Benefit-Cost Analysis of a Package of Early Childhood Interventions to Improve Nutrition in Haiti

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Benefit-cost analysis of a package of early childhood interventions to improve nutrition in Haiti

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Abstract

I conduct a benefit-cost analysis of a package of interventions targeting pregnant women and children that can improve nutrition outcomes in Haiti. Using the Lives Saved Tool (LiST), I estimate that this package can prevent approximately 54,000 cases of child stunting, 7,600 babies being born with low birth weight and 28,000 cases of maternal anemia, if it can be scaled up to cover 90% of the target population every year. These nutrition improvements will avoid 1,800 child deaths, 80 maternal deaths and 900,000 episodes of child illness every year. For those children who avoid being stunted, these interventions will deliver lifetime productivity benefits equivalent to 4 times GNI per capita in present value terms, at a 5% discount rate. The paper tests the effects of various methodological choices on the valuation of avoided mortality, avoided morbidity and lifetime productivity. In the base case scenario, the annualized net benefits of the intervention equal 14.7 billion Haitian gourdes (HTG) and the benefit-cost ratio is 6.6. The different valuation approaches create significant variation in the results, with a high-to-low range 138% as large as the central estimate.

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1. Introduction

Haiti has the poorest health and education outcomes in the Western Hemisphere. Its infant mortality rate (51 deaths per 1000 live births in 2016) is three times higher than the Latin America and Caribbean (LAC) average, while the maternal mortality rate (359 per 100,000 live births) is five times higher than the regional benchmark (World Bank, 2017). A Haitian child born today is expected to live for 63 years, about 10 years less than a child born in the neighboring Dominican Republic (World Bank, 2017). In terms of education, the adult literacy rate in 2015 was 61% while the Caribbean average was 92% (Central Intelligence Agency Fact book, 2018). The literacy rate for youth aged 15-24 is better at 82%, but still very low compared to its neighbors. For a country hunting for sources of economic growth, the future economic development of the country will require an improved human capital base. One-third of the population is under the age of 15. If these children do not achieve higher standards of health and education, their prospects and that of the country are bleak. This assessment would hold true even if the country had not experienced crippling earthquakes and hurricanes.

At the same time, the available resources to solve Haiti's myriad problems are not particularly large. In 2016, the government had expenditures of HTG 120bn or USD 1.9bn (Central Intelligence Agency Fact Book, 2016), while donors spent roughly HTG 63bn or USD 1bn (aidflows.org) for total public resources of only HTG 17,000 or USD 270 per capita. Benefit-cost analysis is a useful tool to determine the effective uses of Haiti's limited funds. It is against this backdrop that this paper undertakes a benefit-cost analysis of an intervention that addresses both health- and education- related challenges in Haiti, and has the potential to be an effective use of funds: the provision of a package of early childhood interventions to address nutrition-related outcomes such as stunting, wasting and low birth weight.

An analysis of this package is motivated by the fact that the intervention has been assessed as one of the most effective uses of development funds globally[1] but a

[1] This package of interventions, or variations of it, has been ranked highly in previous Copenhagen Consensus exercises. It was the top ranked intervention in the 2008 Copenhagen Consensus II (Horton, Alderman and Rivera, 2009) and 2012 Copenhagen Consensus III exercises (Hoddinott, Rosegrant and Torero, 2013) and the third ranked

benefit-cost analysis has not been previously undertaken in the Haitian context. Additionally, undertaking a benefit-cost analysis of this intervention is useful for the purposes of the Guidelines for Benefit-Cost Analysis exercise (Robinson et al, 2017) as it includes three types of benefits – avoided mortality, avoided morbidity and lifetime productivity – as well as immediate and longer-term benefits. This allows testing of the effects of various valuation methods and discounting assumptions on the results.

This paper also extends the literature on the benefit-cost analysis of this particular set of interventions by accounting for both productivity *and* health effects. Previous analyses have only accounted for the former with a primary focus on stunting outcomes (Hoddinott et al. 2013, Horton and Hoddinott, 2014). This is of more than academic interest. The interventions in this package form the basis for Scaling Up Nutrition, a multilateral movement backed by significant government funding committed to ending undernutrition across the world (Scaling Up Nutrition, 2014). The results of previous analyses appear to have had a significant impact on policy, for example, they were cited in outcome documents that committed USD 4.15bn towards implementing elements of this package of interventions (Global Nutrition for Growth Compact, 2013). Omitting health benefits understates the effectiveness of this intervention and may have implications for future nutrition funding.

This paper uses the Lives Saved Tool (LiST) to model both the nutrition and health effects of scaling up this package of interventions to cover 90% of pregnant women and 0-2 year old children in Haiti. Estimates suggest that each year, this will prevent approximately 54,000 cases of child stunting, 7,600 babies being born with low birth weight and 28,000 cases of maternal anemia. The package alone will ensure achievement of World Health Assembly (WHA) 2025 Global Nutrition Target 5: *increase the rate of exclusive breastfeeding in the first 6 months up to at least 50%*, while assisting in getting Haiti halfway towards Target 1: *achieve a 40% reduction in the number of children under-5 who are stunted* and Target 3: *achieve a 30% reduction in low birth weight*. These improvements in nutritional status will avoid 1,800 child deaths,

intervention in Bangladesh Priorities project in 2016 (Rose and Zaman, 2016). In the Post-2015 Consensus, the intervention was partial justification for assigning 'Reduce stunting by 40%' as one of the top 19 targets that the world should focus on over the 15-year period from 2016-2030 (Horton and Hoddinott, 2014).

80 maternal deaths and 900,000 episodes of child illness every year. For those children who avoid stunting, it will also deliver consumption benefits equivalent to 4 times GNI per capita in present value terms, at a 5% discount rate.

In the base case scenario, results indicate that the provision of this package is an effective use of development money, with annualized net benefits of 14.7bn Haitian gourdes (HTG) or USD 273m per year[2] and a benefit-cost ratio of 6.6. Half the benefits are due to avoided mortality, 46% are from lifetime productivity improvements and the remainder is avoided morbidity. Despite these impressive benefits, the package is not likely to be the most effective nutrition or education intervention in the Haitian context in terms of benefit-to-cost.

Additional analyses indicate that the results are sensitive to the choice of valuation methods adopted. In this study, Haitian VSL is estimated using benefit transfer approach suggested by the methods paper (Robinson, Hammitt and O'Keeffe, 2018), with a central estimate of 100x GNI per capita PPP, a high-end estimate of 160x GNI per capita PPP and a low-end estimate of 28x GNI per capita PPP[3]. These correspond to a Haitian VSL of HTG 4.5m (Int$ 179,000 or USD 71,000), HTG 7.2m (Int$ 286,000 or USD 113,000), and HTG 1.3m (Int$ 50,810 or USD 20,000) respectively. I also assess the effects of valuing years of life lost (YLLs) rather than lives saved by applying a value of statistical life year (VSLY) approach. This increases the effective value of lives saved, as the primary beneficiaries of this intervention – children – have significantly more life years left than the average Haitian adult. For valuing morbidity, a benefit transfer approach is adopted, using a willingness-to-pay study conducted in rural China (Guh et al., 2008) as well as a standardized value per year lost to disability (YLD), adjusting for costs borne by third parties. At the 5% discount rate, adopting valuation methods that maximize health benefits leads to net benefits of HTG 28.5bn (USD 449m) per year, while adopting valuation methods that minimize health benefits

[2] Throughout this study, the following 2016 exchange rates are used: USD 1 = HTG 63.34 and HTG 1 = Int$ 25.03. These are sourced from World Bank (2018). Unless otherwise stated, all currencies are in 2016 figures.
[3] The low estimate corresponds to a US VSL of $9.4m transferred to Haiti, using an income elasticity of 1.5 as suggested by the methods paper (Robinson, Hamitt and O'Keeffe, 2018),

results in net benefits of HTG 8.1bn (USD 104m). This high-to-low range of HTG 20.3bn (USD 321m) is 138% as large as the central estimate.

