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**Benefit-Cost Analysis**

# Expanding Community-Based Management of Children Suffering from Moderate and Severe Acute Malnutrition

## Using a standard and a Local RUTF Formula



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Haïti Priorise
Un plan de développement alternatif

# Expanding Community-Based Management of Children Suffering from Moderate and Severe Acute Malnutrition Using a standard and a Local RUTF Formula

## Haïti Priorise

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# Academic Abstract

Tens of thousands of young Haitian children suffering from severe (SAM) and moderate acute malnutrition (MAM) go untreated every year; many of them die and those who survive may face lifelong debilitations. The proposed 12-year intervention would improve and expand the screening and treatment of SAM and MAM for children under 5 years of age (6-59 months of age) using a standard ready-to-use therapeutic food (RUTF). More specifically, current levels of child screening (~80%, mainly those living at or near main roads) would be increased to 95% over a four-year scaling up period and remain at that level for 8 years. The proportion of children suffering from SAM who are treated would increase from ~70% (status quo) to 95% during the scale-up period, and the proportion of children suffering from MAM would increase from ~25% to 95% over the same period. The benefits are measured in terms of the number of years of life saved due to decreased child mortality and valued at one or multiples of GDP/capita, plus for those who successfully recover from SAM, the benefits also include the value of avoiding a brief period of life spent living with the disability of SAM. The costs of the proposed intervention include the hiring and training of additional health workers for screening children under age five, and of nurses for treating more cases of SAM and MAM. Costs also include the up-front costs of improving the performance of screening and treatment systems, and the additional travel, supervision, and other costs associated with scaling up screening and treatment in increasingly rural and hard-to-reach areas. Estimated intervention benefits (valued at 1xGDP and discounted at 3%) are approximately $6.2b gourdes and estimated costs are approximately $1.4b gourdes, generating a benefit/cost ratio of approximately 4.5. Discount rates of 5% and 12% generate benefit/cost ratios of 3.1 and 1.3, respectively. Similar calculations are prepared for an identical intervention, except using an alternative RUTF formula that makes more intensive use of local ingredients – benefit/cost ratios using 3%, 5%, and 12%, are 4.7, 3.2, and 1.4, respectively. The proposed intervention using the standard RUTF product is judged to be highly cost-effective; switching to a local formulation caused only very small changes to costs, and hence to benefit/cost ratios.

# Policy Abstract

## *Overview and Context*

- Problem: Thousands of cases of severe (SAM) and moderate (MAM) acute malnutrition among young children go undetected and untreated every year; hundreds of these children die each year.
- Intervention: A 12-year intervention that improves and expands child screening and treatment programs using ready-to-use therapeutic foods (RUTF) will screen an additional 1.7m children, treat approximately 351,000 additional cases, and save over 5,700 lives.

## *Implementation Considerations*

- Costs: Total cost of the intervention are ~ 1.4b gourdes – ~1/3 would cover the costs of RUTF products, ~1/3 would cover additional personnel costs, and ~1/3 would cover the costs of transporting children to/from treatment centers.
- Implementing Agents: Under the guidance of the Ministère de la Santé Publique et de la Population (MSPP), an expanded and more efficient network of public health employees and clinics, and NGOs active in child health, would manage a nation-wide system that screens 95% of all under-5 children, and a nation-wide system that treats 95% of cases of SAM and MAM.
- Timeline: 12-year program would begin in 2017 and end in 2028. Investments to improve system coordination and efficiency, and to hire and train additional nurses and health workers would take place during a two-year scale-up period. Intervention would operate at scale by 2020.
- Precedent: A loosely coordinated program of public clinics/hospitals and NGOs exists but coverage is incomplete and coordination is lacking. Current screening programs cover approximately 70% of all children under 5 years of age; treatment is provided to approximately 70% of SAM cases but only 25% of MAM cases.
- Risks: Institutional and other impediments to expanding and (especially) to improving the performance of screening and treatment programs could undermine benefits and raise costs.

## *Rationale for Intervention*

- Benefits: Over 5,700 children's lives would be saved; this is equivalent to nearly 375,000 disability-adjusted life years (DALYs).
- Beneficiaries: The primary beneficiaries are children who are treated and who survive, and their families. These benefits would be split approximately evenly between girls and boys.
- Unmeasured Benefits: Fewer malnourished children will reduce the pressure on clinics and healthcare service providers, and on women providing care to malnourished children, some of whom would have otherwise died. Reduced malnutrition in early childhood will improve cognitive abilities, improve attendance and performance in school, and may increase economic productivity later on in life.

## Overview

The current national system for screening and treating severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) reaches approximately 50% of children in Haiti. Consequently, thousands of young children needlessly die each year from untreated cases of SAM and, to a lesser extent, MAM. Most of these deaths could be prevented with comprehensive screening and treatment with community-based provision of a ready-to-use therapeutic food (RUTF), a proven, cost-effective intervention.

## Implementation Considerations

We propose that the existing, national system for screening and treating children be expanded and appropriately staffed to reach all children age 6-59 months. The 12-year program would be scaled-up over an initial three-year period, reach national scale (covering 95% of children) in year four, and be sustained thereafter for eight years. Two types of RUTF are considered in the analysis, one based on a standard formula and another based on a formula that would be developed to make more intensive use of locally available ingredients.

## Rationale for Intervention

Operating at full capacity the proposed intervention would, *annually*, screen approximately 170,000 additional children, identify and treat approximately 32,000 cases of MAM and approximately 3,500 cases of SAM, and avoid approximately 560 child deaths; deaths avoided would be approximately evenly split between girls and boys. The benefit-cost model developed to assess the cost-effectiveness of the proposed intervention suggests that it is highly cost-effective (see below) when the standard RUTF formula is used; cost-effectiveness improves slightly when the local RUTF formula is developed and used, but the evidence to support its effectiveness is not yet available.

Summary Table

| **Interventions** | **Benefit** (in gourdes) | **Cost** (in gourdes) | **BCR** | **Quality of Evidence** |
|---|---|---|---|---|
| Treat wasting with *standard* formula RUTF | $10,846,435,954 | $1,184,266,481 | 9.2 | Strong |
| Treat wasting with *local* formula RUTF | $10,846,435,954 | $1,131,759,778 | 9.6 | Medium |

Notes: All figures assume a 5% discount rate; DALYs avoided are 'valued' at 3XGDP.
Source: Authors' calculations

# Acronyms

CMAM -- Community-Based Management of Acute Malnutrition

DALY – Disability-Adjusted Life Year

GAM – Global Acute Malnutrition (WHZ<-2)

MAM – Moderate Acute Malnutrition (-3<=WHZ<-2)

MSPP -- Ministère de la Santé Publique et de la Population (Ministry of Public Health)

MUAC – Mid-Upper-Arm Circumference (screening tool for identifying cases of SAM and MAM)

RUTF – Ready-to-Use Therapeutic Food

SAM – Severe Acute Malnutrition (WHZ < -3)

