



COMPARATIVE COST-EFFECTIVENESS OF FOUR SUPPLEMENTARY FOODS IN PREVENTING STUNTING AND WASTING IN CHILDREN 6-24 MONTHS IN BURKINA FASO

A Report from the Food Aid Quality Review

PREPARED BY:

Ilana Cliffer
Devika Suri
Breanne Langlois
Ye Shen
Laetitia Nikiema Ouedraogo
Augustin Zeba
Hermann Lanou
Franck Garanet
Stephen Vosti
Shelley Walton
Lindsey Ellis Green
Kenneth Chui
Irwin Rosenberg
Patrick Webb
Beatrice Rogers

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For correspondence, contact:

Beatrice Rogers
Friedman School of Nutrition Science and Policy
Tufts University
150 Harrison Avenue
Boston, MA 02111
Beatrice.rogers@tufts.edu

ACRONYMS

BF	Breastfeeding
CF	Complementary feeding
CFA	West African franc
CI	Confidence interval
CNRST	National Center for Science and Technology Research
CSB+	Corn Soy Blend Plus
CSWB	Corn Soy Whey Blend
DAG	Directed Acyclic Graph
EKM	Etablissement Kafando Mahamadi
EL	Excluding Lost-To-Follow-Up
FANTA	Food and Nutrition Technical Assistance Project
FAQR	Food Aid Quality Review
FBF	Fortified Blended Flours
FDP(s)	Food Distribution Point(s)
FFP	Office of Food for Peace (USAID)
FGDs	Focus group discussions
FVO	Fortified Vegetable Oil
g	Gram
GPS	Global Positioning System
HFIAS	Household Food Insecurity Access Scale
HH	Household
HNPs	Health and Nutrition Promoters
HW	Handwashing
INSD	National Institute of Statistics and Demography
IRB	Institutional Review Board
IRR	Incident rate ratios
IRSAT	Institut de Recherche en Sciences Appliquées et Technologies
IRSS	Institut de Recherche en Sciences de la Santé
kcal	Kilocalorie
km	Kilometers
LAZ	Length-For-Age Z-Score
LNS	Lipid-Based Nutritional Supplements
LNSP	Laboratoire Nationale de Santé Publique
LTFU	Lost-To-Follow-Up
M&E	Monitoring and Evaluation
mg	Milligram
MT	Metric Ton
MUAC	Mid-Upper-Arm Circumference
MYAP	Multi-Year Assistance Program
ORs	Odds Ratios
PLW	Pregnant and Lactating Women
PM2A	Preventing Malnutrition in Children Under Two Years Of Age
RUSF	Ready-to-Use Supplementary Food

RUTF	Ready-to-Use Therapeutic Food
SAM	Severe Acute Malnutrition
SBCC	Social Behavior Change Communication
SC+	Super Cereal Plus
SD	Standard Deviation
SES	Socioeconomic Status
USAID	United States Agency for International Development
USD	U.S. Dollar
ViM	Victoire sur la Malnutrition
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme
WHZ	Weight-For-Height Z-Score
WLZ	Weight-For-Length Z-Score
WPC80	Whey Protein Concentrate with 80 percent protein content

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I. EXECUTIVE SUMMARY

In 2009, the United States Agency for International Development (USAID) Office of Food for Peace (FFP) tasked the Tufts University Friedman School of Nutrition Science and Policy with reviewing the science behind the nutritional needs of vulnerable populations and making recommendations on how to improve the quality and efficiency of USAID food aid programs for nutrition. The result was a report recommending modifications to the product considered the current standard for USAID, Corn Soy Blend Plus (CSB+). The goal of the changes to CSB+ was to improve the cost-effectiveness of the product by increasing its caloric density and improving its micronutrient content without unduly increasing its cost. In addition, the importance of animal source foods for growth in children was highlighted in the report; thus, it was recommended that the CSB+ be updated with the addition of a dairy ingredient.

From July 2014 to December 2016, the Food Aid Quality Review (FAQR) team at Tufts University partnered with the Institut de Recherche en Sciences de la Santé (IRSS) in Burkina Faso to collect data to test the cost-effectiveness of the improved food, called Corn Soy Whey Blend (CSWB), compared with food most commonly used in USAID nutrition programs, CSB+; the World Food Programme (WFP) recommended food, Super Cereal Plus (SC+); and a lipid-based nutrient supplement, Ready-to-Use Supplementary Food (RUSF). The CSB+ and CSWB were delivered with Fortified Vegetable Oil (FVO), and caregivers were instructed to add 30 g of FVO to 100 g of dry flour when preparing porridge out of the flour.

The three primary objectives of the study were:

1. Evaluate the comparative effectiveness of four food aid products in *preventing* stunting and wasting.
2. Determine the comparative cost-effectiveness of the four foods.
3. Identify factors influencing the effectiveness of the four foods.

The trial was done in collaboration with an existing USAID/FFP funded Title II Multi-Year Assistance Program (MYAP) in Burkina Faso managed by ACDI/VOCA and Save the Children. The program, called “Victoire sur la Malnutrition” (or ViM), was designed to prevent undernutrition by providing pregnant and lactating women and children 6-24 months with a monthly ration of a nutritious supplemental food. For the study, the intervention zone was divided into four regions, and each region was randomly assigned to one of the four foods. The aim of the study was to provide an evidence base for choosing among supplementary food products and recommend the most cost-effective product for prevention of stunting and wasting.

Children whose mothers had been participating in the ViM program as pregnant and lactating women were enrolled in the study on a rolling basis as the children reached about 6 months of age, when the ration was transferred from their mothers to them for consumption. Each child was provided with one of the four rations each month for a period of 18 months (6-24 months of age). Anthropometric measurements (length, weight, and mid-upper-arm circumference, or MUAC) and morbidity history of each child were taken monthly during the distributions and for three consecutive months post-intervention. To gather data on potential factors influencing effectiveness, two separate subsets of recipient caregivers were randomly selected to participate in in-depth interviews and in-home observations. In addition, ViM program staff and volunteers participated in focus groups and interviews about perceptions of household use of the foods and the distribution process. Costing data were collected on each of eight programming components — (1) food product/commodity, (2) food distribution, (3) reconditioning of products to address broken or leaking packages, (4) repackaging from bulk to individual packaging, (5) storage, (6) transport, (7) administrative and overhead costs, and (8) caregiver costs — to create a full picture of program costs, including opportunity costs to recipients and volunteers.

In comparing the effectiveness of the four foods, two primary outcomes were assessed in this study: *stunting at end-line*, defined as a length-for-age z-score of less than -2 at the measurement visit when the child was between 22.9 and 23.9 months; and *number of monthly measurements with wasting*, defined as weight-for-length z-scores less than -2 throughout the study period. Logistic regression models were built to assess the odds of stunting at end line in each study arm; negative binomial models were used, where the outcome was the total number of months the child spent wasted. In addition, longitudinal models were examined for mean length-for-age z-scores and weight-for-length z-scores throughout the study period, using mixed-effects regression models. Lastly, Cox proportional hazards models were used to conduct survival analyses, looking at time to first stunting and wasting measurements.

Incremental costs per child reached for each arm were calculated by subtracting the total cost per child reached for the reference arm (CSB+ with oil) from total cost per child in each of the other arms. Similarly, the incremental effect for each arm was calculated by taking the difference in adjusted prevalence of stunting and number of monthly measurements of wasting in each arm from CSB+ with oil. Results were then displayed graphically in order to visualize and interpret the comparative cost-effectiveness of the four foods.

A total of 6,112 children were enrolled in the study: 1,519 in CSB+, 1,503 in CSWB, 1,564 in SC+, and 1,526 in RUSF. The adjusted prevalence of stunting in children at end-line was similar among CSB+ (20 percent), SC+ (20 percent), and RUSF (22

percent), but was significantly higher in the CSWB arm, at 28 percent. Compared with CSB+, the adjusted odds of a child being stunted at end-line were not significantly different for SC+ and RUSF but were twice as high in CSWB. In terms of wasting, the predicted number of monthly measurements with wasting was also significantly higher in the CSWB arm (3.29) compared with CSB+ (2.62), SC+ (2.51), and RUSF (2.42). Children in the CSWB arm had 25 percent more wasted measurements over the study period than children in CSB+, while there were no significant differences in wasting between CSB+, SC+, and RUSF.

Longitudinal trends in both length-for-age and weight-for-length z-scores revealed that none of the four foods prevented the decline in z-scores that typically occurs in children in low-income settings between 6-27 months. Nevertheless, children in the CSWB arm declined in length-for-age at a steeper rate than those in the other three study arms, and those in the RUSF arm declined in weight-for-length at a slower rate.

Excluding caregiver opportunity costs, the most expensive intervention arm was RUSF (\$245 per child reached), followed by SC+ (\$226), CSWB with oil (\$137), and finally CSB+ with oil (\$113). When caregiver opportunity costs are added to these same estimates, the overall cost rose substantially in all arms, but especially so in the three flour-based arms, which required more caregiver preparation and feeding time. From either perspective (with or without caregiver opportunity costs), CSB+ with oil was both the least expensive arm and at least as effective or more so, making it the most cost-effective study arm.

Factors that potentially influence the comparative effectiveness of the four foods were ration sharing and diversion from the intended recipient, preparation techniques, feeding frequency, and hygiene. All four foods were shared often and diverted from the intended recipient, but sharing was more common in the CSWB arm. In addition, children in the CSWB arm were observed consuming the ration less often than in the other arms. Qualitative findings suggest that the CSWB developed a bitter taste after storage for long periods of time in suboptimal conditions, which may have influenced its use and consumption in the households.

The relatively poor performance of the CSWB in this study was unexpected, given its enhanced micronutrient profile and the addition of a dairy ingredient. This result, in addition to the failure of any of the four foods to prevent declines in z-scores over time, signifies that factors other than the products themselves are likely influencing the effectiveness of the foods in preventing stunting and wasting. It is unlikely that CSWB is biologically less effective than the other foods; however, factors related to its use by the recipients may help explain why it may be less effective in a real-world setting. Regardless of study arm, the study foods were not consumed as intended, which may help to explain the finding that none of the four foods prevented declines in z-scores.

The more frequent sharing and less frequent consumption of CSWB than any of the other three foods likely influenced its relative effectiveness.

The results of this study support several recommendations for improving food assistance research and programming.

Product choices:

- Programs should consistently use the most cost-effective products; for prevention of stunting and wasting in blanket supplementary feeding programs, in this study this was CSB+ with oil.
- Future cost-effectiveness research is needed to determine whether sharing of each type of food product would be addressed most cost-effectively by increasing dosage of the specific product or adding a general household food ration.
- The option of continued programming of food aid (in blanket supplementation) without dairy should be considered.

Program choices:

- Greater impact of food aid interventions depends on quality programming, not simply the choice of food product. More research and evidence are needed on effective programming actions for delivery of food aid including studies that consider the impact of community participation, compliance, substitution and diversion.
- The effectiveness of specialized nutritious foods depends on more than their biological efficacy. Social, environmental and behavioral factors must be considered in nutrition program design.
- Volunteer and recipient opportunity costs should be considered in program design; community members helping to run food aid distribution programs should be appropriately compensated for their time.
- Research should be done to determine how blanket supplementation can better address underlying causes of malnutrition

Experimental products research:

- Shelf life studies on new and existing products should be re-thought to take account of field conditions.

- Food science should play a role in the development of products and packaging. Interaction of different micro and macronutrients in the food matrix may be key to palatability of foods.
- Continued investments should be made in research to ensure that food assistance money is spent wisely.

The support of the U.S. Government for operations-relevant studies is key to making all-of-government action on nutrition is effective and sustained.

II. BACKGROUND

Study Rationale

The overarching goal of the United States Agency for International Development (USAID) Office of Food for Peace (FFP) is to reduce the food insecurity of vulnerable populations around the world. The majority of FFP resources are authorized through Title II of the Food for Peace Act, part of the Farm Bill (1). An important part of that effort deals with malnutrition and its negative impact on health, learning, and productivity. Thus, FFP seeks to combat the root causes of food insecurity, improve nutrition, and, through the direct distribution of food aid commodities, provide for important dietary needs of vulnerable people (2).

As part of ongoing efforts to improve the quality and efficiency of USAID food aid programs, the USAID office of FFP enlisted the Tufts University's Friedman School of Nutrition Science and Policy to review the state of science as it relates to the nutritional needs of traditionally vulnerable groups — namely, pregnant and lactating women, and young children. Starting in 2009, this included vitamin and mineral enrichment, fortification technologies, and methods for the delivery of nutrients in the form of supplements. The objective of the resulting project, called Food Aid Quality Review (FAQR) Phase I, was to produce recommendations on how to meet the nutritional needs of recipients cost-effectively with U.S. food aid products.

The FAQR team published a report in 2011 entitled Delivering Improved Nutrition: Recommendations for Changes to U.S. Food Aid Products and Programs (3). The recommended improvements included modifications to Corn Soy Blend Plus (CSB+), the product considered the current USAID standard. Compared with lipid-based nutritional supplements (LNS), such as ready-to-use-therapeutic food (RUTF) and ready-to-use-supplementary food (RUSF)¹, there were some concerns regarding the formulation of CSB+. The product had not been shown to prevent MAM and its micronutrient profile did not reflect the most recent scientific evidence for optimum micronutrient content. In addition, CSB+ had a lower nutrient and calorie density than LNS and likely did not meet the caloric needs of the recipients in the quantities consumed. CSB+ also lacked the essential growth factors provided by animal source foods, such as dairy.

The goal for changes to CSB+ was thus to improve the cost-effectiveness and efficacy of the product by addressing these concerns while keeping costs down. LNS products are much more costly per dose and per kg than CSB products (4), so the recommendations for improvements to CSB+ aimed to achieve the same effects at a lower cost.

¹ RUTF is considered the “gold standard” for treatment of severe acute malnutrition (SAM) (10,22,39).

Extensive literature review and consultations with expert nutritionists underscored the importance of animal source foods for growth in children. It was therefore recommended that CSB+ be updated with a dairy ingredient in addition to a micronutrient premix that meets the most recent scientific evidence for optimum micronutrient content. The specific recommendation was for Whey Protein Concentrate with 80 percent protein content (WPC80), which is cheaper than dried skimmed milk, less volatile in price, reliable in supply, (5) and contains more protein per gram. This newly recommended product is referred to as Corn Soy Whey Blend (CSWB).

Additionally, it was recommended that recipients prepare the CSB flour consistently with Fortified Vegetable Oil (FVO) in a ratio of 100 g CSB+ to 30 g FVO. This would enhance absorption of fat-soluble vitamins and increase calorie density of the prepared porridge.

The FAQR report also recommended strengthening the evidence base for innovations in products and programming, and testing the effectiveness and cost-effectiveness of any recommended program or commodity modifications. USAID/FFP accepted these recommendations and tasked Tufts University with testing CSWB in the field in a second phase of the FAQR.

Food Supplementation for Prevention of Stunting and Wasting

In 2017, approximately 155 million children were stunted (low height-for-age) and 52 million children were wasted (low weight-for-height) worldwide (6). The widely recognized critical “window of opportunity” for prevention of stunting occurs in the first 1,000 days of life, starting during pregnancy and ending at two years of age (7). Studies have thus focused on the “preventing malnutrition in children under two years of age” (PM2A) approach. This approach involves providing a supplement to the target child as well as a family ration to discourage sharing or diversion of the supplement. One such study, commissioned by the Food and Nutrition Technical Assistance (FANTA) Project, compared the effectiveness and cost-effectiveness of preventive and recuperative approaches to malnutrition in infants in Haiti; the study found that the prevalence of stunting, underweight, and wasting was lower in the preventive group than in treatment groups (8). This highlights the importance of preventive approaches to lowering the burden of stunting and wasting. Consensus from recent literature is that among non-wasted children, preventing stunting during the window of opportunity is more effective than attempting to treat stunting after it has already occurred (9); however, the best way to do this has yet to be determined.

The provision of supplementary foods to vulnerable children in food-insecure areas could contribute to preventing stunting and wasting and has been recommended as a key intervention (10). However, real-world studies have shown mixed results regarding

the effectiveness of supplementary feeding products in preventing stunting and wasting. Several studies have shown that the provision of either lipid-based or flour-based fortified supplements is associated with relatively modest improvements in stunting, linear growth, and wasting status (11–19). In many of these studies, declines in linear growth trajectories were observed despite provision of the foods (16,20–22), so the effectiveness of such programs remains unclear.

The choice of product is an important consideration, in terms of both program effectiveness and relative cost-effectiveness. While a few studies have compared supplementation with different types of foods (LNS and Fortified Blended Flours (FBF) both locally and internationally produced) in prevention of stunting and wasting, the studies have found minimal or no significant differences among the foods (23–26). With the exception of FANTA’s PM2A studies in Burundi, Guatemala and Haiti that investigated cost-effectiveness of implementing alternative versions of the program (27), no studies have examined the cost-effectiveness of different products, despite the fact that cost-effectiveness analysis is an essential factor in determining the feasibility of programming these products long-term.

Study Objectives

To determine whether the United States is spending public money wisely in selecting and delivering food assistance for optimal impact, the FAQR team compared the effectiveness and cost-effectiveness of four supplementary foods, including the newly recommended CSWB, in the prevention of stunting and wasting in children 6-24 months in Burkina Faso. The team collected data on effectiveness outcomes (stunting and wasting) and cost, as well as the behavioral and environmental factors that influence effectiveness. The three primary objectives of the study were:

1. Evaluate the effectiveness of the four foods in preventing stunting and wasting.
2. Determine the comparative cost-effectiveness of the four foods.
3. Identify factors potentially influencing the effectiveness of the four foods.

The trial was done in collaboration with an existing USAID/FFP funded Title II Multi Year Assistance Program (MYAP) managed by ACDI/VOCA and Save the Children, called the “Victoire sur la Malnutrition” program, or ViM for short. The aim was to provide an evidence base for choosing among supplementary food products and recommend the most cost-effective product for prevention of stunting and wasting.

Study Foods

The four food aid products used were CSB+ with FVO, CSWB with FVO, Super Cereal Plus (SC+), and RUSF, each delivered in monthly rations calculated to provide 500

kcal/day. Detailed nutrient composition² for the foods can be found in [Annex Table I](#). Prior to study implementation, each food was taste-tested for acceptability by the intended recipients, and all were found to be acceptable. Results of these taste tests can be found in the report [ViM Beneficiary Taste Tests of Title II Food Aid Products, Sanmatenga Province, Burkina Faso \(28\)](#).

The rationale for comparing each of the foods is as follows:

CSB+

CSB+ delivered with FVO acts as the reference arm for the study because it is the current standard (most commonly programmed) USAID and was being distributed by the ViM program in Burkina Faso prior to study implementation. Like most other CSB variations, CSB+ contains cornmeal, soy flour, soybean oil, a vitamin and mineral premix, and antioxidant premix.

CSWB

CSWB delivered with FVO is the updated formulation of CSB+. Similar to CSB+, CSWB contains cornmeal, soy flour, soybean oil, a vitamin and mineral premix, and antioxidant premix. The main difference is the inclusion of WPC80 and enhanced micronutrients.

FVO

FVO is a processed food product fortified with vitamins A and D. It consists of refined, bleached, deodorized, filtered, and purified canola (rapeseed), corn, cottonseed, olive, safflower, soybean, sesame, sunflower, or any other vegetable oil or a combination of these oils. As recommended by FAQR I, the oil was distributed to be prepared with CSB+ and CSWB in a ratio of 30 g oil to 100 g flour.