This amount of variation is larger than the variation resulting from other methodological, statistical and epistemic sources of uncertainty such as the choice of discount rate, inherent impact of the intervention package on health outcomes, and the impact of the package on lifetime productivity outcomes. These sources of uncertainty generate several net benefit estimates that range between 88%-104% of the base case estimate. A short discussion at the end of this paper suggests that while these sources of uncertainty might be considered large, they are unlikely to impact the decisions of a social welfare maximizing policy maker. This is because within a given policy space, the most effective interventions tend to be *one to three orders of magnitude* more effective than typical interventions (Ord, 2013; McEwan, 2015; Copenhagen Consensus Center, 2015; 2016) with benefits to costs so large that effectiveness is likely to outweigh any concerns about uncertainty.

The rest of this case study is structured as follows: the next section outlines the nutrition challenges of Haiti. Section 3 describes the nutrition package and nutrition literature underlying the LiST model. In Section 4, modeled nutrition impacts are presented. Section 5 presents the results of the benefit-cost analysis, including sensitivity analyses. Section 6 concludes and discusses uncertainties in the valuation approaches and its effect on policy.

2. Haiti's nutrition challenges

Haiti's most recent demographic and health survey, EMMUS-VI 2016-17 (IHE and ICF, 2017), shows that the country continues to face significant nutrition challenges, and is likely off-track on four out of the six WHA 2025 Global Nutrition Targets. Comparing EMMUS-VI 2016-17 with the prior demographic and health survey, EMMUS-V 2012 (Ministry of Public Health and Population 2013), the nutrition landscape appears virtually unchanged over five years across a range of key indicators such as stunting, anemia and exclusive breastfeeding (see Table 1). Undernutrition is a source of concern because it impacts both health outcomes (Fishman et al., 2004; Black et al., 2008; Olofin et al, 2013; Forouzanfar et al., 2016), as well as current and future productivity (Haas and Brownlie 2001; Alderman and Behrman, 2006; Prendergast and Humphrey, 2014).

Table 1. Haiti's progress on 2025 Global Nutrition Targets

WHA 2025 Global Nutrition Targets	**2012 Baseline and 2025 Target**	**Current status**	**Status**
1. Stunting: 40% reduction in the number of children under 5 who are stunted	Baseline: 21.9%* Target: 13.6%	2016: 21.9%**	Off-track
2. Anemia: 50% reduction in anemia of women of reproductive age	Baseline: 46.0%^ Target: 23.0%	2016: 48.8%**	Off-track
3. Low birth weight: 30% reduction in low birth weight	Baseline: 18-23%^^ Target: 13-16%	2016: No data	Unknown but likely off-track
4. Childhood overweight: No increase in childhood overweight	Baseline: 3.6%* Target: 3.6%	2016: 3.4%**	On-track
5. Breastfeeding: Increase the rate of exclusive breastfeeding in the first 6 months up to at least 50%	Baseline: 39.7%* Target: 50.0%	2016: 39.9%**	Off-track
6. Wasting: Reduce and maintain childhood wasting to less than 5%	Baseline: 5.2%* Target: 5.0%	2016: 3.7%**	On-track

* From EMMUS-V; ** From EMMUS-VI; ^ Micronutrients database, WHO (2014); ^^ Lower bound from LiST, upper bound from UNICEF Low birth weight database adapted from EMMUS-V.

The prevalence of stunting is currently 21.9% (IHE and ICF, 2017). This compares to 7% in neighboring Dominican Republic in 2013 and 11% in the Latin American and Caribbean region in 2014 (World Bank, 2017). The prevalence of moderate and severe stunting among rural children (23.9%) was higher than among urban children (18.0%), and children from the poorest quintile of households were about 3.5 times more likely to be stunted than children from the richest quintile of households (9.4% vs. 34.1% prevalence). A meta-analysis by Olofin et al. (2013) indicates that severely stunted children are over 5-6 times more likely to die in early childhood from all-cause mortality, diarrheal disease and acute lower respiratory infection (major causes of mortality among children under five) than non-stunted children. Even moderately stunted children are 46-67% more likely to die from these causes than non-stunted children.

A wealth of evidence also suggests stunting detrimentally affects cognitive and physical development in childhood (Prendergast and Humphrey, 2014; Bhutta et al., 2013). Iannotti et al. (2016) provide Haitian specific evidence of this effect. They follow 583 Haitian 6-11 month old children from an urban slum in Cap-Hatien for one year and find that linear growth is predictive of faster achievement of motor and language skills, even after controlling for a range of maternal and child characteristics. Several studies also indicate that stunting is associated with lower education attainment (Nandi et al., 2016), lower asset accumulation in adulthood (Victora et al., 2008) and significantly lower consumption in adulthood (Hoddinott et al., 2011) (see Section 5.5 for a more in-depth discussion of the long-term consequences of stunting).

Anemia among women of reproductive age (WRA) continues to be a major problem in Haiti with the most recent survey data indicating anemic prevalence of 48.8%. Haiti has the highest rates of anemia relative to other Latin American and Caribbean countries (Mujica-Coopman et al., 2015). Anemia is associated with poor health and low working productivity, particularly for manual laborers (Balarajan et al., 2011). One estimate places the annual economic cost of anemia in developing countries at $3.64 per capita or 0.81% of GDP (Horton and Ross, 2007). In pregnant women, anemia increases the risk of preterm birth, low-birth weight and maternal mortality (Murray-Kolb et al., 2012; Brabin et al., 2012).

Low birth weight (LBW) is likely to be a significant challenge for Haiti, though ascertaining the 2012 baseline and current rate is difficult. There is no recognized, widely accepted time series data for LBW globally that would allow accurate tracking against WHA targets (World Health Organization, 2017). Using EMMUS-V, WHO estimates that 23% of children were born with low birth weight (UNICEF, 2014). LiST recently introduced a mechanism to estimate LBW, converting assessments of size at birth and length of gestation using regional associations between these factors and LBW from selected studies (Child Health Epidemiology Reference Group SGA–Preterm Birth Working Group, 2017). LiST estimates a 2012 LBW rate of 18% for Haiti. Given that stunting is one major consequence of sub-optimal birth outcomes (Aryastami et al., 2017; Rahman et al., 2016, LiST, 2016), and the prevalence of stunting has not changed in five years, it is highly possible there have been no improvements in LBW since 2012. There are no Haitian specific studies on the impacts of low birth weight, though studies from other countries document that low birth weight is associated with increased neonatal mortality, lower cognitive development and productivity (Katz et al., 2013, Gu et al., 2017, Alderman and Behrman 2006). Katz et al. (2013) find that babies born in the lowest decile in terms of birth weight have about twice the risk of neonatal and post-neonatal mortality relative to normal-sized babies. The meta-analysis by Gu et al. (2017) shows that the mean difference in IQs between LBW and non-LBW individuals is 10 points. One estimate suggests that low birth weight is associated with a 5-10% reduction in wages in adult life (Alderman and Behrman, 2006).

