Macronutrient Supplementation and Food Prices in HIV Treatment\textsuperscript{1,2}

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Abstract

Infection caused by HIV and malnutrition have a complex interaction and often coexist geographically. Malnutrition has synergistic immune effects and HIV affects nutritional status. HIV care and treatment programs are compelled to confront this dual burden to optimize HIV outcomes. In this article, we review the published literature concerning intervention studies in adults and children and the effect of food prices on HIV treatment programs. While the evidence base is relatively incomplete for specific macronutrient interventions in the context of HIV treatment, it is clear that a new standard of care is needed, guided by experience, rationale, and existing data, in which malnourished patients may easily access nutritional therapies within HIV treatment. From this clinical foundation, we may both treat patients and evaluate novel therapies. Some HIV care and treatment programs provide food-based supplements; however, rising food costs and economic instability may jeopardize the success of these programs. HIV treatment programs may struggle to meet the needs of patients with potential increased rates of malnutrition and food insecurity in the setting of high food prices. J. Nutr. 140: 213S–223S, 2010.

Introduction

Nutrition and HIV infection have a complex and dependent interaction. Gastrointestinal function and nutritional status are often affected by HIV, its secondary complications, and by therapies. Proper nutrition also directly affects immune status, moderates the efficacy of medications, may reduce the severity of side effects, and can affect important outcomes, including quality of life and productivity. Poor nutritional status as measured by low BMI is predictive of mortality among those with HIV infection (1–3). Multiple strategies to improve nutritional outcomes exist, including antiretroviral therapy (ART),\textsuperscript{5} treatment of confections, nutritional counseling, medications affecting intake or metabolism, and exogenous delivery of nutrients with nutritional supplements. Most research to date has occurred in developed countries, but the application of knowledge is currently needed, and will be increasingly needed, in developing settings where the burden of HIV disease is highest (4). In this article, we examine the interaction of HIV and nutrition and review published data from studies concerning the effect of macronutrient supplementation in the context of HIV infection in adults and children in developing settings. A number of recent reviews have examined the role of micronutrient status and supplementation in the context of HIV (5,6). In this paper, we will focus on the role of macronutrients and also explore the implications of food and commodity prices for HIV treatment programs.

HIV and nutrition

There are an estimated 22 million individuals, with almost 2 million children under the age 15 y, infected with HIV in sub-Saharan Africa. Pediatric HIV in Africa comprises 10% of all HIV infections in the region and 90% of all children infected globally. In 2007 alone there were 420,000 newly infected children and 290,000 child deaths (4). With these epidemiological trends and increasing access to treatment, adult and