WHZ -- Weight-for-Height Z-score

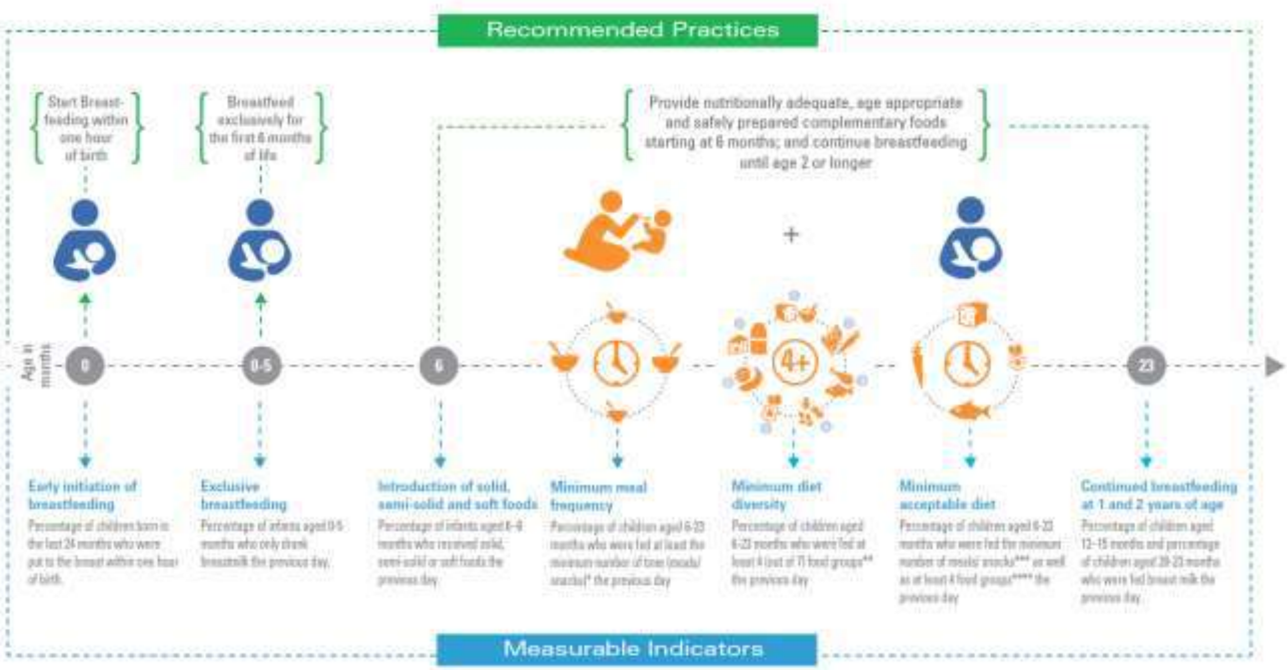
YLD – Years Lost Due to Disability

YLL – Years of Life Lost

# Introduction

There is deep knowledge of, and consensus on, recommended food and micronutrient consumption practices for pregnant and lactating women (Hanson et al. 2015), and of feeding practices for infants and young children (UNICEF 2016b). Figure 1 summarizes these practices for young children, and provides measurable indicators of the success with which socioeconomic systems, including the caregivers within them, adhere to these practices.

Figure 1 – Recommended Feeding Practices and Measureable Indicators for Young Children




Source: UNICEF 2016

Despite this knowledge and available indicators of success, children in developing countries in general (UNICEF 2012), and in Haiti (UNICEF 2015) in particular, fail to receive adequate diets[1], and hence suffer the nutritional and health consequences, which, if left untreated, can lead to increased levels of morbidity and mortality, and long-term cognitive and physical impairments for those who survive (Black et al. 2103).

This paper focuses on the field-based identification and treatment of children who consume well below recommended dietary intakes (and who may also suffer from diseases and/or infections) and whose mortality risks consequently increase. More specifically, we identify an intervention that would increase the screening for severe acute malnutrition (SAM) and moderate acute

[1] We acknowledge that disease pressure and infections can play significant roles in determining the health and nutritional status of children, and that these factors require specific investments to address.

malnutrition (MAM), and deliver treatment to the vast majority of children who suffer from these conditions. The proposed intervention envisions the strengthening of existing organizations and the individuals within them that provide screening and treatment services, and enhancing the coordination among them. We estimate the costs and the benefits (in terms of lives saved, primarily) of the proposed intervention over a 12-year period and judge this to be a cost-effective intervention.

While the proposed intervention is nation-wide and would eventually reach children in very distant locations, for practical purposes the proposed intervention is narrowly focused on saving the lives of malnourished children aged six months to five years of age. That is to say, in this paper we are *not* proposing a system-wide investment in rural areas that would reduce household food insecurity or child undernutrition generally. Rather, we propose one investment that focuses on improving the nutritional status of selected groups of children who the food and economic systems have essentially failed – children suffering from SAM and MAM. Doing so will save the lives of many children, but it will not, admittedly, 'fix' the entire socioeconomic system. Indeed, we acknowledge that once treated and cured of SAM or MAM, these children will be placed back into the resource-poor households that 'produced' these cases of malnutrition in the first place; our underlying model allows for the possible re-appearance of treated children in the SAM or MAM treatment programs and accounts for these costs. Fixing the socioeconomic system that continues to generate child malnutrition will take time and broad-based investments that increase the productivity of rural inhabitants engaged in agricultural and non-farm activities (DIFD 2015). These investments, too, are needed. However, while these broad-based, poverty-reducing investments are made, we recommend quick action in dealing with one of the very unfortunate and avoidable consequences of this underperforming system – intervene to avoid child deaths now.

## Scope of Child Wasting in Haiti

Malnutrition is a pervasive problem in Haiti, especially in rural areas where screening and (especially) treatment services are lacking. In 2012, approximately 5.2% of children under 5 years of age were wasted; 1.3% were suffering from SAM (WHZ<-3) and 3.9% suffered from MAM (-3<=WHZ<-2) (UNICEF 2012). Malnutrition increased among children between 2012 and 2015 for various reasons (Meds & Foods for Kids, personal communication). Currently, it is estimated that approximately 6.2 percent of the 1.3m children under the age of five suffer from global acute malnutrition (GAM); 4.5 percent suffer from MAM and 1.5 percent suffer from SAM (UNICEF 2015). Children suffering from malnutrition attributable to Hurricane Matthew are only now becoming officially recognized.

## Recent and Current Efforts to Address Acute Malnutrition in Children

Beginning in 2007, Haiti began to experiment with Community-Based Management of Acute Malnutrition (CMAM) programs designed and managed by the MSPP, which embrace community-based distribution of ready-to-use therapeutic food (RUTF), that were being recognized worldwide as more effective and cost-effective than clinic-based programs for treating SAM (Puett et al. 2013). Although the Haitian experiment with CMAM programs provided mixed successes and generally fell short of results achieved in other developing countries, programs were continued with the stated objective of addressing the institutional and other factors that contributed to the relatively low effectiveness and efficiency of CMAM programs in Haiti (Phillips and Rhatigan 2011). CMAM programs continue to be undertaken in Haiti; over 4,000 multi-purpose community health workers (ASCPs) have been trained in the Haitian health system (Alfred 2017), but coverage is limited to geographic areas located near major roads, and coordination among individuals involved in screening and those dispensing treatment is generally poor. It is important to note that current health policy in Haiti allows health workers to screen for GAM, but requires that nurses treat identified cases of SAM and MAM, hence, the pools of both health workers and nurses have to be scaled up to meet the tasks set out by the proposed interventions.

A reported 13,039 of the estimated 19,322[2] children suffering from SAM in 2015 received timely and effective care (UNICEF 2015); a much smaller proportion of children suffering from MAM received treatment. NGOs and PVOs are currently responsible for a significant portion of screening for SAM and MAM in Haiti, though data to comprehensively assess their efforts, costs, and impacts are not available. Some organizations append screening activities to other health- and nutrition-related programs (e.g., Meds & Foods for Kids), while others pursue screening activities alongside commercial ventures (e.g., Boutik Sante). Regardless of the *modus operandi* adopted, the screening and treatment activities undertaken by these organizations tend to have several things in common: they cover the costs of health workers engaged in screening activities; they screen for both SAM and MAM, using MUAC; some provide treatment, but many refer caregivers to clinics, etc., where treatment can be provided; they focus most of their referral activities on children with SAM; they cover at least some of the out-of-pocket costs (e.g., transportation, etc.) faced by caregivers seeking treatment; and, there is usually an upper bound on the number of times that an individual child can receive treatment or resources to seek treatment. With some notable exceptions, our proposed intervention takes these ongoing screening and treatment activities as our point of departure.