Exclusive breastfeeding has remained basically unchanged between 2012 and 2016, with the rate plateauing at 40%. Sankar et al. (2015) show that exclusive and extended breastfeeding are associated with a lower risk of child mortality. Partially breastfed and non-breastfed 0-6 month-olds have 4.8 times and 14.4 times greater risk of mortality, respectively, relative to exclusively breastfed infants. Children between 6-23 months who were not breastfed had approximately two times greater risk of mortality, relative to breastfed infants. Iannotti et al. (2013) demonstrate that frequency of breastfeeding is predictive of earlier achievement of fine motor outcomes in Haitian children. However, breastfeeding is not associated with improved growth outcomes in Haiti (Heidkamp et al., 2015).

Two aspects of nutrition appear to be on-track in Haiti. Prevalence of wasting has shown steady decline over the last decade, reducing from 10.1% in 2005-06 (EMMUS-

IV) to 5% in EMMUS-V and then to 3.7% in 2016-17 (EMMUS-VI). Child overweight remains below WHA target of 5%.

Outside of indicators linked to WHA targets, other nutrition-related statistics echo a broad pattern of undernutrition. In Haiti, 38% of the population is food insecure. Among 6-23 month-old children, only 14% receive the Infant and Young Child Feeding (IYCF)-recommended amount of nutrition, 29% have sufficiently diversified diets and only 44% receive an IYCF-recommended amount of meals per day (Ministry of Public Health and Population, 2013).

3. Intervention description and LiST approach

Bhutta et al. (2013) describe a package of ten evidence-based interventions to address various forms of undernutrition, some elements targeted at pregnant women, others targeted at children aged 0-2 and one, salt iodization, targeted at the entire population. Using a previous version of LiST, Bhutta et al. estimate that scaling up this package of interventions to 90% coverage rates of the target population in 34 countries will help reduce stunting by 20.3% as well as avoid 1,000,000 under-5 deaths. The interventions, target population and total cost in 2010 Int$ are summarized in Table 2.

Table 2. Package of interventions to improve maternal and child nutrition, target and beneficiary populations, and estimated costs to scale up coverage to 90% in 34 countries

Intervention	Intervention population	Beneficiary population	Cost (in 2010 Int$, million)
Salt iodization	Whole population	Whole population	$68
Multiple micronutrient supplementation in pregnancy, including iron folate	Pregnant women	Pregnant women and children in utero	$472
Calcium supplementation in	Pregnant women	Pregnant women	$1,914

pregnancy		and children in utero	
Energy protein supplementation in pregnancy	Pregnant women	Pregnant women and children in utero	$972
Vitamin A supplementation in childhood	Children 6-59 months	Children 6-59 months	$106
Zinc supplementation in childhood	Children 12-59 months	Children 12-59 months	$1,182
Breastfeeding promotion	Mothers of children aged 6-23 months	Children aged 6-23 months	$653
Complementary feeding education	Mothers of children aged 6-23 months	Children aged 6-23 months	$269
Complementary food supplementation	Mothers of children aged 6-23 months	Children aged 6-23 months	$1,359
SAM Management	Children 6-23 months severely wasted	Children aged 6-23 months	$2,563
TOTAL			$9,559

Source: Adapted from Bhutta et al. (2013).

The LiST model was used to estimate nutrition outcomes in the 2008 and 2013 *Lancet* Nutrition Series. Further updates were made after 2015 to reflect the latest and best scientific evidence (Clermont and Walker, 2017). LiST models both the direct effects of interventions on mortality, as well as the indirect effect, via nutrition pathways on health outcomes. For example, the effect of complementary feeding education is first modeled as a 30% reduction in the odds of stunting following Panjwani and Heidkamp (2017). The software then models the subsequent reduction in stunting on health outcomes using the relative risk associations between stunting and child mortality from Olofin et al. (2013). In this way, the model is able to produce estimates of key nutrition outcomes as well as lives saved from the interventions. Table 3 below outlines the interventions modeled in LiST for this paper, including the presumed baseline coverage of these interventions in Haiti.

Table 3. LiST inputs

LiST intervention category	LiST intervention name	Baseline coverage	Source of intervention baseline coverage	Intervention coverage
Pregnancy	Multiple micronutrient supplementation in pregnancy	0%	Assumed based on Engle-Stone et al. (2017)	90%
Pregnancy	Calcium supplementation	0%	Assumed based on Engle-Stone et al. (2017)	90%
Pregnancy	Balanced energy supplementation	0%	Assumed based on Engle-Stone et al. (2017)	90%
Breastfeeding	Promotion of breastfeeding (Health System AND Home / Community)	36.7%	LiST proxy: % of those exclusively breastfeeding from EMMUS-VI	90%
Preventative	Complementary feeding – education only	29.3%	LiST proxy: Those living on less than $.190 per day sourced from EMMUS-VI	90%
Preventative	Complementary feeding – supplementation and education	29.3%	LiST proxy: Those living on less than $.190 per day sourced from EMMUS-VI	90%
Preventative	Vitamin A supplementation	30%	UNICEF Vitamin A coverage database	90%
Preventative	Zinc supplementation	0%	Assumed	90%
Curative	SAM treatment for severe acute malnutrition	80%	Vosti and Adams (2017)	90%

It is difficult to precisely identify coverage rates for the interventions in Haiti. Where possible, coverage rates have been inferred from existing studies and if these were unavailable, proxies applied by LiST have been used. Pregnancy-related interventions are from Engle-Stone et al. (2017) which supposes no coverage of the pregnancy interventions, assuming that instead, women are receiving only iron and folic acid tablets. Proxies embed in LiST have been applied for breastfeeding promotion, complementary feeding - education and complementary feeding – education and supplementation. Vitamin A supplementation is from UNICEF Vitamin A coverage database and is also a LiST default. Lastly, severe acute malnutrition treatment coverage is assumed to be 80%, following Vosti and Adams (2018).

The following provides a short overview of some of the modeled effects and latest evidence behind the interventions, though interested readers should consult the 2017 *Journal of Nutrition* supplement on nutrition modeling in LiST for more detailed assessments of the evidence including limitations (Walker and Clermont, 2017) as well as the LiST visualizer tool.[4]

The three pregnancy-related interventions directly impact maternal mortality, maternal anemia, and birth outcomes, with flow-on effects to other nutrition-related outcomes and child mortality. Calcium supplementation is the only intervention that affects maternal mortality directly, resulting in avoided pre-eclampsia and a 20% lower mortality risk for food-insecure mothers (Ronsmans and Campbell, 2011). The intervention also reduces preterm births by 12% (Imdad, Jabeen and Bhutta, 2011). Multiple micronutrient (MMN) supplementation is assumed to be as effective as iron supplementation, lowering maternal anemia by 67% (Pena-Rosas et al., 2015). MMN supplementation also reduces the risk of preterm birth by 6% or 16% depending on the mother's body mass index (BMI) at birth, and the risk of SGA birth by 3% for women with a BMI greater than 18.5 (Smith et al., 2017). The provision of balanced energy protein to food-insecure pregnant women leads to a 21% reduction in SGA (Ota et al., 2015).