\textsuperscript{5} Abbreviations used: ART, antiretroviral therapy; REE, resting energy expenditure; SAM, severe acute malnutrition.
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<tr>
<th>First author</th>
<th>Year</th>
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<tbody>
<tr>
<td>Sandige H (79)</td>
<td>2004</td>
<td>Malawi</td>
<td>Commercially produced RUTF vs. local RUTF</td>
<td>Reaching &gt; −0.5 WHZ</td>
<td>Randomized after inpatient stabilization; concurrent HIV-uninfected children in both arms</td>
<td>None</td>
<td>78 HIV-infected children</td>
<td>46 reached WHZ &gt; −0.5; 7 died; 9 lost to follow up; 16 did not reach WHZ &gt; −0.5 or relapsed; rate of weight gain slower in children with HIV 3.6 ± 4.7 g (kg⁻¹ d⁻¹) vs. 5.6 ± 4.0 g (kg⁻¹ d⁻¹) (P &lt; 0.001)</td>
<td>Outpatient feeding of malnourished children with HIV can improve nutritional status</td>
</tr>
<tr>
<td>Amadi B (84)</td>
<td>2005</td>
<td>Zambia</td>
<td>Formula with elemental protein vs. standard protocol milk/oil then soy porridge</td>
<td>4 wk</td>
<td>Randomized after inpatient stabilization</td>
<td>None</td>
<td>106 HIV-infected children</td>
<td>Elemental formula vs. control intervention increased weight-for-age Z-score 1.2 (0.8–1.5) vs. 0.70 (0.4–1.2) (P = 0.007) and WHZ 1.8 (1.1–2.3) vs. 0.8 (0.4–1.6) (P &lt; 0.001); no screening of tuberculosis; inpatient antibiotic rates not reported</td>
<td>Elemental formula improves weight gain during in-patient nutritional rehabilitation for SAM more than milk/oil formula and soy porridge; locally made foods with reduced antigenicity should be tested</td>
</tr>
<tr>
<td>Ndekha MJ (12)</td>
<td>2005</td>
<td>Malawi</td>
<td>1) RUTF diet [175 kcal·(kg⁻¹ d⁻¹)]; 2) RUTF supplement (fixed 500 kcal·d⁻¹); 3) maize/soy [175 kcal·(kg⁻¹ d⁻¹)²]</td>
<td>Reaching 100% WHZ</td>
<td>Randomized after inpatient stabilization</td>
<td>None</td>
<td>93 HIV-infected children</td>
<td>52/93 (56%) of all children reached 100% WHZ; those on RUTF gained weight more rapidly and were more likely to reach 100% WHZ than the other 2 dietary groups (P &lt; 0.05); 11 children died; bimodal distribution of recovery rates</td>
<td>HIV-infected children not receiving ART benefit from home-based nutritional rehabilitation; bimodal recovery distribution suggests 2 populations of HIV-infected patients</td>
</tr>
<tr>
<td>Sadler K (78)</td>
<td>2008</td>
<td>Malawi</td>
<td>RUTF and family ration of 2 kg of a blended maize and soy flour with oil (700 kcal·d⁻¹)</td>
<td>Reaching &gt;85% of the reference median weight-for-height</td>
<td>Nonrandom prospective cohort after inpatient stabilization</td>
<td>None reported</td>
<td>186 HIV-infected children with SAM</td>
<td>64 of 186 recovered; 92 of 186 (49.5%) died; 30 lost to follow up; median length of stay inpatient for children who recovered was 69 d; median length of stay for patients who died was 15 d. HIV more common in marasmic children compared with edematous malnutrition (39.5 vs. 11.2%)</td>
<td>Patients present with advanced malnutrition; main reasons for defaulting from follow up were prohibitive transport costs and long walking distances to central nutrition unit; management of SAM in high prevalence HIV areas requires linkage to HIV testing and treatment; decentralized outpatient treatment with RUTF, and timely inpatient care for infections</td>
</tr>
</tbody>
</table>
| Fergusson P (135) | 2008 | Malawi | Corn/soy flour blend (5 kg) and cooking oil (500 mL) | Four mo after discharge | Nonrandom prospective cohort after inpatient stabilization. Control, 385 non-HIV-infected children | None at admission, and status not tracked | 79 HIV-infected children ages 6–60 mo | 35.4% (28/79) died compared with 10.4% (39/375) in HIV-uninfected children (P < 0.001). All survivors recovered >85% WHZ and no edema; at 4 mo WHZ was similar in HIV-infected and -uninfected children (−0.85 vs. −0.64, NS). After 4 mo of follow-up, only 3 children required readmission; mean increases in Z-scores for skinfolds similar.

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Control, 385 non-HIV-infected children.

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Hughes S (98) | 2009 | Malawi | High protein supplement (amount not specified); prior studies in this group used RUTF | Reaching WHZ > 0 | Nonrandom prospective cohort. Children with SM, nutritional edema, and/or WHZ < −3 receiving inpatient nutritional stabilization; discharge with high protein supplement. Control, 32 non-HIV-infected children | None available until end of study 2 patients received ART | 24 HIV-infected children 1–5 y with SM | Baseline CD4% were 15.7% in HIV-infected children with SM vs. 37.7% in HIV-uninfected children (P < 0.0001). Presence of severe immunosuppression of CD4% < 15% increased from 46% on admission to 86% at nutritional recovery; all HIV-infected children with SM and no edema had CD4% < 15% at nutritional recovery qualifying for ART; mean time to reach recovery not reported.