SC+

SC+ is the World Food Programme (WFP) standard of care and is composed of white or yellow corn, de-hulled soybeans, dried skim milk powder, sugar, refined soybean oil, and vitamin/mineral premix. Since oil is incorporated into the product, the recipients in this study arm did not receive an additional monthly ration of oil, as they did in the CSB+ and CSWB arms. The inclusion of oil means that more advanced and thus expensive packaging is required to make the product shelf stable — an aspect that will be explored in cost-effectiveness analyses.

RUSF

RUSF is USAID's version of the LNS, Plumpy'Sup[™], composed of oilseeds, tree nuts, pulses, cereals, sugar, dairy protein, vegetable oils, and a vitamin/mineral premix. Less

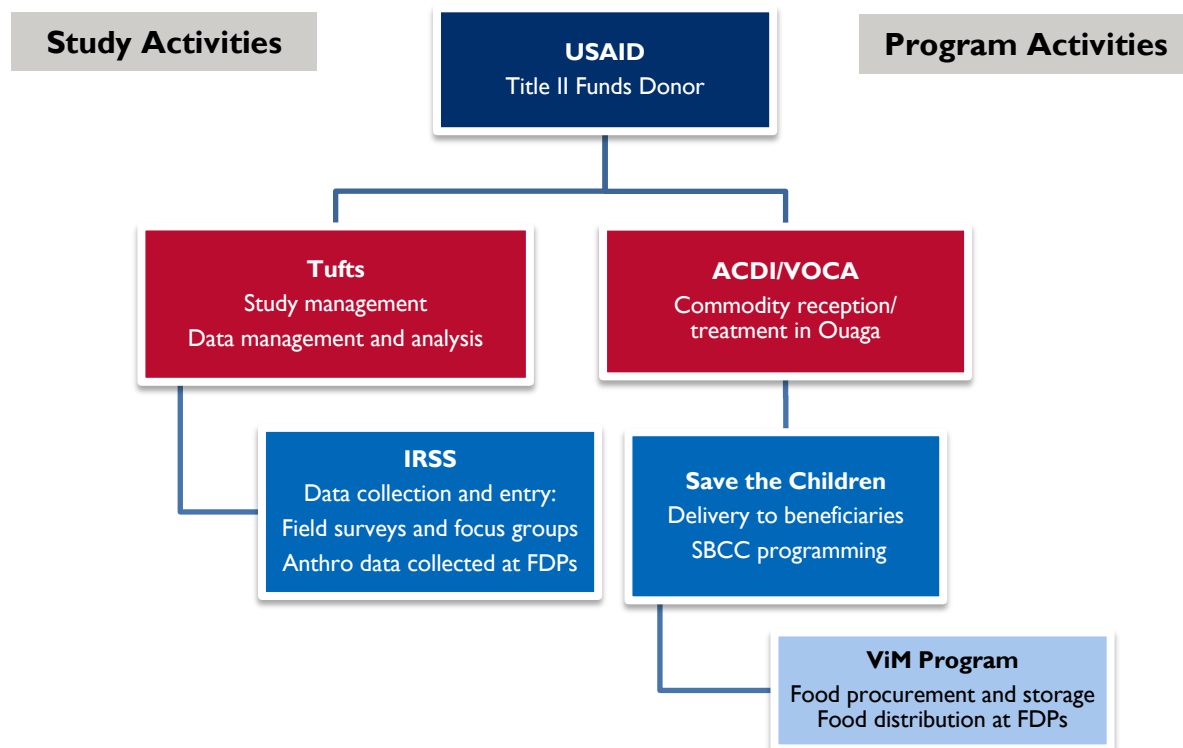
² Detailed specifications for each of the foods except the new product, CSWB, can also be found in the [product descriptions \(40\)](#).

RUSF per day is required to treat children due to its higher energy density and fat content relative to the fortified flours. In addition, it requires no preparation, can be consumed directly from the packet, and comes packaged in daily rations, which may influence compliance. RUSF was used as the LNS comparator in this study to help answer questions about the comparative cost-effectiveness of LNS products versus FBF.

Partners and Institutional Roles

This USAID FFP study was a collaboration among the Tufts University Friedman School of Nutrition Science and Policy in Boston, United States; Institut de Recherche en Sciences de la Santé (IRSS), a partner research institute housed in the National Center for Science and Technology Research (CNRST) in Burkina Faso; and supplementary feeding program (ViM) implementing partners ACDI/VOCA and Save the Children. Fat content analyses on household porridge samples were conducted by the Laboratoire Nationale de Santé Publique (LNSP) and the Institut de Recherche en Sciences Appliquées et Technologies (IRSAT), in Burkina Faso. [Figure I](#) shows the institutional roles of the main partners.

Figure I: Institutional roles in Burkina Faso FAQR field study



Notes: USAID – United States Agency for International Development; IRSS – Institut de Recherche en Sciences de la Santé; SBCC—social behavior change communication; ViM – Victoire sur la Malnutrition; FDP – Food Distribution Point; FDPs – Food distribution points

III. METHODS

Setting

This study took place in the Center-North region of Burkina Faso and covered four departments of Sanmatenga Province: Barsalogho, Kaya, Namissiguima, and Pissila. Burkina Faso is an arid, land-locked country in West Africa with high levels of food insecurity (29). According to the latest Demographic and Health Survey, from 2010, stunting rates in Burkina Faso were 13 percent for children 6-8 months and 41.6 percent for children 18-24 months. Wasting rates were similarly high, at 34 percent for children 6-8 months and 19 percent for those 18-24 months. Sanmatenga, one of 45 provinces in Burkina Faso, has roughly 643,939 inhabitants according to the latest figures available from the National Institute of Statistics and Demography (INSD) in Burkina Faso and a population density of 50 people per square kilometer. Compared with the national average life expectancy at birth in Burkina Faso (56.7 years), the average in Sanmatenga Province is lower, at 54.2 years (30). In the Center-North region, 29 percent of children under five years of age were stunted in 2010 compared with the national average of 35 percent; however, at 25 percent, wasting rates were considerably higher than the national average of 16 percent (29).

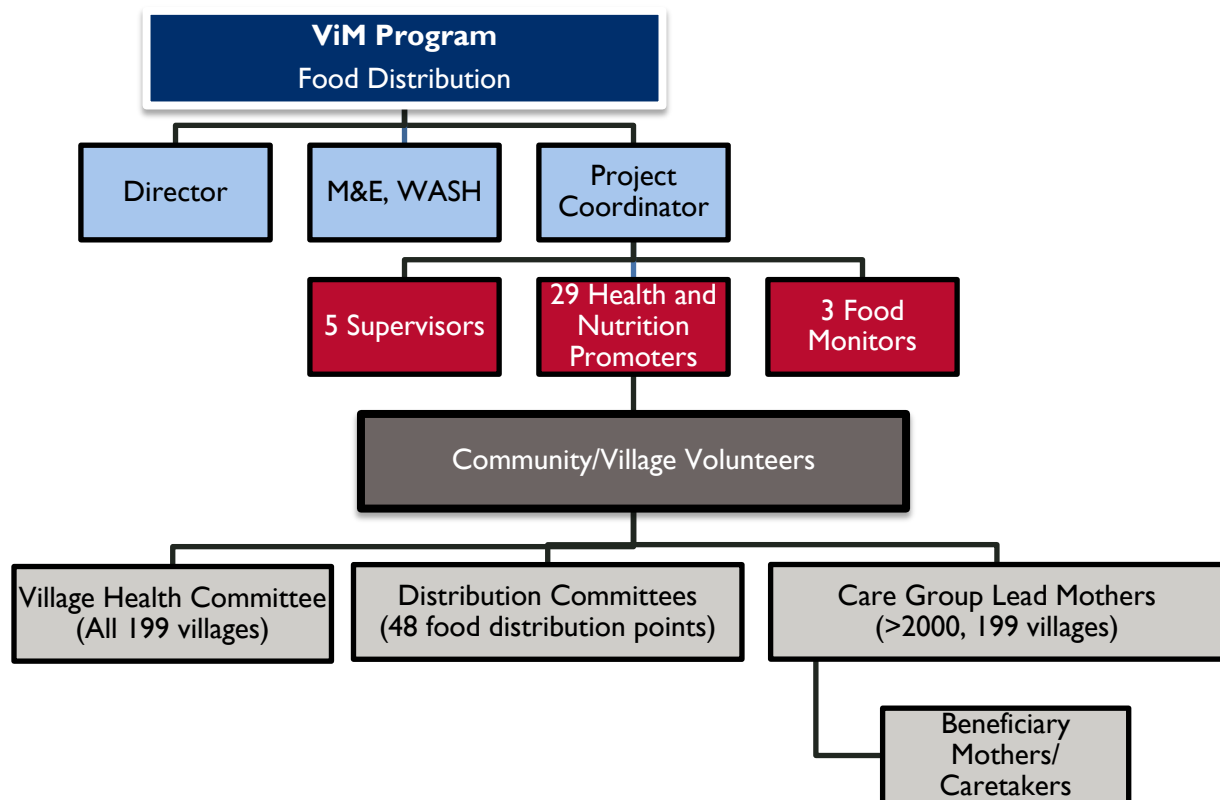
ViM Program Design

The study was embedded in a blanket supplementary feeding program designed to prevent undernutrition in high-risk areas by providing pregnant and lactating women (PLW) and children 6-24 months with a monthly ration of a nutritious supplemental food. This distribution program was part of a larger intervention focused on reducing food insecurity and improving household income. The ViM program reached 111,252 recipients across all program aspects, about 44,000 of whom were children 6-24 months who received supplementary foods as part of the program's nutrition component. Food distributions occurred between August 2011 and September 2016 (31).

The organizational structure of the ViM program is shown in [Figure 2](#).

The nutrition component of the ViM program was based on volunteer participation from the community and used the Care Group model (32) to communicate messages to the recipients about behavior change. Health and Nutrition Promoters (HNPs) employed by the ViM program were each in charge of a Care Group consisting of 10-15 "lead mothers" who had been elected by their communities to help disseminate behavior change education. These Care Groups met regularly with the ViM HNPs to get training, supervision, and support. In addition, the HNPs supported the food distribution committees, volunteers from each village who had been elected by their communities to help distribute the food aid commodities.

Figure 2: Organization of the ViM program nutrition component including staff, volunteers, and recipients



Participants in the ViM supplementary feeding program were required to meet a number of conditions prior to receiving their foods each month. Pregnant women had to attend pre-natal care visits, children had to be vaccinated, and all recipients had to attend health education sessions with their lead mothers. Food distribution committee members verified that participants had met these conditions prior to distributing the foods. Typically, women were enrolled in the program while pregnant and received food for their own consumption until their child reached 6 months, at which time the ration was transferred to the child for consumption. Lists of recipients at each site, including their ages and home villages, were kept by the monitoring and evaluation team for the ViM program, and updated each month to reflect the current situation.

Food distributions occurred regularly each month, on a date within four calendar days of the distribution date the previous month. This regularity was a necessary condition for the study, in order to obtain anthropometric measurements of children at regular intervals. Prior to the study, the ViM program had been distributing CSB+ and oil to all food recipients; however, once the study began, the catchment area was divided into four geographically distinct zones, one for each study arm. For logistical clarity and to avoid cross-contamination, each study arm was assigned to one week of the month for

distribution: CSB+ was distributed the first week of each month, RUSF the second, SC+ the third, and CSWB the fourth. Prior to leaving the central warehouse for distribution, the CSB+ and CSWB were repackaged from the 25 kg bags in which they arrived from the United States into smaller, ration-sized bags. The week prior to scheduled distributions for each arm, trucks would gather the foods from the central warehouse in Ouagadougou and transport them to the sites designated for that food. An example of a distribution schedule is found in [Annex Table 2](#).

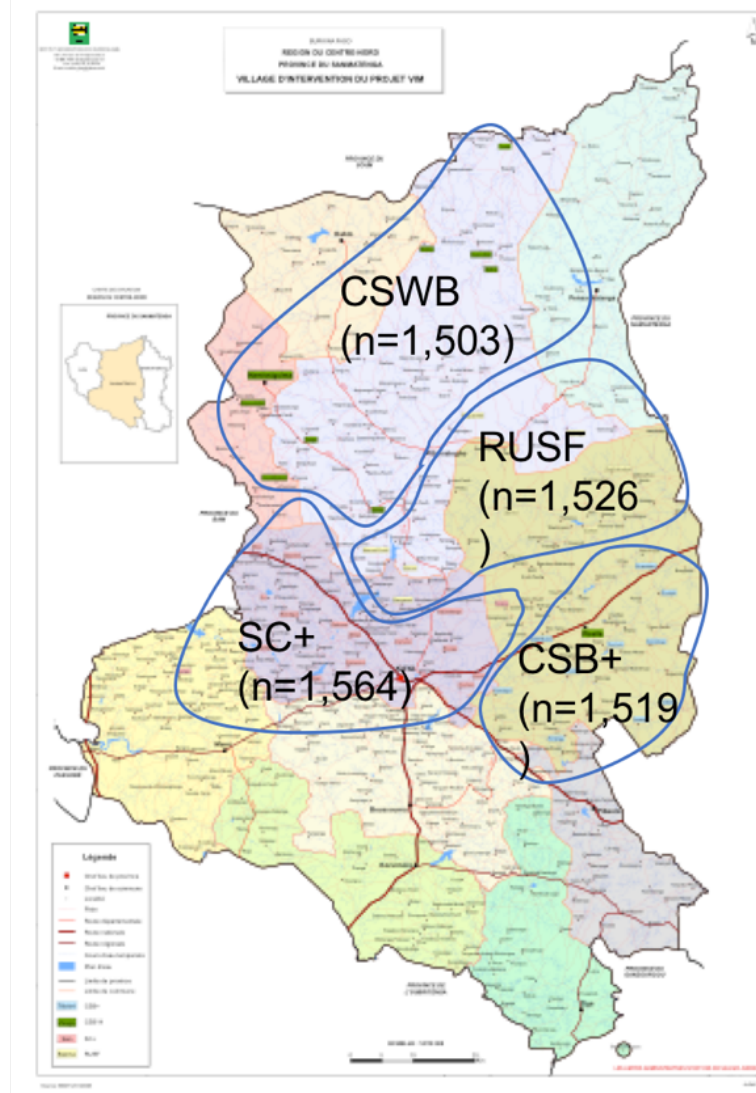
In addition to distributing the four study foods, the ViM program provided households with extra rations during the “lean season,” from June to September. Regardless of study arm, each household received the same household ration of 10 kg split green peas and 4 L of oil monthly during this time, in addition to their normally scheduled rations.

Study Design

This was a four-pronged, geographically clustered effectiveness trial with random assignment to study arms. The 48 food distribution points (FDPs) were non-randomly clustered into four geographically contiguous groups and then randomly assigned one of the four foods. FDPs were geographically grouped together in lieu of cluster-randomized due to the logistical constraints of the ViM program, and to avoid potential cross-contamination of the products across study sites. As the purpose of the study was to compare the cost-effectiveness of the four foods to each other, the study was not designed with a control group. In addition, all children in the region are considered vulnerable to malnutrition, thus it would be unethical to deprive any particular group of children from receiving an intervention designed to improve their health and nutrition status.

[Figure 3](#) shows the layout of the study sites and arms across Sanmatenga Province. Though pregnant and lactating women were not studied during this trial, all recipients served by a given FDP received the assigned food for that FDP, including both pregnant and lactating women and children 6-24 months, to avoid any risk of confusion among the foods. The number of FDPs per cluster was based on estimates of enrolling an equal number of children in each study arm per month, so that enrollment would start and end at roughly the same time for each arm. Consequently, each cluster does not have the same number of FDPs; however, the number of total recipients in each cluster is comparable. Blinding was not possible in this study. Both the participants and those distributing the food knew what food was being provided.

This study was reviewed and approved by the Tufts University Institutional Review Board (IRB) and the ethics board of the Ministry of Health in Burkina Faso. It is registered on ClinicalTrials.gov under identifier NCT02071563.

Figure 3: Map of study sites in Sanmatenga Province, Burkina Faso

Children were enrolled in the study on a rolling basis from August 2014 until the desired sample size was reached in July 2015. The last data collection point was in December 2016.

Study Methods

Sample size calculations: The calculated target sample size of 1,500 children per arm was based on a statistical power of 80 percent and an alpha level of 0.05 to detect 5 percentage point differences in the primary outcomes of stunting and wasting. Assuming 30 percent attrition, to get 1,000 analyzable cases per study arm, the goal was therefore to enroll 1,500 children per arm. Sample sizes for in-depth interviews and in-depth interviews were based on feasibility. [Table 1](#) below shows desired sample sizes for each group of participants.

Table 1: Sample sizes by type of subject³

Subject	Data Collection	Frequency	Frequency Per Individual	Per Study Group	With Attrition ¹	Total Subjects
Recipient Child	Growth Measurements	Monthly	21	1,000	1,500	6,000
Recipient Caregivers	In-depth interview ²	Ongoing	Once	400	445	1,780
	In-depth interview and in-home observations	Ongoing	Once	50	56	224
	Focus group discussions (FGDs)	Quarterly	Once	60 (6 FGDs/group)	N/A	240
Health and Nutrition Promoters	Individual interviews	Quarterly	Once	N/A	N/A	36 (all)
Lead Mothers	Individual Interviews	Quarterly	Once	80	N/A	320
Distribution Committee	FGDs (logistics, cost, perceived barriers)	Quarterly	Once	24 (6 FGDs/group)	N/A	240
Village Elders	Community questionnaire	Pre-data collection	Once	3 elders per village	N/A	597
Total						9,401

¹ Calculated based on 30% attrition in recipient child and 10% attrition in interviews

² Does not include the interviews that occur within in-home observations

Sampling and enrollment: Because the ViM program was a blanket supplementary feeding program with no anthropometric cutoffs or other health-related criteria for entry, all children whose caregivers had been participating in the ViM program became eligible for study enrollment when the ration was transferred to them for consumption. While this usually happened when children were 6 months old, there was some variation.

Study enumerators used lists of ViM recipient children, kept and updated monthly by the ViM monitoring and evaluation team, as the sampling frame for enrollment of children at each distribution site who were receiving the ration for the first time. The teams enrolled all children on the ViM list up to 12 months of age, who were effectively transferred the ration that day; the team also enrolled any children whose names did not appear on the list, but who were given the child ration that day per the HNP's decision. Any children who should have been enrolled but missed the distribution were enrolled the next time they came to the site to receive their ration. Exclusion criteria included children over 12 months, as well as those who had a MUAC measurement of less than 11.5 cm and were thus classified as severely malnourished and referred to the hospital for treatment.

Two separate subsets of recipient caregivers were randomly selected to participate in in-depth interviews and in-home observations. At the end of every enrollment day, each

³ Sample sizes achieved are found in the results section in [Tables 4](#) and [5](#).

enrolled child was assigned a unique ID. A random number generator was then used to select IDs for participation. In addition, each random selection was again randomly assigned a number between 2 and 18 to indicate which month relative to enrollment the interview or observation would occur. This was done to spread the interviews and observations evenly throughout the study period.

Villages were selected for focus group discussions with recipient caregivers and distribution committee members purposively, considering factors such as proximity to markets and the distribution site, to ensure inclusion of various viewpoints and experiences. Individual participants in recipient caregiver focus groups were chosen by asking each neighborhood in the selected village to offer a volunteer who had not also been selected for an observation or an interview.

Focus group discussions were also conducted with distribution committee members; these were done with all distribution committee members in the selected village.

All 36 ViM HNPs were included in individual interviews. Lead mothers were randomly selected for interviews based on a list of all lead mothers for the ViM program. This list of lead mothers proved difficult to update, as lead mothers would often trade places in the community with another woman and fail to inform the ViM program. Therefore, enumerators would often find that a woman who had been selected from the list was not actually the current lead mother in that village. The sampling was thus considered to be for the position of lead mother in that village, and not necessarily the specific woman, and the enumerator would interview the woman who identified herself as the current lead mother.