Three interventions have a direct impact on stunting with effect sizes dependent on the food security status of the beneficiary household. Relative to food-secure households exposed to complementary feeding promotion, the odds of stunting are 1.3 times higher for food-secure populations without promotion, 1.74 times higher for food-insecure households with promotion and supplementation, and 1.95 times higher for food-insecure populations without any intervention (Panjawi and Heidkamp, 2017). Zinc supplementation leads to a 10% reduction in the odds of stunting (Bhutta et al., 2013), while also reducing mortality from pneumonia and diarrhea for zinc-deficient populations

[4] The LiST visualizer tool can be accessed at http://listvisualizer.org/

(Yakoob et al., 2013). Reductions in stunting are translated to reductions in disease-specific child mortality using relative risks from Olofin et al. (2013).

The remaining interventions affect child mortality and morbidity. Vitamin A supplementation reduces diarrhea-related mortality by 53% and the incidence of diarrhea by 38% for vitamin A deficient children (Imdad et al., 2011). Promotion of breastfeeding leads to an increase in early, exclusive and extended breastfeeding, with effect sizes dependent on the location of promotion (Sinha et al., 2017). Late initiation of breastfeeding increases infectious mortality risk of neonates by 35% relative to early-initiation of breastfeeding (NEOVITA, 2016). No breastfeeding during the first month increases the risk of neonatal mortality by 5.4 times relative to exclusive breastfeeding (LiST, 2017). For children 1-5 months, partial breastfeeding increases risk of mortality by 2.8 – 4.7 times depending on the cause, relative to exclusive breastfeeding, while for children 6–23 months, no breastfeeding increases the risk of mortality by 1.5 to 3.7 times relative to extended breastfeeding (Lamberti et al., 2011, 2013; LiST, 2017). Treatment for SAM increases recovery rate from wasting by 78%, while being wasted leads to an increase in cause-specific mortality risk between 1 and 12 times depending on the severity of wasting (Olofin et al., 2013).

4. Nutrition and health impacts from the intervention package

The time period chosen for analysis is 2016 to 2025. The year 2016 corresponds to the most recent year for which GNI per capita data is available from the World Bank database (World Bank, 2018). The end-point corresponds to the final year of the WHA Global Nutrition Targets. Each year, the intervention will cover 90% of all pregnant women and 0-2 year-old children. The average number of births over the ten years is 260,000 according to DemProject, a population projection package that comes with LiST.

The intervention package leads to a wide array of improved nutrition outcomes. The intervention reduces the prevalence of stunting by 20.3%, the same effect size as documented for 34 countries in Bhutta et al (2013). It takes four years for the full effects to materialize; but by 2020, the intervention package avoids 54,000 cases of stunting ever year. This would reduce the prevalence of stunting from 21.9% to 17.5%, approximately halfway to meeting WHA Global Nutrition Target 1.

Additionally, 28,000 cases of maternal anemia would be avoided per year due to multiple micronutrient supplementation. This would reduce the prevalence of maternal anemia by 23%. Given the focus of the intervention on pregnant women, it does not have a significant impact on WHA Target 2, which covers all women of reproductive age.

The intervention would improve birth outcomes significantly. LiST estimates that LBW would fall from 17.9% to 14.9%, a reduction of 16%. This corresponds to roughly 7,600 LBWs avoided per year and represents a halfway movement towards WHA Nutrition Target 3. Rates of exclusive breastfeeding due to promotion in health system, homes and communities would increase from 41.9% to 62.3%, enabling Haiti to fully meet WHA Nutrition Target 4.

Due to direct and indirect mechanisms, LiST predicts that the package of interventions would avoid, on average, 1,217 child deaths, 577 neonatal deaths and 82 maternal deaths for a total of 1,876 lives saved per year. For children, almost 90% of the deaths avoided are from diarrheal and respiratory causes. The package would reduce child mortality rate by 10% to 61 per 1,000, neonatal mortality rate by 9% to 23 per 1,000 and maternal mortality rate by 9% to 328 per 100,000 live births. Results are summarized below in Table 4.

Table 4. Average annual number of child, neonatal and maternal deaths avoided due to intervention

Causes	**Neonatal deaths avoided (<1 month)**	**Child deaths avoided (1-59 months)**	**Maternal deaths avoided**	**Total**
Pneumonia	55 (95% CI: 12, 94)	645 (95% CI: 58,	-	700 (95% CI: 70,

		1270)		1364)
Diarrhea	2 (95% CI: 1, 3)	416 (95% CI: 123, 663)	-	417 (95% CI: 70, 1364)
Prematurity	184 (95% CI: 25, 326)	-	-	184 (95% CI: 25, 326)
Asphyxia	177 (95% CI: 29, 315)	-	-	177 (95% CI: 29, 315)
Sepsis	159 (95% CI: 35, 268)	-	-	159 (95% CI: 35, 268)
Other causes	-	157 (95% CI: 73, 384)	82 (95% CI: 25, 124)	239 (95% CI: 98, 508)
All	577 (95% CI: 101, 1005)	1217 (95% CI: 254, 2317)	82 (95% CI: 25, 124)	1876 (95% CI: 335, 3322)

LiST is also able to predict avoided cases of child illness from the intervention package across diseases such as diarrhea, pneumonia and meningitis. The vast majority (99%) of illness avoided is from diarrhea, with the interventions preventing 893,000 cases annually. Due to the frequent nature of diarrhea cases in Haitian infants, each child covered by the intervention is likely to avoid 0.75 cases of diarrhea on average per year.

5. Benefit-cost analysis

5.1 Common assumptions – Discount rates and assumed growth

This paper uses discount rates of 3%, 5% and 12%. Three percent is used following recommendations of the iDSI reference case (Wilkinson et al., 2016) and also since it is a common value adopted in health economics papers. Five percent is used since it is also common, and used in other benefit-cost analyses of this intervention (Hoddinott et al. 2013, Horton and Hoddinott, 2014). The use of a 12% discount rate is based on the advice of a counsel of senior Haitian economists who suggested this value as an appropriate social discount rate for the country. This counsel had gathered for the *Haiti Priorise*[5] exercise conducted by the Copenhagen Consensus Center.

Estimating the value of future health and productivity benefits requires projecting future GNI per capita. Haiti is infamous for having extremely poor per capita output growth throughout the last century, with periods of significant real output decline (Khan, 2010). In PPP terms, per capita GNI grew only 0.6% p.a. over the period 1970 to 2015 (Penn World Tables - Feenstra et al. 2015) and this figure is applied as the projected annual per-capita growth rate over the life of the intervention.

5.2 Costs

In previous analyses, the cost of this intervention for a range of developing countries has been estimated at around $100 per child for a two-year program in 2010 Int$ (Bhutta et al., 2013; Hoddinott et al., 2013; Horton and Hoddinott, 2014). Several factors such as poor infrastructure, a fragmented health landscape consisting of private, public and NGO facilities working in isolation and limited government administrative capacity, mean that costs are likely to be higher for Haiti.

Studies in the *Haiti Priorise* series are used to calibrate costs of this package. Engle-Stone et al. (2017) perform a benefit-cost analysis of micronutrient provision to pregnant women and find a cost of HTG 2660 to deliver micronutrients *and* calcium

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[5] *Haiti Priorise* was a research and advocacy project conducted by the *Copenhagen Consensus* over the period 2015 to 2017. The project commissioned 42 cost-benefit analyses papers across 18 topic areas covering key Haitian policy questions. For more information see www.haitipriorise.com

supplementation. That paper also identifies a cost of HTG 320 per child provided with multiple micronutrients, including Vitamin A. Costs in that paper were estimated using an 'ingredients approach': identifying and modeling the individual components – transport, packaging, storage, supplements, health workers to deliver the interventions at scale – and verifying costs with organizations working 'on-the-ground' in Haiti. This paper uses these costs for the elements in the intervention package that are the same.