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Because nutritional recovery can occur as CD4% declines, all children with HIV and SM deserve ART; ART should not be delayed awaiting clinical nutritional recovery because all children will ultimately fulfill ART criteria.

1 Abbreviations: RUTF, Ready-to-use therapeutic food; WHZ, weight-for-height Z-score; SM, severe malnutrition.

2 1 kcal = 4.184 kJ.
pediatric HIV infection is likely to be a major public health issue for many years.

HIV infection has many nutritional effects. These include an increase in resting energy expenditure (REE) (especially with opportunistic infections), decreased dietary intake, neuropsychologic effects (e.g., depression), anorexia, malabsorption (especially with infections of the gastrointestinal tract), decreased quality of life, decreased work productivity, and decreased dietary diversity in developing settings (7–10). HIV infection is also associated with loss of lean body mass, which can occur early in the disease (8). With decreased dietary intake, persistent inflammation, and increased REE, wasting is a common complication. Low BMI, failure to gain weight after weight loss, and weight loss during the first 4 wk of ART are risk factors for increased mortality (1,2,11). Among children, lower initial weight-for-height Z-score is associated with a poor outcome and growth failure is predictive of mortality (12,13). Disturbances in growth can be detectable well before the onset of opportunistic infections or other manifestations of HIV disease progression (14). The interaction between undernutrition and HIV is even more consequential, because there is considerable geographic overlap of HIV and baseline malnutrition in developing countries. Diets in areas of food insecurity and prevalent HIV, such as parts of sub-Saharan Africa, can be inadequate in both energy and diversity of nutrients (7).

HIV treatment addresses viral replication and persistent inflammation and restores immune function. Access to HIV medications is increasing slowly in southern Africa but is not available to all adults and children who need it (15). ART reduces morbidity and mortality but also improves nutritional indicators such as weight and BMI and results in improved growth in children (16–19). ART is the intervention most likely to benefit the nutritional status of HIV-infected patients with advanced viral disease but alone is insufficient. Importantly, malnutrition is still predictive of mortality even with ART (1,2).

Although access to HIV/AIDS treatment has expanded, children are significantly less likely than adults to receive antiretroviral drugs (4). Due in part to limited availability of pediatric formulations of ART, concerns about CD4 count and other monitoring variables, and limited trained medical personnel in developing countries, the WHO recommended that ART be initiated in children only after CD4- and clinical-based criteria were met (20). However, recent data showing reduced mortality in infants with earlier ART initiation and increased ART access has prompted a change in recommendations to begin ART at the time of HIV diagnosis in infants (21–23).

Whereas ART may benefit nutritional status, it may have other effects such as the immune reconstitution syndrome, a generalized inflammatory condition that may occur after initiation of ART. Treatment with ART may itself increase metabolic demand (24) and, anecdotally, seems to increase appetite. In the setting of food insecurity, the increased need for intake may not be met without direct intervention from HIV programs.

**Nutritional counseling**

Dietary intake may be influenced positively by nutritional counseling, by raising awareness about needed quantities of food to meet increased demand and adequate dietary diversity, and should be recommended in HIV care by the WHO (25). In multiple studies, counseling has been shown to increase intake and improve weight and fat mass and may also increase fat-free mass and lean body mass (26–31).

The goal of nutritional counseling is to improve the quality of the diet to reach required amounts of energy, protein, and micronutrients as well as to increase intake to meet changes in REE. Indeed, counseling can increase intake itself (26,28–31) and can be employed with relatively few resources to accomplish dietary diversity, which is associated with improved micronutrient intake and improved child growth (32–35). Counseling remains the first-line therapy in most programs for mild and moderate malnutrition.

** Macronutrient intervention studies**

In resource-limited environments, the effect of counseling may be limited by the availability of food, and macronutrient supplementation with food baskets or preprepared and packaged supplements for the individual may be the best approach. Supplementation may address not only lack of access but also wasting and micronutrient deficiencies and through increasing BMI may have nutritional as well as immunologic effects (36). Although counseling may help, provision of exogenous energy through supplementation is recommended by the WHO for those with BMI < 18.5 and for malnourished children (20,25).

