AN INVESTMENT FRAMEWORK FOR NUTRITION IN ZAMBIA: REDUCING STUNTING AND OTHER FORMS OF CHILD MALNUTRITION

DISCUSSION PAPER

NOVEMBER 2016

Julia Dayton Eberwein
Jakub Kakietek
Meera Shekar
Ali Subandoro
Audrey Pereira
Zia Hyder
Rosemary Sunkutu

WORLD BANK GROUP
Health, Nutrition & Population

AN INVESTMENT FRAMEWORK FOR NUTRITION IN ZAMBIA:

Reducing Stunting and Other Forms of Child Malnutrition

Julia Dayton Eberwein, Jakub Kakietek, Meera Shekar, Ali Subandoro, Audrey Pereira, Zia Hyder, Rosemary Sunkutu and Jonathan Kweku Akuoku

November 2016

Health, Nutrition and Population (HNP) Discussion Paper

For information regarding the HNP Discussion Paper Series, please contact the Editor, Martin Lutalo at mlutalo@worldbank.org or Erika Yanick at Eyanick@worldbank.org.

RIGHTS AND PERMISSIONS

Health, Nutrition and Population (HNP) Discussion Paper

An Investment Framework for Nutrition in Zambia:
Reducing Stunting and Other Forms of Malnutrition

Julia Dayton Eberwein, Jakub Kakietek, Meera Shekar, Ali Subandoro, Audrey Pereira, Zia Hyder, Rosemary Sunkutu, and Jonathan Kweku Akuoku

Health, Nutrition and Population Global Practice, World Bank, Washington, DC, USA

The authors are grateful for the support from the Bill & Melinda Gates Foundation

Abstract: This paper builds on global experience and Zambia's specific context to identify an effective nutrition approach along with costs and benefits of key nutrition interventions. It is intended to help guide the selection of the most cost-effective interventions as well as strategies for scaling these up. The paper considers both relevant "nutrition-specific" interventions, largely delivered through the health sector, and multisectoral "nutrition-sensitive" interventions, delivered through other sectors such as agriculture, education, and water and sanitation. We estimate that the costs and benefits of implementing 10 nutrition-specific interventions would require an annual public investment of $40.5 million and would avert over 112,000 DALYs, save over 2,800 lives, and prevent 62,000 cases of stunting. Economic productivity could potentially increase by $915 million annually over the productive lives of the beneficiaries, with an impressive internal rate of return of 32 percent. However, because it is unlikely that the Government of the Zambia or its partners will find the $40.5 million necessary each year to reach full coverage, we also consider scale-up scenarios based on considerations of their potential for impact, burden of stunting, resource requirements, and implementation capacity. The two scenarios that scale up the nine most cost-effective nutrition-specific interventions (excluding the public provision of complementary foods) are the most advantageous in terms of cost-effectiveness and resource requirements and would require $11 million to scale up to partial levels and $23 to scale up to full-coverage levels. Among the 8 nutrition-specific interventions we consider, school-based deworming is low cost and effective. The interventions we reviewed in the agriculture sector are expensive when compared to nutrition-specific interventions, although very little cost-effectiveness data are available for the nutrition-sensitive interventions to make careful comparisons. These findings point to a powerful set of nutrition-specific interventions and a candidate list of nutrition-sensitive approaches that represent a highly cost-effective approach to reducing child malnutrition in Zambia.

Keywords: nutrition-specific interventions, nutrition-sensitive interventions, cost-effectiveness of nutrition interventions, Zambia, nutrition financing.

Correspondence Details: Meera Shekar, World Bank, 1818 H Street NW, Washington DC, 20433 USA; Tel: 202-473-6029; mshekar@worldbank.org

TABLE OF CONTENTS

ACKNOWLEDGMENTS

This analytical work was carried out at the request of the Zambia National Food and Nutrition Commission (NFNC) and is the result of collaboration with many partners. We are grateful to Secretary to the Cabinet, Dr. Rowland Msiska and his team and to Dr. Peter Mwaba, Permanent Secretary MOH and his team for support and valued guidance. The Executive Director and other officials of the NFNC provided overall coordination support, communicating with various sectors including MOH, MOA, MOE, for accessing necessary information. Sincere thanks are extended to Nutrition Cooperating Partners including DfID, WHO, UNICEF, USAID, Sida, EU, CDC. CHAI, Concern Worldwide for providing technical and other inputs.