Informed consent was sought from the recipient caregivers of recipient children for their children's participation in the study. Consent was also sought from the recipient caregivers of all eligible children for their own participation. The consent process was conducted by the study enumerators in the caregiver's native language. During the process, participation requirements, risks and benefits to participating, and the study duration were explained. Informed consent was administered verbally and in writing. Enumerators were trained in how to invite caregivers to participate in the study without putting pressure on them; it was made clear that the decision whether to participate would have no effect on the continued receipt of the food ration and on any other aspects of the ViM program.

Data Collection

Field work was done in collaboration with the IRSS. This Burkinabe institution was responsible for enumerator recruitment and training, participant enrollment, data collection, data entry and cleaning, and preliminary analyses.

Both quantitative and qualitative data were collected to assess comparative

effectiveness, cost-effectiveness, and factors that influence the effectiveness of the four foods. Data collection instruments for each of these study aspects are summarized in [Table 2](#).

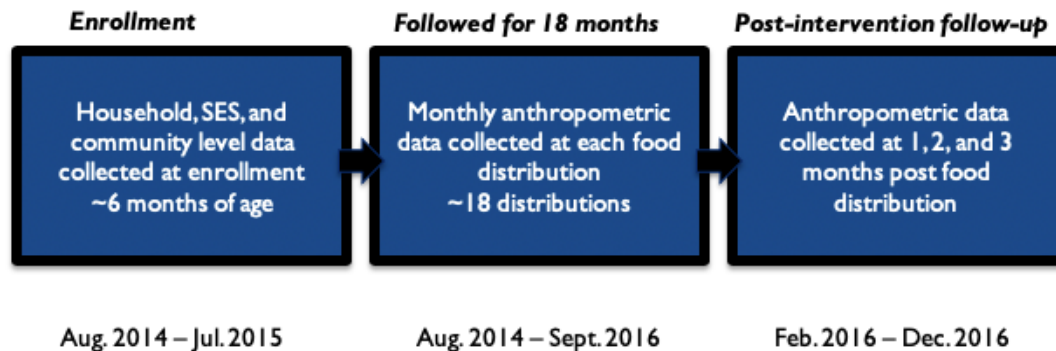
Table 2: Data collection instruments by study topic

Effectiveness	Cost-effectiveness	Influencing Factors
Monthly anthropometry	Distribution observations	Distribution observations
Monthly morbidity and treatment surveys	Warehouse observations	Individual interviews with recipients, lead mothers, and HNPs
Socio-economic surveys at enrollment and exit	Individual interviews with recipients and lead mothers	In-home observations with recipients
Community questionnaires	In-home observations with recipients	Focus group discussions with recipients and distribution committees
	Financial records	

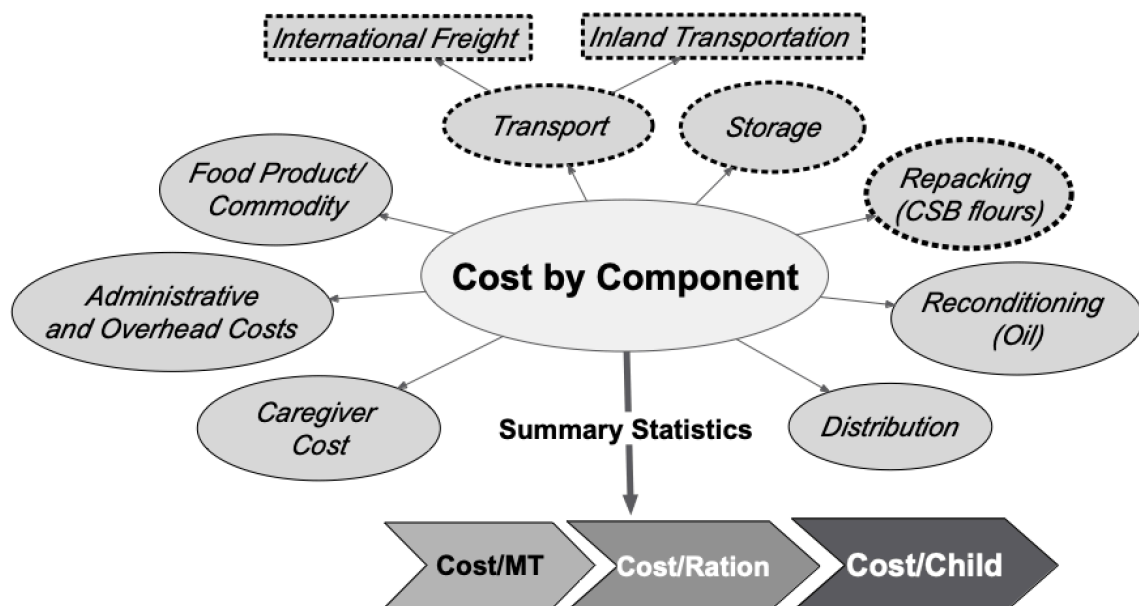
At the time of enrollment and exit, data were collected on demographics, food security, individual socio-economic status, and community-level information on access to healthcare, education, and roads. For effectiveness, enrolled children were each followed for a period of 18 months while they were receiving the ration; the gathered data included monthly measurements of their recumbent length, weight, and MUAC, as well as morbidity and any healthcare treatments received in the previous two weeks. Similar anthropometric and morbidity surveys were conducted for three consecutive months after the child stopped receiving the ration ([Figure 4](#)).

In addition to these data, which were collected on every enrolled child, a subset of caregivers underwent in-home observations and a separate subset was administered in-depth interviews on use and perceptions of the food products. These were done to identify factors that potentially influence the effectiveness of the four foods. Water samples were taken from each household interviewed and observed to check for contamination with *E. coli* as a measure of water contamination. Porridge samples were also collected to check for actual fat content in prepared samples of the foods. Porridge samples were not taken from the RUSF study arm, as porridges were not typically prepared in this arm.

Focus Groups were organized with both recipient caregivers and distribution committee members, to contribute additional insight into qualitative factors that could influence effectiveness.

Figure 4: Enrollment timeline

Cost data collection consisted of observations of the FDPs, the main warehouse in Ouagadougou, and the entire food distribution process from the warehouse to the recipients. In-depth interviews were also conducted with key informants from the ViM program, to gather data related to the last mile of the food distribution program; those results are presented in a separate report entitled *The Last Mile of Food Aid Distribution: Insights Gained through FAQR's Field Studies in Malawi, Burkina Faso, and Sierra Leone*. All categories of cost data collection are summarized in [Figure 5](#) below.

Figure 5: Costing components with dotted borders showing where adjustments for losses incurred were made

The data collection instruments were pretested in the field prior to data collection to ensure comprehension of the questions. Forms were written originally in English and then translated into French and back into English to ensure proper translation.

Short descriptions of each data collection instrument follow:

Community questionnaire: The questionnaire was administered to village leaders in each of the 199 villages in the ViM catchment area prior to the start of anthropometric data collection. It was used to gather information about village access to services and infrastructure such as roads, education, clean water, and healthcare.

Monthly anthropometry and morbidity: Enumerators recorded each child's length, weight, and MUAC as well as data on illnesses and health interventions in the previous two weeks. Teams of five enumerators (four data collectors and one supervisor) were present at each site to enroll and measure children. While each team had its own way of organizing themselves during the distribution and measurement process, teams used standardized methods for measuring the children. All measurements were taken twice on each child, by measuring first weight, then MUAC, then length, and then repeating the entire process. The measurers called out the measurements, and the supervisor repeated the measurement back to the measurer to ensure accuracy and then noted the measurement on the data collection forms. If the difference between the first and second measurement was large (greater than 0.3 kg for weight, 0.5 cm for MUAC, and 0.5 cm for length), a third measurement was taken and the two closest measurements were averaged.

Entry/Exit survey: At both entry into and exit from the study, data were collected about household food security and possessions. The Household Food Insecurity Access Scale (HFIAS) was used to measure food security (33), and validated possessions questions from the Burkina Faso Demographic and Health Surveys (29) were used as indicators of socio-economic status.

Recipient caregiver in-depth interview: The interview included questions about the caregiver's perception of the ration, its benefits, and how much the recipient child liked it, as well as how the caregiver used and prepared the ration and what quantity was served to the child. The interview also included questions on child diet diversity in the 24 hours prior to the interview. Each study participant selected for an in-depth interview was randomly assigned at enrollment to do the interview in a particular month. Interviews were scheduled for specific weeks by the Field Research Director to ensure that each study arm was represented equally in each week following food distribution. There were thus an equal number of interviews in each study arm every week. This was done to avoid potential bias in answers that would occur if the interviews were clustered at consistent time points from the distribution date. At the end of the interview, enumerators collected porridge samples from the households in the three study arms in which people were expected to make porridge (CSB+, CSWB, SC+), and collected water samples to test for *E. coli* in households in all study arms.

Recipient caregiver focus group discussion: Focus group discussions were held with recipient caregiver mothers to allow for open-ended discussion of their perceptions and experiences with the food distribution program.

Recipient caregiver in-home observation: Observers (all female) were sent into households for a period of four consecutive days to conduct structured non-participatory observations of recipient behaviors. They observed how caregivers prepared the ration (if they prepared it), how they consumed it (if it was consumed), and any hygienic factors that could influence the effectiveness of the foods. Observers used a pre-coded grid in 30-minute increments from 06:00 to 18:00 to record feeding and hygiene practices. Qualitative notes were also taken on events related to childcare, health, and feeding. In-home observers arrived at the homes of participants the day before the observation was to start, to conduct the informed consent process with the head of household and the participating caregiver. Once consent was given, observers spent the day in the household without taking any notes, to habituate the household to their presence before starting the four-day observation. Observers typically slept in nearby households or public areas in the village rather than in the household they were observing, to minimize any burden and avoid changes in cooking and feeding behaviors due to the presence of a guest in the household. In addition, at the end of the observation (the morning after the last full day of observation), enumerators conducted the in-depth interview with observation participants. Porridge (when appropriate) and water samples were collected from the households.

Lead mother in-depth interview: Interviews with lead mothers focused on the training the lead mothers received and the messages they gave to the recipient caregivers in their Care Groups.

HNP in-depth interview: Interviews with HNPs focused on the training they received and the messages they gave to the lead mothers.

Distribution committee focus group discussion: During group discussions, distribution committee members focused on the training they received, their role in the distribution process, and any perceived barriers to distributing the foods.

Distribution observation: Each FDP was observed once during the study period to gather costing information on how long it takes to distribute each of the commodities, staff time involved, the flow of recipients, how long recipients stay at the sites, and food safety and hygiene.

Last mile interviews: In-depth interviews were conducted with ViM staff members to gather qualitative data on the last mile of food distribution, defined as the part of the supply chain between when the foods arrive in the central warehouse in Ouagadougou

and when they get to the hands of the recipients.

Warehouse observation and chart extraction: Warehouse observations were done to gather information about warehouse and commodity dimensions (for storage calculations), time spent prepackaging foods, average storage time, and losses. These data were collected directly by the Field Research Director, with the exception of those pulled from recipient interviews and observations. All costing data sources are summarized in [Table 3](#) below.

Table 3: Costing data sources

Cost Component/ Activity	Definition	Data Source
Food Product/Commodity	Cost of the specific specialized nutritious food and additional fortified oil (if applicable)	Billing records from Didion Milling, Challenge Dairy, and Edesia; historical data from FFP and realistic price quote from Didion Milling
International Freight	Cost of international shipping from the United States to Ouagadougou, Burkina Faso	Billing records from ACDI/VOCA and realistic quotes from BKA Logistics
Inland Transportation	Cost of transportation from the main warehouse in Ouagadougou to FDPs in the study sites	Billing records from Etablissement Kafando Mahamadi (EKM) and Save the Children
Storage	Cost of storing the foods at the main warehouse in Ouagadougou, including space, labor, fumigation, destruction, utilities, commodity handling, lab testing and analysis, and other services and supplies	Warehouse documents and accounting records from ACDI/VOCA
Repacking (CSB+ and CSWB ONLY)	Cost of repacking 50 kg bags of CSB+ and CSWB into 2.25 kg bags (labor and materials)	Warehouse documents and accounting records from ACDI/VOCA
Reconditioning (FVO ONLY)	Cost of reconditioning fortified oil that was leaking from the cans (labor and materials)	Warehouse documents and accounting records from ACDI/VOCA
Distribution	Cost of labor (including staff cost and opportunity cost of volunteer distribution committee members) and fixed supplies	Observation instruments from the study and accounting records from ACDI/VOCA
Administrative and Overhead Costs	Cost labor (including implementation partners' staff cost and opportunity cost of lead mothers involved in SBCC), training, and administrative overhead costs	Accounting records from ACDI/VOCA and Save the Children, and interview instruments from the study
Caregiver Cost	Monetary and opportunity cost of caregivers' time participating in the program (included in program and caregiver perspective)	Observation and interview instruments from the study

Enumerator Selection, Roles and Training

Candidate enumerators were interviewed by the IRSS coordination team and selected to participate in an initial training session. A total of 31 full-time enumerators were selected from this session. Those who were not selected were put onto a list as back-up enumerators in case of need. After the initial training session, additional enumerators were trained due to lack of sufficient staff. By the end of the study, a total of 72 enumerators were collecting data for the study, grouped into categories based on their roles: anthropometry enumerators (36), back-up anthropometry enumerators (15), anthropometry supervisors (9), interviewers (3), interviewer supervisor (1), in-home observers (5), in-home observation supervisor (1), and focus group moderators (2). In addition, the study recruited four full-time data entry agents.

Training

General training: Supervisors and enumerators were all trained on the purpose of the overall research, research ethics (including the informed consent process), maintaining neutrality and obtaining the confidence of the participant, and data collection and enrollment logistics. In addition, they were each trained on their respective data collection instruments by going through questionnaires and doing role plays in which volunteers interviewed each other in front of the group and everyone noted the answers they deemed appropriate. The group then compared answers and discussed any discrepancies. This served as a way of standardizing the group to record answers to the questions consistently. In addition, enumerators were sent into the field to gain practical experience administering the questionnaires before collecting data. All enumerators attended refresher trainings for their respective modes of data collection at least once every three months and attended meetings on an ad hoc basis when necessary.

Translation training: Because Mooré, the local language in the study region, is not a commonly written language, all forms were written in French and orally translated on the spot into Mooré. As part of the training process, to ensure regularity in the translations, enumerators agreed upon the best translations as a group and voice recordings were made of these translations. These recordings were available to all enumerators to review prior to going into the field for data collection.

Standardization for anthropometry: Enumerators who conducted anthropometric measurements were standardized prior to starting data collection and every three months thereafter. In this process, the enumerators were tested for both inter-measurer and intra-measurer reliability: They each measured the same set of 10 children two times, then compared these measurements with the average for each child and

compared each of their two measures for each child. Acceptable divergence from the mean for inter-measurer reliability) and between their two measures (for intra-measurer reliability) was set by the research team after literature review at no more than 0.5 cm for length, 0.1 kg for weight, and 0.5 cm for MUAC.

Observer training: The in-home observers were trained on methods for conducting non-participant observations, remaining professional while staying in people's homes, and the logistics of setting up in-home observations and obtaining household consent.

Focus group training: The focus group animators were trained on focus group techniques including using a semi-structured interview guide, probing with open-ended questions, and remaining neutral.

Global Positioning System (GPS) training: All enumerators who conducted interviews or observations had to collect GPS data from the households where they conducted interviews and observations, and were thus trained to use the Garmin eTrex 20 handheld GPS.

Water testing training: Enumerators who conducted in-depth interviews and in-home observations were trained in administering the Aquagenx compartment bag test for E. coli concentration, a portable field-based test for estimating the coliform forming units in a 100 ml sample of water.

Porridge sampling training: Enumerators were instructed how to take small samples of porridge from all households participating in in-depth interviews and in-home observations. Protocol for sampling the porridge was as follows: 1) Ask the caregiver if there is any leftover premade porridge, and if so, sample from that batch. In the absence of porridge that is already made, ask the caregiver to prepare the porridge as she normally does and provide a small sample. 2) Stir the porridge for a minimum of 15 minutes to fully homogenize any oil. 3) Immediately after stirring, place a sample of 40 ml into the receptacle and close the lid. 4) Label the sample with the participant's code, village, and time of sampling. 5) Place the sample into a cooler for transport and put the sample directly in the freezer upon arrival at the office.

Lab Analyses

All porridge samples were analyzed for fat and moisture content by the LNSP, and 10 percent duplicates were analyzed for quality control by the IRSAT. The protocol for lab analyses was set after multiple validation tests with both laboratories, in which samples with known quantities of oil were sent to the labs for blind tests and values provided by the labs were compared with the known actual values of oil. Validation tests were repeated until the protocol was refined to the point that the laboratory values matched the known values within 2 g. The final established protocol was as follows:

1. Dry the entire sample of porridge at 105°C for one night to transform it to dry matter.
2. Weigh the dry matter to calculate moisture content with the following formula:

$$\% \text{ Moisture} = \frac{PE - (P_f - P_o) \times 100}{PE}$$

PE = Full weight of sample plus receptacle

P_o = Empty weight of receptacle

P_f = Final weight (receptacle + full weight of sample plus receptacle)

3. The dry matter must be placed in a blender to fully homogenize the sample.
4. Run 5 g of the fully homogenized sample through the Soxhlet machine for four hours using 250 ml of hexane.
5. After weighing the empty beaker, place the beaker in the steamer at 105°C for one hour. Fat content is determined by gravimetric analysis.
6. Finally, fat content is determined using the following formula:

$$\% \text{ fat matter} = \frac{PF - PV \times 100}{PE}$$

PF = Final weight (beaker + fat matter)

Pv = Empty weight of the beaker

PE = Total weight

Data Management, Entry, and Cleaning

All data were collected in the field on paper forms and brought back to the office to be double-entered into a CSPro database by four data entry agents. The paper forms were stored in locked cabinets throughout the study period, and only the data manager had access. Forms that were used multiple times, such as those used to collect monthly anthropometric data, were requested from the data manager by the supervisors at the beginning of the day the forms were needed, taken into the field, and then given back to the data manager for entry and storage. Data were entered on a rolling basis as they arrived from the field; each time a form was entered, it was tracked that the form had been entered and by whom. Each data entry form had its own database.

Questionnaires and entered data were audited for errors on a weekly basis by the Field Data Manager with overall supervision by the Field Research Director, Data Collection Coordinator, and senior management. Both source document accuracy and entered data were audited; data collection forms were field-checked by the supervisors and spot-checked by the coordination team, and entered data were compared to data entry forms as well as double-entered.

Every data entry form (100 percent) was double-entered into the database. Data entry agents worked in teams, with one agent entering all the data, and the second agent entering the same data into a second database. The databases were then compared on a regular basis for discrepancies. Any discrepancies were compared with the original questionnaires to find the correct data point. This process was completed for each database until the comparison of the duplicate databases turned up zero discrepancies. A few of the forms also contained the same demographic information in the header of the data collection instrument, and this information was also compared across forms for consistency. Enumerators were sent back into the field to address any inconsistencies. In addition, to prevent major differences in data collection between enumerators, global checks were done for common errors and other checks were done using basic descriptive statistics to ensure there was minimal inter-enumerator variation. If common errors were found, refresher training was conducted with the enumerators as necessary.

Data were exported into Stata software and field-cleaned by generating descriptive statistics and checking for implausible and missing values. Cutoffs for implausible values were based on literature review and biological plausibility. Enumerators were sent back into the field to correct any non-time-varying missing or implausible values. Time-varying missing and implausible values were noted but could not be corrected.

