median weights (28 kg) and heights (132 cm) with light to moderate activity levels.
***US Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine, National Academy of Sciences, 2001. (For the protein, vitamins and minerals; energy assumed to be the same as 1989 values).

For the HGSF rations, a decision should be made as to how much of the RDA for the selected nutrients the school meal will meet. A goal in many school feeding programs in developing countries is to provide at least one-third of the daily energy requirements. If dietary diversity is a goal, then setting this goal for protein and micronutrients might also be a goal. What is provided in the ration will vary by food security in the area, availability of food, and the school feeding budget.

B. Nutrient Requirements and the Planning Tool

Energy Requirements

Energy requirements for the individual are based on the resting basal metabolic state; physical activity levels resulting in energy expenditure; the adequacy of other nutrients; and the disease state, which increases energy requirements. At the population level, most recommended energy requirements are set based on resting basal metabolic state and physical activity levels. The 1989 energy requirements for U.S. children less than ten years of age are based on dietary energy intakes associated with normal growth.[25]

Energy requirements change based on the type of work the individual is engaged in. Laborers expend more energy than people with a desk job. Children who walk long distances to school will have higher energy requirements than those living close to their school. People who are heavier expend more energy than their lighter counterparts. Some of the micronutrients act as co-enzymes in energy-related metabolism, and deficiencies in these micronutrients will affect energy metabolism and increase energy requirements. People with higher energy requirements also have higher requirements for some of the micronutrients, partially so they can play their role in energy metabolism and generation in the body. Being sick, which increases metabolism, for even a short time will increase energy requirements. Chronic illness will increase daily energy requirements; however, the chronically sick person may also be decreasing physical activity. For example, it is recommended that HIV-positive individuals who are asymptomatic and symptomatic for the disease consume 10% and 20%, respectively, more energy than individuals who are HIV-negative.[26] Feeding the sick child is often difficult due to anorexia during illness. Recuperative or restorative feeding (increasing energy intakes) after the illness is important to help the child regain any weight he/she lost during the illness.

For HGSF rations and the planning tool, it is recommended to use the standard US RDA for children of different age groups. Children in developing countries may have higher requirements because they are required to do more work around the house, walk longer distances to school, and may, in fact, be underweight, but it is not known how this differs by country. The proportion of energy met by the school ration will be dependent on the geographic region. In acute (e.g., seasonal) or chronic food security settings, the proportion of energy met by the school ration may be higher than one-third the daily requirement.

Protein Requirements

Protein and energy requirements are inextricably linked. The body's priority is to meet its energy requirements first. If energy requirements are not met, protein, which provides 4 kcal per gram, will be utilized for energy and will not fulfill its main role of building new and replacing old tissue and muscle. Adequate fat and carbohydrate intake ensure dietary amino acids are used for protein

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[25] US Recommended Dietary Allowances, 1989.

[26] World Bank. HIV/AIDS, Nutrition, and Food Security: What We Can Do: A Synthesis of International Guidance. Washington, DC: World Bank; 2007.

synthesis.[27] While there is not an essential carbohydrate[28] per se, adequate carbohydrate intake is important and is often referred to as "protein saving." Because glucose is needed for brain metabolism and the body can only convert protein (i.e., muscle tissue) to glucose, inadequate carbohydrate intake will result in the conversion of muscle to the glucose needed for brain function. While fat can be and is converted to "ketone bodies" which the brain can also use, the body continues to use a combination of glucose (converted from body protein) and ketone bodies when there is no dietary source of glucose.

In the 1960s, nutritionists working in developing countries were focused on protein deficiency and efforts were focused on improving the amino acid quality of certain crops (e.g., increasing the lysine content of maize). It was recognized that much of the deficiency in protein was related to the deficiency in energy; however, as we will see, there are still problems in developing countries with this approach because consumption of low-quality proteins (those that have limited amounts of one or more of the essential amino acids) will increase requirements for protein.

In setting protein requirements in the United States, the quality of protein has been considered, determined by the digestibility of the protein and its corrected amino acid score (PDCAAS):

Digestibility x amino acid score = protein quality

US protein requirements are based on a healthy population consuming 67% of its protein from animal products, which supply the most digestible and all the necessary amino acids, and the rest from plants. Because the US population has a mixed diet, even vegetarians will be able to meet their protein requirements by combining different plant proteins to ensure that all the necessary amino acids are available for protein synthesis in the body.