The Bill & Melinda Gates Foundation (BMGF) was also a strong partner with the World Bank in advancing this work, and provided financial support. Ellen Piwoz from the BMGF provided valuable technical inputs.

Sophie Naudeau and Jamele Rigolini gave useful comments during the peer review process.

Finally, the team is grateful to Musonda Rosemary Sunkutu, Sr HNP Specialist, World Bank, for continued guidance and coordination support, and Charity Inonge Mbangweta, Project Assistant for providing logistical support. Trina Haque, HNP Practice Manager, Health, Nutrition and Population Global Practice, World Bank, also provided guidance and support. The authors are grateful for the skilled editing provided by Hope Steele.

The authors are grateful to the World Bank for publishing this report as an HNP Discussion Paper.

ABBREVIATIONS AND ACRONYMS

BMGF	Bill & Melinda Gates Foundation
BMI	body mass index
CCT	Conditional cash transfers
CHW	community health worker
CIDA	Canadian International Development Agency
DALYs	disability-adjusted life years
DFID	Department for International Development
DHS	Demographic and Health Survey
EDF	European Development Fund
EU	European Union
FAO	United Nations Food and Agriculture Organization
GAFSP	Global Agriculture and Food Security Programme
GBD	global burden of disease
GDP	gross domestic product
GHE	Global Health Estimates
HIV	human immunodeficiency virus
IHME	Institute for Health Metrics and Evaluation
IITA	International Institute of Tropical Agriculture
LiST	Lives Saved Tool
LBW	low body weight
M&E	monitoring and evaluation
MCDMCH	Ministry of Community Development, Mother and Child Health
MCDP	First 1000 Most Critical Days Programme
MOH	Ministry of Health
NFNC	National Food and Nutrition Commission
NFNSP	National Food and Nutrition Strategic Plan
NIH	National Institutes of Health
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
ORS	oral rehydration solution
PAF	population attributable fractions
REACH	Renewed Efforts Against Child Hunger and Malnutrition
STH	soil-transmitted helminth
SUN	Scaling Up Nutrition
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children’s Fund
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WAZ	weight-for-age Z-score
WDI	World Development Indicators
WFP	World Food Programme
WHZ	weight-for-height Z-score
WHO	World Health Organization
WHO-CHOICE	Choosing Interventions that are Cost-Effective
YLD	years of life spent with disability (from a disease)
YLL	years of life lost (from a disease)

All dollar amounts are U.S. dollars.

GLOSSARY OF TECHNICAL TERMS

Aflatoxins are a group of toxic compounds produced by certain molds, especially *Aspergillus flavus*, which contaminate stored food supplies such as animal feed, maize, and peanuts. Research shows that human consumption of high levels of aflatoxins can lead to liver cirrhosis (Kuniholm et al. 2008) and liver cancer in adults (Abt Associates 2014). It is widely understood that there is a relationship between aflatoxin exposure and child stunting, but this relationship has not yet been adequately quantified in the published literature (Unnevehr and Grace 2013; Abt Associates 2014).

A **benefit-cost ratio** summarizes the overall value of a project or proposal. It is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms. The benefit-cost ratio takes into account the amount of monetary gain realized by implementing a project versus the amount it costs to execute the project. The higher the ratio, the better the investment. A general rule is that if the benefit from a project is greater than its cost, the project is a good investment.

Biocontrol (also called *biological control*) is the use of an invasive agent to reduce pest or mold population below a desired level. Aflatoxins can be reduced through biocontrol; the most effective method involves a single application of a product (such as aflasafe™) that contains strains unique to the specific country or location.

Biofortification is the breeding of crops to increase their nutritional value. This can be done either through conventional selective breeding or through genetic engineering.

Capacity development for program delivery is a process that involves increasing in-country human capacity and systems to design, deliver, manage, and evaluate large-scale interventions (World Bank 2010). This includes developing skills by training public health personnel and community volunteers to improve the delivery of services. These efforts typically accompany program implementation or, when possible, precede program implementation. In this costing analysis we allocate 9 percent of total programmatic costs to capacity development for program delivery.