Data Analyses

Effectiveness

The primary purpose of this study was to assess the comparative effectiveness of the four foods as used in a real-world program setting in preventing stunting, defined as length-for-age z-score (LAZ) less than -2, and wasting, defined as weight-for-length z-score (WLZ) less than -2. For all analyses, CSB+ was used as the reference group, comparing the performance of each study group with that of CSB+ because it was the standard of care for the ViM program prior to the implementation of this study.

Logistic regression models were built to investigate the odds of stunting at end-line in each study arm. End-line was defined as the measurement where the child's age was between 22.9-23.9 months. Children without an end-line measurement were considered lost-to-follow-up (LTFU) for the stunting models. Since wasting is more of a temporary state than stunting, and children tend to fluctuate in and out of it, wasting models were done with negative binomial regression models where the outcome was the total number of months the child was measured as wasted. For this reason, the definition of LTFU used for the stunting models is not relevant to the wasting models; instead, the

wasting models adjusted for the number of times each child was measured throughout the study period.

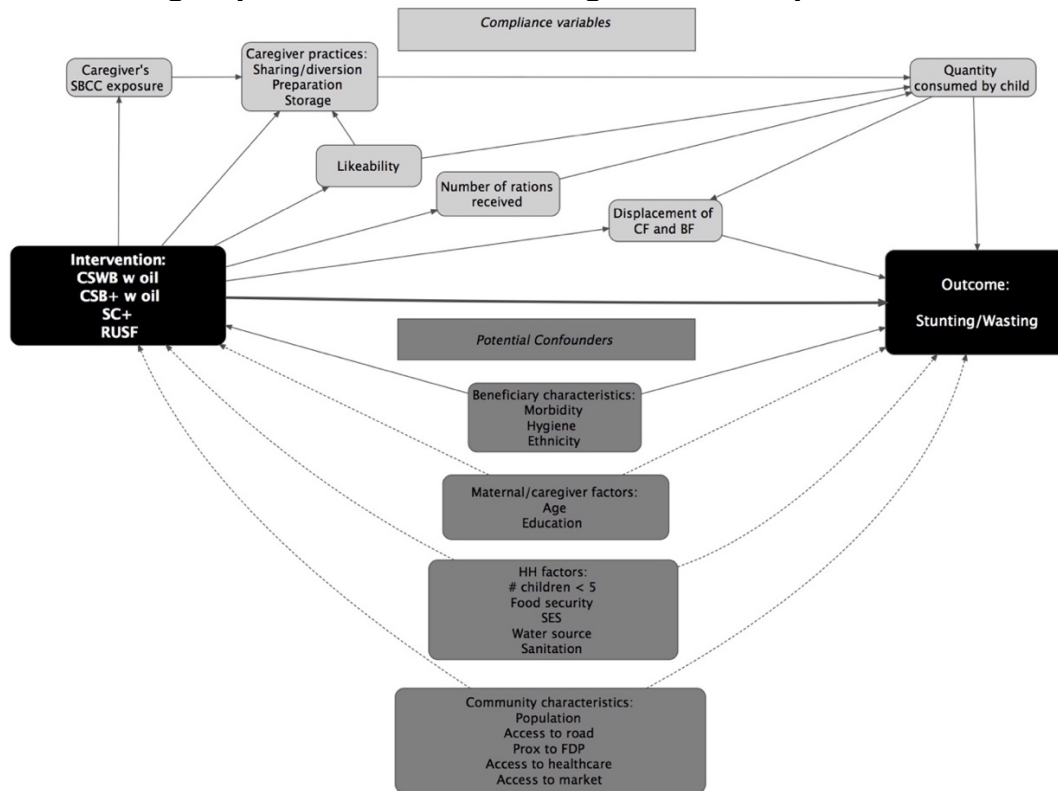
In addition to these primary models, a number of secondary outcomes were examined. The probability of ever being wasted throughout the study period was modelled using logistic regression, and longitudinal models were examined for mean LAZ and WLZ throughout the study period using mixed-effects regression models. Lastly, survival analyses were conducted to look at time to first stunting and wasting measurements using Cox Proportional Hazards Models. Hazards ratios obtained from these models show the wasting and stunting rates per unit time (months) for each study arm compared to CSB+.

In modeling the relationships between the outcomes of stunting and wasting and the study foods, potentially confounding factors were chosen *a priori* based on the literature, as shown in a directed acyclic graph (DAG) ([Figure 6](#)) including factors that may influence nutritional status, including baseline z-scores, access to healthcare, and socio-economic status. To ensure that children LTFU did not alter the results, all stunting models were estimated twice, both with children LTFU (intention to treat) and without.

Models for both stunting and wasting were fit with and without multiple imputations for missing covariate data, using predictive models for the missing data, and compared for consistency. Models using multiple imputations did not produce different results from those where these data were missing. Stunting models including children LTFU were fit by assuming best- and worst-case scenarios, where all children LTFU were assumed to be healthy (not stunted) and where all children LTFU were assumed to be stunted. All models, both with and without LTFU children, produced consistent results, indicating that the children who were LTFU most likely did not have anything in common that made them different from those with measurements. All models were evaluated for multicollinearity and any influential outliers.

For the Cox Proportional Hazards models, Kaplan-Meier curves for each categorical predictor were examined to check the shapes of the survival functions and assess proportionality. Final variable selection was made after testing equality across levels of each variable with Cox proportional hazards models for continuous predictors and non-parametric log-rank tests of equality for categorical predictors. Final models were checked for the proportionality assumption that the ratio of hazards for any two individuals is constant over time using interaction terms between each predictor and the time variable (months to recovery), and goodness-of-fit tests were done using Cox-Snell residuals.

Figure 6: Directed Acyclic Graph (DAG) showing relationships among intervention groups, outcomes, mediating factors, and potential confounders



Notes: BF, breastfeeding; CSWB, corn-soy whey blend; CSB+, corn soy blend plus; SC+, supercereal plus; RUSF, ready to use supplementary food; SBCC, social behavior change communication; CF, complementary feeding; HH, household; SES, socio-economic status; FDP, food distribution point.

Cost-effectiveness

The comparative cost-effectiveness of the four products was assessed by linking the costs of programming each of the study foods to the effectiveness outcomes. All costing components were summarized to obtain a total, loss-adjusted cost per child reached for each intervention arm. The costing components were adjusted for losses using percent losses at each of the supply chain steps for which data on losses were available.

Some important considerations were made in calculating cost-effectiveness. Most of the costing components were collected as part of the ViM distribution program, and the food product and international freight costs were obtained from ViM purchase records. The product and freight costs, however, were unrealistically high because the study procured smaller quantities than would normally be purchased for a program, and the CSWB was produced only for the study. Therefore, both actual costs incurred by the program during the study and more realistic cost estimates based on historical prices for programs operated at scale were reported and compared.

Costs incurred by multiple stakeholders (donor, implementer, volunteer, caregiver) were considered for cost-effectiveness analyses. These costs were combined into two perspectives: the program perspective and the combined program and caregiver perspective. The program perspective included all of the costs incurred by the implementing agency; this included the estimated value of the time volunteers spent involved in program activities such as distribution and SBCC. The combined program and caregiver perspective considered the additional costs incurred by the caregivers of the program recipients. This included the estimated value of the total time caregivers spent doing program-related activities such as traveling to get the study foods, cooking the foods, and feeding them to the child. Opportunity costs for volunteers and for caregivers were obtained by multiplying the respective time-use by an estimated hourly shadow wage. The shadow wage was estimated as the equivalent of \$0.36 2018 U.S. dollar (USD) per hour, based on the mandated minimum hourly wage for agricultural workers specified in Burkina Faso law (34). This estimation is justifiable but may be unrealistically high, since not all workers are covered by the government mandated wage.

To link cost per child reached in each arm with the effectiveness outcomes, the total cost per child reached for the reference arm CSB+ with oil was subtracted from that in each of the other arms to get the incremental cost per child reached for CSWB with oil, RUSF, and SC+ compared with CSB+ with oil. In a similar manner, the incremental effect for each arm was calculated by taking the difference in adjusted prevalence of stunting at end-line and adjusted number of monthly measurements with wasting per child, from CSB+ with oil. Incremental cost per child reached and effectiveness outcomes were then graphically linked on an incremental cost-effectiveness plane. These planes, which are tools typically used to visualize and interpret cost-effectiveness in economic evaluations, included uncertainty ranges for cost and confidence intervals for effectiveness. Uncertainty ranges of cost for each arm were constructed based on one standard deviation above and below the largest driver of cost differences for each perspective: mean realistic product prices for the program perspective, and mean time-use in study food preparation for the caregiver perspective. The “base case scenario” includes values used for each case to calculate costs prior to doing sensitivity analyses.

All costs were converted from West African franc (CFA) to 2018 USD based on corresponding exchange rates, adjusted for inflation. Cost and cost-effectiveness analyses were conducted using Excel and R Version 3.4.1.

Influencing Factors

Data analyses for factors that could be influencing effectiveness were descriptive in nature, and mostly consisted of calculating frequencies and percentages as well as measures of central tendency such as means and medians. Focus group discussions were

analyzed inductively using NVivo 12 software by reviewing each line of text and categorizing it into emerging themes.

IV. RESULTS

Baseline Characteristics and Sample Demographics

A total of 6,112 children were enrolled: $n = 1,519$ in CSB+; $n = 1,503$ in CSWB; $n = 1,564$ in SC+; $n = 1,526$ in RUSF. Program exposure was similar across the arms; each received an average of 17 distributions, close to the target number of 18 per child. *Lost-to-follow-up* was defined as having no end-line measurement between age 22.9 and 23.9 months, and was also similar across arms (14-17 percent).

At baseline, anthropometric characteristics among participating children were similar across study arms, with some slight differences in z-scores: CSB+ had a lower average LAZ at baseline and SC+ had a higher average WLZ. By study arm, 7-8 percent were classified as wasted and 7-10 percent, stunted. Overall, children at enrollment averaged 6 months of age, 7.04 kg in weight, 65.71 cm in length, and 13.62 cm in MUAC. There were no major differences in household characteristics across study arms. However, the CSB+ arm had slightly higher percentages with no education and belonging to the lowest wealth quintile, and the SC+ arm had a lower percentage with five or more children less than 5 years of age in the household. The arms were comparable regarding all other demographic characteristics, which are displayed in [Table 4](#). [Table 5](#) shows characteristics of the study communities by arm. There were some differences among arms regarding the presence of a market, phone service, and public transport access.

Table 4: Demographic characteristics of children in blanket supplementary feeding program ViM at enrollment by study arm, Sanmatenga Province, Burkina Faso, 2014-2016

	Study Arm				
	OVERALL (n = 6,112)	CSB+ with oil (n = 1,519)	CSWB with oil (n = 1,503)	SC+ (n = 1,564)	RUSF (n = 1,526)
Child age (months)	6.25 ± 0.94	5.93 ± 0.78	6.56 ± 0.92	6.31 ± 0.72	6.20 ± 1.16
Maternal age (years)	25.98 ± 6.40	25.87 ± 6.31	25.90 ± 6.48	26.50 ± 6.49	25.63 ± 6.30
Weight (kg)	7.04 ± 0.94	6.87 ± 0.91	7.15 ± 0.95	7.16 ± 0.93	6.98 ± 0.93
Length (cm)	65.71 ± 2.77	64.94 ± 2.58	66.31 ± 2.85	65.97 ± 2.59	65.62 ± 2.88
MUAC (cm)	13.62 ± 1.07	13.52 ± 1.08	13.64 ± 1.06	13.74 ± 1.07	13.55 ± 1.06
Length-for-age z-score	-0.60 ± 1.10	-0.72 ± 1.07	-0.56 ± 1.16	-0.53 ± 1.04	-0.58 ± 1.11
Weight-for-length z-score	-0.54 ± 1.05	-0.54 ± 1.05	-0.58 ± 1.04	-0.44 ± 1.04	-0.59 ± 1.04
Wasted (WHZ < -2)	478 (8)	121 (8)	125 (8)	111 (7)	121 (8)
Stunted (LAZ < -2)	531 (9)	148 (10)	135 (9)	110 (7)	138 (9)
Male sex	3,110 (51)	774 (51)	779 (52)	802 (51)	755 (49)
Current breastfeeding	6,095 (100)	1,515 (100)	1,498 (100)	1,556 (100)	1,526 (100)
Child is a twin	229 (4)	49 (3)	59 (4)	50 (3)	71 (5)
Ethnic majority	5,535 (91)	1,398 (92)	1,342 (89)	1,418 (91)	1,377 (90)
Caregiver education level					
None	4,987 (83)	1,327 (88)	1,217 (82)	1,229 (79)	1,214 (81)
Literate	422 (7)	86 (6)	121 (8)	103 (7)	112 (7)
Primary	356 (6)	61 (4)	78 (5)	112 (7)	105 (7)
Secondary	199 (3)	23 (2)	44 (3)	81 (5)	51 (3)
Higher	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)
Number children < 5 years of age in HH					
0-1	1,178 (19)	248 (16)	276 (18)	375 (24)	279 (18)
2	2,033 (34)	499 (33)	505 (34)	581 (37)	448 (30)
3	1,178 (19)	304 (20)	287 (19)	281 (18)	306 (20)
4	753 (12)	201 (13)	178 (12)	151 (10)	223 (15)
5+	941 (15)	264 (17)	253 (17)	166 (11)	258 (17)
Food Security					
Food secure	2,630 (44)	607 (41)	654 (44)	699 (46)	670 (45)
Mildly insecure	1,043 (17)	280 (19)	257 (17)	243 (16)	263 (18)
Moderately insecure	1,487 (25)	381 (25)	362 (25)	385 (25)	359 (24)
Severely insecure	844 (14)	230 (15)	201 (14)	204 (13)	209 (14)
Wealth Quintiles					

Lowest	1,196 (20)	375 (25)	267 (18)	294 (19)	260 (17)
Mid-Low	1,209 (20)	297 (20)	309 (21)	302 (20)	301 (20)
Medium	1,206 (20)	331 (22)	297 (20)	288 (19)	290 (19)
Mid-High	1,206 (20)	263 (18)	293 (20)	317 (21)	333 (22)
Highest	1,205 (20)	232 (15)	323 (22)	341 (22)	309 (21)
Current illness					
Fever	487 (8)	121 (8)	113 (8)	105 (7)	148 (10)
Diarrhea	352 (6)	86 (6)	69 (5)	116 (7)	81 (5)
Edema	9 (0)	4 (0)	3 (0)	1 (0)	1 (0)

Notes: Values are means \pm sd and n (%). CSB+ = Corn Soy Blend Plus, CSWB = Corn Soy Whey Blend, SC+ = SuperCereal Plus, RUSF = Ready-to-Use Supplementary Food

Table 5. Community characteristics of study villages by study arm, Sanmatenga Province, Burkina Faso, 2014-2016

	OVERALL (n=199)	Study Arm			
		CSB+ (n=29)	CSWB (n=55)	SC+ (n=70)	RUSF (n=45)
Population in 2014	1,614 ± 1,399	2,220 ± 1,219	1,652 ± 1,882	1,339 ± 860	1,596 ± 1,400
Distance to closest market if no market in village (km)	4.3 ± 4.6	2.7 ± 3.3	4.9 ± 4.6	4.3 ± 3.7	4.6 ± 6.1
Months per year road is passable by motorbike	9.35 ± 2.21	10.07 ± 2.14	9.38 ± 2.29	9.37 ± 2.25	8.8 ± 2.01
Months per year road is passable by vehicle	8.00 ± 2.87	8.69 ± 2.73	7.95 ± 2.53	7.67 ± 3.51	8.13 ± 2.14
Services present:					
Market	61 (31)	13 (45)	15 (27)	14 (20)	19 (42)
Phone service	144 (72)	25 (86)	49 (89)	46 (66)	24 (53)
Public transport access	38 (19)	2 (7)	11 (20)	14 (20)	11 (24)
Primary school	151 (76)	22 (76)	44 (80)	52 (74)	33 (73)
Secondary school	11 (6)	2 (7)	3 (5)	3 (4)	3 (7)
Health center	26 (13)	5 (17)	8 (15)	9 (13)	4 (9)
Pharmacy	28 (14)	5 (17)	8 (15)	10 (14)	5 (11)
ViM distribution site	48 (24)	8 (28)	13 (24)	16 (23)	11 (24)
Community health agents	191 (96)	27 (93)	53 (96)	66 (94)	45 (100)
Traditional birth attendant	136 (68)	21 (72)	36 (65)	45 (64)	34 (76)
Number of water pumps					
None	10 (5)	1 (3)	3 (5)	3 (4)	3 (7)
1	36 (18)	2 (7)	11 (20)	16 (23)	7 (16)
2 to 3	53 (27)	9 (31)	11 (20)	20 (29)	13 (29)
4 to 5	47 (24)	5 (17)	15 (27)	16 (23)	11 (24)
6 or more	53 (27)	12 (41)	15 (27)	15 (21)	11 (24)
Number of protected wells					
None	115 (58)	23 (79)	30 (55)	39 (56)	23 (51)
1 or more	84 (42)	6 (21)	25 (45)	31 (44)	22 (49)
Number of unprotected wells					
None	144 (72)	21 (72)	34 (62)	55 (79)	34 (76)
1 or more	55 (28)	8 (28)	21 (38)	15 (21)	11 (24)
Number of surface water areas					
None	145 (73)	19 (66)	40 (73)	57 (81)	29 (64)
1 or more	54 (27)	10 (34)	15 (27)	13 (19)	16 (36)

Notes: Values are means ± sd and n (%). CSB+ = Corn Soy Blend Plus, CSWB = Corn Soy Whey Blend, SC+ = SuperCereal Plus, RUSF = Ready-to-Use Supplementary Food

A total of 1,654 out of 1,972 household interviews were completed, representing a response rate of 84 percent. The 16 percent that were not completed were mostly due to out-of-country travel or relocation. Household characteristics for this subsample were generally consistent with the larger study sample described above, with some differences noted in level of education, number of children less than 5 years old, and wealth. Fifty-one percent of the interviewed households (excluding the RUSF arm) provided a porridge sample, and almost all provided a water sample (99.6 percent). Among this subsample, a total of 209 in-home observations were completed. Almost all intended HNP interviews were completed (32/35 = 91 percent), and 86 percent of lead mother interviews were completed (276/320).

Effectiveness

Stunting

The adjusted prevalence of stunting in children at end-line ranged from 20 to 28 percent; three of the four study arms (CSB+, SC+, and RUSF) had comparable adjusted rates of stunting at end-line, while children in the CSWB arm had higher rates of stunting at end-line ([Figure 7](#)). Compared with CSB+ (reference arm), the adjusted odds of a child being stunted at end-line were twice as high in CSWB but were not significantly different for the SC+ or RUSF arms (OR=2.07; 95% CI=1.46, 2.94) ([Table 6](#)). Different models of LTFU scenarios slightly altered the magnitude of the odds ratios but did not change the overall relationships ([Annex Table 3](#)). Results of the Cox Proportional Hazards model showed that children in the CSWB arm became stunted slightly earlier than those in the other three arms, meaning that they spend less time being healthy before becoming stunted; 26% more stunting events happen per month in the CSWB arm than in the other three arms (HR=1.26, 95% CI=1.00, 1.59). [Table 7](#) shows Hazards Ratios and [Figure 8](#) shows Kaplan-Meier curves from models for time to first stunting event. Examination of post-intervention follow-up data showed no changes in results for stunting.

Examining longitudinal linear growth of children over the duration of the study, [Figure 8](#) shows adjusted length-for-age z-scores for children in the four study arms, from age 6 to 27 months. Children in the study arms CSB+, SC+, and RUSF showed similar trajectories over the 18 months during the intervention period (up to 24 months of age), while children in the CSWB arm had a significantly steeper decline in length-for-age z-score, resulting in a significantly lower length-for-age z-score at study end-line. These relationships persisted into the post-intervention follow-up period (25-27 months). While none of the four foods was able to prevent the decline in LAZ typically seen in low income settings such as Burkina Faso, the CSB+, SC+, and RUSF arms were slightly significantly more effective at reducing the magnitude of the decline than the CSWB arm.