The amino acid score is based on the first limiting essential amino acid divided by the content of the same amino acid reference pattern of essential amino acids. For example, whole wheat flour has a lysine (the limiting essential amino acid) content of 2.6% and the value of lysine in the reference pattern for essential amino acids is 5.1%. Therefore, the amino acid score for young children consuming wheat flour is 2.6/5.1 x 100 = 51. However, the protein quality of a food also needs to take the true digestibility of the protein into consideration when determining protein quality. The digestibility has been determined for proteins from different types of food, with animal products having the highest (best) digestibility ratings.

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[27] WHO. *Protein and Amino Acid Requirements in Human Nutrition.* Report of a Joint WHO/FAO/UNU Expert Consultation. WHO Technical Report Series 935. Geneva: WHO; 2007.

[28] The definition of essentiality for the nutrients is based on the need to consume nutrients because they cannot be created in the body to meet the body's requirements for them. For example, water is really a nutrient because while metabolic water is created in the body through the energy generation process (the final reaction in the electron transport system), not enough water is generated and additional water intake is required.

Table 3 gives examples of foods and their true digestibility, amino acid score, and PDCAAS.

Table 3: True digestibility, amino acid score, and PDCAAS for selected proteins

Protein	**Digestibility**	**Amino Acid Score (%)**	**PDCAAS**
Egg	98	121	118
Cow milk	95	127	121
Beef	98	94	92
Soy	95	96	91
Wheat (white flour)	91	47	42

Source: Schaafsma G. The protein digestibility-corrected amino acid score. *Journal of Nutrition.* 2000; 130:1865S-1867S.

Protein is manufactured in the body when a complete set of the essential amino acids is available at the time of protein synthesis. These amino acids need to be available within 4 to 6 hours after a meal. There are eight essential amino acids for adults. Additional amino acids are required for growing infants and children.[29] While protein quality (digestibility and the complete set of amino acids) is highest for animal proteins, a complete set of amino acids can be obtained by combining and consuming a wide variety of plant sources of protein. If only one plant source is consumed, which is the case in many households in developing countries where only the staple food is consumed, overall protein requirements will increase to meet the requirements for the limiting amino acid.

Table 4 shows the amino acid requirements for adults by body weight.

Table 4: Essential amino acid requirements for adults

Amino acid	**mg per kg body weight**
Isoleucine	20
Leucine	39
Lysine	30
Methionine + cysteine*	10.4 + 4.1= 15
Phenylalanine + tyrosine*	25
Threonine	15
Tryptophan	4
Valine	26

*Not essential amino acids but contain a portion needed for synthesis of the like-amino acid.

Source: WHO. Protein and Amino Acid Requirements in Human Nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation. WHO Technical Report Series 935. Geneva: WHO; 2007.

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[29] Essential amino acids: leucine, isoleucine, lysine, threonine, phenylalanine, tryptophan, methionine, valine for adults, and additionally histidine, cysteine, tyrosine, and arginine for growing infants and for children.

Recommended amino acid intakes for children three years of age will be 10%-20% higher than adults and as much as 150% higher for infants (less than one year of age) and even higher for children recovering from malnutrition.[30]

Table 5 shows the PDCAAS percentages for different foods and from the same foods for children 2-5 years of age recovering from malnutrition.

Table 5: PDCAAS values of different foods from the literature with reference to children 2-5 years of age and for children 2-5 years of age recovering from malnutrition (column three)

	PDCAAS (%) from different sources in the literature	**PDCAAS (%) from Michaelsen, et al.**
Animal sources		
Beef	92	94
Egg	118	-
Cow milk	121	112
Whey protein concentrate	114-116	-
Skim milk powder	125	-
Vegetable sources		
Oats	45-51	60
Rapeseed meal	46	-
Maize	52	35
Wheat	42-54	37
Cassava	57	44
Rice	65	54
Black beans	72	45
Yam	73	55
Potato	82	71
Soy	90-91	93

Source: Michaelsen K, Hoppe C, Roos N, et al. Choice of foods and ingredients for moderately malnourished children 6 months to 5 years old. Background paper presented at the WHO, UNICEF, WFP & UNHCR Consultation on Dietary Management of Moderately Malnourished Children Less than Five Years of Age, 2008.