In industrialized settings, various approaches have been used with adults such as supplemental formulas, including those with hydrolyzed/elemental protein and special protein formulas with whey, glutamine, arginine, or high-protein content (26–31,37–52); lipids, including fish oil or (n-3) fatty acid sources (48,53–57); and carbohydrate interventions (58). Gastrostomy tube formula feeding (59,60), parenteral nutrition (44,57,61,62), and appetite stimulants (63,64) are also prescribed. Some interventions included nutritional counseling (26,28–31,65) and exercise or resistance training in patients with stable weight or weight loss (66–73). Other methods to treat wasting and lipodystrophy have been examined, including anabolic steroids, growth hormone treatments (74,75), and cytokine inhibitors (76). In general, studies show that supplementation may increase energy intake but do not reliably result in increases in fat-free mass, body cell mass, or HIV-related outcomes like CD4 count and viral load (77).

There has been a relatively limited study of macronutrient supplementation in HIV care and treatment in developing settings given the scale and persistence of malnutrition. Several authors have examined the effects of corn and soy flour porridge (37), ready-to-use therapeutic feeds (12,78,79), and even of food supplementation (80,81). We identified 20 macronutrient studies in children (12,78,79,82–98). All pediatric studies examined patient outcomes during or after inpatient nutritional stabilization for severe acute malnutrition (SAM). A meta-analysis of 17 of these studies on SAM in children showed no mortality difference between treatment of HIV-infected children in an outpatient community-based therapy program or an inpatient nutritional rehabilitation unit, suggesting that HIV-infected children may be treatable as outpatients (99). Fourteen studies examined only inpatient outcomes. Most had no comparison group or used HIV-uninfected patients as the control. Outpatient macronutrient supplementation after stabilization was examined in 6 studies (Table 1), where ready-to-eat foods,
formula, or a food package was used. Few studies included patients on ART and none were conducted exclusively in the setting of ongoing outpatient HIV care and treatment programs, where less malnourished children are likely present for treatment. Only 3 of 6 studies included an HIV-infected comparison group randomized to receive a different macronutrient supplement.

For the existing pediatric studies, HIV infection is a consistent risk factor for death and time to nutritional recovery in children with SAM. Mortality rates in SAM remain high (45.9–49.5%) even with intervention (12,78). However, aggressive diagnosis of HIV in children with SAM may help target these children for earlier intervention. There have been no studies prospectively examining the effects of macronutrient supplements for HIV-infected children followed in HIV care, in part because SAM is often the most obvious and pressing need in developing settings. In addition, there are scant data on the combined effect of ART and nutritional interventions. Children with mild and moderate malnutrition with HIV have also not been evaluated, except when recovering from SAM. Because moderately malnourished children often present to medical care late in the course of HIV (78), this demographic may be large and needs examination. Other work involving HIV-infected children in on-going HIV care is undergoing analysis (Mark Manary, personal communication).

Data concerning macronutrient supplementation in adults are even more limited. All studies examining macronutrient interventions in adults in developing settings are listed in Table 2. For adults, notably absent are substantial data regarding effects of food-based supplementation in HIV care and treatment programs in developing settings, a strategy already in use by various groups including USAID and others (100,101). Some data also suggest that adherence to medical treatment is improved in such programs (102). Limited published information, abstracts, and unpublished work are emerging regarding HIV-related outcomes such as viral load, CD4 counts (77,103), clinical symptoms, coinfections, and hospitalizations (98,104). Important determinants of intake have not been measured, including food security or household food inventory. Economic productivity, comorbidities, including hospitalizations, and quality of life remain largely unexamined. This information is critical in programmatic planning, but randomized studies in the context of ART are sparse for both adults and children.

Despite insufficient data to recommend specific macronutrient interventions in developing settings, the WHO recommends integration of therapeutic and supplemental feeding programs into HIV care and treatment (25). Program capability and donor involvement will be critical in increasing access to such feeding programs and ultimately in determining nutritional outcomes in the face of increased food prices.