[2] Authors' calculations: 1,288,122*.015.

# Proposed Intervention

We propose two interventions, both aim to (identically) expand and improve upon the current MSPP-managed public and NGO-provided programs for screening and treating young children for SAM and MAM. One intervention uses a *standard* RUTF formula to treat both SAM and MAM, though different amounts of RUTF are used in each case; the other uses an alternative RUTF formula that makes more intensive use of *locally available* ingredients but which meets all of the UNICEF RUTF specifications (Ryan et al. 2015). Expanding and improving the screening and treatment programs will require up-front investments in training and program enhancement and coordination, and annual outlays to cover salaries, travel and other field costs of healthcare providers, product procurement, transport and storage costs, and overall program management costs. For cases of SAM and MAM, caregiver transportation to/from treatment facilities are also included in the overall intervention budget.

We envision 12-year interventions (running from 2017 through 2028), with the first four years serving as a training, capacity strengthening, and programmatic scaling up period, during which the human resources (including training of health professionals and nurses) and financial resources to support (e.g.) improved coordination and M&E activities will be scaled up. By year 2020, the improved and expanded system will operate at full capacity for the final eight years.

In the case of the *local* RUTF formula, resources ($50,000) are budgeted in the first year for the identification and refinement of the local formula, and for honing in-country production processes to produce it.[3]

The benefits in terms of lives saved will begin to accrue in year two of the interventions, and will increase as the interventions mature and as their geographic coverage increases. Both interventions are envisioned to be functioning at scale by year four (i.e., 95% of children under the age of five throughout the country will be screened for GAM beginning in 2020, and 95% of those identified as suffering from MAM or SAM will initiate treatment[4]). These interventions will save lives and avoid the periods of time during which children live with the disabilities of SAM. The value to society of these benefits accrue over the lifetimes of the cohorts of children whose lives are saved by the proposed interventions. Value weights for lives saved are pegged to GDP/capita, or multiples of GDP/capita.

It is important to note that our point of departure for this analysis is the status quo regarding the screening and treatment of SAM and MAM in Haiti. The current system, which screens approximately 80% of children, but which treats approximately 70% of SAM and only 25% of

[3] Methods for identifying alternative RUTF formulas exist (e.g., Ryan et al. 2015); a team comprised of nutritionists, food technologists and economists would have to be assembled to develop and test alternative formulas.

[4] For an array of reasons, not all children who initiate treatment complete treatment; the model identifies and 'follows' these children, because their treatment costs and mortality patterns are different.

MAM cases, suffers from chronic stock-outs of RUTF and does not consistently pay health workers or nurses. Moreover, the coordination among individuals and organizations that screen children and those that offer treatment services is poor. Our proposed intervention makes up-front investments in improving the performance of the overall system, but focuses particularly on contracting and training a larger number of fully-paid health workers and nurses, and substantially increasing the stocks of RUTF available locally for treating cases of SAM and MAM. The proposed interventions also addresses the perennial issue of resource-poor households being unable to cover the costs of transportation to/from treatments clinics – we propose covering these weekly or bi-weekly transportation costs.

The proposed intervention envisions making use of the existing collection of public/NGO/private relationships that exist in the SAM/MAM screening and treatment 'space.' It will be up to the MSPP and to those implementing the intervention to choose the appropriate partnerships so that the services provided are per protocol and uniform across service-providers, and effective and cost-effective. The nature of these relationships may vary spatially, e.g., in remote rural areas NGOs may have to assume greater roles in both screening and treatment, while in urban areas, public sector actors may be well-placed, well-staffed, and well-provisioned to take on screening and treatment tasks. That said, the current system suffers from several problems that undermine coverage and efficiency: 1) gaps at the extensive margin (screening and especially treatment options are very limited in most rural areas); 2) inefficiencies related to scale of operation of the many small organizations and activities; 3) lack of coordination among organizations providing the *same* services; 4) lack of coordination between those screening and identifying cases of SAM and MAM, and the clinics, hospitals, etc., that offer treatment options for most SAM cases, but few MAM cases. These inefficiencies and suboptimal coordination activities need to be addressed for the proposed intervention to be impactful and cost-effective. Therefore, at start-up, $50,000 is allocated to collecting and analyzing data on the current 'state of affairs' regarding screening and treatment of MAM and SAM, a MSPP convening of key stakeholders to discuss and decide upon investments required to improve efficiency, information sharing, and coordination, and to make and to monitor the results of these investments.

For cost and other reasons, it is also important to note that in the context of SAM and MAM screening and treatment in Haiti, the proposed scaling up is mainly a 'scaling-out' activity. While improvements in screening and especially treatment of MAM in urban areas are needed, the most important investments (costs) and gains (mortality declines) will be made in and flow from rural areas. Therefore, as the proposed intervention scales up (and out), the health worker time and transportation costs will increase as more-distant populations that are seasonally (at least) cut off from major road transportation networks are reached, screened, and treated.

## Key Assumptions Associated with Proposed Interventions[5]

To generate estimates of the expected benefits and costs associated with the proposed interventions, the following assumptions were made.

Regarding the benefits associated with treating a case of MAM:

(1) Of MAM children identified and treatment initiated, 2% will die during treatment (Lenters 2013), 12% will default during treatment (Bachmann 2009; Nackers 2010; Wilford 2011; Puett 2013; Frankel 2015; Isanka 2016; input from in-country contacts), 2% will complete treatment but will be non-responders (Nackers 2010; Wilford 2011; Puett 2013; Frankel 2015; Isanka 2016; input from in-country contacts) and the remaining 84% will complete treatment and recover (Lenters 2013).
(2) The expected mortality rate for untreated MAM is 1.5% (based on Olofin 2013). Therefore, the number of child deaths averted via treatment of MAM is 1.26% (1.5%*84%=1.26%) of the total number of children identified as suffering from MAM and for whom treatment is initiated.
(3) For children who would have died from MAM before age 1, the intervention saves 63.5 years of life (undiscounted). For children who would have died from MAM at age 1, the intervention saves 64.5 years of life. For children who would have died from MAM at age 2, the intervention saves 65.5 years of life. For children who would have died from MAM at age 3, the intervention saves 65.6 years of life. For children who would have died from MAM at age 4, the intervention saves 64.9 years of life. Together, these are YLL.
(4) There is no disability weight associated with moderate wasting, so no YLD are calculated.
(5) Total DALYs for MAM are therefore the sum of YLL per death averted in each age group times the number of additional child deaths averted in each age group.
(6) The local RUTF formula is assumed to be as effective as the standard RUTF formula.[6]

Regarding the benefits associated with treating a case of SAM:

(1) Of SAM children identified and treatment initiated, 4% will die during treatment (Lenters 2013), 12% will default during treatment (Bachmann 2009; Nackers 2010; Wilford 2011; Puett 2013; Frankel 2015; Isanka 2016; input from in-country contacts), 4% will complete treatment but will be non-responders (Nackers 2010; Wilford 2011; Puett 2013; Frankel 2015; Isanka 2016; input from in-country contacts) and the remaining 80% will complete treatment and recover (Lenters 2013).

[5] A complete set of assumptions are included in the spreadsheet model. Assumptions based on the literature and on other sources are cited there, as are all the calculations used to generate all of the 'ingredients' that go into estimating benefits and costs.