In developing countries, where protein quality is limited, it makes sense to meet energy first and increase the diversity of plant products consumed and add higher quality proteins when possible. The Michaelsen paper cited above recommends that children less than five years of age recovering from malnutrition obtain PDCAAS values of 70%-80%. It is recommended by Michaelsen that children recovering from moderate malnutrition and consuming diets with low PDCAAS values (from plants) should consume about one-third of their requirements for protein from animal sources. It

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[30] WHO. *Protein and Amino Acid Requirements in Human Nutrition*; 2007.

needs to be remembered that the values in the last column above are for young children recovering from malnutrition. The PDCAAS values may be higher (better) for school-age children and approach the values in column two in the table above. In addition, the values above are for single foods and not a mixed diet. PDCAAS values for plant products can be improved by substituting the protein in plants for the proteins in animal products. **Table 6** shows the limiting amino acids for some foods consumed in developing countries; **Table 7** shows examples of the improvement of PDCAAS values for children less than five years recovering from malnutrition when plant proteins are exchanged with proteins from meat.

Table 6: Limiting amino acids from foods consumed in developing countries

Food	**Limiting amino acid**
Wheat	Lysine
Rice	Lysine
Legumes	Tryptophan and methionine (or cysteine)
Maize	Lysine and tryptophan
Soy	Methionine
Animal products	None

Table 7: PDCAAS values (%) with the first limiting amino acid (in brackets) if various proportions of the protein content of the plant are exchanged with meat (beef) (for children <5 years recovering from malnutrition)

	0%	10%	25%	50%
Rice	54 (lys)	62 (lys)	73 (lys)	93 (lys)
Maize	35 (lys)	43 (lys)	55 (trp)	67 (trp)
Soy	93 (lys)	97 (lys)	100 (trp)	98 (trp)
Black beans	45 (SSA)	50 (SSA)	60 (SAA)	88 (SAA)
Potato	71 (SSA)	75 (SSA)	82 (SAA)	93 (SAA)
Cassava	44 (lys)	52 (lys)	64 (lys, thr)	80 (thr)
Yam	55 (lys)	61 (trp)	66 (trp)	75 (trp)

lys=lysine; SSA=sulfur-containing amino acids; trp=tryptophan; thr=threonine

Source: Michaelsen K, Hoppe C, Roos N, et al. Choice of foods and ingredients for moderately malnourished children 6 months to 5 years old. Background paper presented at the WHO, UNICEF, WFP & UNHCR Consultation on Dietary Management of Moderately Malnourished Children Less than Five Years of Age, 2008.

If we use the 70%-80% PDCAAS goal for school children (which is probably conservative), soy and potato would both meet this goal if they were consumed alone and providing the only source of protein in the diet. Rice would reach the 70%-80% goal when 25% of its protein is substituted with beef protein. Black beans, cassava, and yam would only reach the goal at 50% substitution levels and maize would nearly reach the goal at 50% substitution with beef protein. Consuming a mix of animal and plant products (legumes, cereals, green, leafy vegetables) will further complement the limiting amino acids in staple crops, making it easier to reach the 70%-80% goal. If the HGSF Initiative can increase the diversity of each school meal, it will increase the likelihood of children meeting their protein requirements. Even combining potatoes with maize, for example, or maize and beans will provide a full complement of amino acids that can be used to synthesize proteins in the body.

In the United States protein requirements are set based on body weight, with the RDA for protein 0.8 grams of protein per kilogram of body weight for adults (for children less than two years 1.2 to 2.2 grams of protein per kilogram of body weight, and for children 7-10 years of age 1.0 grams of protein per kilogram of body weight).[31] These requirements assume normal body composition for people in the United States and a large proportion of dietary protein coming from animal products (67%), which is what is normally consumed in the United States. The requirements would be higher for people with higher lean body mass and lower for people with higher adipose tissue mass. Higher protein intakes would not be recommended for obese individuals.[32] Daily protein requirements will be higher for people consuming monotonous, plant-based diets. Like energy, protein requirements will increase based on the disease state. For example, people in catabolic states, after surgery, for example, require more protein than healthy individuals. An individual with untreated tuberculosis, for example, will require 25% more protein.[33]

The presentation shown at the HGSF meeting in Nairobi and again at the Global Child Nutrition Forum was challenged by participants working to promote soy protein products in developing countries because the illustrative model did not correct for protein quality. The illustrative model shows the child meeting 48% of protein requirements when consuming a ration consisting of 500 g of cooked maize porridge. This is correct based on simple calculations using food composition tables which do not correct for protein quality. However, based on amino acid composition of maize (lysine and tryptophan are limiting amino acids), more maize would be needed to meet the requirement for these amino acids, and thus, 500 g of cooked maize meal would meet far less of the actual protein requirement, if only maize were consumed.

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[31] National Research Council. *Recommended Dietary Allowances*. 10th Edition. Washington DC: National Academy Press; 1989.

[32] Institute of Medicine of the National Academies. *Dietary Reference Intakes: Applications in Dietary Assessment.* Food and Nutrition Board of the Institute of Medicine. Washington, DC: National Academy Press; 2000.