**Food prices**

Global food prices in the 21st century have risen dramatically and well above expected inflationary increases in the last decade. A composite index of food prices by the United Nations FAO rose from 92 to 146 from 2001 to January 2009 and more than doubled from 85 to 185 for nonrice cereals (105). The price index of rice has more than doubled from 102 in 2004 to 231 in January 2009 (106). All grain prices reached historic highs in 2008 and recent moderations (40–50%) in petroleum (107) and international food prices have not reached local market level. Thus, for HIV-infected patients in clinics, prices are still high and have begun to rise again in 2009 (108).

The reasons for the price growth are multifold, including global market speculation, lower crop yields in certain areas, demand for biofuels, violence affecting planting, poor weather (109), and harvesting (110). In low-income food-deficit countries, prospects for early 2009 cereal crops point to lower output for African maize and Asian wheat. Lower Asian rice crop yields may further increase global grain prices (111).

Food prices are not the only issue affecting food intake. According to the FAO, declining purchasing power may limit food access, endangering dietary intake and causing more people to fall below the hunger threshold (112). At the household level, families may shift their purchasing and food use patterns. Under economic constraints, there is an initial preservation of staples such as maize or rice, whereas intake of nonstaple foods, including more expensive meats, eggs, fish, and other nutrient-rich foods, declines due to cost (113). An increase in deficiencies of specific micronutrients is also expected as households choose a narrower selection of foods or eat varied foods or entire meals with less frequency (114,115). Energy and macronutrient (carbohydrates, fat, and protein) intake may also decrease with rising prices (116).

Food security is a critical determinant of household food usage. Adults infected with HIV may sacrifice their own sustenance for children or family members and will need direct support. Children may not have sufficient nutritional support because of sick or deceased family, affecting household income and oversight of feeding. With baseline community malnutrition, these same patients may share their ‘nutritional medication’ to help the family survive and by virtue of insufficient intake, HIV-related outcomes may be affected. An important component to dealing with the crisis of food prices is therefore ongoing assessment of food security. Nutrition-related outcomes will need to be tracked longitudinally to react most efficiently to crises such as droughts, wars, and increased food prices and to prevent nutritional deficiencies in HIV-infected patients in care and treatment.

Increasing food prices and reduced food intake have special relevance in HIV infection. Food insecurity decreases the ability to maintain adequate intake in the face of increased metabolic demand in HIV infection. Decreased access to food may affect adherence to ART, because food can sometimes mitigate medication side effects and decreased dietary intake could conceivably increase these effects. Household resources for transportation to clinic appointments may be redirected to food, thus decreasing access to medications and other medical care. For this reason, food supplementation integrated into HIV care and treatment programs can address many of these concerns and improve adherence through decreased medication side effects and potential incentive for clinic visits. To ensure the best outcomes for patients infected with HIV, governments and programs must promote long-term economic growth for food security and simultaneously provide short-term safety nets, especially in the current global economic crisis. The need becomes obvious in large, food-insecure areas in southern Africa and elsewhere. The success of macronutrient programs in the context of HIV treatment may be inversely related to the baseline nutritional status of populations they target.