[6] The local formula for Haiti has not yet been developed. However, by design, it will meet all of the UNICEF requirements for a RUTF for young children suffering from SAM (Ryan et al. 2015).

(2) The expected mortality rate for untreated SAM is 6.5% (based on Olofin 2013). Therefore, the number of child deaths averted via treatment of SAM is 5.2% (6.5%*80%=5.2%) of the total number of children identified as suffering from SAM and for whom treatment is initiated.
(3) For children who would have died from SAM before age 1, the intervention saves 63.5 years of life (undiscounted). For children who would have died from SAM at age 1, the intervention saves 64.5 years of life. For children who would have died from SAM at age 2, the intervention saves 65.5 years of life. For children who would have died from SAM at age 3, the intervention saves 65.6 years of life. For children who would have died from SAM at age 4, the intervention saves 64.9 years of life. Together, these are YLL.
(4) Nutritional recovery from SAM (defined as WHZ >= -2 in Lenters (2013) and assumed to be 'recovered enough' to avoid disability associated with SAM) is expected for 80% of children treated for SAM. Those children who achieve nutrition recovery are assumed to have avoided disability for a period of six months (Puett et al. 2013). YLD are then calculated by applying a disability weight of 0.128 (Salomon et al. 2015) for six months of life.
(5) The total DALYs for SAM are then the sum of YLL per death averted in each age group times the number of additional child deaths averted in each age group plus the sum of YLD per recovered case of SAM in each age group times the number of additional children avoiding disability via treatment of SAM in each age group.

Children can and do relapse, i.e., once successfully treated for SAM or MAM, children can again become acutely malnourished. No data are available for Haiti on the proportion of treated children who relapse. To deal with this issue, we assume that until children age out of the intervention's target age range (6-59 months), all treated children who survive SAM or MAM reenter the total pool of children in their age cohort the following year, and hence are able to re-appear as SAM or MAM cases.[7]

Regarding costs, a key set of assumptions were needed regarding the number of additional health workers and nurses that would be required to screen and to treat additional cases of SAM and MAM, with special attention paid to how these needs might change as the proposed intervention was scaled up. After extensive interaction with in-country collaborators, the following set of agreed-upon assumptions were included in the model (Table 1).[8]

[7] While the costs associated with treating the same child multiple times for SAM or MAM are included in the model, the benefits of saving a life can only accrue once.
[8] The effects increases and decreases in health worker and nurse productivity on costs and on benefit/cost ratios is addressed in sensitivity analyses, below.

Table 1 – Assumed Health Worker and Nurse Productivity, by Stage of Intervention Scale-up

| Health worker and nurse productivity assumptions | Screening | In-take | Follow-up |
|---|---|---|---|
| | | | |
| **At 25% coverage** | | | |
| children per hour per health worker/nurse | 20 | 3 | 4 |
| total hours actively screening/treating per day | 4 | 4 | 4 |
| total kids screened/treated per health worker/nurse per day | 80 | 12 | 16 |
| | | | |
| **At 26-50% coverage** | | | |
| children per hour per health worker/nurse | 20 | 3 | 4 |
| total hours actively screening/treating per day | 3.5 | 3.5 | 3.5 |
| total kids screened/treated per health worker/nurse per day | 70 | 10.5 | 14 |
| | | | |
| **At 51-75% coverage** | | | |
| children per hour per health worker/nurse | 20 | 3 | 4 |
| total hours actively screening/treating per day | 3 | 3 | 3 |
| total kids screened/treated per health worker/nurse per day | 60 | 9 | 12 |
| | | | |
| **At 76-90% coverage** | | | |
| children per hour per health worker/nurse | 20 | 3 | 4 |
| total hours actively screening/treating per day | 2.5 | 2.5 | 2.5 |
| total kids screened/treated per health worker/nurse per day | 50 | 7.5 | 10 |
| | | | |
| **At 91-95% coverage** | | | |
| children per hour per health worker/nurse | 20 | 3 | 4 |
| total hours actively screening/treating per day | 2 | 2 | 2 |
| total kids screened/treated per health worker/nurse per day | 40 | 6 | 8 |

Source: Authors' calculations

Although the numbers of health workers and nurses to be hired are not large, their monthly compensation does affect the overall cost of the proposed intervention. Our baseline assumptions are: health workers receive US$175 per month, nurses receive US$400 per month, and all salaries are paid on time.[9]

## Limitations of Proposed Intervention

The proposed intervention has several important limitations.

First, not all cases of SAM can be successfully treated with RUTF. Some complicated cases involving infections, diseases, or other medical issues must be treated in clinics or hospitals (Lenters et al. 2016) and the cost of treating these cases can be significantly higher than treating

[9] Reported estimates of actual salaries received by health workers and by nurses varied from US$150/month to US$400/month, and from US$250 to US$800/month, respectively – we assess the impact of higher and lower salary assumptions in sensitivity analyses.

uncomplicated cases. The costs associated with these complicated cases are not included in this model. However, the bulk of the benefits of the proposed intervention are derived from discovering and treating cases of *MAM*, for which complications and hence mortality rates are much lower (Lenters et al. 2016). Therefore, omitting the costs of treating the small percentage of complicated SAM cases from the analysis is not expected to have a large effect on the intervention's benefit-cost ratio.

Second, as indicated in the introductory section, this intervention does not 'fix' the socioeconomic system that continues to 'produce' thousands of cases of GAM each year. Additional, broad-based investments will be required to achieve sustained reductions in poverty; our proposed intervention would save thousands of children's lives while poverty-focused investments are being designed and implemented.

Third, the proposed intervention focuses on screening and treating *additional* children who suffer from SAM and MAM. We acknowledge the need for substantial investments and improvements in the *current* system that screens approximately 80% of Haitian children and treats approximately 70% of SAM cases and 25% of MAM cases. We include substantial resources for those purposes, but more resources and (perhaps especially) more time might be required to enhance the current system.

Fourth, and related, the proposed intervention may increase some of the costs of the current system, e.g., current health workers and nurses may lobby for the same consistent payment of salaries that our 'new' hires are envisioned to receive. None of these potential 'spill-overs' from the proposed intervention to the current system, some of which may increase the benefit/cost ratio while others may reduce it, are included in the model developed and presented below.

Finally, and again related, the model cannot address the many potential institutional shortcomings (e.g., a failure to effectively integrate public sector and NGO activities in child screening and treatment) that may reduce the benefits of the proposed intervention or undermine its efficiency. Sensitivity analyses (presented below) attempt to address this and other shortcomings – if these results accurately capture these potential shortcomings, then the intervention is worth serious consideration even under pessimistic circumstances.

# Calculation of Costs and Benefits

## Estimated Costs of Proposed Interventions

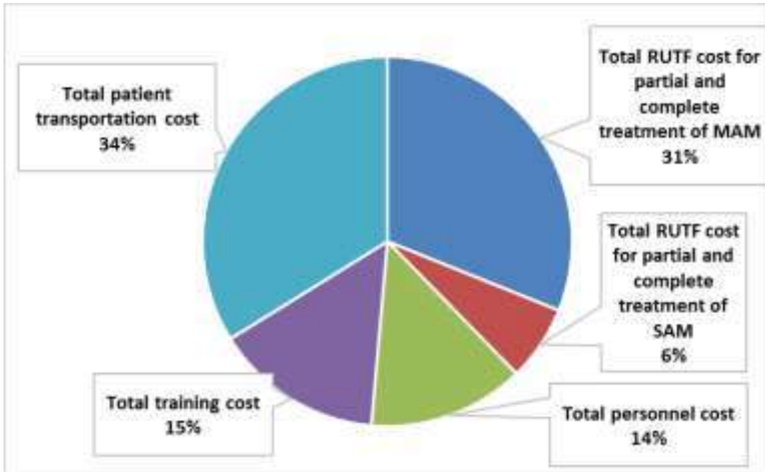
The proposed interventions are comprised of training and program costs, which vary over the 12-year intervention period, primarily to allow for the envisioned scaling up and up-grading of the program during the first four years, but also because the population of children under five and the estimated prevalence rates of SAM and MAM also vary over time.