[33] WHO. *Protein and Amino Acid Requirements in Human Nutrition*; 2007.

In **Table 8** PDCAAS values for animal protein (100) and PDCAAS values for different plant proteins (e.g., 54 for rice) have been used as correction factors to adjust protein requirements for school children consuming only the staple food. This is illustrative since we do not know the PDCAAS values for school children. It should be confirmed with scientists who are working to establish PDCAAS values that these correction figures for school-age children are reasonable.

Table 8: Correction factors for protein requirements in children 7-10 years old (28 g/day) based on PDCAAS values and the consumption of one food (0% substitution) alone or the substitution of various proportions of meat protein (beef) (e.g., 10% of rice protein is substituted for beef protein)

	0%	**10%**	**25%**	**50%**
Rice protein correction factor	100/54=1.85	100/62=1.61	100/73=1.37	100/93=1.08
Protein requirement (g)	52 g (28 g x 1.85)	45 g (28 g x 1.16)	38 g (28 g x 1.37)	30 g (28 g x 1.08)
Maize protein correction factor	100/35=2.86	100/43=2.33	100/55=1.82	100/67=1.49
Protein requirement (g)	80 g (28 g x 2.86)	65 g (28 g x 2.33)	51 g (28 g x 1.82)	42 g (28 g x 1.49)
Potato protein correction factor	100/71=1.41	100/75=1.33	100/82=1.22	100/93=1.07
Protein requirement (g)	39 g (28 g. x 1.41)	37 g (28 g x 1.33)	34 g (28 g x 1.22)	30 g (28 x 1.07)
Cassava protein correction factor	100/44=2.27	100/52=1.92	100/64=1.56	100/80=1.25
Protein requirement (g)	63 g (28 g x 2.27)	54 (28 g x 1.92)	44 g (28 g x 1.56)	35 g (28 g x 1.25)
Yam protein correction factor	100/55=1.82	100/61=1.64	100/66=1.52	100/75=1.33
Protein requirement (g)	51 g (28 g x 1.82)	46 g (28 g x 1.64)	43 g (28 g x 1.52)	37 g (28 g x 1.33)

This would mean only 18% of the protein requirement would be met for a child 7-10 years old consuming 500 g of cooked maize meal porridge (14 grams of protein in maize divided by 80 grams of protein required per day when only maize is consumed). It would also mean the child would have to consume about five more portions of maize to meet his/her protein requirements (or requirements for the limiting amino acids), which would exceed energy requirements by 1700 kcal. Of the foods compared here, maize and cassava have the poorest protein quality.

Making recommendations on how to correct for protein quality in the planning tool using only staple foods or a combination of foods is difficult. It is suggested that corrections to protein requirements be made when only one staple is consumed by children (column one above). If legumes or animal products are added in any amount to the staple, it is recommended to keep protein requirements at 28 grams per day. This is not totally accurate because very small amounts of legumes or meat may not raise the PDCAAS sufficiently. However, it will help planners to see that a diet with only one staple is not adequate to meet protein requirements and encourage the addition of food with amino acids profiles that will complement the amino acids in the staple food. Planners should be given advice with the tool about what food combinations will provide a better source of protein to children.

Micronutrients

When iodine is present in the soil, it is present in plants. When the soil is deficient in iodine, usually in mountainous areas where water has washed iodine away over time, iodine can be added to the diet by iodizing salt, which is a major development activity supported by UNICEF and other organizations. Meeting the dietary requirements of school-aged children becomes relatively easy if adequately iodized salt (15 ppm) is added while cooking the ration.

The bioavailability of other micronutrients depends on the nutrient and the type of food it comes from. The most absorbable and useable forms of vitamin A, iron, and zinc are from animal products. Vitamin A (retinol) is only present in animal products and is readily available to meet vitamin A requirements. Plants have substances that are not considered to be vitamin A but have “vitamin A activity” because they can be converted to vitamin A (retinol) when there is a physiologic need for it. These substances are several of the carotenoids (e.g., ß-carotene found in green, yellow, and orange plants). Some food composition tables list vitamin A (retinol) and the carotenoids separately The values for the carotenoids can be converted to the equivalent amount of vitamin A (retinol). The most updated correction factors are shown below:

1 Retinol Activity Equivalent (RAE) = 1 µg of vitamin A (retinol)
1 RAE = 2 µg of ß-carotene supplement
1 RAE = 6 µg of all-trans-ß-carotene in food
1 RAE = 12 µg of other pro-vitamin carotenes from food

There is research showing that vitamin A activity is better in fruits because the absorption of carotenoids in green, leafy vegetables is limited by factors in these foods that limit their absorption. Food composition charts do not correct for this.