**Supplementation within HIV care and treatment programs**

Despite a relatively weak evidence base, many organizations are integrating food supplementation practices in HIV treatment programs using a variety of methods. This is prudent given the clinical needs of these patients. Multiple approaches are employed, using different types, quantities, and duration
<table>
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<th>First author</th>
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<th>Results</th>
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<tr>
<td>Bakeine J (37)</td>
<td>1997</td>
<td>Uganda</td>
<td>Formula vs. corn/soy blend 4200 kcal-d^{-1} recommended</td>
<td>8 wk</td>
<td>Randomized trial</td>
<td>None</td>
<td>22 adults</td>
<td>Lower baseline BMI in formula group; increase in BMI from 53.4 to 55.5 (P &lt; 0.005) in formula group; both groups with decreases in CD4 counts, significant in corn/soy blend group; significant increases in serum albumin and triceps skinfold thickness</td>
<td>Early therapeutic nutrition intervention can improve nutritional and immune status; formula may be preferred because of micronutrient content and lack of antinutrients in corn/soy blend that can bind micronutrients</td>
</tr>
<tr>
<td>Bowie C (80)</td>
<td>2005</td>
<td>Malawi</td>
<td>Food supplementation (maize, pulse, oil, corn/soy blend)</td>
<td>12 mo, rolling</td>
<td>Prospective cohort</td>
<td>None</td>
<td>360 adults</td>
<td>No disenrollment criteria; at 12 mo of follow-up, no change in survival between groups; total BMI change per 100 d was +0.39 compared with historic control; &gt;40% died by 12 mo</td>
<td>Some suggestion of early survival benefit of food supplementation; no benefit of food supplementation to survival at 12 mo</td>
</tr>
<tr>
<td>Cantrell RA (81)</td>
<td>2008</td>
<td>Zambia</td>
<td>1) Individual ration corn/soy blend and vegetable oil (970 kcal-d^{-1})</td>
<td>6–12 mo intervention</td>
<td>Randomized controlled trial</td>
<td>All initiating ART</td>
<td>636 food insecure patients initiating ART</td>
<td>70% had desirable medication possession ratio (&gt;95%) vs. 48% in control group (RR, 1.5; 95% CI, 1.2–1.8); no significant differences in weight gain or CD4 count at 6 or 12 mo</td>
<td>Food to patients initiating ART may improve adherence</td>
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of supplementation. Methods vary including individual food-by-prescription, provision of family rations, and varied enrollment criteria using BMI or food insecurity measures (78,81,100,102).

To improve the evidence base, we and others have initiated site-level distribution of food-based supplements where possible in addition to standard of care and included rigorous evaluation into such programs to document effectiveness. The prevalence of these programs at site level is unknown, but reports come from many countries, including Malawi, Kenya, Tanzania, Uganda, Mozambique, and Zambia (12,37,81,100,117).

Macronutrient supplementation programs help ensure adequate intake for HIV-infected patients who must meet the additional metabolic demands of inflammation, viral turnover, and coinfections. In addition, supplementation has the potential to be therapeutic by addressing functional immune deficiencies such as T-cell depletion and dysfunction caused by even mild forms of malnutrition (protein-energy malnutrition and deficiencies of zinc, vitamin A, and others).

Macronutrient supplementation interventions are increasingly important in HIV care and treatment. Although providing population-wide solutions to food insecurity is desirable, there will be a continued need to provide supplements through HIV treatment programs to patients with the goal to improve adherence, quality of life, and HIV-related outcomes. It is imperative that implementers and researchers understand the efficacy and operational logistics of engaging in this important activity.

Our review identified multiple studies in pediatric and adult patients addressing nutrition in the context of HIV infection. There are no prospective studies, however, evaluating a cohort of infants or children receiving ART or children with nutritional diagnoses other than severe protein energy malnutrition. With expanding access to medications and trained personnel for children infected with HIV, this is a sizeable knowledge gap for which information on optimal practices and treatment for malnutrition in the setting of ART will be increasingly important. Similarly, in adults, the evidence base is weak and requires new, large, well-designed programmatic research in the context of ongoing HIV treatment to determine best practices. Studies published to date are insufficient to understand the benefits of particular strategies in practice. Aside from data to support therapeutic feeding for SAM in children, the application of macronutrient supplementation for large portions of the HIV population remains unexamined. This includes adults and children with mild and moderate malnutrition in the context of HIV care and treatment. In addition, there are few studies of HIV outcomes concerning the optimal type and dosage of the many food-based therapies in current use, based on which patients are most likely to benefit. Until then, like many chronic diseases for which the evidence base is incomplete, best practices are determined by clinical experience, biologic rationale, and suggestions in available studies. Best practice is the core of the WHO guidelines that advocate food or macronutrient supplementation when clinically warranted for adults with lower BMI, children with low weight-for-height Z-scores, and for the provision of the recommended daily allowance for micronutrients for adults and children (25).