Training costs, which are faced primarily during the first 4 years of the proposed intervention[10], are those required to generate the larger pool of health workers for screening young children for SAM and MAM, and a larger pool of nurses for treating children with SAM and MAM. These additional trained health workers are then deployed, and the field costs and the program management costs (including additional supervision costs) associated with these deployments are all included in our cost estimates. Additional, clinic-based nurses are also deployed, and the field, program management, and (especially) RUTF purchase, transportation, and storage costs associated with their treatment activities are included in costs estimates. Again, all cost figures take as given the personnel and other costs associated with current SAM and MAM screening and treatment activities, i.e., we focus only on the *additional* costs associated with expanding and improving on the set of better-coordinated national programs involving NGOs and public sector entities.

Figure 2 depicts the composition of costs across broad cost categories for children aged 6-12 months[11] during 2018, the first of the scale-up years of the proposed intervention involving the standard RUTF product. Approximately 37% of all costs are attributable to procuring, transporting, and storing the RUTF product used to treat cases of SAM and MAM. Training and personnel costs also represent a large share of costs during this scaling-up period, as do the costs of providing transportation to/from treatment centers for children suffering from SAM or MAM and their caregivers[12].

[10] The model envisions some staff turnover; the costs of training replacement health workers and nurses are included in cost calculations.
[11] There are five cohorts of children that comprise the target under-five population in this model: 6-12 months, 1-2 years, 2-3 years, 3-4 years, and 4-5 years. Each cohort has its own characteristics (size, MAM- and SAM-specific mortality rate, etc.) and hence its own cost and benefit profiles. We present the costs of the 6-12 month cohort here; data on the other cohorts are available in the model.
[12] The cost of caregivers' time dedicated to accompanying treated children is not included in the model.

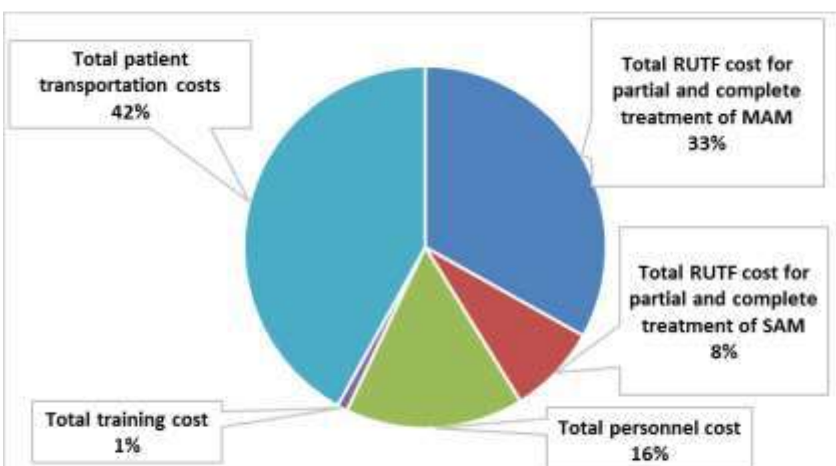
Figure 2 – Intervention Costs (%), Standard RUTF Formula, Scale-Up Year, Children 6-12 Months




Source: Authors' calculations

Figure 3 presents the cost composition information for the same cohort of children, but for the year 2020, by which time the proposed interventions are completely at scale, i.e., 95% of children are being screened, and 95% of those identified with SAM or MAM initiate treatment. The pool of trained health workers and nurses is now much larger, so overall personnel costs rise vis-à-vis the scale-up period. The number of treated children increases and so does the share of costs associated with transporting malnourished children and their caregivers to/from treatment facilities. Note that a small proportion of total costs continues to be dedicated to training health workers and nurses, due to staff turnover.

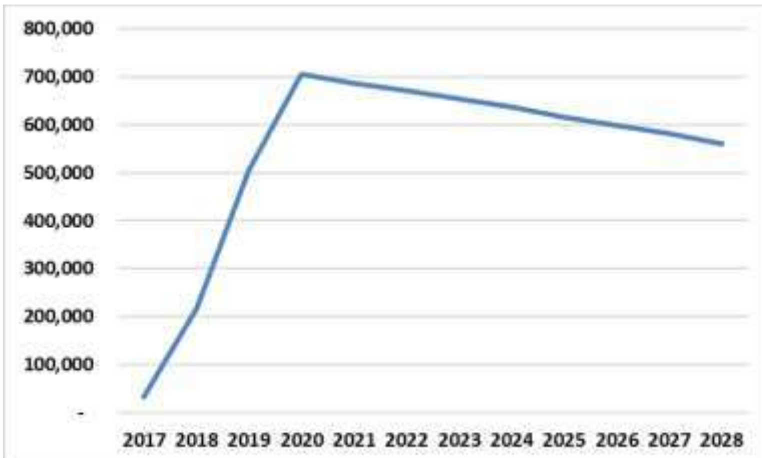
Figure 3 – Intervention Costs (%), Standard RUTF Formula, At-Scale Year, Children 6-12 Months




Source: Authors' calculations

Total (undiscounted) cost of the proposed 12-year intervention for the cohort of children aged 6-12 months is substantial (approximately USD 6.5m), rising sharply over the scale-up period and then declining slowly as the size of the 6-12 month cohort declines and the prevalence of SAM and MAM decreases over time. Figure 4 reports these costs. Recall that the 6-12 month cohort is one of five cohorts that comprise the entire intervention – the sum total of (undiscounted) costs for *all* cohorts is approximately USD 27.6m.

Figure 4 – Total Cost of Proposed Intervention, Standard RUTF Formula, Children 6-12 Months, by Year (USD)




Source: Authors' calculations

## Estimated Benefits of Proposed Interventions

The expected national benefits associated with the proposed interventions focus primarily on reductions in age-specific mortality rates among the larger segment of the population of under-5 children that will be identified and treated for SAM and MAM, and hence have the potential to significantly reduce the years of life lost (YLL) and the years living with the disability associated with surviving untreated SAM in early childhood.

The number of lives saved will depend heavily on the proportion of children with GAM, and especially on the proportion of underweight children suffering from SAM. Table 2 presents a set of actual, calculated, and predicted values for SAM, MAM, and GAM, from about 1994 through 2028.