Vitamin A requirements do not need to be corrected for because most food composition tables adjust for the vitamin A activity based on its source. If there is a separate column in the food composition table for the amount of carotenoids in foods, then the conversion or correction factors above would need to be used in order to obtain the amount of vitamin A (retinol) provided by these foods.

Zinc and iron are also present in plants but their forms are not usually bioavailable, and therefore, they are not absorbed well due to other factors in plants (e.g., phytates) that compete with the minerals, including zinc and iron, for absorption. The type of iron from plant sources is called non-heme iron, while the type of iron from animal sources (animal flesh, as opposed to dairy products and eggs which are not as well absorbed) is called heme-iron. The minerals may also compete with each other for absorption, but there is conflicting information as to how significant this is when these minerals are present together in food as opposed to pharmacologic amounts from supplements.

Absorption of iron, which is tightly controlled based on iron stores in the body, is based on iron status (iron stores) and the type of iron (heme or non-heme). When iron stores are present (250 mg to 1,000 mg of iron stores), non-heme iron absorption ranges from 2% to 4%, but when an individual has no iron stores, absorption reaches 5%.

When a mixed diet consisting of plants and animal flesh (>90 g) is consumed the absorption of non-heme iron increases from 2-4% to 4-12% in people with iron stores and from 5-20% in people with no iron stores (see **Table 9**). Absorption of heme-iron is good, with 25% of iron from animal flesh (heme-iron) absorbed.

Table 9: Absorption of non-heme iron from a plant-based diet and in a mixed diet in iron replete and deficient individuals

	% non-heme iron absorbed from diet with <30 g of animal flesh	% non-heme iron absorbed from diet with >90 g. animal flesh
Iron–stores present*	2-4%**	4-12%**
Iron–no stores	5%**	20%**

*250 mg-1,000 mg

**Monsen ER, Hallberg L, Layrisse M, et al. Estimation of available dietary iron. *American Journal of Clinical Nutrition.* 1978; 31:134-141.

US iron requirements are based on people consuming a mixed diet with 10% of iron coming from heme-iron sources. The bioavailability of iron from this diet is estimated at 18%. For US vegetarians, it is estimated that the iron bioavailability would be only 10%, which would increase requirements by 1.8 times (for school children iron requirements would be 18 mg). However, for a very restricted diet, with only 5% bioavailability, requirements would increase by 3.6 times. Children in developing countries consuming only maize would require 36 mg of iron per day instead of 10 mg of iron from a US diet. For the illustrative model, 36 mg of iron was used for the daily iron requirement when children are consuming only a plant-based diet.[34] It is recommended that if legumes are added to the staple diet, the requirement should be 18 mg (18% bioavailability), and if animal flesh is added (at least 90 grams), the requirement should fall back to 10 mg of iron/day (18% bioavailability).

For zinc, 15 mg was used for the requirement in the illustrative model when only a plant- based diet is consumed, based on observations that zinc requirements are 50% higher in US vegetarians.[35] This should continue to be used as a correction factor in the planning tool. The requirement for zinc should fall back to 10 mg of zinc/day when legumes, nuts, or animal products are added to the diet.

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[34] Institute of Medicine. Dietary Reference Intakes (for selected vitamins and minerals). Food and Nutrition Board; 2001.

[35] Ibid.

Using these higher requirements for iron and zinc means that only 16% of the iron and 20% of the zinc requirements would be met by consuming 500 grams of cooked maize porridge. When animal products were added to the plant-based diet, the requirements dropped to 10 mg per day for each, which is the RDA for 7- to 10-year-olds in the United States consuming a mixed diet. This correction factor could be used in the planning tool as well. It should be noted that animal products should be carefully defined, which was not done for the illustrative model. While milk and eggs are obviously animal products, they are not good sources of iron. In addition, high calcium levels in milk inhibit iron absorption, and the bioavailability of the iron in eggs is similar to plants.

There are nutrient-nutrient beneficial and competitive effects which will not be addressed in great detail in this paper. Minerals of the same valence compete with one another for the same receptor sites that assist with absorption in the gut. The zinc-iron competition is well known and seems to worry zinc enthusiasts more than iron enthusiasts. In reality, at levels in food, there is probably not a lot of competition. When an iron supplement with pharmacological doses is taken with food, zinc absorption would be affected. Iron absorption (and probably zinc) is decreased when dairy products are added to the diet due to their high levels of calcium. One study in Germany[36] found an increase in iron absorption in the diet by 30-50% in women when dairy products were not consumed with a meal. Another study[37] in the United States found similar results for zinc and calcium in the diet or a supplement. Adding vitamin C increases non-heme iron absorption.