Cost-benefit analysis is an approach to economic analysis that weighs the cost of an intervention against its benefits. The approach involves assigning a monetary value to the benefits of an intervention and estimating the expected present value of the net benefits, known as the *net present value*. Net benefits are the difference between the cost and monetary value of benefits of the intervention. The net present value is defined mathematically as:

$$Net\ present\ value = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

where C_t is net cash inflows, C_0 is the initial investment, the index t is the time period, and r is the discount rate. A positive net present value, when discounted at appropriate rates, indicates that the present value of cash inflows (benefits) exceeds the present value of cash outflows (cost of financing). Interventions with net present values that are at least as high as alternative interventions provide greater benefits than interventions with net present values equal to or lower than alternatives. The results of cost-benefit analysis can also be expressed in terms of the benefit-cost ratio.

Cost-effectiveness analysis is an approach to economic analysis that is intended to identify interventions that produce the desired results at the lowest cost. Cost-effectiveness analysis requires two components: the total cost of the intervention and an estimate of the intervention's impact, such as the number of lives saved. The cost-effectiveness ratio can be defined as:

$$Cost\text{-}effectiveness\,ratio = \frac{total\ cost\ of\ implementing\ the\ intervention}{impact\ of\ the\ intervention\ on\ a\ specific\ outcome}$$

The analysis involves comparing the cost-effectiveness ratios among alternative interventions with the same outcomes. The intervention with the lowest cost per benefit is considered to be the most cost-effective intervention among the alternatives.

A **DALY** is a **disability-adjusted life year**, which is equivalent to a year of healthy life lost due to a health condition. The DALY, developed in 1993 by the World Bank, combines the years of life lost from a disease (YLL) and the years of life spent with disability from the disease (YLD). DALYs count the gains from both mortality (how many more years of life lost due to premature death are prevented) and morbidity (how many years or parts of years of life lost due to disability are prevented). An advantage of the DALY is that it is a metric that is recognized and understood by external audiences such as the World Health Organization (WHO) and the National Institutes of Health (NIH). It helps to gauge the contribution of individual diseases relative to the overall burden of disease by geographic region or health area. Combined with cost data, DALYs allow for estimating and comparing the cost-effectiveness of scaling up nutrition interventions in different countries.

A **discount rate** refers to a rate of interest used to determine the current value of future cash flows. The concept of the time value of money suggests that income earned in the present is worth more than the same amount of income earned in the future because of its earning potential. A higher discount rate reflects higher losses to potential benefits from alternative investments in capital. A higher discount rate may also reflect a greater risk premium of the intervention.

The **internal rate of return** is the discount rate that produces a net present value of cash flows equal to zero. An intervention has a non-negative net present value when the internal rate of return equals or exceeds the appropriate discount rate. Interventions yielding higher internal rates of return than alternatives tend to be considered more desirable than the alternatives.

The **Lives Saved Tool (LiST)** is an estimation tool that translates measured coverage changes into estimates of mortality reduction and cases of childhood stunting averted. LiST is used to project how increasing intervention coverage would impact child and maternal survival. It is part of an integrated set of tools that comprise the Spectrum policy modeling system.

Monitoring and evaluation, operations research, and **technical support for program delivery** are all elements of cost-effective and efficient program implementation**. Monitoring** involves checking progress against plans through the systematic and routine collection of information from projects and programs in order to learn from experience to improve practices and activities in the future, to ensure internal and external accountability of the resources used and the results obtained, and to make informed decisions on the future of the intervention. Monitoring is a periodically recurring task. **Evaluation** is the assessing, as systematically and objectively as possible, of a completed project or intervention (or a phase of an ongoing project). **Operations research** aims to inform the program designers about ways to deliver interventions more effectively and efficiently. **Technical support** entails ensuring that training, support, and maintenance for the physical elements of the intervention are available. In this costing exercise, we allocate 2 percent of total intervention costs for monitoring and evaluation, operations research, and technical support.

Nutrition-sensitive interventions are those that have an indirect impact on nutrition and are delivered through sectors other than health such as the agriculture, education, and water, sanitation, and hygiene sectors. Examples include biofortification of food crops, conditional cash transfers, and water and sanitation infrastructure improvements.

Nutrition-specific interventions are those that address the immediate determinants of child nutrition, such as adequate food and nutrition intake, feeding and caregiving practices, and treating disease. Examples include community nutrition programs, micronutrient supplementation, and deworming.