There are no Haiti-specific costs for other parts of the package, so I use these two unit cost figures as reference points with which to estimate the full intervention cost in the Haitian context. The approach for the rest of the package is to assume that the costs of the unknown components are *proportionally* the same with respect to the known components as they were originally presented in Bhutta et al.[6] The HTG 2660 cost to deliver micronutrients and calcium supplementation in pregnancy is the reference point for the interventions delivered to mothers, and the cost of HTG 320 to deliver multiple micronutrients is the reference point for interventions targeted at children.

For example, in Bhutta et al (2013), the unit cost of breastfeeding promotion is 57% the cost of delivering micronutrients and calcium supplementation. Therefore, knowing that micronutrients and calcium cost HTG 2660 per mother, the cost of breastfeeding promotion is calculated as 57% * 2660 HTG = HTG 1521 per pregnant woman. The same approach is applied to components directed at *children* using the HTG 320 for micronutrient supplementation as the reference unit cost for Vitamin A supplementation.

Finally, community management of severe acute malnutrition (SAM) and salt iodization represent unique cases that need to be considered differently. Since management of SAM is a treatment as opposed to a preventative intervention, costs are adjusted as per Hoddinott et al. (2013) by multiplying the cost of SAM treatment by twice the prevalence rate in Haiti. Another *Haiti Priorise* paper, Vosti and Adams (2017), estimates a cost of treatment for SAM at HTG 6334 per wasted child and this is multiplied by twice the prevalence rate for a unit cost of HTG 165. In effect, this amortizes the high unit cost of SAM treatment over a wider universe of children who will receive the preventative

[6] For the purposes of this exercise, I take Bhutta et al.'s AFRO D region costs to be the relevant comparator for Haiti, which are presented in the appendix of that paper on page 31.

regime. Salt iodization is assumed to cost HTG 2 per child treated. This is the unit cost identified in Hoddinott et al. 2013, adjusted for inflation and converted to gourdes at market rates.

The estimated unit costs for the intervention components are presented in Table 5. The total cost of the package is HTG 13,857 per child, or USD 219. To reach scale, this intervention would require an additional HTG 2.6bn or USD 41m in the first year, 2016. In subsequent years, I assume that half the costs of the package are attributable to labor which increase at the same rate as GNI per capita growth rate.

Table 5. Estimated costs per child and costs to scale up to 90% coverage in the first year

Intervention	Estimated unit cost for Haiti, 2016 (in HTG and USD)	Estimated annual costs to scale to 90% (in HTG and USD)	Basis for unit cost estimation
Salt iodization	HTG 2.00 USD 0.03	HTG 0.5m USD 0.01m	Following Hoddinott et al, 2013 adjusted for inflation
Multiple micronutrient supplementation in pregnancy, including iron folate	HTG 2660 USD 42.00	HTG 620m USD 9.8m	Estimated in Engle Stone et al. (2017)
Calcium supplementation in pregnancy	Incl. in above	Incl. in above	Estimated in Engle Stone et al. (2017)
Energy protein supplementation in pregnancy	HTG 2,656 USD 41.93	HTG 619m USD 9.8m	Proportional increase based on 2660 HTG to deliver MMN and Ca to pregnant women in Haiti
Vitamin A supplementation in childhood	HTG 320 USD 5.05	HTG 50m USD 0.8m	Estimated in Engle Stone et al. (2017)
Zinc supplementation in childhood	HTG 596 USD 9.47	HTG 155m USD 2.4m	Proportional increase based on HTG 320 to deliver Vitamin A to children in Haiti
Breastfeeding promotion	HTG 1,521 USD 24.02	HTG 210m USD 3.3m	Proportional increase based on HTG 2660 to deliver MMN and Ca to pregnant women in Haiti

Complementary feeding education	HTG 560 USD 8.84	HTG 88m USD 1.4m	Proportional increase based on HTG 2660 to deliver MMN and Ca to pregnant women in Haiti
Complementary food supplementation	HTG 5,312 USD 83.86	HTG 835m USD 13.2m	Proportional increase based on HTG 2660 to deliver MMN and Ca to pregnant women in Haiti
SAM Management	HTG 165 USD 2.60	HTG 4.3m USD 0.07m	HTG 6344 per child treated estimated in Vosti and Adams (2017) multiplied by twice prevalence rate as per Hoddinott et al, 2013
TOTAL	HTG 13,857 USD 219	HTG 2,582m USD 40.8m	

5.3 Benefits from avoided mortality

Section 4 indicates that the intervention package saves 1,876 lives per year. Mortality benefits are valued using the approaches suggested by the methods paper (Robinson Hammitt and O'Keffe 2018). These are:

i) Context-specific VSL - apply a context-specific VSL to all lives saved. This value should be derived from a criteria-driven literature review of high-quality studies appropriate to the characteristics of the risks and the population under consideration

ii) Benefit-transfer VSL: apply a VSL, transferred from high-income countries with appropriate adjustments for income elasticity, to all lives saved.

iii) Benefit-transfer VSLY: estimate a value for each year of life saved, by dividing the VSLs from above by the average age of an adult[7] in the target population.

Context-specific VSL: To the best of my knowledge, there are no stated or revealed preference studies conducted in Haiti that would elucidate the willingness to pay for a reduction in mortality risk for diarrhea, lower respiratory infection or any other disease. The review by Robinson, Hammitt and O'Keeffe (2018) also did not identify any Haiti-specific literature.

[7] Adult is defined as an individual 20 years or older

Benefit-transfer VSL: The methods paper suggests three approaches to assigning a value of mortality avoided:

- Central estimate: 100x GNI per capita PPP
- High estimate: 160x GNI per capita PPP
- Low estimate: Transferring USD 9.4m (2015 US dollars) to Haiti using income elasticity of 1.5. This corresponds to a multiplier of 28x GNI per capita PPP.

These correspond to a Haitian VSL of HTG 4.5m (USD 71,000), HTG 7.2m (USD 113,000), and HTG 1.3m (USD 20,000), respectively. These VSL values are multiplied by the lives saved by the intervention to estimate the monetary value of the benefit.

Benefit-transfer Value of Statistical Life Year (VSLY): The methods paper suggests that when dealing with very young or very old individuals, an approach which values avoided YLLs should be considered. A constant VSLY is calculated by dividing the VSL from the approaches above by the average age of a Haitian adult (39 years). The VSLY values are therefore HTG 114,000 (USD 1800), HTG 182,000 (USD 2900) and HTG 32,000 (USD 500) derived from the central, high and low VSLs respectively. According to Haiti life tables, an avoided child death at age two yields 66 avoided YLLs, and an avoided maternal death at age 27 yields 46 avoided YLLs. These YLLs are multiplied by deaths avoided and the relevant VSLY to estimate mortality benefits.

The results of each of these approaches to valuation are presented in Table 6.