Figure 7: Predicted prevalence of stunting at end-line, by study group

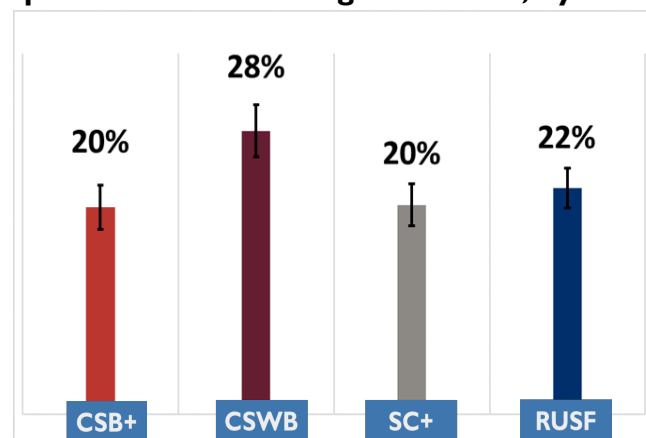


Figure 8: Adjusted Kaplan-Meier curve for time to first stunting event, by study arm

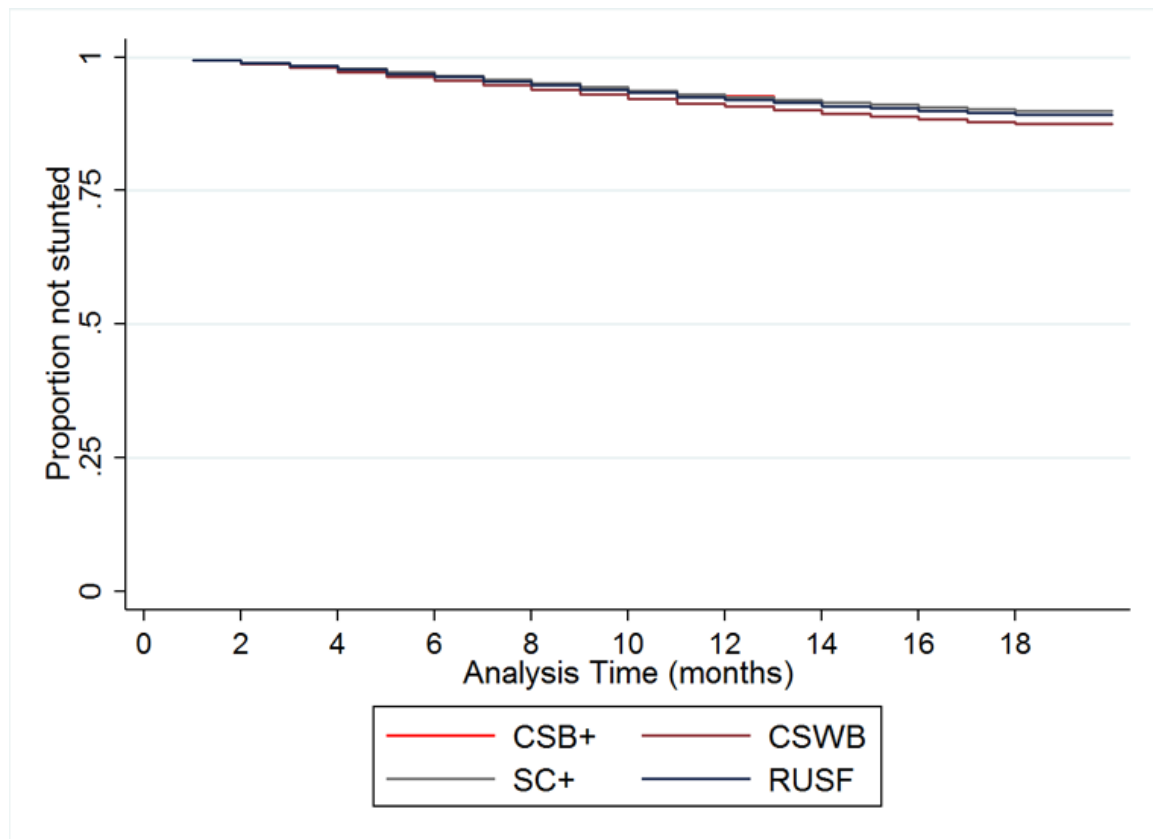
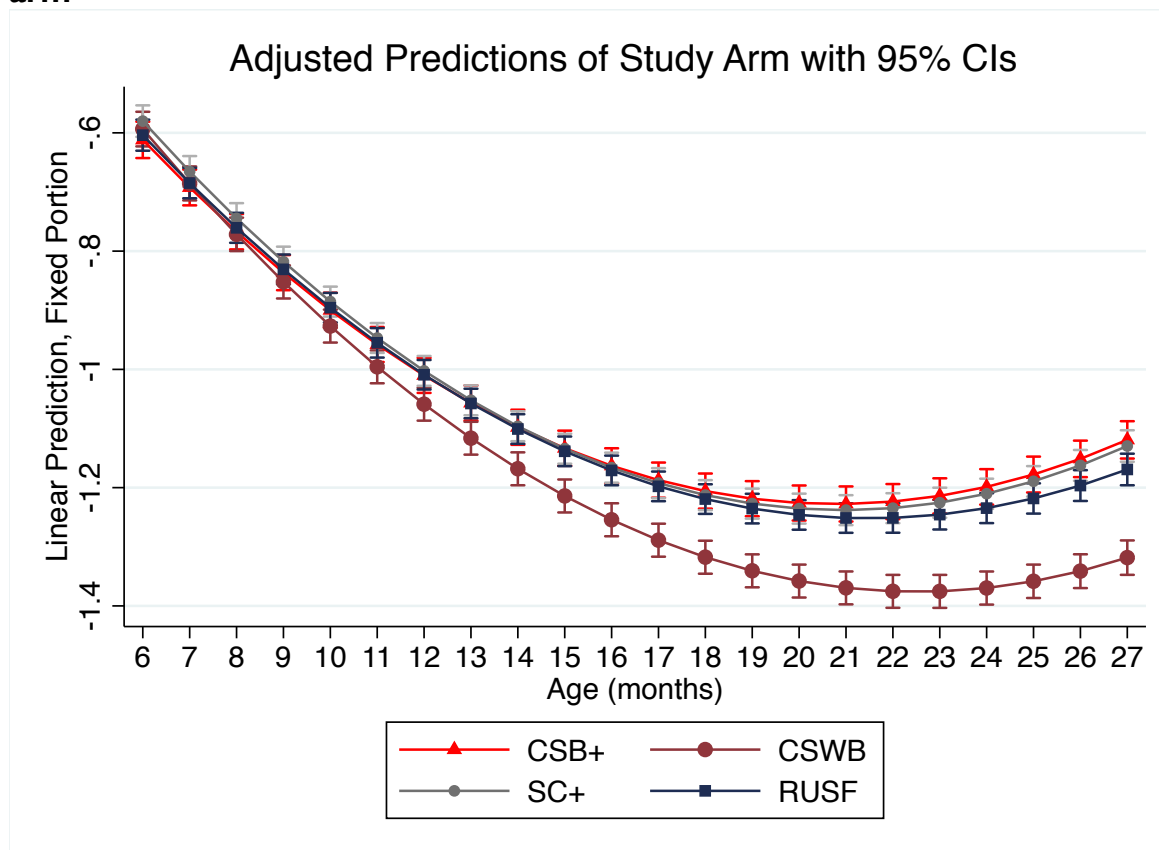


Figure 9: Adjusted length-for-age z-scores from 6 to 27 months, by study arm**Table 6: Logistic regression models for stunting at end-line, showing ORs**

Stunting at End-Line ¹	Adjusted ² OR	95% CI	Pseudo R-squared
Study arm (Ref = CSB+)			
CSWB	2.07*	1.46, 2.94	0.4063
SC+	1.02	0.73, 1.44	
RUSF	1.21	0.89, 1.66	

¹Stunting defined as length-for-age z-score < -2, excludes children LTFU, n = 4,268

²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents.

* p < 0.05

Table 7: Cox Proportional Hazards models for time to stunting, showing HRs

	Time to First Stunting ¹	Adjusted ² HR	95% CI
Study arm (Ref = CSB+)			
CSWB		1.26*	1.00, 1.59
SC+		1.00	0.80, 1.25
RUSF		1.08	0.88, 1.32

¹Stunting defined as length-for-age z-score < -2, excludes children LTFU, n = 4,268

²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents.

* p < 0.05

Wasting

The predicted number of months children in each arm expected to be wasted when measured ranged from 2.42 to 3.29 over the 18 months (Figure 9). Children in the CSWB arm had 29 percent more wasted measurements over the study period than children in CSB+ (the reference arm), while there were no significant differences in wasting between CSB+ and SC+ or RUSF (IRR=1.29; 95% CI=1.09, 1.51) (Table 7). Similarly, children in the CSWB arm were 57% more likely to have ever recorded a wasted measurement compared with children in the other three study arms (OR = 1.57; 95% CI=1.18, 2.08) (Table 8). Results of the Cox Proportional Hazards model showed that children in the CSWB arm had a wasting event earlier than those in the other three arms; 40% more wasting events happen per month in the CSWB arm than in the other three arms (HR=1.40, 95% CI=1.15, 1.70). Table 9 shows Hazards Ratios (HR) and Figure 10 shows Kaplan-Meier curves from models for time to first wasting event.

Examining longitudinal weight gain of children over the duration of the study, Figure 11 shows adjusted weight-for-length z-scores for children in the four arms, from age 6 to 27 months. Children in the RUSF arm appeared to experience a shallower decline in weight-for-length z-score in the first half of the study period and have higher weight-for-length z-scores in the second half of the study period, compared with the other arms. The decline in weight-for-length was thus slower in the RUSF arm, and children had less far to recover. Post-intervention measurements showed the arms converging by 27 months, indicating that any effects of the study foods on wasting during the intervention were not lasting.

Figure 10: Predicted monthly measurements of wasting over study period, by study group

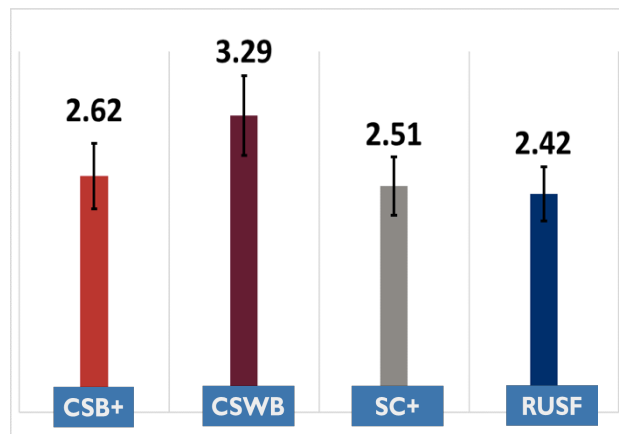


Figure 11: Adjusted Kaplan-Meier curve for time to first wasting event, by study arm

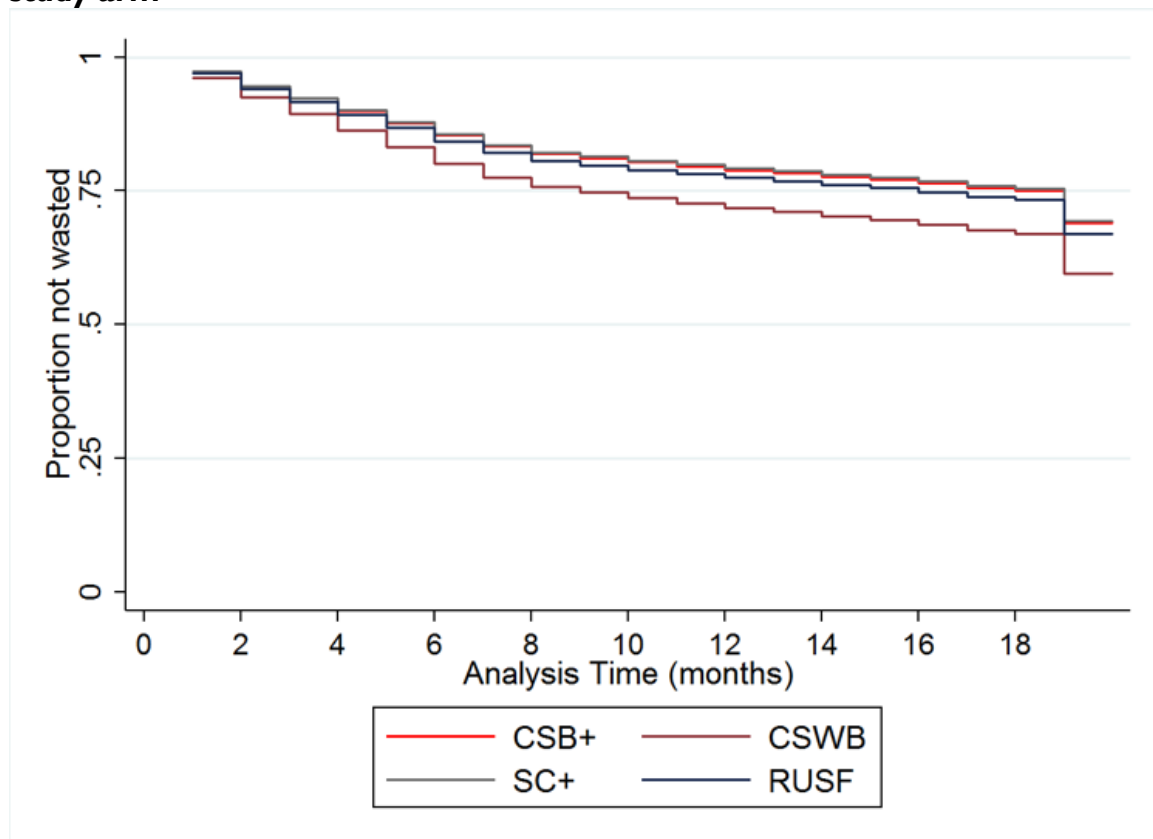


Figure 12: Adjusted weight-for-length z-scores from 6 to 27 months, by study arm

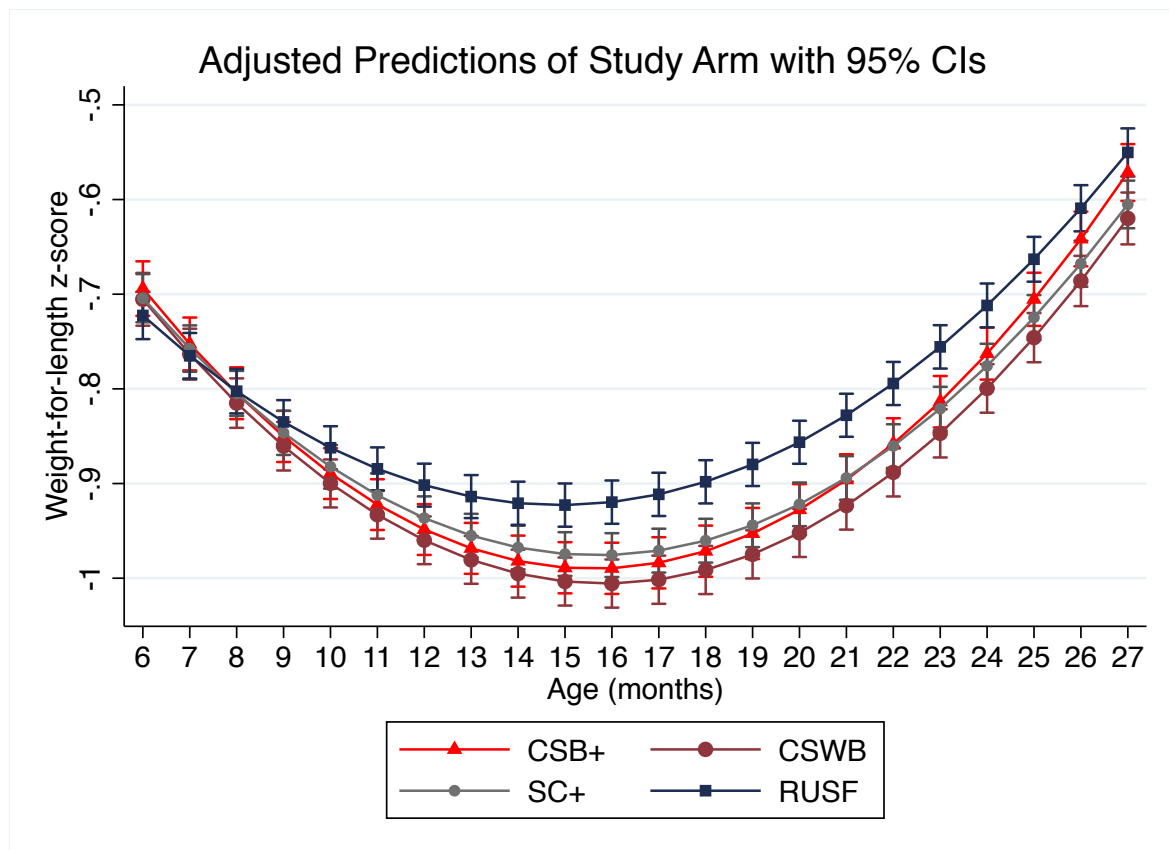


Table 8: Negative binomial regression models for wasting, showing incident rate ratios (IRR)

Total monthly measurements wasted ¹	Adjusted ² IRR	95% CI	Pseudo R-squared
Study arm (Ref = CSB+)			
CSWB	1.29*	1.09, 1.51	0.1619
SC+	1.01	0.86, 1.18	
RUSF	0.95	0.82, 1.09	

¹Wasting defined as weight-for-length z-score < -2, includes children lost-to-follow-up, n = 4,995

²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents.

* p < 0.05

Table 9: Logistic regression models for probability of ever being wasted, showing adjusted odds ratios (OR)

Ever wasted ¹	Adjusted ² OR	95% CI	Pseudo R-squared
Study arm (Ref = CSB+)			
CSWB	1.57*	1.18, 2.08	0.3714
SC+	1.13	0.87, 1.46	
RUSF	1.08	0.84, 1.38	

¹Wasting defined as weight-for-length z-score < -2, includes children lost-to-follow-up, n = 4,995

²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents.

* p < 0.05

Table 10: Cox Proportional Hazards models for time to wasting, showing HRs

Time to First Wasting ¹	Adjusted ² HR	95% CI
Study arm (Ref = CSB+)		
CSWB	1.40*	1.15, 1.70
SC+	0.99	0.81, 1.19
RUSF	1.08	0.91, 1.28

¹Wasting defined as weight-for-length z-score < -2, includes children lost-to-follow-up, n = 4,995

²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents.