Sensitivity analysis is a technique that evaluates the robustness of findings when key variables change. It helps to identify the variables with the greatest and least influence on the outcomes of the intervention, and it may involve adjusting the values of a variable to observe the impact of the variable on the outcome.

Stunting is an anthropometric measure of low height-for-age. It is an indicator of chronic undernutrition and is the result of prolonged food deprivation and/or disease or illness. It is measured in terms of Z-score (or standard deviation score; see definition below); a child is considered stunted with a height-for-age Z-score of −2 or lower.

Underweight is an anthropometric measure of low weight-for-age. It is used as a composite indicator to reflect both acute and chronic undernutrition, although it cannot distinguish between them. It is measured in terms of Z-score (or standard deviation score; see definition below); a child is considered underweight with a weight-for-age Z-score of −2 or lower.

Wasting is an anthropometric indicator of low weight-for-height. It is an indicator of acute undernutrition and the result of more recent food deprivation or illness. It is measured in terms of Z-score (or standard deviation score; see definition below). A child with a weight-for-height Z-score of −2 or lower is considered wasted.

A **Z-score** or **standard deviation score** is a calculation used to explain deviations from an established norm. It is calculated with the following formula:

$$Z\text{-}score = \frac{(observed\ value) - (median\ reference\ value)}{standard\ deviation\ of\ reference\ population}$$

EXECUTIVE SUMMARY

The overall objective of this paper is to provide technical assistance to the Government of Zambia in the implementation of its nutrition policy and programs. It provides the Government of Zambia with the tools needed to leverage adequate resources from domestic budgets, as well as from development partners in support of implementing the nutrition scale-up plan. The executive summary highlights the main findings and discusses the implications for nutrition policy in Zambia. The remainder of the report is more technical in nature and is written for a broader audience, including planners and programmers. The analysis is expected to bring to bear evidence of potential for impact and allocative efficiency into Zambia's nutrition programming.

The prevalence of chronic undernutrition, as measured by stunting in children under five, was 40 percent in 2013–14 and, although this represents a decline from 53 percent in 2001–02, it nevertheless represents a heavy burden of undernutrition in Zambia. Micronutrient deficiencies (*hidden hunger*) are also prevalent, with vitamin A deficiency and anemia rates particularly high. There is geographical disparity in stunting rates in the country; the highest rates are in the Northern region (almost 50 percent), followed by Muchinga, Eastern, Luapula, and Central provinces, which all had stunting rates above 40 percent in 2013–14.

Malnutrition, particularly in very young children, leads to increased mortality, increased illness, and longer-term adverse effects on cognitive abilities and schooling outcomes, thereby producing irreversible losses to human capital that contribute to later losses in economic productivity. Undernutrition is responsible for about one-half of under-five child mortality and one-fifth of maternal mortality in developing countries. In the longer term, stunting results in a 10 to 17 percent in loss in wages. Furthermore, Zambia loses over $186 million in GDP annually to vitamin and mineral deficiencies alone (World Bank 2013).

At the same time, nutrition interventions are consistently identified as among the most cost-effective development actions and the costs of scaling up nutrition interventions are modest. Cost-benefit analysis shows that nutrition interventions are highly effective (World Bank 2010, 2012; Hoddinott et al. 2013). It is estimated that investing in nutrition can increase a country's gross domestic product (GDP) by at least 3 percent annually (Horton and Steckel 2013). The global cost to scaling up key nutrition interventions is estimated at $10.3 billion per annum (World Bank 2010). These investments would provide preventive nutrition services to about 356 million children, save at least 1.1 million lives, avert 30 million disability-adjusted life years (DALYs), and reduce the number of stunted children by about 30 million worldwide.

The paper identifies costs and benefits of key nutrition programs in Zambia and is intended to help guide the prioritization of the most cost-effective interventions. The report uses the costing framework established by *Scaling Up Nutrition: What Will It Cost?* (World Bank 2010) and applies it to the specific context of Zambia. Combining costing with estimates of impact (in terms of lives saved, DALYs averted, and cases of stunting averted) and cost-effectiveness analysis, the results will aid in priority setting by identifying the most cost-effective packages of interventions in situations where financial and human resources are constrained.