Adding vitamin C to the ration, which can be supplied by adding some types of fruit and vegetables, will improve the absorption of non-heme iron, if these foods are consumed at the same time as the staple and other foods in the ration. In the planning tool, it is recommended to assume 18% bioavailability of iron in the diet when these foods are added (iron requirement of 18 mg of iron/day).

C. Food Preparation and Storage

Rations may consist of raw foods, such as fruits, or foods that need to be cooked such as porridges, animal foods, and vegetables. Dried foods (e.g., dried fish, dried fruits, vegetables) may also be an option. Meals that need to be cooked can be prepared at schools or at centralized kitchens and transported to schools. In many school feeding programs, parents and school committee members volunteer their time to cook and serve the food. Wherever food is prepared, infrastructure may need to be improved to store, handle, and process the ingredients for the ration in a way that ensures the preservation of nutrients in the ration and safety and hygiene of the ration. The USDA Assessment Team found that there were no guidelines for the storage, preparation, and serving of food in the four countries. In countries where the World Food Programme was supporting school feeding these standards did exist, but there was great variation in adhering to these standards and in the available infrastructure for storing and preparing foods.

In addition to ensuring food safety and hygiene, guidance should be given to schools on how best to preserve the nutrients during storage and while cooking. Some fruits, such as avocado pears, can

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[36] Gleerup A, Rossander-Hulthen L, Gramatkovski E, Hallberg L. Iron absorption from the whole diet: comparison of the effect of two different distributions of daily calcium intake. *American Journal of Clinical Nutrition.* 1995; 61:97-104.

[37] Wood RJ, Zheng JJ. High dietary calcium intakes reduce zinc absorption and balance in humans. *American Journal of Clinical Nutrition.* 1997; 65:1803-9.

be stored for several months at a time without spoiling, if they are stored under the right conditions. Some of the vitamins (C, A) are heat-labile, so minimizing the exposure to cooking time is essential to prevent nutrient losses. Some of the vitamins (C) are destroyed by exposure to oxygen. In some cultures sodium bicarbonate is added to green vegetables during cooking, which gives them a vibrant green color. Unfortunately, it also destroys vitamin B-1 (thiamin). Drying foods such as mangoes and green leafy vegetables is a practice in some areas of the world and is a way to utilize these excellent foods when they are not in season. Drying these foods in the shade instead of the sun helps preserve the vitamin A activity and probably other vitamins.

Food composition tables do not consider losses to foods. Foods are analyzed in the laboratory setting and some losses in that setting will be similar to the normal losses experienced in schools, but the losses in schools can potentially be higher if foods are older (stored for a long time), not stored properly, cooking is longer, etc. Again, school cooks need information that will mitigate these losses.

For the planning tool, there should be a simple calculation that corrects for farm-to-table food losses. It is reasonable to expect at least 20% food losses. The planning tool should provide a correction factor of adding 20% for the amounts of food/crops needed. Schools should conduct their own monitoring of food losses from transport and storage.

D. Special Considerations

While accurate and up-to-date food and nutrient composition tables are not widely available for foods in developing countries, there are some existing tables that can be used. **Table 10** lists known food composition tables for the Africa region.

Table 10: Food composition tables for use in Africa

Name	Country	Date	Source
FAO/USDA Food Composition Table for Use in Africa	Africa	1968	http://www.fao.org/docrep/003/x6877e/X6877E00.htm
MRC Food Composition Tables	South Africa	1991	*MRC Food Composition Tables. Third edition* Langenhoven ML, Kruger M, Gouws E, Faber M. Third print. Parow: South African Medical Research Council. 1991 (English) Contact: Nutritional Intervention Research Unit, Medical Research Council, PO Box 19070, Tygerberg 7505, South Africa. Tel +27 -21-938 0405; Fax +27 -21-938 0321; Email: Natasha.danster@mrc.ac.za

Nutrient Composition of Commonly Eaten Foods in Nigeria	Nigeria	1995	EB Oguntona & IO Akinyele Food Basket Foundation Publication Series 1995 (English) Contact: Executive Chairman, Food Basket Foundation International, 46 Ondo Street, Old Bodija Estate, Ibadan, Oyo State Nigeria
Tanzania Food Composition Tables	Tanzania	2008	www.hsph.harvard.edu/nutritionsource/files/tanzania-food-composition-tables.pdf
Other	Africa		www.fao.org/infoods/tables_africa_en.stm

The lack of accurate food composition data will be the major limitation for developing the planning tool. As mentioned above, there is little adjustment in the food composition tables for the quality of the nutrient from various food sources or losses during cooking.