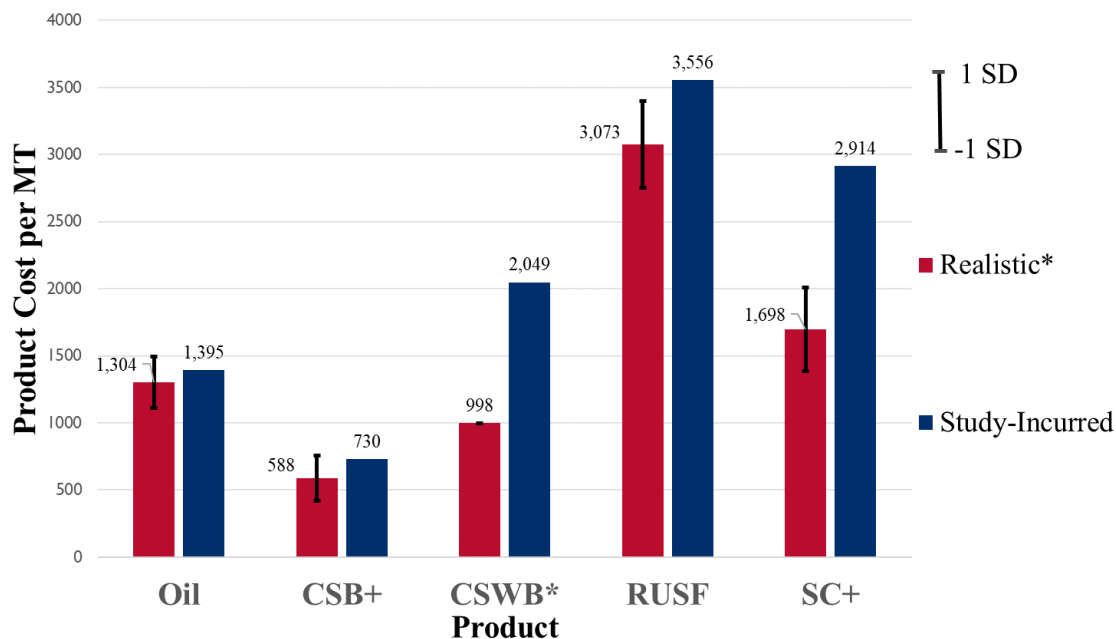
* p < 0.05

Overall, the CSB+, SC+, and RUSF study arms showed similar effectiveness in preventing stunting and wasting, while the CSWB arm showed slightly lower effectiveness in this study. None of the foods prevented growth faltering. Further exploration and explanation of these findings are found in the section on [Factors Influencing Effectiveness](#) (see [below](#)).

Cost-effectiveness

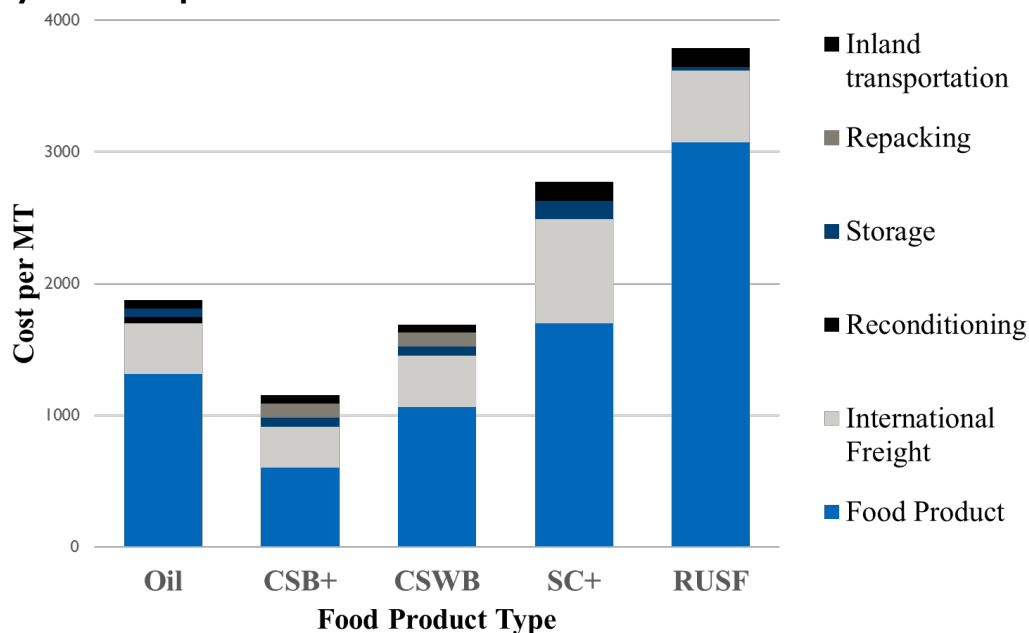
Cost: Program perspective

As shown in Figure 12, the realistic prices of the five food products differed from their corresponding study-incurred prices: RUSF, SC+, and CSWB had much lower realistic costs, while realistic and study-incurred costs were similar for CSB+ and oil. This trend also applied to another cost component, international freight. Thus, realistic costs were used for all food products for product and international freight costs in the cost and cost-effectiveness analyses.

Figure 13: Study-incurred versus realistic product cost (2018 USD) per metric ton (MT)

When comparing all product and supply chain cost components across the five products in Figure 13, product and international freight costs were the main drivers to the much higher total cost per metric ton for RUSF and SC+. While product cost for RUSF was the highest of the five products, SC+ had the highest supply chain costs (international freight, inland transportation, and storage).

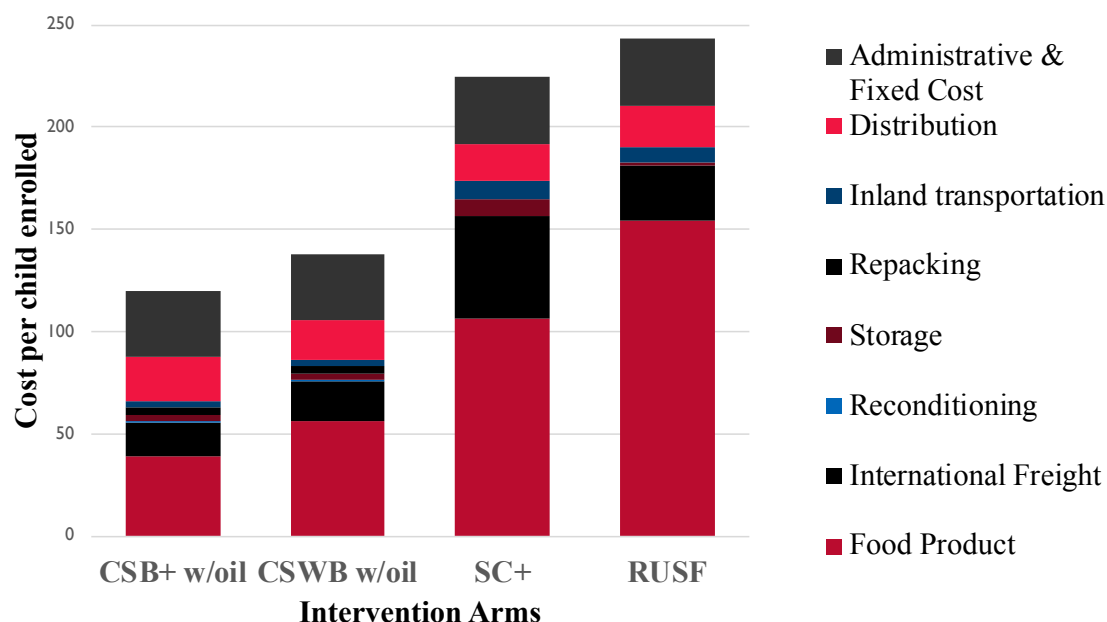
To compare all cost components across the four study arms (Figure 14), SC+ (\$226 USD) and RUSF (\$245 USD) arms had much higher total cost per child enrolled than CSB+ with oil (\$122 USD) and CSWB with oil (\$140 USD), even though the latter two had additional cost components (i.e., reconditioning of the oil and repacking of the flours into small sizes). Although the product cost remained the highest cost driver for each arm, other cost components made up more than half of the total cost for all arms except RUSF. These overall findings were consistent for total cost per monthly ration across arms.

Figure 14: Cost (2018 USD) per MT compared across products, breakdown by cost components

The opportunity cost of the program volunteers' time was included in the cost analyses from the program perspective as part of the distribution costs, valued at \$0.36 2018 USD per hour. The opportunity cost of the distribution committee member activities was on average \$19.80 USD per child enrolled, with minimal differences across arms, and the opportunity cost of lead mothers was \$0.16 USD per child enrolled. It was clear that the community volunteers perceived their unpaid distribution work as a burden, which some passed off to the recipients by asking for donations of \$0.20 (100 CFA) from caregivers before they would distribute the ration to them. This could deter the caregivers who were the worst off from collecting the ration, which raises concerns about the distribution program's ability to reach the most vulnerable recipients. Strict enforcement of distribution program rules prohibiting asking for donations could also disrupt the distribution process if volunteers refuse to dispense the foods without proper compensation for their time. These findings call into question the use of volunteer labor to operate food assistance programs. The hours worked and opportunity costs are substantial for the volunteers, but the costs to the program to pay volunteers at minimum wage are relatively small and could reduce the burden to the community while improving program performance.

Overall, losses included in the cost analyses were 6.15 percent for CSWB, 2.28 percent for CSB+, 0.47 percent for oil, 0.03 percent for SC+, and 0.003 percent for RUSF. Most of the CSWB and CSB+ losses were a result of spoilage during storage.

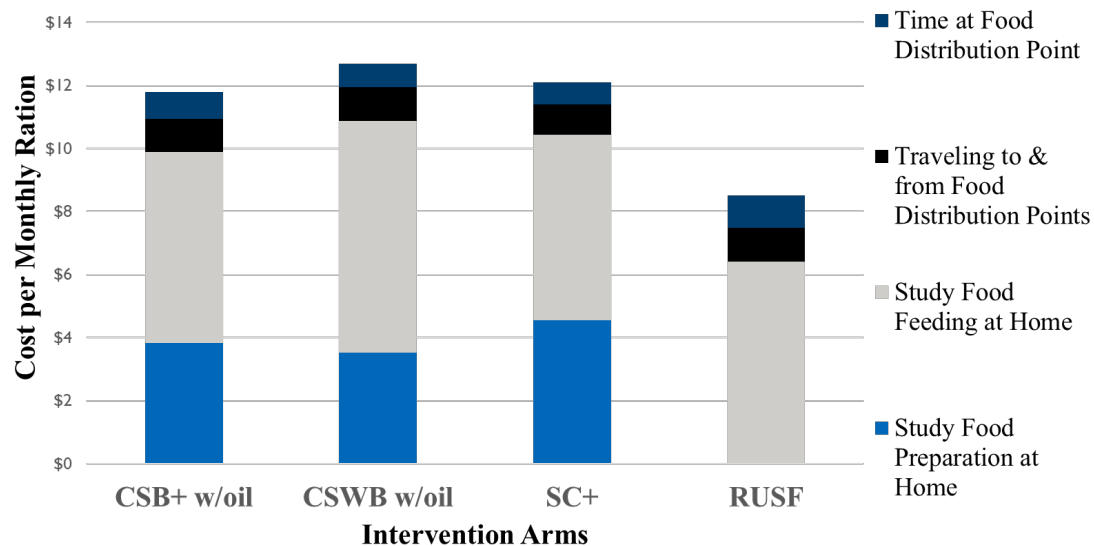
Figure 15: Cost (2018 USD) per child enrolled compared across study arms, breakdown by cost components



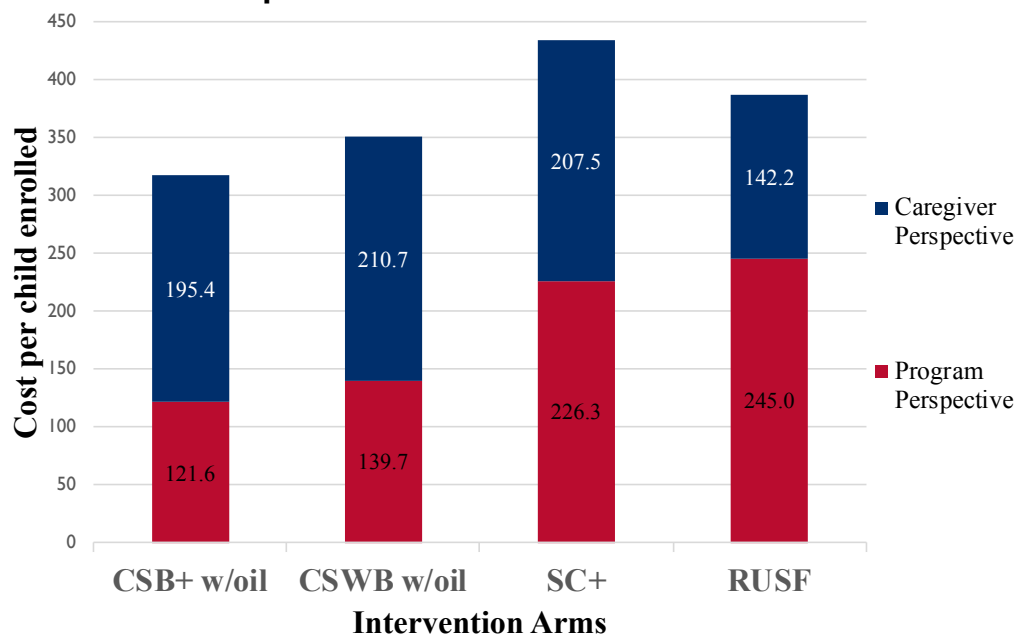
Cost - Adding the caregiver perspective

To estimate cost from the caregiver perspective, the opportunity cost of caregivers' time per monthly ration for each included caregiver activity is shown in Figure 15. Study food feeding and preparation and feeding required substantial time (hence the associated opportunity cost) because these were daily activities. In contrast, monthly activities such as travel time to and from the FDPs as well as food collection time took up to one entire day per monthly ration in all arms. Study food preparation was the highest cost driver for all three flour-based arms. At \$8.50 USD, RUSF had the lowest total caregiver opportunity cost per monthly ration because it required no preparation. Caregivers in CSB+ with oil, CSWB with oil, and SC+ had similar caregiver opportunity costs per monthly ration, at \$11.80, \$12.70, and \$12.10 respectively.

Figure 16: Caregiver opportunity cost (2018 USD) per monthly ration compared across arms, breakdown by caregiver activities attributable to study foods



As shown in [Figure 16](#), the addition of caregiver opportunity cost valued at \$0.36 USD per hour for the program and caregiver perspective was substantial, especially among the three flour-based arms. It also affected the relative cost rankings of the four arms. Thus, SC+ became the most expensive arm while total cost for RUSF dropped considerably, though it remained the second most expensive arm. Sensitivity analyses revealed that if the hourly shadow wage was \$0.84 USD per hour or higher, RUSF would become the lowest cost arm.

Figure 17: Program and caregiver perspective, total cost (2018 USD) per child enrolled compared across arms

Cost-effectiveness - Stunting

While CSB+, RUSF, and SC+ were similar in terms of effectiveness in stunting prevention, they carried very different costs. Total cost per child enrolled from the program perspective ranged widely, from \$127 USD in the CSB+ with oil arm to \$254 USD in the RUSF arm. However, point estimates for adjusted prevalence of stunting at end-line did not statistically differ in the CSB+ with oil, SC+, and RUSF arms (ranging from 20.1 percent in CSB+ with oil to 21.9 percent in RUSF, with overlapping 95 percent confidence intervals). In addition, the adjusted prevalence of 27.5 percent in the CSWB with oil arm was significantly lower than that in the CSB+ with oil arm (Table 10). The CSB+ w/oil was thus the most cost-effective food for stunting prevention.

Figure 17a shows that CSB+ with oil was the most cost-effective of the four arms, with considerations of uncertainty for both cost (sensitivity analyses based on realistic costs) and effectiveness (confidence intervals) for stunting. With the addition of caregiver opportunity cost valued at \$0.36 USD per hour from the program and caregiver perspective (Figure 17b), CSB+ with oil remained the most cost-effective option, but RUSF substantially improved in cost-effectiveness.

Table 11: Summary cost and effectiveness results for adjusted prevalence of stunting at end-line (~24 months old) – model excluding LTFU (EL)

Excluding LTFU n=4,268	CSB+ w/oil arm		CSWB w/oil arm		SC+ arm		RUSF arm	
	Mean	Uncertainty Range¹	Mean	Uncertainty Range¹	Mean	Uncertainty Range¹	Mean	Uncertainty Range¹
Program Perspective Total Cost (2017 USD) per child	126.6	(117.3, 135.9)	145.7	(143.1, 148.2)	236.8	(216.2, 257.5)	254.3	(237.4, 271.3)
Adjusted Prevalence of Stunting (%) at end-line (Model EL ²)	20.1%	(18.0%, 22.2%)	27.5%*	(25.0%, 30.0%)	20.3%	(18.3%, 22.4%)	21.9%	(20.0%, 23.9%)

¹ Uncertainty ranges for total cost per child were constructed based on 1 standard deviation above and below the realistic product/commodity cost for CSB+, RUSF, SC+, and FVO. Uncertainty ranges for adjusted prevalence of stunting at end-line were constructed based on 95% confidence intervals around the adjusted marginal means estimated from the respective model.

² Adjusted ORs for each arm compared with CSB+ w/oil in the Model EL: RUSF (adj. OR: 1.02; 95% CI: 0.73, 1.44); SC+ (adj. OR: 1.21; 95% CI: 0.89, 1.66); CSWB w/oil (adj. OR: 2.07; 95% CI: 1.46, 2.94)

* p < 0.05 for odds ratio compared to CSB+ w/oil arm in the respective model

Figure 18: Incremental cost-effectiveness plane for stunting averted compared with CSB+, base-case scenario with uncertainty ranges for (a) program perspective and (b) program and caregiver perspective

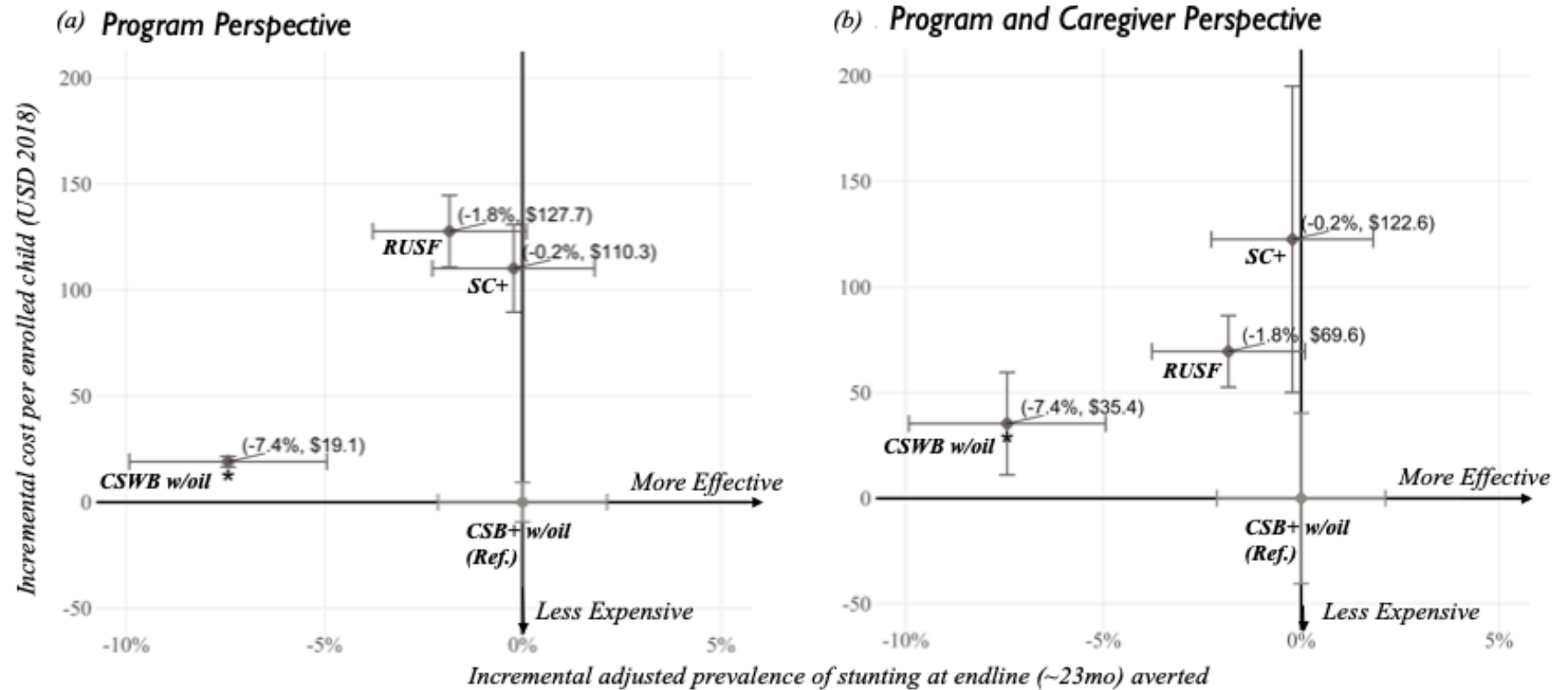


Table 12: Summary cost and effectiveness results for adjusted number of monthly measurements with wasting – model including LTFU