We first estimate costs and benefits of implementing 10 high-impact nutrition-specific interventions in Zambia**.** We refer to this as the "full coverage" scenario and estimate that it would require an annual public investment of $40.5 million. The expected benefits are huge: over 112,000 DALYs and 2,800 lives would be averted and saved respectively annually, while nearly 62,000 cases of stunting among children under five would be averted annually (see Box 1 for a summary of key findings).

Given resource constraints, few countries are able to effectively scale-up all ten nutrition-specific interventions to full national coverage immediately. We therefore consider four potential scale-up scenarios for Zambia, based on considerations of burden of stunting, potential for impact, costs, and capacity for implementation.

- **Scenario 1**: Scale up by region
- **Scenario 2**: Scale up by intervention
- **Scenario 3**: Scale up by region and intervention
- **Scenario 4**: Scale up by varying program coverage

The two scenarios that scale up the nine most cost-effective interventions (excluded is the public provision of complementary foods) are the most advantageous when considered in terms of cost-effectiveness and resource requirements (see Box 1). One scenario (Scenario 4b) would scale up all nine interventions nationwide to partial coverage levels and would require $11.2 million in public resources annually. This scenario is the most cost-effective, with a cost per DALY averted of $166. The second most cost-effective scenario (Scenario 2) would scale up the same interventions to full coverage levels and would require an annual investment of $23.7 in public resources. Although not quite as cost-effective as Scenario 4b, Scenario 2 would reach more beneficiaries and therefore reduce more malnutrition. The choice between the two scenarios will likely depend on the level of resources that can be leveraged for nutrition.

Box 1: Key Findings

The full scale-up of 10 interventions nationwide would require **$40.5 million** per year in public investment and generate these benefits annually:

- Over 112,000 DALYs averted
- Over 2,800 lives saved
- Over 62,000 cases stunting averted
- $915 million added to the economy
- ***cost per DALY averted = $410***

Most of the 10 interventions are very cost-effective, although the *public provision of complementary food for the prevention of moderate acute malnutrition is much less cost-effective.*

In the event that scale-up to full coverage is not immediately feasible, the two most cost-effective gradual scale-up scenarios are:

1) **Lowest cost & most cost-effective**. Implementing all interventions except the public provision of complementary foods at partial coverage levels nationwide (Scenario 4b) would require $11.2 million and save over 69,000 DALYs and 1,600 lives: cost per DALY averted = $166.
2) **Second most cost-effective with greater impact.** Implementing all interventions except the public provision of complementary foods nationwide (Scenario 2) would require $23.7 million and save over 99,000 DALYs and over 2,300 lives: cost per DALY averted = $232.

Preliminary evidence suggests that at least one intervention outside the health sector (nutrition-sensitive interventions) would be cost-effective in improving nutritional outcomes. For Zambia, school-based deworming is low cost and effective, whereas our review of some other nutrition-sensitive interventions suggests that these are more expensive when compared to nutrition-specific interventions, although very little cost-effectiveness data are available to make careful comparisons. More robust data are needed to build on these findings and to identify other effective nutrition-sensitive interventions.

The costs presented in the preceding analysis assume scale-up to full coverage in one year. However, recognizing that a slower, incremental scale-up may be more feasible, we also estimate the cost for scaling up selected scenarios over a five-year scale-up time frame: to achieve the “full coverage” scenario would require an estimated $134.5 million, Scenario 2 would require $70.8 million, and Scenario 4b $34.7 million over five years.

These investments in nutrition could also yield tremendous economic benefits for Zambia. The full scale-up investment of $40.5 million also has the potential to increase economic productivity over the productive lives of the beneficiaries by $915 million annually and yield an impressive rate of return on the investment of 32 percent. The investment would also yield large net present values of between $4.4 and $13.8 billion depending on the discount rate assumed.

We have identified an annual financing gap for nutrition-specific interventions of at least $11.2 million on top of the current expenditures on nutrition in Zambia. Only $1.5 million of the $15.6 million current annual expenditures on nutrition came from the domestic government budget and the rest from international donors (see Table 18 in the main report). Donor pledges for 2014–16 are estimated at more than $36 million for the three-year period. This represents a dramatic increase and will go a long way toward financing the needed interventions. Nevertheless, it will not cover both the current expenditures (about $16 million per year) and the additional resources needed for the most modest scenario (4b) of $11.2 million per year. It will therefore be essential to leverage additional government resources for nutrition interventions, rather than to continue to rely exclusively on donors.