Table 2 – Rates of SAM, MAM, and GAM in Haiti, 1994-2028

| | Year | SAM (%) | MAM (%) | GAM (%) |
|---|---|---|---|---|
| Actual | 1994 | 3 | 6.4 | 9.4 |
| Actual | 2000 | 1.5 | 4.1 | 5.6 |
| Actual | 2006 | 3.3 | 7 | 10.3 |
| Actual | 2012 | 1.3 | 3.9 | 5.2 |
| Calculated | 2013 | 1.6 | 4.9 | 6.5 |
| Predicted* | 2016 | 1.49 | 4.52 | 6.02 |
| Predicted* | 2017 | 1.43 | 4.46 | 5.89 |
| Predicted* | 2018 | 1.37 | 4.39 | 5.77 |
| Predicted* | 2019 | 1.32 | 4.32 | 5.64 |
| Predicted* | 2020 | 1.26 | 4.26 | 5.51 |
| Predicted* | 2021 | 1.20 | 4.19 | 5.39 |
| Predicted* | 2022 | 1.14 | 4.12 | 5.26 |
| Predicted* | 2023 | 1.08 | 4.06 | 5.14 |
| Predicted* | 2024 | 1.02 | 3.99 | 5.01 |
| Predicted* | 2025 | 0.96 | 3.92 | 4.88 |
| Predicted* | 2026 | 0.90 | 3.85 | 4.76 |
| Predicted* | 2027 | 0.85 | 3.79 | 4.63 |
| Predicted* | 2028 | 0.79 | 3.72 | 4.51 |
| | | | | |
| Data source for actual: http://data.unicef.org/topic/nutrition /malnutrition/ | | | | |
| *Predicted using linear trend based on 1994-2013 data | | | | |

Source: Authors' calculations

Since subsets of the under-5 population have different prevalence rates for SAM and MAM (WHO Global Database on Child Growth and Malnutrition, 2014), for each year of the proposed intervention period, the prevalence of SAM and MAM are also broken down by age cohort. Table 3 presents the predicted prevalence rates for SAM and MAM for six cohorts comprising the under-5 population in Haiti for 2017.[13]

[13] Age-group-specific prevalence rates for SAM and MAM also vary over time, in accordance with predicted under-5 prevalence rates of GAM (see Table 2).

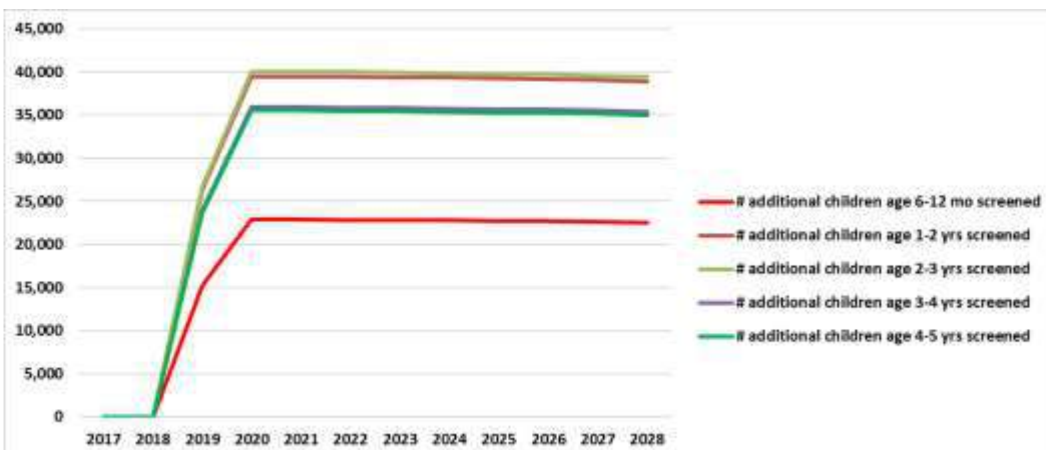
Table 3 – Prevalence Rates for SAM and MAM in 2017, Under-5 Population, by Age Cohort

| Age Cohort (years) | SAM (%) | MAM (%) |
|---|---|---|
| .5-0.99 | 2.54 | 7.54 |
| 1-1.99 | 0.77 | 6.40 |
| 2-2.99 | 0.77 | 2.17 |
| 3-3.99 | 0.88 | 2.97 |
| 4-4.99 | 1.54 | 3.89 |

Source: Predicted using data from WHO Global Database on Child Growth and Malnutrition, 2014

The proposed intervention will increase the number of children screened for GAM (from the current levels of approximately 70% to 95%) and consequently increase the numbers of children with SAM and MAM for whom treatment is initiated.[14,15] Figure 5 depicts the additional numbers of children that will be screened for SAM and MAM, for all child cohorts 6-59 months. Note that initial programmatic investments in year zero of the simulation (2017) generate no new additional children screened, and that 2018-2020 are scale-up years during which a larger cadre of health workers and nurses are trained, equipped, and deployed.

Figure 5 – Additional Children Screened, All Age Cohorts




Source: Authors' calculations

Figure 6 depicts the numbers of cases of SAM and MAM that are partially or completely treated. Once again, the large share of addition MAM cases relative to SAM cases, which is the primary source of the proposed intervention's benefits, is clear.

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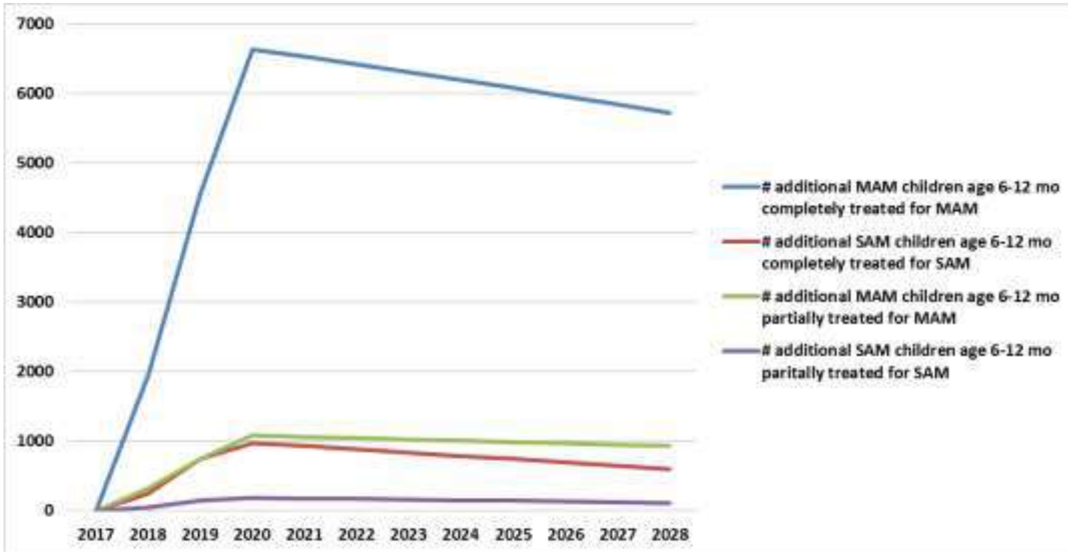
[14] For all model simulations, the proportion of children identified as suffering from SAM for whom treatment is initiated increases from the status quo level of 70% to 95% during the scale-up period. The proportion of children identified as suffering from MAM increases from the status quo level of 25% to 95% during the scale-up period.

[15] Not all children with SAM or MAM are completely treated, i.e., some children die during treatment, others default (perhaps because caregivers choose not to continue treatment). The model identifies these cases and adjusts treatment costs accordingly.

Figure 6 – Additional of Cases of SAM and MAM Partially and Completely Treated, Children 6-12mos

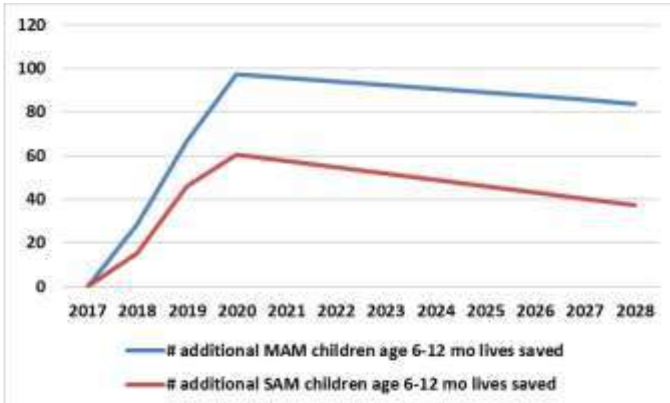



Source: Authors' calculations

IIncreased rates of screening and treatment save lives. Figure 7 reports the number of lives saved among children age 6-12 months[16] that are attributable to expanding screening and treatment activities for SAM and for MAM over the duration of the proposed intervention. Although the proportional number of deaths averted due to SAM treatment (6.5%) is much higher than that of MAM (1.5%), the 'stock' of additional MAM cases is much larger than that of SAM cases, so the numbers of lives saved by enhancing the MAM treatment program 'outnumber' those of the enhanced SAM treatment program. The total number of lives saved among the under-5 population over the 12-year proposed intervention period is 5,768. The total undiscounted number of disability-adjusted life years (DALYs) saved (adjusting for when during the under-5 period the deaths are averted) is 374,476.