Making a planning tool out of the graphic representations in the illustrative model was suggested during the workshop. There are several nutrition linear programming tools available which assist with planning nutritious diets. Most are not user-friendly, so they would be cumbersome to use for schools. It is envisioned that a tool using these graphics could be developed which would be more user-friendly. Foods could be chosen from a list which is tied with the nutrient composition of the foods. The target nutrients could be selected based on the education and nutrition goals of the program and the types and amounts of foods determined that would supply these target nutrients for the number of children in each age group. Different foods could be compared, and a list of back-up foods could be kept on a secondary chart if the ration changes on a daily or seasonal basis. The variation of foods in the ration will depend on the availability of foods from farmers. The planning tool would help in "placing orders" with farmers to supply the desired food for the ration. Ideally, the ration would be changed on a daily basis to optimize variety in the child's diet. The costs of foods could be entered to give the "best buys" of nutrients for available foods. It would be useful to make some adjustments (correction factors) for the types of foods providing protein, iron, and zinc, as discussed above. Iron and zinc will be the easiest, as discussed. Protein may be a little more challenging.

Different tabs for the tool could be:

Select the food
Select the amount or portion size of the food
Select the age group and sex of the children being fed
Select the cost of the food
Select the number of children to be fed
Select the number of days children are to be fed
Correct the child's daily requirements for protein, iron, and zinc based on the types of food consumed
Correct for food losses from farm to table

Outputs: nutrients met per ration per age group and sex, cost of the ration/child (per day; per school year), the total amount of each food for the food ration with and without correction factors for quality.

E. Nutrition Education and Behavior Change

It was also suggested by HGSF partners that a tool with the same graphics used in the planning tool could be developed as an educational tool and/or a tool to monitor what children are consuming at home. Children could point to foods and the amounts they consumed the day before, and the information would show up in the graphics and could be used to discuss with children how they are meeting their nutritional requirements and how they might improve their diets. Since parents control what is consumed at home, using this educational tool with parents would also be useful. Amounts/measures which children understand would be needed for this exercise so children could estimate the amounts of foods they consume, and this might be challenging. Cup measures could be provided as visuals, and children would select measures of 50 g, 100 g, 200 g, etc., to input into the tool. The accuracy of this approach would need to be tested against a more reliable estimate of dietary intake (weighing food consumed at home). If this proves accurate, the tool would also help track what children are eating at home, for which there is very little information worldwide.

Changing behaviors and dietary practices should be part of the strategic design for HGSF programs. Qualitative research should be conducted to determine what school children are consuming at home; how to mitigate the substitution effect (children eating less at home); how children and their families view diversification; how to increase the demand for a more varied diet; how to improve the food intake and nutritional status of farm families, particularly children less than two years of age; and what farmers are willing to grow and how they can or will “buy into” HGSF. Many development projects focus on improving supply (e.g., of food, drugs, health services). Giving attention to increasing demand for HGSF programs should receive equal attention.

IV. Conclusions

Existing school feeding rations consist primarily of staple foods which have been shown to improve enrollment, attendance, and retention. School feeding programs do not significantly improve the nutritional status of school children unless the staple food is fortified, which will improve the micronutrient status of school children. Parents need to be educated to continue to feed the same amounts of food at home, mitigating the “substitution effect” (children eating less at home when they are served a meal at school), which is often observed with school feeding programs. Home Grown School Feeding will help to improve livelihoods of farmers and can, with careful planning by school officials and farmers, increase the diversity of foods offered to children as school feeding rations. Home Grown School Feeding programs can also educate parents about the importance of adequate nutrition for school children and smallholder farmers about how to use the foods they grow or purchase to improve the nutritional status of all family members.

Determining the composition of the ration for HGSF programs will depend on a number of factors including the availability and affordability of food and crops; the confidence farmers have in markets and what they are willing to grow; what children are willing to eat; and the cost of and losses from transportation, storage, food processing, and preparation of crops. If improving nutrition of school children is an objective of school feeding then deciding on the types of crops, based on the nutrients they provide, will be an important factor in planning what is grown and served to children. School officials will need to plan with farmers to ensure that nutritious foods are available in each season of the year.