The reaction of HIV treatment programs to increased food prices will be determined by several factors. The first determinant is the level of community food insecurity and the scale of undernutrition. This may be affected by economic, political, and environmental conditions and must be considered in nutritional programming. The second determinant of program response is the current priority of nutrition within HIV treatment programs and for clinicians involved in direct care. While everyone desires good nutrition, increasing the profile of the significance of nutrition will help programs establish written policies and prioritize infrastructure and personnel to carry out nutritional assessments and to implement effective programs. The nutrition community must continue to play a role in advocating for inclusion of these services.

Third, raising the profile of nutrition at the program level will also determine the funding priority for nutritional interventions. In a climate where donors are giving less (118), the importance of nutrition in HIV must be conveyed to both program directors as well as international funders of HIV and nutrition programs. Nutritionists should employ all arguments, including clinical experience, study data, economic data, and human rights. Donors may respond more readily to community nutritional problems when they affect HIV outcomes. Risk factors directly related to mortality, such as baseline nutritional status, merit donor attention and continued donor commitment. Continued advocacy and leadership by the nutrition community will make nutritional interventions more available and ultimately more effective.

Last, measuring the effects of both changes in baseline food security and nutritional status, then linking them to immunologic and clinical outcomes will be increasingly important. Populations and communities change continually under new and old stressors. Yet we must understand better the efficacy of existing approaches as nutritional programs attempt to meet the metabolic demands of patients. To prioritize and fund improved access to needed nutritional treatments, nutritional data collection systems are critical. Measurements from food security, market pricing, and serum nutrient testing in the laboratory would be helpful. Data collection systems will help not only with research but also provide nutritional indicators of early warning for crises such as increased food prices, seasonal variation, political violence, and other insults to the stability of food access for a family affected by HIV.

Increasing food prices have the potential to affect adversely both child and adult nutritional status, worsen HIV outcomes by affecting baseline BMI, and make macronutrient interventions essential. In the face of rising food prices, it is clear from this review of the limited data on the safety and efficacy of macronutrient interventions that comprehensive HIV treatment is required. Macronutrient intervention should be included in global funding priorities. In addition, we must identify the most useful macronutrient interventions. While HIV treatment programs struggle to meet the growing nutritional need on the ground, researchers and HIV advocates should join the call to establish a basic nutritional standard of care in HIV treatment. This standard should incorporate adequate energy and U.S. Recommended Daily Allowance micronutrient intake as part of a package of services that must also include supplementation programs and access to therapeutic feeding. Comprehensive services integrated seamlessly into HIV treatment programs have the greatest chance to improve survival, to increase medication adherence, to sustain viral response to first-line HIV regimens, to minimize morbidities related to nutritional deficiencies, and to improve quality of life and food security.

Other articles in this supplement include (119–134).

Acknowledgments
K.S. designed and conducted research; K.S., W.F., and C.D. analyzed data and wrote the paper; and K.S. had primary responsibility for final content. All authors read and approved the final manuscript.
Literature Cited


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35. Baikene J, Mathias PM, Mugyenyi PN. The effects of early nutritional supplementation with Nutrilif or Con Soya Blend on the nutritional and immune status of adults with HIV infection in Uganda. Proc Nutr Soc. 1997;56:282A.


104. Ndelka M voF, Manary M. Randomized controlled trial comparing the impact of supplementary feeding with either ready-to-use food or corn-soy blend among malnourished antiretroviral therapy clients in Malawi. In: 2nd Annual HIV and AIDS and Nutrition Research Dissemination Conference, Abstracts from symposium held at College of Medicine in January 2007; Malawi Medical Journal, College of Medicine and Medical Association of Malawi; Blantyre, Malawi. 2007. p. 95–100.


133. Semba RD, de Pee S, Sun K, Bloem MW, Raju VK. The role of expanded coverage of the national vitamin a program in preventing morbidity and mortality among preschool children in India. J Nutr. 2010;140:208–12.