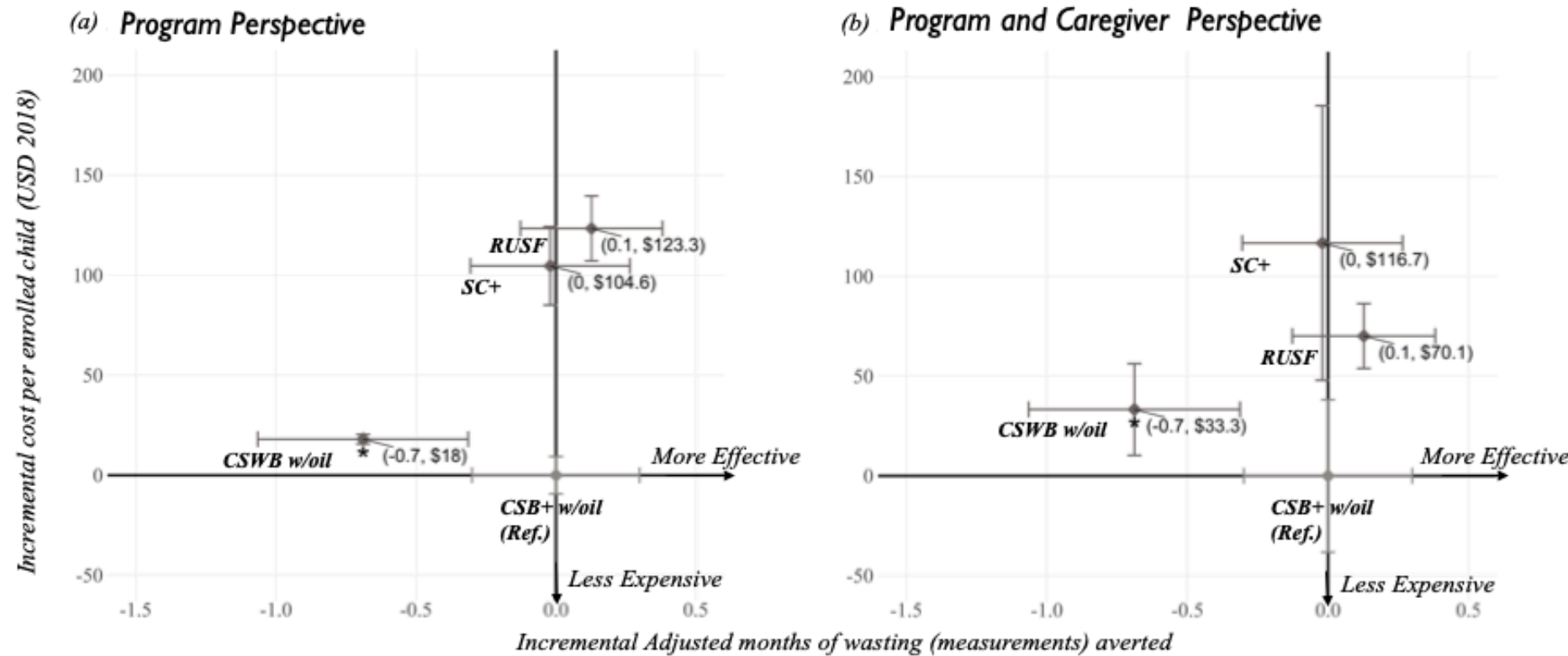
Including LTFU n = 4,995	CSB+ w/ oil arm		CSWB w/ oil arm		SC+ arm		RUSF arm	
	Mean	Uncertainty Range ¹	Mean	Uncertainty Range ¹	Mean	Uncertainty Range ¹	Mean	Uncertainty Range ¹
Program Perspective Total Cost (USD) per child	121.6	(112.8, 130.5)	139.7	(137.2, 142.1)	226.3	(206.7, 245.9)	245.0	(228.7, 261.2)
Adjusted Number of Monthly Measurements with Wasting per child ²	2.4	(2.1, 2.7)	3.1*	(2.7, 3.5)	2.4	(2.1, 2.7)	2.3	(2.0, 2.5)

¹ Uncertainty ranges for total cost per child were constructed based on 1 standard deviation above and below the realistic product/commodity cost for CSB+, RUSF, SC+, and FVO. Uncertainty ranges for adjusted number of months with wasting were constructed based on 95% confidence intervals around the adjusted marginal means estimated from the respective model.

² Adjusted IRRs for each arm compared with CSB+ w/oil in the model: RUSF (adj. IRR: 0.93; 95% CI: 0.80, 1.09); SC+ (adj. IRR: 0.93; 95% CI: 0.80, 1.09); CSBWB w/oil (adj. IRR: 1.29; 95%CI: 1.09, 1.51)

* p < 0.05 for incidence risk ratio compared to CSB+ w/oil arm in the respective model

Figure 19: Incremental cost-effectiveness plane for wasting averted compared to CSB+ w/ oil, base case scenario with uncertainty ranges for (a) program perspective and (b) program and caregiver perspective



Cost-effectiveness – Wasting

Similar to stunting, the total cost per child reached from the program perspective ranged widely from \$121 USD in CSB+ with oil to \$245 USD in RUSF. However, point estimates for adjusted number of monthly measurements with wasting did not statistically differ in the CSB+ with oil, SC+, and RUSF arms (ranging from 2.3 in RUSF to 2.4 in CSB+ with oil and SC+, with overlapping 95 percent confidence intervals), and the adjusted 3.1 monthly measurements with wasting in the CSWB with oil arm was significantly lower than that in the CSB+ with oil arm (Table 11). Thus, CSB+ with oil, RUSF, and SC+ were similar in effectiveness for wasting prevention despite differences in cost, making CSB+ the most cost-effective food for wasting prevention.

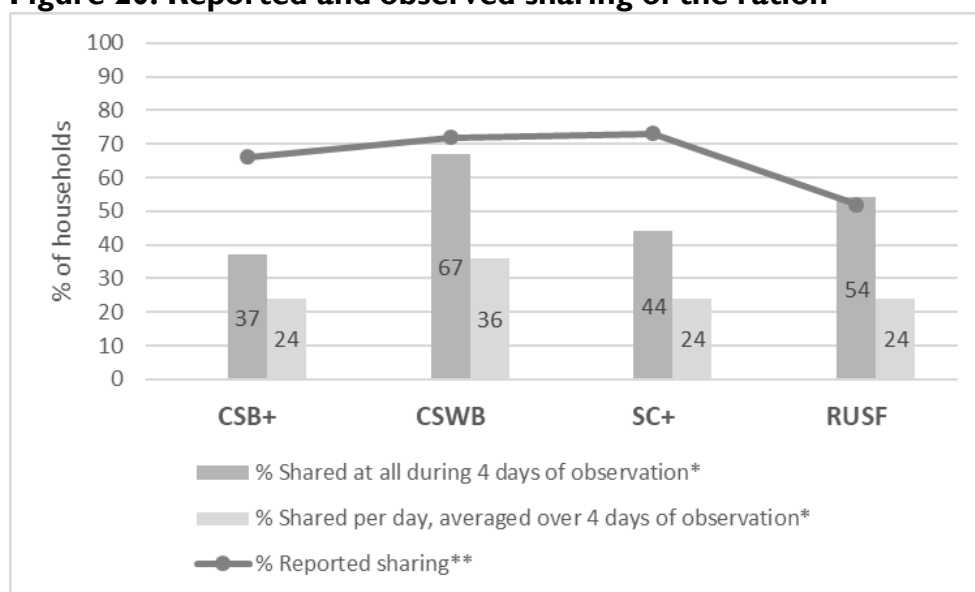
Conclusions about comparative cost-effectiveness rankings for wasting among the four arms remain the same as those stated for stunting. [Figure 18a](#) shows the cost-effectiveness comparisons for wasting from the program perspective, and [Figure 18b](#) shows the cost-effectiveness comparisons for wasting from the combined program and caregiver perspective.

Factors Influencing Effectiveness

Ration Sharing and Diversion

Sharing was defined as consumption of the ration by anyone other than the recipient child, and was evaluated both as reported and directly observed in the home. [Figure 19](#) shows the percentages of reported and observed sharing by study arm. Overall, sharing was common. It was reported and observed in all study arms.

Reported sharing was lowest in RUSF and highest in the CSWB and SC+ arms. In the in-home observations, CSWB had the highest percentage that shared at least once during the observation period (67 percent of households) and CSB+ had the lowest (37 percent of households). On average, CSWB had the highest percentage that shared per day (36 percent of households) and CSB+, SC+, and RUSF each had 24 percent.

Figure 20: Reported and observed sharing of the ration

* Among the subsample of households that had an in-home observation, where the ration was present (CSB+: n=46 all days; CSWB: n=29 on Days 1,2,3 & n=30 on Day 4; SC+: n=28 on Days 1,2,3 & n=27 on Day 4; RUSF: n=32 on Days 1,2, n=33 on Day 3 & n=31 on Day 4)

** Percentage of non-missing values (< 5% missing in each arm)

Among those who reported sharing, overall the most common reasons cited were other children needed or wanted it (70 percent), the mother needed it for breastfeeding (21 percent), and the moral obligation to share (22 percent). In focus group discussions, sharing of the ration was commonly described in all study arms, most often with siblings or other children. The moral obligation to share was a common theme. Some participants described needing to share either with other children or others who did not receive their own rations.

There was no reported or observed selling of any ration in any of the study arms. This was consistent in focus group discussions: participants adamantly stated that they did not sell or exchange the ration. However, overall 13 percent of caregivers reported giving the ration to other households, with the highest percentage in the SC+ arm (17 percent). Eight percent in the CSB+ arm and 7% in the CSWB arm reported giving the oil away (Table 12). In household observations, there was no observed giving away of the CSB+, CSWB, SC+, or oil rations to other households, but two households were observed giving away RUSF and two were observed giving away porridge in the CSWB arm (Table 12).

Most (91 percent overall) reported that they did not use the ration for purposes other than those intended. CSWB had the highest percentage reporting they used the ration for other family meals or other purposes (17 percent). The percentages using oil for other family meals or purposes other than porridge preparation for the target child in the CSB+ and CSWB arms were 21 percent and 22 percent respectively. In the in-home

observations, the percentages using oil for purposes other than porridge preparation were higher than reported in the CSB+ and CSWB arms, at 39 percent and 37 percent respectively (Table 12).

Table 13: Descriptive statistics of the interviewed and observed households

	CSB+ w/oil	CSWB w/oil	SC+	RUSF	Total
Reported, n (%)	n = 430	n = 418	n = 385	n = 421	N = 1,654¹
How long ration lasted the previous month					
All mo. with leftovers	61 (14)	42 (10)	57 (15)	66 (16)	226 (14)
All mo. w/out leftovers	81 (19)	54 (13)	65 (17)	168 (40)	368 (22)
Finished before end of mo.	280 (65)	311 (75)	260 (68)	181 (43)	1,032 (63)
Unknown	6 (1)	7 (2)	3 (1)	6 (1)	22 (1)
Have given the ration to others	38 (9)	49 (12)	66 (17)	55 (13)	208 (13)
Have given the oil to others	36 (8)	29 (7)	n/a	n/a	65 (8)
What else is the ration used for					
No other purpose	382 (89)	349 (84)	379 (98)	397 (95)	1,507 (91)
Other family meals	24 (6)	49 (12)	2 (1)	1 (0)	76 (5)
Other purpose	23 (5)	19 (5)	4 (1)	22 (5)	68 (4)
What else is the oil used for					
No other purpose	342 (80)	326 (78)	n/a	n/a	668 (79)
Other family meals	72 (17)	74 (18)	n/a	n/a	146 (17)
Other purpose	16 (4)	17 (4)	n/a	n/a	33 (4)
Recipient child consumed the ration the last time it was prepared/served	383 (91)	389 (95)	345 (94)	415 (99)	1,532 (94)
Recipient child normally consumed the ration	424 (99)	412 (99)	383 (99)	418 (99)	1,637 (99)
How much the recipient child likes the ration					
Hates	1 (0)	2 (0)	2 (1)	3 (1)	8 (0)
Does not like	17 (4)	23 (6)	36 (10)	11 (3)	87 (5)
Neutral	14 (3)	6 (1)	14 (4)	11 (3)	45 (3)
Likes	209 (49)	176 (42)	126 (34)	189 (45)	700 (43)
Loves a lot	187 (44)	209 (50)	198 (53)	203 (49)	797 (49)
Observed, n (%)	n = 50	n = 55	n = 51	n = 53	n = 209
Ration present on all four days ²	46 (92)	27 (49)	25 (49)	28 (53)	126 (60)
Gave the ration to other households	1 (2)	0	0	1 (4)	2 (2)
Gave the fortified oil to other households	0	0	n/a	n/a	0
Gave the porridge to other households	0	2 (7)	0	n/a	2 (2)
Used oil for something other than porridge preparation	18 (39)	10 (37)	n/a	n/a	28 (22)

¹ Percentages out of 1,654 completed interviews (16%, or 318/1,972, were not completed)

² Percentages of households where activity was observed happening at least once over four days of observation, among households where ration was present on all four days

How Long a Ration Lasts

Most households (63 percent) reported that the ration was finished before the next monthly distribution, or approximately 30 days. Only 34 percent reported that the ration lasted the entire month. By study arm, CSWB had the highest percentage reporting it did not last, at 75 percent, and RUSF had the lowest, at 43 percent (Table 10). During in-home observations, only 60 percent of the observed households had the ration present on all days of the observation. By study arm, there were notable differences. In the CSB+ arm, the ration was present on all days of observation in almost all households (92 percent), while in the other three arms the ration was present on all days in only about half of households (49-53%). Taken together, these findings show that the rations were being used more quickly in the CSWB, SC+, and RUSF arms, and there was better compliance in the CSB+ arm.

In focus group discussions, participants in the CSWB and RUSF arms talked about how the ration did not last the whole month. In the CSWB arm, participants described how the ration did not last because it gets shared or others consume it. In RUSF, participants said that the recipient ate more than the recommended amount. In one FGD in the RUSF arm, participants stated that the older recipient children eat more than younger children.

Preparation

In the CSB+ and CSWB arms, caregivers were instructed to add 30 g fortified oil per 100 g of flour. In the lab analyses of porridge samples collected during the interviews, the average quantities of added oil were lower than the recommended target: 7.3 g per 100g in CSB+ and 6.6g per 100g in CSWB. In the in-home observations, oil was observed to be measured in 73 percent and 65 percent of observed porridge preparations in CSB+ and CSWB respectively. Flour and water were measured in 82 percent and 65 percent of preparations of CSB+ and 72 percent and 63 percent of CSWB. Flour and water ingredients were observed to be measured fewer times in SC+ (42 percent and 24 percent) (Figure 20).

On average over the four-day in-home observation period, fewer than half of households in the CSB+ with oil, CSWB with oil, and SC+ arms were observed preparing the porridge (35 percent, 48 percent, and 46 percent of households where the ration was present, respectively). A common theme in focus group discussions was the opportunity costs of preparing or serving the ration. Caregivers in all study arms talked about having difficulty preparing or serving the ration three times a day as instructed. They discussed how it interferes with other activities and how they cannot comply if they are away from home, particularly during the rainy season when caregivers are working in the fields during the day. This theme often overlapped with that of

conflict with husbands if the caregivers left work to prepare the ration. Others, however, explicitly stated that preparing the ration was most important and did not interfere with their other activities.

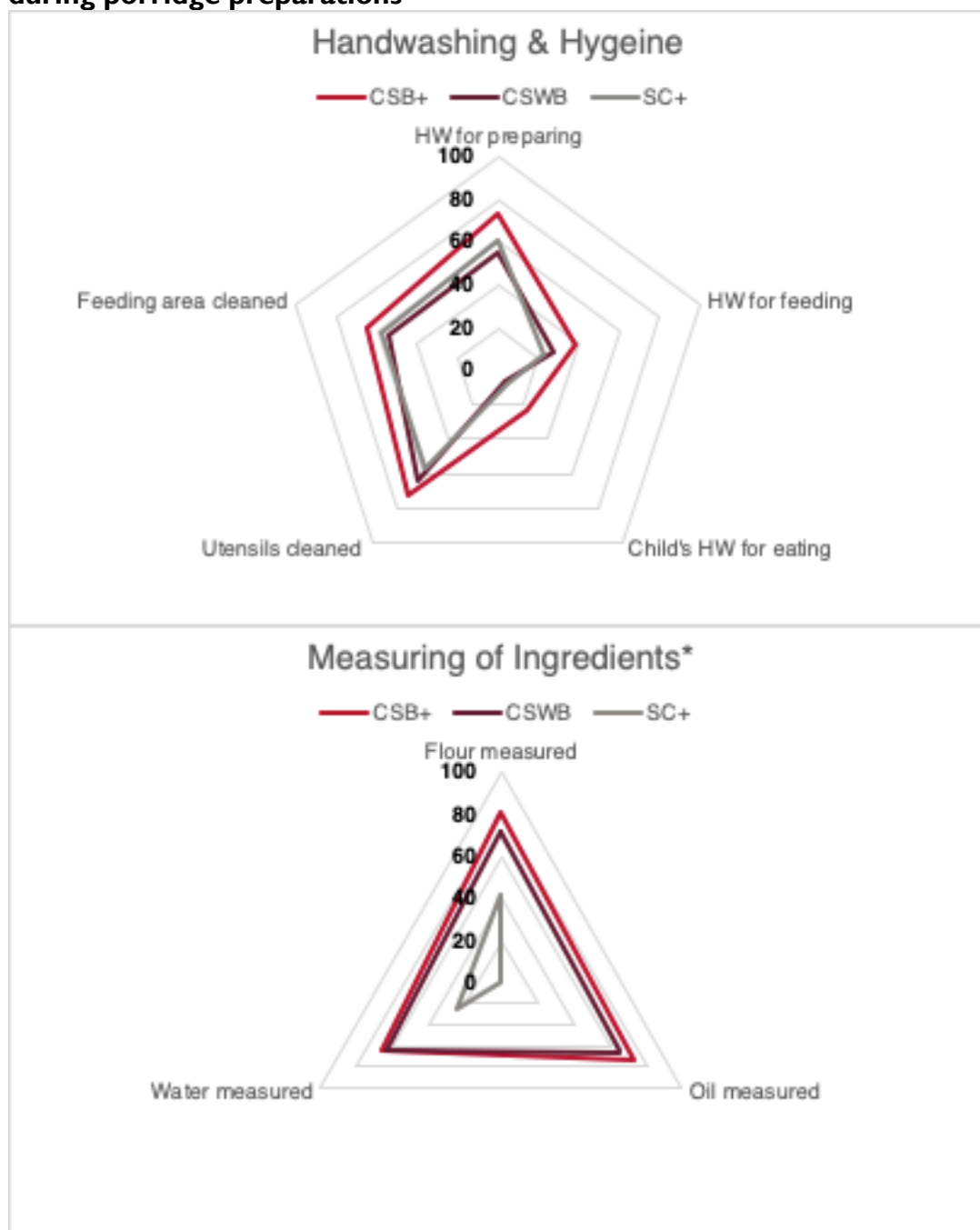
Contamination with E. coli, Storage, and Hygiene

Water samples taken from water stored in the households were tested for levels of *E. coli*, with the majority of samples showing either unsafe or high-risk contamination. These findings were consistent across all study arms (72-78 percent unsafe or high-risk by arm).