The analysis presented here takes an innovative approach by estimating the costs and benefits not only of nutrition-specific interventions but also of selected nutrition-sensitive interventions implemented outside of the health sector. While recognizing that the evidence base for the impact of nutrition-sensitive interventions is less conclusive, we considered seven nutrition-sensitive interventions in the agriculture and education sectors that have shown some potential for improving nutrition outcomes. These include four interventions in the agriculture sector: biofortification of vitamin A-rich maize and sweet potato, aflatoxin control in maize, and the promotion of diet diversity. Four interventions in the education sector are also considered: school-based based deworming, school-based promotion of good hygiene, school-based treatment of bilharzias, and school-based feeding. The estimated annual costs are $58 million for scaling up all four of the agricultural interventions and $22 million for the four in the education sector. However, these must be considered rough approximations, because there are significant limitations in both the available data and in the methodological approaches. In addition, we were not able to estimate the benefits of these interventions because of data and methodological shortcomings, although we do report benefits calculated by researchers for other countries. Nevertheless, this preliminary costing analysis suggests that the nutrition-sensitive interventions considered here—with the exception of school-based deworming—are significantly more costly than the nutrition-specific interventions.

In summary, these findings point to a powerful set of nutrition-specific interventions and a candidate list of nutrition-sensitive approaches that represent a highly cost-effective approach to reducing the high levels of child malnutrition in Zambia.

PART I – BACKGROUND

COUNTRY CONTEXT

Zambia is a landlocked southern African country with a vibrant economy primarily dependent on mining and agriculture.[1] The county's estimated 14.1 million inhabitants live in an area of 752,618 square kilometers, which is subdivided into 10 provinces and 89 districts (Figure 1). The climate is generally tropical with some modifications by elevation. The Zambian economy has been historically dependent on the copper industry, although agriculture now provides more jobs. Since 2003 the economy has been growing at over 5 percent per year; its growth rate was over 7 percent in 2012. Despite having one of the higher per capita GNI in the region—of $1,540 in 2013 (World Bank 2014)—Zambia has a poverty rate of over 60 percent (World Bank 2012b). Further, Zambia ranks low at 164 out of 187 countries on the Human Development Index (UNDP 2012).

Figure 1. Map of the Republic of Zambia

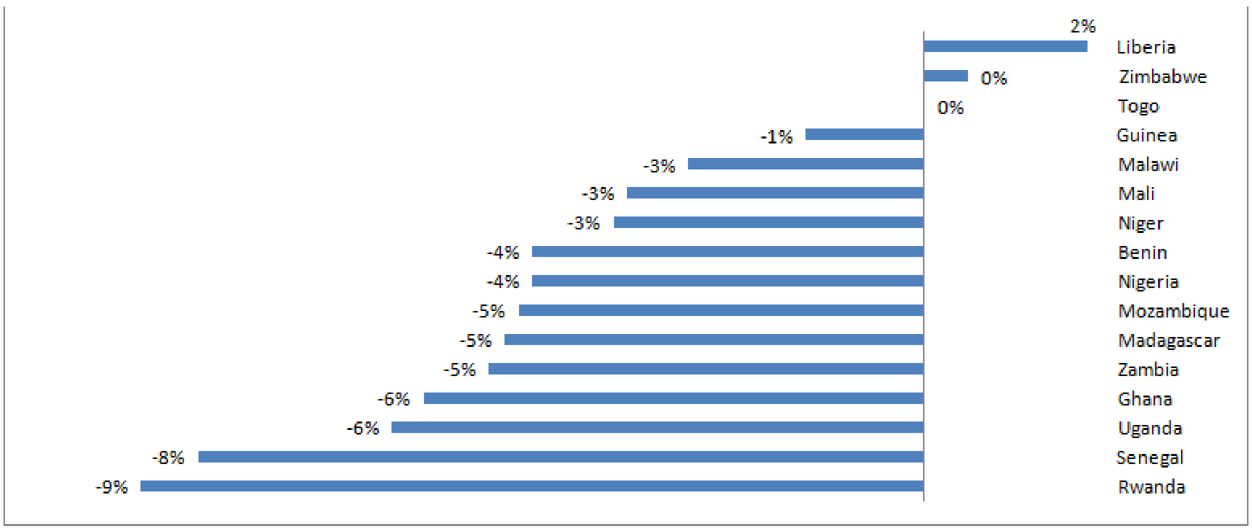
Source: World Bank Group, internal map, 2009.