Planning should also involve a decision about how much the child’s nutritional requirements can be met by a school breakfast or lunch. A planning tool that is user- friendly could help with this planning. Food composition information is one of the limitations of existing nutrition planning tools. In addition, most existing programs do not correct for bioavailability or quality of certain nutrients from different foods. For example, iron and zinc are better absorbed from some animal sources. The amino acid profile and digestibility are better in animal proteins compared to plant proteins. This is complicated by the fact that nutrient absorption increases when the individual is deficient. Using a correction factor for the real availability of iron, zinc, and protein in rations that are plant-based would give realistic estimates of the impact of these rations on the nutritional status of children. It could also help in forming messages to parents about what they should be providing to children at home to help fill the gap in the nutrient intake for children.

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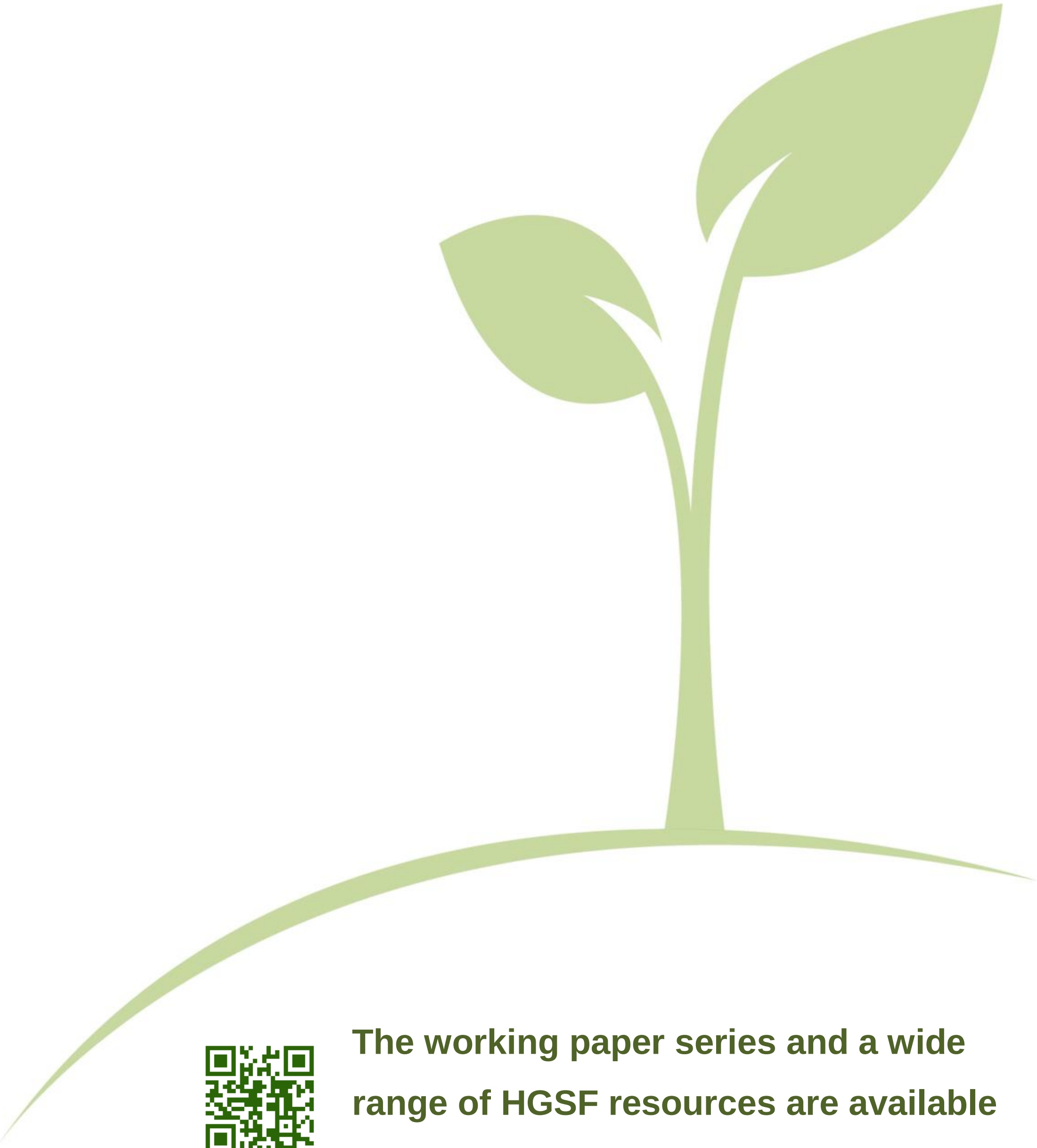

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