Table 6. Annual value of benefit accrued from avoided mortality

Benefit transfer (VSL Approach)			
Discount rate	**Central: HTG 4.5m VSL**	**High: HTG 7.2m VSL**	**Low: HTG 1.3m VSL**
3%	HTG 8,629 USD 136	HTG 13,806 USD 218	HTG 2,449 USD 39
5%	HTG 8,624 USD 136	HTG 13,799 USD 218	HTG 2,448 USD 39
12%	HTG 8,608 USD 136	HTG 13,773 USD 217	HTG 2,443 USD 39
Benefit transfer (VSLY Approach)			
Discount rate	**Central: HTG 114k VSLY**	**High: HTG 182k VSLY**	**Low: HTG 32k VSLY**
3%	HTG 14,186 USD 224	HTG 22,698 USD 358	HTG 4,027 USD 64
5%	HTG 14,178 USD 224	HTG 22,686 USD 358	HTG 4,025 USD 64
12%	HTG 14,152 USD 223	HTG 22,643 USD 357	HTG 4,017 USD 63

Source: Estimates by the author. All values are in millions of HTG or millions of USD

The results from the table indicate that the choice of VSL multiplier which one uses to estimate a Haiti VSL has a large effect on the result. Moving from the central estimate of VSL to either high or low, changes benefits by approximately +/- 60%. Moving from a VSL-based to a VSLY-based approach also has a significant upward effect on the benefits calculation. Since children and mothers are younger than the average Haitian adult, the effect of using valuing YLLs by VSLY is to monetize lives saved at an additional 1.7x and 1.2x, respectively, above the existing VSL multipliers. At the extreme upper-end, this means children are effectively valued at almost 270x GNI per capita when applying VSLY derived from the high end VSL. The choice of discount rate has the least effect on the results.

5.4 Benefits from avoided morbidity

Benefits from avoided morbidity are valued using the approaches suggested in the methods paper (Robinson and Hammitt, 2018). These are:

i) Use willingness-to-pay (WTP) estimates identified by a criteria-driven literature review to estimate value of morbidity reduction plus avoided third-party costs not accounted for in the WTP estimate
ii) Value QALYs or DALYs using a valuation function and add third-party avoided costs
iii) Value QALYS or DALYs at constant VSLY and add third-party costs
iv) Approximate morbidity reductions by avoided cost of illness (individual and third party)

Out of these, I apply approaches (i) and (iii), noting that the appropriate valuation function is not available and that approach (iv) is inadequate in that it does not account for quality of life effects.

WTP Approach: I searched available literature for high-quality studies that estimate the WTP for avoiding diarrheal disease in developing countries. The focus on diarrhea is motivated by the fact that this makes up the vast majority of benefit gained from avoided morbidity. The only relevant study is Guh et al. (2008), in which the authors survey respondents from rural China to estimate the willingness to pay to avoid cases of shigellosis, a leading cause of diarrhea. Guh et al. report a variety of results across age and location. For the purposes of this case study, the focus is on the willingness to pay for avoiding diarrhea in children under 5, which was generated from the responses of caregivers. Results indicate a willingness to pay to avoid a case of diarrhea in children under 5 at Int$ 35.40 (2002 international dollars)[8] which is 1.6% of annual per capita income of respondents. This is transferred to the Haitian context using 2016 GNI per capita PPP and an income elasticity of 1.0 for a value of Int$ 29, HTG 715 or USD 11.30 per case of diarrhea.

[8] Guh et al. (2008), Table 4 reports WTP figures for 0-1 year olds and 2-5 year olds separately. Therefore, it is theoretically possible to assign different valuations for these different age groups. However, given the small sample size of the 0-1 year olds (12), we combine them to form one WTP for avoiding diarrhea in children under 5 generally.

Monetized DALY + third-party costs approach: The methods paper suggests a sensitivity analysis where each YLD is valued at a constant VSLY + costs borne by third parties. The approach for estimating VSLY is discussed in the previous section with central, high and low values of HTG 114,000 (USD 1800), HTG 182,000 (USD 2900) and HTG 32,000 (USD 500) respectively. Each incidence of diarrhea leads to 0.0019 DALYs, according to Global Burden of Disease 2016. Three types of costs borne by third parties are calculated: i) outpatient costs ii) inpatient costs and iii) cost of caregiver time. In Haiti, there is a mix of private, NGO and public health care facilities, so some portion of costs are borne by external parties. The cost of caregiver time is included because estimates of VSL / VSLY are based on WTP to reduce risks to one's self, and not to others. The total value of the monetized DALY + third-party costs is $Int 18, HTG 456 and USD 7.2 per case of diarrhea.

The calculation of outpatient costs assumes:

- 38% of children with diarrhea are taken to health care facilities for treatment based on estimates of similar metric for lower respiratory infections (DHS 2012)
- Each outpatient visit in Haiti costs HTG 487 or USD 7.50 (McBain et al. 2017)
- 65% of all costs are borne by public or NGO health facilities (World Development indicators, World Bank 2016)

The calculation of inpatient costs assumes:

- 8.2% of patients who seek care are referred to a hospital facility (Hutton et al., 2007)
- Each outpatient visit in Haiti costs HTG 3900 or USD 60.00 (Sklar, 2017)
- 65% of all costs are borne by public or NGO health facilities (World Bank 2016)

The calculation of caregiver costs assumes:

- One adult is responsible for caregiving across the entire duration of the illness
- The average, unskilled rural wage is HTG 2600 per month
- Cost of time is approximated by 50% of rural wage as per the methods paper by Whittington and Cook (2018)

- The average duration of an episode of diarrhea is calculated at 6.0 days (GBD, 2016)

The results of the two valuation approaches are presented in Table 7.

Table 7. Annualized benefit from avoided morbidity per year

Discount rate	Benefit transfer from Guh et al. (2008)	Monetized DALY + third-party costs approach based on Central VSLY	Monetized DALY + third-party costs approach based on High VSLY	Monetized DALY + third-party costs approach based on Low VSLY
3%	HTG 655 USD 10	HTG 416 USD 7	HTG 533 USD 8	HTG 275 USD 4
5%	HTG 655 USD 10	HTG 416 USD 7	HTG 533 USD 8	HTG 275 USD 4
12%	HTG 655 USD 10	HTG 416 USD 7	HTG 533 USD 8	HTG 275 USD 4

Source: Estimates by the author. All values are in millions of HTG or millions of USD

The results indicate that across all approaches, the estimates of avoided morbidity benefit are relatively consistent with a range of HTG 275m to HTG 655m per year, with results from the method's paper preferred method (benefit transfer) at the upper end of this range.

5.5. Lifetime productivity benefits

The results of Section 4 indicate that there is a 20.3% reduction in stunting from the intervention, avoiding 54,000 cases of stunting per year at steady state. It is typical to assess the long-term benefits of stunting as an increase in lifetime productivity (Hoddinott et al. 2013; Horton and Hoddinott, 2014). Monetizing lifetime productivity benefits has been well-explored in the literature on returns to education (Psacharopolous 1973; Psacharopolous and Patrinos, 2010). The typical approach has been to calculate age-earnings profiles (i.e. how much individuals earn at particular ages) for each level of education, and to compare differences between these profiles to assess the benefit of jumps between education levels or increases in years of education attained. This approach has typically focused on formal wages, without accounting for non-wage benefits, unemployment, income growth, mortality and benefits outside of education.

Given that VSL includes the effects of mortality risk reductions on future earnings, it is important to assess the possibility that lifetime productivity benefits are ‘double-counted’ with the health benefits identified previously. From a theoretical perspective, one could argue that valuation of avoided mortality and morbidity does not include the productivity benefits from avoided stunting. This is because valuation of mortality should only account for ‘baseline’ productivity, and embedded in that baseline is average stunting risk. As such, productivity gains above baseline are incremental to valuations implied by avoided mortality and morbidity and there is no double-counting.