[16] Recall, once again, that the model contains four additional age cohorts, each of which has its own GAM prevalence rates and other characteristics that influence both costs and benefits.

Figure 7 – Additional Lives Saved by the Proposed Intervention, Children 6-12mos




Source: Authors' calculations

## Benefit-Cost Analyses

Benefits are aggregated and discounted for each intervention in the following way:

(1) the numbers of lives saved related to the treatment of SAM and MAM are estimated for each year of the simulation period, and then discounted by 3%, 5%, and 12%, regardless of the year in which the lives are saved;
(2) the total number of lives saved (discounted, at three rates) in each year is then weighted by 1XGDP, 3XGDP, and 8XGDP, using the year-specific estimates of GDP that were provided; and finally
(3) the present value of the benefit stream (DALYs*GDP, discounted at three rates) associated with the intervention is calculated, and set alongside the symmetrically discounted intervention cost stream.

Table 4 presents the summary measures of estimated benefits and costs, discounted at 3%, 5% and 12%, and the resulting benefit/cost ratios, for the two proposed interventions, one making use of a *standard* RUTF formula and the other making use of the *local* RUTF formula. Note that the benefit/cost ratios are all considerably greater than one for both of the interventions, even at 12% discount rate and valuing disability-adjusted life years saved at 1XGDP.

Note also that identifying and producing a *local* RUTF formula reduces the costs associated with the proposed intervention[17]; since the expected benefits are identical, the benefit/cost ratios are somewhat higher than those of the standard formula.[18]

[17] Ingredient costs are assumed to decrease by 20%; realized savings on ingredient costs may be higher or lower for Haiti, depending on ingredient-specific supply-demand relationships, and how these play out over the intervention period.

Our review of the literature, our interactions with in-country collaborators with extensive experience in child health issues, and the results of our extensive sensitivity analyses (selected results are presented in the next section) lead us to conclude that the quality of evidence that we have assembled in the case of the standard RUTF is 'strong'. Because direct evidence is lacking on the effectiveness of the local RUTF formula (vis-à-vis the standard RUTF formula) (Lenters et al. 2016), we believe the evidence is 'medium' for this intervention.

[18] The cost reduction associated with developing and shifting to a local formula will depend heavily on the fixed costs of doing so. For the standard formula, the benefit/cost ratio of the proposed intervention is 4.5. If we assume a 20% reduction in ingredient costs, the fixed costs associated with switching formulas in year 1 could be as large as approximately $971,000(USD) and the benefit/cost ratio would still be >= 4.5.

Table 4 – Summary of Baseline Costs and Benefits of Proposed Interventions

| | Discount | Benefit (DALY value = 1XGDP) | Cost | BCR | Quality of Evidence |
|---|---|---|---|---|---|
| Treat wasting with *standard* RUTF formula | 3% | $6,224,239,197 | $1,377,612,779 | 4.5 | Strong |
| | 5% | $3,615,478,651 | $1,184,266,481 | 3.1 | |
| | 12% | $978,773,092 | $ 729,543,281 | 1.3 | |
| Treat wasting with *local* RUTF formula | 3% | $6,224,239,197 | $1,316,062,103 | 4.7 | Medium |
| | 5% | $3,615,478,651 | $1,131,759,778 | 3.2 | |
| | 12% | $978,773,092 | $ 698,181,399 | 1.4 | |
| **Intervention** | **Discount** | **Benefit (DALY value = 3XGDP)** | **Cost** | **BCR** | **Quality of Evidence** |
| Treat wasting with *standard* RUTF formula | 3% | $18,672,717,590 | $1,377,612,779 | 13.6 | Strong |
| | 5% | $10,846,435,954 | $1,184,266,481 | 9.2 | |
| | 12% | $2,936,319,276 | $ 729,543,281 | 4.0 | |
| Treat wasting with *local* RUTF formula | 3% | $18,672,717,590 | $1,316,062,103 | 14.2 | Medium |
| | 5% | $10,846,435,954 | $1,131,759,778 | 9.6 | |
| | 12% | $2,936,319,276 | $ 698,181,399 | 4.2 | |
| **Intervention** | **Discount** | **Benefit (DALY value = 8XGDP)** | **Cost** | **BCR** | **Quality of Evidence** |
| Treat wasting with *standard* RUTF formula | 3% | $49,793,913,574 | $1,377,612,779 | 36.1 | Strong |
| | 5% | $28,923,829,211 | $1,184,266,481 | 24.4 | |
| | 12% | $7,830,184,735 | $ 729,543,281 | 10.7 | |
| Treat wasting with *local* RUTF formula | 3% | $49,793,913,574 | $1,316,062,103 | 37.8 | Medium |
| | 5% | $28,923,829,211 | $1,131,759,778 | 25.6 | |
| | 12% | $7,830,184,735 | $ 698,181,399 | 11.2 | |

Source: Authors' calculations

## Sensitivity Analyses

Many sets of sensitivity analyses were undertaken to assess the effects of changes in key assumptions and model parameter choices on our estimates of DALYs saved and of intervention costs, and on benefit-cost ratios. To summarize these results and to establish programmatic upper and lower bounds on the benefit-cost ratio of the proposed intervention, we constructed two composite scenarios, one optimistic and another pessimistic, with each scenario comprising a collection of model parameters known to have significant effects on the benefit-cost ratio of the proposed intervention. The 'optimistic' scenario contains a collection of parameter values that would generate *higher* benefits and *lower* costs; the 'pessimistic' scenario does the opposite. Table 5 reports the assumptions used in the baseline (results reported in Table 4, above), and the optimistic and pessimistic scenarios.

Table 5 – Parameter Assumptions Used to Construct the Baseline, Optimistic and Pessimistic Scenarios

| Parameter | Baseline | Optimistic | Pessimistic |
|---|---|---|---|
| Health Worker Salary – New Hires | $175/mo | $135/mo | $350/mo |
| Nurse Salary – New Hires | $450/mo | $250/mo | $700/mo |
| Health worker recruitment and initial training | $2000/worker | $1500/worker | $4000/worker |
| Nurse recruitment and initial training | $4000/nurse | $3000/nurse | $8000/nurse |
| Supervision and retraining of health workers and nurses | $10,000 yrs 1 & 2, $15,000 yr 3, & $20,000 yr thereafter | $10,000/yr for all years | $20,000/yr for all years |
| Transportation Payments to Caregivers | $6-$9/visit, scaled up | $6/visit | $9/visit |
| Treatment visits | Every week | Every other week | Every week |
| Price of RUTF | $54.93/carton (Unicef, reported avg 'country office' price paid to MFK, Haiti in 2016) | $51.28/carton (Unicef, reported avg 'offshore' price paid to MFK, Haiti in 2016) | $61.20 (Unicef, reported avg 'offshore' price paid to MFK, Haiti in 2014) |
| Mortality rate untreated SAM | 6.5% (Based on Olofin HR using average of all-cause mortality and cause-specific mortality) | 9.9% (Based on Olofin HR using all-cause mortality) | 3.1% (Based on Olofin HR using cause-specific mortality) |
| Mortality rate untreated MAM | 1.5% (Based on Olofin HR using average of all-cause mortality and cause-specific mortality) | 2.2% (Based on Olofin HR using all-cause mortality) | 0.9% (Based on Olofin HR using cause-specific mortality) |
| Rate of SAM/MAM over time | Linear trend | Historical pattern | Linear trend |

Table 6 presents the results of the scenarios sensitivity analyses. The *pessimistic* scenario, which includes much higher costs and lower benefits due to reductions in mortality attributable to SAM and MAM (and hence fewer lives saved), generates a benefit-cost ratio of approximately 2.1. The optimistic scenario, which include lower costs and higher benefits due to increases in mortality attributable to SAM and MAM (and hence more lives saved) yields a benefit-cost ratio of 10.6. We believe these scenarios capture the expected range of benefit-cost ratios for the proposed intervention, with the baseline value of 4.5 being our preferred estimate.