[1] Zambia is bordered by the Democratic Republic of Congo and Tanzania to the north, Malawi and Mozambique to the east, Zimbabwe, Botswana, and Namibia to the south, and Angola to the west.

NUTRITIONAL STATUS IN ZAMBIA

Overall health status in Zambia has been steadily improving in recent years. Life expectancy rose dramatically, from 42 years in 2000 to 57 years in 2012 (World Bank 2014). Under-five child mortality declined from 143 per 1,000 live births in 2000 to 89 in 2012. Infant mortality rates also declined from 86 per 1,000 live births in 2000 to 56 in 2012 (World Bank 2014). Zambia's rate of improvement compares favorably with that of other Africa countries, as shown in Figure 2. Between 2005 and 2010, under-five mortality rates in Zambia declined by more than 5 percent.

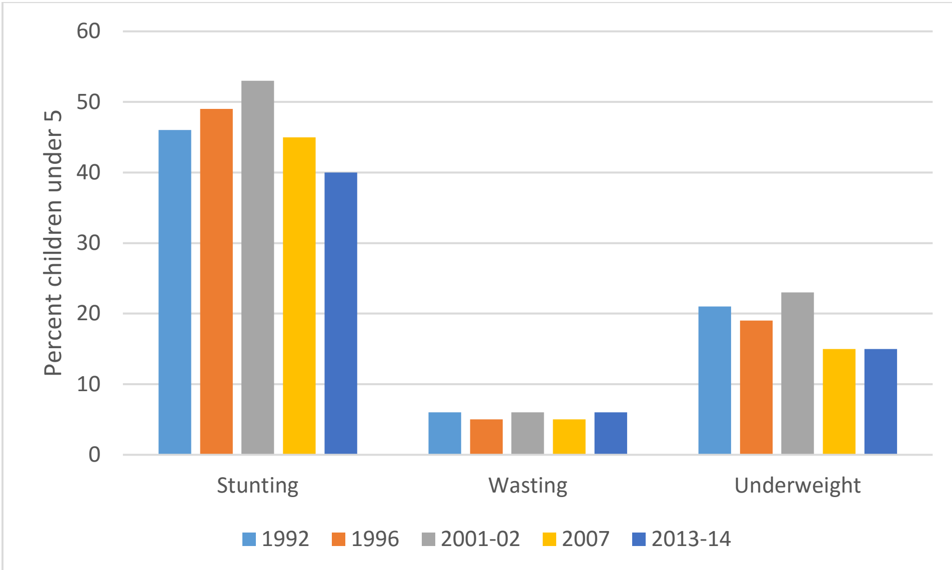
Figure 2. Changes in Child Mortality in Various Countries in Sub-Saharan Africa, 2005–2010



Source: World Bank analysis, based on DHS datasets.

The prevalence of chronic malnutrition, as measured by stunting in children under five years of age, remains very high: this was 40 percent in 2013–14. This represents a decline since the recent high of 53 percent of children under five stunted in 2001–02 (Figure 3). Stunting is a measure of chronic undernutrition and reflects long-term poor caloric intake and poor quality of nutrition, including micronutrient deficiencies. Rates of wasting (acute undernutrition) are much lower, at 5 to 6 percent, and have remained unchanged since the early 1990s. Taken together, these findings suggest that children are not suffering from short-term or seasonal food shortages as much as they are from relying on a poor diet that lacks sufficient nutrients for healthy growth over the long run. On a positive note, the share of children who are underweight has declined from 23 percent in 2001–02 to 15 percent in 2013–14.