Nevertheless, because 54,000 children avoid stunting, while ‘only’ 1,800 children avoid death each year, potentially 3% of the productivity benefits could be double-counted with mortality benefits. It is certainly less than that, since health benefits are obtained from multiple pathways only one of which is avoided stunting. The percentage of under-5 mortality reduction attributable to interventions that directly avoid stunting – zinc supplementation, complementary feeding supplementation and promotion – is 25% according to LiST output. This suggests that perhaps 3% * 25% = 1% of lifetime productivity benefits overlap with mortality avoided benefits. Including this dampening effect, unsurprisingly, does not change the results materially and is not reported.

Due to the long period of time that must elapse between provision of nutrition in childhood and identifying effects in adulthood, only a handful of studies have been able to robustly estimate the long-term consequences of not being stunted on schooling and lifetime productivity (see McGovern et al., 2017 for a recent, thorough review of the evidence). The seminal studies in this genre are by Hoddinott et al. (2008) and Hoddinott et al. (2011). Both studies concern a group of Guatemalan children who were provided with protein supplementation (*atole*) in 1969-1977 and were tracked down and identified in 2002-2004. Compared to a control group that were provided with no protein (*fresco*), the treatment cohort had 25 percentage points (45% versus 20%) lower prevalence of *severe* stunting. The 2008 study indicates that non-stunted men had 46% higher wages than stunted men, while there was no difference in wages for women. The 2011 study shows that men have 20% higher hourly earnings for each 1 S.D. increase in HAZ scores, while for women the increase is 7.2% but it is not statistically significant. The authors also estimate per capita *consumption* between treatment and control groups, noting that the benefit of linear growth in childhood might not show up in the labor market but in other ways, for example the marriage market. Those who were stunted as children had 66% lower per capita consumption 35 years later compared to their non-stunted peers.

The only other long-term follow-up study that can shed light on the effect of child stunting on adult wages is Gertler et al. (2015). In that study, a group of stunted Jamaican children were exposed to psycho-social stimulation, while a control group were not exposed to stimulation. In adulthood, the children in the treatment group had 25% higher wages than the control. Additionally, their wages were equivalent to a group of non-stunted children identified at baseline. The results of that study suggest that stunting in Jamaica – in the absence of an effective solution to address cognitive decline – was associated with a 25% decrease in wages.

Victora et al., (2008) summarize the available findings (at that time) from longitudinal cohort studies in Brazil (Victora et al, 2003), Guatemala (Martorell et al, 2005; Grajeda et al 2005) and India (Sachev et al. 2005; Bhargava et al, 2005) of childhood HAZ on future income and assets. They note that a 1-point HAZ increase at age two is associated with 8% higher wages in Brazil, 8-25% higher wages in Guatemala and 18-27% more assets in India at adulthood. McGovern et al. (2017) note that the median effect across a range studies that control for unobserved confounding and measurement error is that a 1 cm increase in height is associated with a 4% and 6% increase in wages for men and women, respectively.

Several studies have shown that reduction in stunting leads to higher education attainment, which is an indicator of future wages. Nandi et al. (2016) show that children in villages near the city of Hyderabad provided with a supplementary feeding program were 7.8% more likely to be enrolled in school and completed 0.84 more years of schooling 16 years later, compared to control villages. Victora et al (2008), using the aforementioned studies from Brazil, Guatemala and India, and also including cohort studies from Philippines and South Africa show that an increase in 1 S.D. HAZ at age two leads to 0.5 years of extra schooling. In the Haitian context, 0.5 to 0.84 years of schooling would correspond to 4-7% increase in wages, according to the latest wage data (ECVMAS, 2012).

There is ample evidence that stunting reduces lifetime schooling, earning capacity and consumption. However, while the direction of the effect is clear, the magnitude is not. Only two long-term studies are available and they suggest that avoiding stunting is responsible for a boost to wages of 46% in Guatemala and 25% in Jamaica. In lieu of better evidence, I apply the value of 35%, halfway between these two figures.

Key assumptions of the calculation:

- Avoiding stunting prevents a 35% per capita wage reduction in adulthood
- The intervention results in increased wages in adulthood beginning at age 16 until 60
- The average wage of a Haitian adult in 2016 is HTG 51,505 and is assumed to grow by 0.6% per year in real terms. The wage rate is calculated by the equation, wage = GNI per capita * labor force participation / labor share of income. GNI per capita is HTG 44,891 (World Bank, 2018), labor force participation rate is 43.5% and the labor share of income is assumed to be 50%.

The results of this calculation are presented below in Table 8.

Table 8. Annualized lifetime productivity benefit per year

Discount rate	Benefit, HTG and USD millions

3%	HTG 14,471 USD 228
5%	HTG 8,017 USD 127
12%	HTG 1,594 USD 25

Clearly the discount rate has a pronounced effect on lifetime productivity benefits. This is unsurprising given the long-lived nature of the benefits (up to 60 years after the intervention) and the fact the benefits of increased productivity only start 16 years after the intervention commences. Even moving from a 3% to 5% rate would almost halve the benefits. Choosing a 12% discount rate diminishes the benefits significantly and shifts the relative importance of the intervention firmly towards avoided mortality and morbidity.

5. Discussion and Conclusion

Table 9 summarizes the results of the previous sections using base case estimates. The base case includes avoided mortality benefits using a VSL of HTG 4.5m, morbidity effects using benefit transfer from Guh et al. (2008) and productivity benefits. The provision of the early child nutrition package is beneficial in the Haitian context.

If the intervention package can be scaled up to 90% of the target population, it will annually prevent about 40,000 cases of child stunting, 7,600 babies born with low birth weight and 28,000 cases of maternal anemia. These nutrition improvements will avoid 1,800 child deaths, 80 maternal deaths and 900,000 episodes of child illness every year. For those children who avoid being stunted, it will deliver productivity benefits equivalent to 4x GNI per capita in present value terms, at a 5% discount rate.

However, the costs of the intervention are not small at HTG 13,857 (USD 219) per child over two years. The marginal costs required to scale-up the package of interventions to 90% are HTG 2.6bn (USD 41m) per year. The benefit cost ratio is 6.6 at the 5% level. Other studies focusing on health, nutrition and education interventions in the *Haiti*

Priorise series suggest there are more effective ways to use of funds to build an improved human capital base in Haiti. For example, wheat flour fortification which has a BCR of 24 (Engle-Stone et al., 2017) and psychosocial stimulation with a BCR of 17 (Rabbani, 2017).

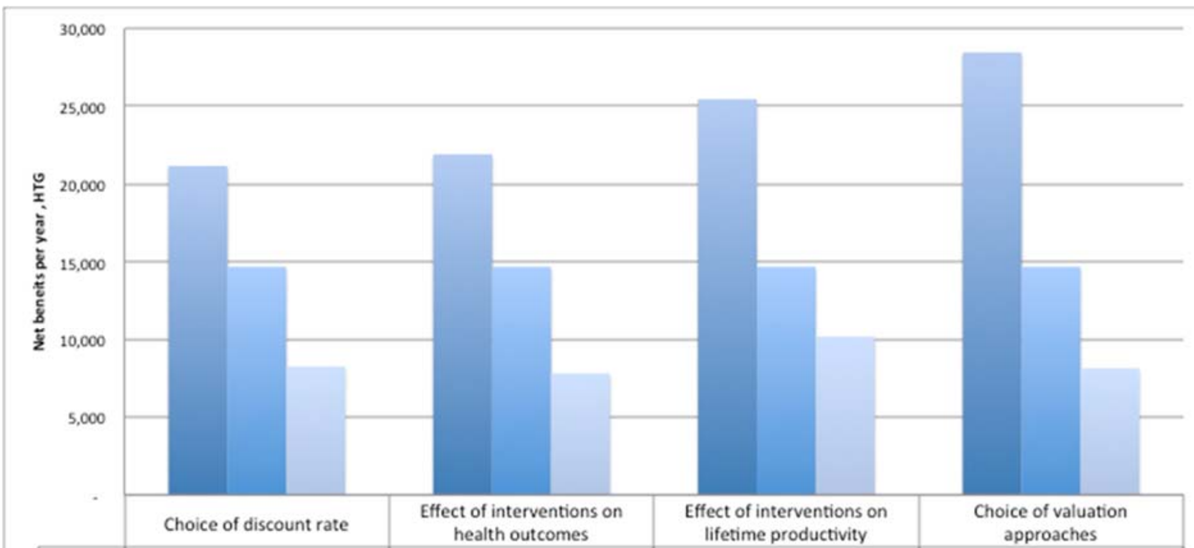
Table 9. Summary of costs and benefits of nutrition intervention – base case results