In focus group discussions, difficulty maintaining proper hygiene was a common theme across all arms. Lack of soap or inability to buy soap was described in several of the focus groups. With regard to handwashing, some described using ash/lye or just water when soap was not available. In the FBF arms, handwashing prior to ration preparation was adhered to in most porridge preparations observed in the home (74 percent in CSB+, 55 percent in CSWB, and 62 percent in SC+), but handwashing for feeding and washing the child's hands for eating were adhered to considerably less (respectively 38 percent and 24 percent in CSB+, 28 percent and 6 percent in CSWB, and 23 percent and 8 percent in SC+) (Figure 20).

Storage of the ration was observed in most households that had an interview, and almost all was observed to be indoors, off the floor, sealed or covered, or kept in the original container (Table 13). In some of the focus group discussions, however, lack of good, sealable containers for the flours was described as a challenge. Participants in the CSB+ and CSWB arms explained how insects got inside when they stored the ration and stated that they need good covers and containers.

Figure 21: Gaps in handwashing and measuring of ingredients observed during porridge preparations



Notes: HW = handwashing, CSB+ = Corn Soy Blend Plus, CSWB = Corn Soy Whey Blend, SC+ = SuperCereal Plus * SC+ not delivered with oil, so oil measured is not applicable; RUSF is not typically prepared, thus is not included in the diagrams.

Table 14: Storage of the ration observed during interviews

	CSB+ w/oil	CSWB w/oil	SC+	RUSF	Total
Ration storage observed, n (%)	n = 430	n = 418	n = 385	n = 421	n = 1,654¹
Yes	301 (70)	220 (53)	233 (61)	279 (66)	1,033 (63)
No, there is no more food	95 (22)	169 (41)	130 (34)	90 (21)	484 (29)
Refuse/Cannot access food	33 (8)	130 (34)	17 (4)	51 (12)	128 (8)
Where the ration was stored, n (%)	n=301	n=220	n=233	n=279	n=1033
Indoor	297 (99)	219 (100)	232 (100)	277 (99)	1,025 (99)
Outdoor in the shade	0 (0)	2 (1)	0 (0)	1 (0)	3 (0)
Outdoor not in the shade	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)
Off the floor	211 (70)	164 (75)	163 (70)	194 (70)	732 (71)
On the floor	19 (6)	32 (15)	19 (8)	27 (10)	97 (9)
Hanging	7 (2)	12 (5)	4 (2)	27 (10)	50 (5)
Sealed/Covered	252 (84)	176 (80)	183 (79)	203 (73)	814 (79)
Unsealed/Open	11 (4)	12 (5)	5 (2)	4 (1)	32 (3)
Kept in the original container	228 (76)	134 (61)	203 (87)	193 (69)	758 (73)
Other	44 (15)	48 (22)	53 (23)	62 (22)	207 (20)

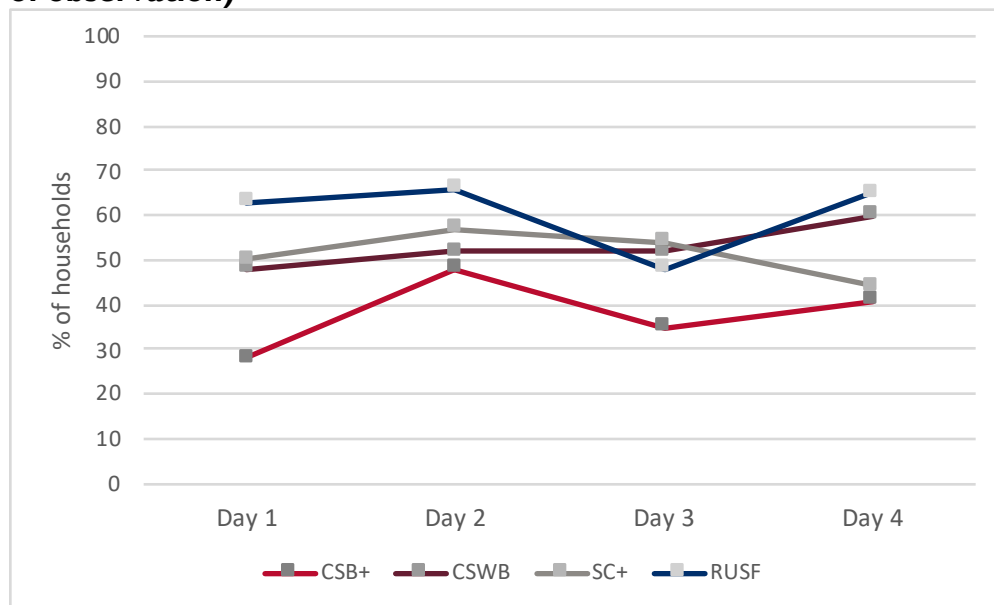
¹ Percentages out of the 1,654 completed interviews (16%, or 318/1,972, were not completed)

Consumption by the Recipient Child

Almost all caregivers reported that the recipient child normally consumed the ration (99 percent in each arm), displayed in Table 12 (see page 56). Observed consumption of the ration by the recipient child was lower than reported (Figure 21). Among households where the ration was observed to be present, the recipient child was observed consuming the ration in only 49 percent of households on average over the four days of observation. CSWB had the lowest percentages where the recipient child was ever observed consuming the ration (observed at all in 44 percent of households and 28 percent of total household-days of observation) and RUSF had the highest (observed at all in 65 percent of households and 40 percent of household-days).

Most caregivers reported in the interviews that the recipient child either liked or loved the ration a lot [Table 12](#) (page 56). The likeability of the ration by the child was also described in most focus group discussions across all arms. In some of the discussions, however, participants said that the recipient child did not accept the ration in any form. This theme arose in each arm, usually when the child was sick or vomiting.

Figure 22: Observed consumption of the ration by the recipient child (% of households where recipient child was ever observed eating the ration, by day of observation)



* Among households where the ration was present (CSB+: n=46 all days; CSWB: n=29 on Days 1,2,3 & n=30 on Day 4; SC+: n=28 on Days 1,2,3 & n=27 on Day 4; RUSF: n=32 on Days 1,2, n=33 on Day 3 & n=31 on Day 4)

When asked in what form their children consumed the ration, most caregivers reported that it was always or usually consumed in its recommended form, either as a porridge for the FBF arms (82 percent in CSB+, 79 percent in CSWB, and 78 percent in SC+) or directly from the packet for RUSF (93 percent). Divergence from the recommended form meant it was consumed either as raw flour without preparation or mixed with other foods (1 percent in CSB+, 1 percent in CSWB, 21 percent in SC+, and 5 percent in RUSF) or as couscous (15 percent in CSB+, 18 percent in CSWB, and 0.3 percent in SC+). The SC+ was consumed raw more often than the other flours due to its taste; the flour is sweeter and more palatable than the CSWB and CSB+ flours when consumed raw.

Bitter Taste

Reports of bitter taste arose in two separate focus group discussions in the CSWB arm. Participants described how the ration was spoiled when they received it, tasted bitter, and could not be used:

“Often, there are insects inside, and if we taste it, we find that it’s too bitter-tasting. We can’t use it to make porridge or couscous. We can only throw it out.” (FGD #3, Respondent 3)

“Last month, the flour they gave us could not be used, besides giving it to the animals. Even the animals don’t want it. It’s very bitter.” (FGD #3, Respondent 6)

“Since the beginning, the flour spoils because it spends a long time at the source... Most of the time, this flour expires before it reaches us. When you get this flour and return home, you will often find debris in it. At its starting place, the flour goes bad, before you receive it, and when you get it, it isn’t edible, because often it smells bad and it is bitter. Then you have to leave this flour and get your own flour.” (FGD #4, Respondent 3)

Others described how they were told to exchange the bad flour at the distribution site and how “now the flour is new” and “good.”

In organoleptic lab tests conducted by North Carolina State University, professional tasters agreed that CSWB that had been stored in Burkina Faso for 10+ months was bitter. They described it as having a fishy smell and a stale, dirty aftertaste, while the newer batches of the same product did not (35).

V. SUMMARY AND RECOMMENDATIONS

Summary of Findings

In this comparison of four supplementary foods in the prevention of stunting and wasting in children 6-24 months in Burkina Faso, RUSF and SC+ performed similarly to CSB+ with oil in terms of effectiveness for both primary outcomes (end-line stunting and monthly measurements showing wasting) but were notably more expensive. CSWB with oil was less effective in reducing stunting and wasting than CSB+ with oil, despite similar nutrient formulations. CSB+ with oil was thus the most cost-effective product in this scenario, as it was comparable in effectiveness to RUSF and SC+, more effective than CSWB with oil, and the least expensive product.

The relatively poor performance of CSWB was surprising, considering its similar formulation to CSB+ with oil but with the addition of an animal source food (whey protein concentrate), which has been shown in many studies to improve growth in children (36–38). In addition, none of the four foods appeared to prevent declines in z-scores typical in regions such as Burkina Faso. These findings suggest that factors other than the product itself were likely influencing the effectiveness of the products; performance cannot be attributed solely to product composition.

It is unlikely that CSWB was less biologically efficacious than the other foods; however, factors related to its use by the recipients may help to explain why it may be less effective in the real-world setting studied. Recipient children did not consume the food supplements according to instructions regardless of study arm (foods were shared, prepared with less oil than recommended, and not prepared daily), which may help to explain the finding that none of the four foods prevented declines in z-scores. The CSWB, however, was shared more frequently than any of the other three foods and eaten less frequently by the recipient child as demonstrated by multiple metrics, both observed and reported. One potential explanation for this divergent finding is the bitter taste of the CSWB after long periods of in-country storage, reported by recipients.

The cost-effectiveness interpretations and results were straightforward, as the least expensive product was comparable in effectiveness to much more expensive products. The results including caregiver opportunity costs demonstrate that considering not only cost-effectiveness, but also the recipient perspective, may alter decisions around product and program selection for food assistance.

Recommendations

Given the results of this study, including minimal effects in preventing stunting and wasting and the relatively poor performance of CSWB, several recommendations for future food assistance research and programming can be made:

Product choices:

- Indications from this study are that lipid-based nutritional supplements such as RUSF may not be sufficiently more effective in prevention of stunting and wasting than FBF to justify their considerably greater cost. This is an important consideration in product choice. **Programs should consistently use the most cost-effective products; for prevention of stunting and wasting in blanket supplementary feeding programs. In this study, the most cost-effective ration was CSB+ with oil.**
- All of the products used lend themselves to sharing. **Future cost-effectiveness research is needed to determine whether sharing of each type of food product would be most cost-effectively addressed through increasing dosage of the specific product or adding general household food assistance or by other means.**
- CSB+ has no dairy ingredient; the other foods studied do. While no conclusion about the role of dairy can be made in this study, **the option of continued programming of food aid (in blanket supplementation) without dairy should be considered.**

Program choices:

- Greater impact of food aid interventions depends on quality programming, not simply the choice of a food product. **More research and evidence are needed on effective programming actions surrounding delivery of food aid.** Future studies should include consideration of the impact of community participation, compliance, substitution, and diversion.
- The effectiveness of specialized nutritious foods depends on more than their biological efficacy. **Social, environmental and behavioral factors must be taken into account in nutrition program design.**
- The burden to volunteers working in distribution is great, as is the burden to the recipients themselves. **Volunteer and recipient opportunity costs should be considered in program design; consideration should be given to compensating community members helping to run food aid distribution programs for their time.**
- Blanket supplementation alone may not be the most effective or cost-effective way to prevent wasting and stunting. **Research to determine the optimum role of blanket supplementation to address malnutrition is needed.**

Experimental products research:

- Storage of some products in suboptimal but realistic conditions may influence food quality and consumption; **shelf life studies on new (and existing) products should be rethought to consider true field conditions.**
- Food science should play a role in the development of products and packaging. Interaction of different micro- and macronutrients in the food matrix may be key to palatability of foods.
- **Continue to make investments in cost-effectiveness research to ensure that money is spent cost-effectively on food assistance.** Efficacy studies alone would not have discovered the potential storage issues with CSWB; results of this study underscore the importance of field studies in real-life situations.

The support of the U.S. Government for operations-relevant studies is key to making all-of-government action on nutrition effective and sustained.

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ANNEXES

Annex Table I: Nutrient composition of study foods

	CSB+ with Oil per Approx. 500 kcal	SC+ per 500 kcal	CSWB with Oil per Approx. 500 kcal	RUSF per 500 kcal
	Per 75g CSB+ and 22.5g FVO	Per 126g	Per 75g CSWB and 22.5g FVO	Per 100g
Water (g)	7.86	10.82	0	13.7
Energy (kcal)	483.15	500	487.92	500
Protein (g)	9.66	18.02	12.91	13
Total Lipid (fat) (g)	26.52	10.19	27.72	15
Carbohydrate	51.28	82.9	46.96	51
Fiber, total dietary (g)	3.75	5.3	4.8	0
Sugars, total (g)	2.05	19.66	3.82	22
Minerals				
Calcium (mg)	381.75	766.42	320.77	600
Iodine (µg)	30.01	50.51	30.01	150
Copper	0.29	0.48	1.04	
Iron (mg Ferrous Fumerate)	3.01	5.05	5.04	5.5
Iron (mg EDTA)	1.88	3.16	1.88	2.5
Iron (total)	7.89	13.01	9.94	10
Magnesium (mg)	60.75	106.06	63.38	150
Manganese (mg)	0.48	0.77	0.57	0.68
Phosphorous (mg)	381.75	717.17	367.5	457
Potassium (mg)	457.5	906.57	567.38	770
Sodium (mg)	3.75	60.61	97.97	<250
Selenium	0	15.15	5.7	35
Zinc (mg)	4.88	8.48	4.48	15
Vitamins				
Vitamin C, total ascorbic acid (mg)	68.4	115.66	67.5	100
Pantothenic Acid (mg)	1.46	2.72	1.64	3
Thiamin (mg)	0.36	0.62	0.33	1
Riboflavin (mg)	1.21	2.2	1.02	2.5
Niacin (mg)	6.75	11.34	6.93	15
Vitamin B6 (mg)	5.79	1.53	0.94	1.5
Folate, DFE (mcg_DFE)	156.75	261.36	146.25	230
Vitamin B12 (µg)	1.5	2.93	1.5	3
Vitamin A (mcg_RAE)	1047	1318.9	779.07	1200
Vitamin A (IU)	4074	4532.84	4061.25	4001.16

Vitamin E (alpha-tocopherol) (mg)	8.26	11.1	8.46	16.5
Vitamin D (D3) (µg)	11	13.89	8.28	12
Vitamin D (IU)	720.75	569.45	713.7	480
Biotin	6.15	10.35	0	12
Vitamin K (phylloquinone) (µg)	70.93	56.69	72.13	30

Annex Table 2: Sample ViM distribution schedule

Group CSB +	Nov-14		Dec-14	
	Date Approv	Distribution day	Date Approv	Distribution day
DOUAGA	27 au 31 Oct 2014	3 to 5	24 to 28 Nov 2014	1 to 3
ISSAOGO		3 to 5		3 to 5
KOMSILGA		3 to 5		3 to 5
OUANOBIAN		6 to 7		4 to 5
POULALE		4 to 7		4 to 7
RIMKILGA		3 to 5		3 to 5
TALLE-MOSSI		3 to 4		3 to 4
TAMDOGO		3 to 5		3 to 5
TEBERE		6 to 7		8 to 9
TOUROUM		3 to 5		3 to 5

Group RUF	Nov-14		Dec-14	
	Date Approv	Distribution day	Date Approv	Distribution day
BANGASSE	3 to 7 Nov 2014	10 to 12	1 to 7 Dec 2014	8 to 10
BARSALOGHO		10 to 14		8,9,10,12 and 15
BASMA		10 to 12		8 to 10
DIBILOU		10 to 12		8 to 10
GOEYA		10 to 14		8,9,10,12 and 15
GONEGA		10 to 11		8 to 9
KAMSE PEULH		13 to 14		15 to 16
KOGOYENDE		13 to 14		15 to 16
OUINTOKOUILIGA		17 to 19		17 to 19
ROFFENEGA		13,14 and 17		15 to 17

Group SC++	Nov-14		Dec-14	
	Date Approv	Jour de distribution	Date Approv	Jour de distribution
BASNERE	10 to 15 Nov 2014	17 to 19	8 to 12 Dec 2014	17 to 19
BISSIGA		17 to 19		17 to 19
DAMANE		17 to 18		17 to 18
DAMESMA		17 to 18		17 to 18
DELGA		17 to 19		17 to 19
GAH		17 to 18		17 to 18
KALAMBAOGO		17 to 20		16 to 19
KONEAN		24 to 25		22 to 23
KOULOGO		20 to 21		22 to 23

NAMSIGUI		20,21 and 24		19 and 22 to 23
NAPALGUE		19 to 21		19 and 22 to 23
NOAKA		17 to 20		16 to 19
RASLA		17 to 18		17 to 18
SIAN		20 to 21		22 to 23
TIFFOU		21 and 24		22 to 23
ZORKOUM		24 to 26		19 and 22 to 23

	Nov-14		Dec-14	
Group CSB 14	Date Approv	Jour de distribution	Date Approv	Jour de distribution
BAFINA	17 to 22 Nov 2014	27 to 28	15 to 20 Dec 2014	22 to 23
FOUBE		24 to 28		17 to 19 and 22 to 23
GUENDBILA		24 to 26		18 to 20
KOUNDIBOKIN		19 to 20		18 to 19
MADOU		24 to 25		18 to 19
NAMISSIGUIMA		24 to 25		18 to 19
NAWOUBKIBA		27 to 28		22 to 23
SANBA		24 to 26		18 to 20
ZONGO		24 to 26		22 to 23
PISSILA		24 to 28		17 to 19 and 22 to 23

Annex Table 3: LTFU scenarios, stunting models

Stunting at End-Line ¹	Adjusted ² OR	95% CI	Pseudo R-squared
Model 1, excludes LTFU n=4,268			
Study arm (Ref = CSB+)			
CSWB	2.07*	1.46, 2.94	0.4063
SC+	1.02	0.73, 1.44	
RUSF	1.21	0.89, 1.66	
Model 2, multiple imputations³ n=5,204			
Study arm (Ref = CSB+)			
CSWB	1.65*	1.28, 2.12	NA
SC+	0.88	0.68, 1.14	
RUSF	1.02	0.80, 1.29	
Model 3, assumes all LTFU healthy n=4,991			
Study arm (Ref = CSB+)			
CSWB	1.59*	1.15, 2.19	0.3683
SC+	0.82	0.59, 1.12	
RUSF	1.12	0.84, 1.50	
Model 4, assumes all LTFU stunted n=4,958			
Study arm (Ref = CSB+)			
CSWB	1.74*	1.33, 2.27	0.2847
SC+	1.30*	1.01, 1.67	
RUSF	1.13	0.89, 1.44	

¹Stunting defined as length-for-age z-score < -2²Adjusted models control for age, sex, maternal age, wealth, baseline anthropometric status, twin status, caregiver education, ethnicity, children < 5 years old in the household, household food insecurity, illness in the last two weeks, season total distributions received, and village-level access to water, sanitation, market, phone service, road, public transport, transport methods from the village, pharmacy, health center, and health agents³Multiple imputations procedures used for missing covariate data

* p < 0.05