Table 6 – Summary of Costs and Benefits of Proposed Intervention: Baseline, Optimistic, and Pessimistic Scenarios for the Standard RUTF Intervention[19]

| Scenarios | Benefit (in gourdes) | Cost (in gourdes) | BCR | Quality of Evidence |
|---|---|---|---|---|
| Baseline | $6,224,239,197 | $1,377,612,779 | 4.5 | Strong |
| Optimistic | $10,980,359,443 | $1,032,666,625 | 10.6 | Strong |
| Pessimistic | $3,528,828,004 | $1,678,392,109 | 2.1 | Strong |

Notes: All figures assume a 3% discount rate; benefits are 'valued' at 1XGDP.
Source: Authors' calculations

# Conclusions

Thousands of young Haitian children die unnecessarily each year. Many of these deaths are preventable by expanding programs to identify and treat children with SAM and MAM. Designing and implementing these programs will not be cheap, but the benefits to society will be very large.

In this paper and in its accompanying spreadsheet-based model, we propose a 12-year investment in expanding and improving national programs for screening and for treating cases of SAM and MAM in children under 5 years of age. The envisioned intervention would be a MSPP-managed hybrid of NGO and public institutions that come together to form an efficient, coordinated system. We propose a 4-year scale-up period during which the required pool of additional health workers (for screening) and nurses (for treatment) are hired and trained, and the required investments in improving system coordination and supervision are made.

The program is expected to save over 5,700 lives and thousands of others will have the benefit of avoiding the disability associated with untreated cases of SAM. Because these are 'young lives' that will be saved, the total number of disability-adjusted life years saved by this intervention is nearly 375,000. Although historically the burden of malnutrition tended to be skewed toward boys (e.g., in 1994-1995, the ratio of the prevalence of SAM between boys and girls was approximately 1.8 {=3.9/2.2} and for MAM approximately 1.5 {=11.2/7.6}), more recent data (2012) suggest that the burden of SAM is now higher for girls (0.8 = 1.1/1.4), but that the burden of MAM remains a bit higher for boys (1.2 = 5.6/4.8) (WHO Global Database on Child Growth and Malnutrition, 2014). If this historical trend in the gender composition of child malnutrition continues over the timeframe envisioned by this intervention, the burden of both SAM and MAM will increasingly fall disproportionately on young girls.

[19] We present summary statistics only for the standard RUTF formula; results for simulations run for the local RUTF formula are very similar.

The costs of the program, estimated to be over $1.4b gourdes (discounted at 3%, or approximately $21.7m USD, also discounted at 3%) are considerable, and most of the caregiver time costs (not accounted for in this model) would be shouldered by the women responsible for delivering children to screening and treatment centers . However, when the values of the lives saved are set against the costs of saving them, the results strongly suggest that the proposed intervention is worth serious consideration by policy makers. More specifically, at a 3% discount rate and valuing lives saved at 1XGDP, the benefit cost ratio is 4.5. Sensitivity analyses suggest that even under pessimistic assumptions the benefit/cost ratios (at 3% discount) never falls below 2.1.

By translating our estimates of total children treated, total children recovered, total lives saved and total DALY averted by the proposed intervention into cost per child treated, child recovered, life saved and per DALY averted, we can compare our estimates to others in the literature. Our estimates suggest that over the 12-year life of the proposed intervention and discounting costs at 3%, the proposed intervention will cost approximately US$62 per treated child, US$74 per child recovered, US$3,769 per life saved, and US$58 per DALY averted (see Table 7, row 1).[20] To improved comparability to estimates in the literature, which all consider treatment of SAM only, cost estimates are also provided (row 2 of Table 7) for a similar proposed intervention that *treated only SAM*. Ranges of cost estimates ([bracketed], rows 1 and 2, Table 7) represent those generated by the optimistic and pessimistic scenarios (see Table 5 for scenario assumptions). Acknowledging methodological differences in translating lives saved to DALYS,[21] our estimates (row 2) are fairly comparable to those of other estimates of the cost-effectiveness of community-based treatment of SAM with RUTF.

[20] Arrived at dividing total discounted costs (from Table 4) by the total number of children treated, children recovered, lives saved and by the total number of DALYs, respectively.

[21] These studies all used some variant of the Fox-Rushby methodology, which includes age discounting. We used the methodology provided by Copenhagen Consensus Group, which does not. As a result, our ratio of cost per life saved to cost per DALY averted is higher than these studies because our estimates of lives saved translate into many more DALYs.

Table 7 – Comparison of Cost-Effectiveness Estimates

| Study | Country | Cost per Child Treated* | Cost per Child Recovered* | Cost per Life Saved* | Cost per DALY Averted* |
|---|---|---|---|---|---|
| Current study, treatment of SAM and MAM | Haiti | $62 [41-75] | $74 [50-90] | $3769 [1595-8163] | $58 [25-125] |
| Current study, treatment of SAM only | Haiti | $122 [72-153] | $152 [89-192] | $2341 [905-6209] | $36 [14-93] |
| Frankel et al. 2015, treatment of SAM only | Nigeria | | $219 | $1117 | $30 |
| Puett et al. 2012, treatment of SAM only | Bangladesh | $165 | $180 | $869 | $26 |
| Wilford et al. 2011, treatment of SAM only | Malawi | $169 | $185 | $1365 | $42 |
| Bachmann 2009, treatment of SAM only | Zambia | $203 | | $1760 | $53 |

Source: Authors' calculations for current study; estimates from cited literature.
*Reported in US dollars

We conclude that expanding and improving the national programs for screening and treating SAM and MAM using the *standard* RUTF formula is worth pursuing. Investing in the development and use of an alternative *local* RUTF formula for treating SAM and MAM modestly improves the cost/benefit ratio for the proposed intervention, but there is some uncertainty regarding the effectiveness of the new formula.

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Haiti faces some of the most acute social and economic development challenges in the world. Despite an influx of aid in the aftermath of the 2010 earthquake, growth and progress continue to be minimal, at best. With so many actors and the wide breadth of challenges from food security and clean water access to health, education, environmental degradation, and infrastructure, what should the top priorities be for policy makers, international donors, NGOs and businesses? With limited resources and time, it is crucial that focus is informed by what will do the most good for each gourde spent. The Haïti Priorise project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country. We engage Haitans from all parts of society, through readers of newspapers, along with NGOs, decision makers, sector experts and businesses to propose the best solutions. We have commissioned some of the best economists from Haiti and the world to calculate the social, environmental and economic costs and benefits of these proposals. This research will help set priorities for the country through a nationwide conversation about what the smart - and not-so-smart - solutions are for Haiti's future.

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