Discount	Annual benefit from mortality avoided (HTG millions)	Benefit from avoided morbidity per year (HTG millions)	Productivity benefit per year (HTG millions)	Benefit per year (HTG millions)	Cost per year (HTG millions)	Benefit to Cost Ratio	Net benefit per year (HTG millions)
3%	8,629	656	14,471	23,755	2,618	9.1	21,137
5%	8,624	655	8,017	17,296	2,618	6.6	14,678
12%	8,608	655	1,594	10,857	2,619	4.1	8,238

Considering distributional effects, the intervention will favor poorer sections of Haitian society since nutrition and health outcomes tend to be negatively correlated with wealth (IHE and ICF, 2016). Households in the lowest quintile of wealth are 3.5 times more likely to have stunted children, half as likely to have fully vaccinated children and 40%-50% less likely to seek health treatment for diarrhea, fever or respiratory infection. Only 48% of mothers in the lowest wealth quintile had 4 antenatal care visits and even less (13%) gave birth in a health facility. In comparison, the corresponding numbers for mothers in the richest quintile were 87% and 79%.

As demonstrated in the previous sections, the choice of valuation approaches can significantly alter the results. However, it is important to compare this source of variation with other forms of uncertainty to understand the relative importance of methods choices on policy implications. To assess this, I compare results from the base case scenario at 5% discount rate – i.e. where net benefits equal HTG 14,678m in Table 9 – with other sources of uncertainty. The first source of uncertainty is the discount rate, similar for many papers in economics, not just papers undertaking benefit-cost analysis. Second, I recalculate the results using the upper and lower ends of the 95% confidence intervals for the impact of the interventions on child and maternal mortality. This gives an assessment of the extent of uncertainty of the intervention package with respect to health impacts. Third, results are recalculated using the ends of the 95% confidence interval for the effect of the interventions on stunting[9], along with the low and high end of possible wage impacts on stunting[10]. This gives an assessment of the extent of uncertainty of the intervention package with respect to lifetime productivity. Lastly, I compare the various methodological combinations of health valuation approaches and present the combination of choices that maximize the benefits (high VSLY, use of benefit transfer for valuing mortality and morbidity), against the choices that minimize the benefits (low VSL, monetized DALY approach for morbidity). The results of these tests are presented in Figure A below.

Figure A. Effect of uncertainty on net benefits



	Choice of discount rate	Effect of interventions on health outcomes	Effect of interventions on lifetime productivity	Choice of valuation approaches
High	21,137	21,892	25,432	28,451
Central	14,678	14,678	14,678	14,678
Low	8,238	7,793	10,154	8,122

The results indicate that choice of valuation approach create somewhat greater variation in the net benefit estimates than other sources of uncertainty. The high-to-low range resulting from various discounting choices is 87% of the central value. The

[9] These effect sizes are 11.7% reduction in stunting at the low end, and a 30.7% reduction in stunting at the high end.

[10] These effect sizes are 25% boost to life time wages as suggested by Gertler et al. (2015), and 66% boost to lifetime consumption as suggested by Hoddinott et al 2011, and used in former BCAs such as Horton and Hoddinott (2014).

inherent uncertainty in the intervention's effect on health outcomes is 108% of the central value. The uncertainty in the effects of the intervention on lifetime productivity is 93% of the central value. The choice of valuation methods generates more variation in results with a high-to-low range of 158% of the central estimate. Closer inspection reveals that there is more variation at the upper end of the net benefits estimate, driven by the methodological approach that effectively values children at 270x GNI per capita (see Section 5.3).

It is important to understand the implications of these sources of uncertainty for policy makers seeking to use benefit-cost analysis to improve their allocation decisions. If the results of an analysis provide BCRs for two interventions of say, 4 against 8 or 2 against 0.9, one might still rationally choose the higher BCR policy. However, there is sufficient uncertainty in how to monetize impacts in a benefit-cost framework, not to mention the underlying effects of interventions themselves and their transferability to other contexts, which warrants caution in asserting the conclusion too confidently. Discouragingly, a survey of high-quality impact evaluations in development indicates that the range of impacts *for the same intervention* across different contexts is approximately +/- 100% (Vivalt, 2017).

However, benefit-cost analysis can be useful for identifying super-effective outliers – interventions with benefits to costs so large that effectiveness is likely to outweigh any concerns about uncertainty. There is considerable evidence that within any given policy space, outliers tend to be *one to three orders of magnitude* more effective than typical interventions and *two to four orders of magnitude* more effective than least effective interventions. Ord (2013), citing Jamison et al (2006) demonstrates that within global health the cost-effectiveness of all the interventions covered in Disease Control Priorities 2 span a range of four orders of magnitude from 0.02 to 300 DALYS per $1000, while the median value was 5. In a review of primary school interventions to improve learning outcomes in the developing world, McEwan (2015) shows that the cost to improve test scores by 0.2 standard deviations has a range of less than $1 to more than $1000 across 76 experiments. Subbiah et al. (2008) investigating benefit-cost ratios for disaster early warning systems in nine developing countries, note a range between 0.9 and 500.

Several research projects conducted by Copenhagen Consensus Center consistently demonstrate similar distributions of intervention effectiveness in a multi-sectorial setting. In *Post-2015 Consensus*, where benefit-cost analysis was conducted on proposed targets in the Post-2015 development agenda, the BCRs for the highest, lowest and median target were ~2000, 0.3, 10 at a 5% discount rate (Copenhagen Consensus Center, 2015). In a project focusing on interventions in Bangladesh the equivalent values were 663, 0.4 and 4 (Copenhagen Consensus Center, 2016).

Encouragingly, the search for super-effective outliers, as opposed to making incremental improvements in existing interventions, is potentially the optimal strategy for a utility maximizing policy maker using benefit-cost analysis to inform her decisions. If the typical intervention in her portfolio has say, a benefit-cost ratio of 5 and the most effective intervention possible is 500, doubling the efficiency of 99% of the funds under her control (an extremely difficult endeavor even under perfect certainty) would deliver as much social welfare as directing 1% of her funds to the most effective intervention available.

For the Guidelines for BCA project, the implication of the above is that even though the methods papers show what one might consider large variation in recommendations, this is unlikely to matter to policy makers seeking to maximize social welfare who use BCA to identify outliers of effectiveness. It would be worthwhile to formally test this hypothesis; for example, by taking a large sample of benefit-cost analyses and examining how changes in methods change policy implications in a multi-sectorial setting. This could be an avenue for future research.

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