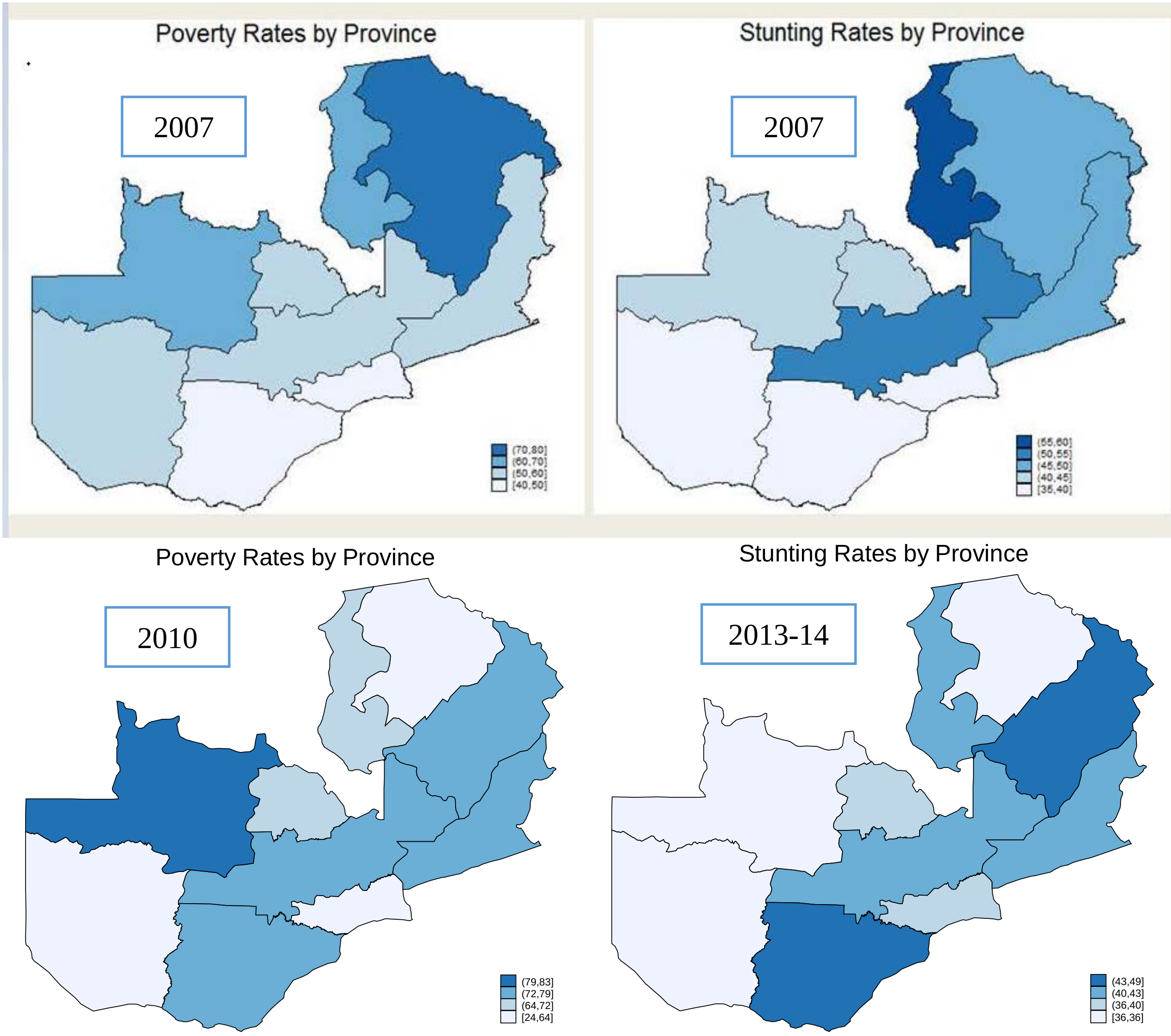
Figure 3. Trends in Nutritional Status among Children Under Five Years in Zambia, 1992–2014



Source: DHS 2013–14.

There is regional variation in malnutrition as well an association between malnutrition, as measured by stunting, and poverty rates (Figure 4). In addition, Figure 4 shows the change in the geography of both stunting and poverty between 2007 and 2013–14. Although provinces in the northeast and central area (Luapula, Northern, Eastern, and Central provinces) all had stunting rates at or above 50 percent in 2007, these rates have all come down to the mid and low 40s. This compares with lower rates in Lusaka, Southern, and Western provinces. Poverty rates were highest in the Northern province in 2007 but declined there in 2010, while increasing in the south and western provinces. Overall there was a slight increase in the poverty rate nationally, with 60 percent of Zambians living in poverty in 2010 as compared to 57 percent in 2007.

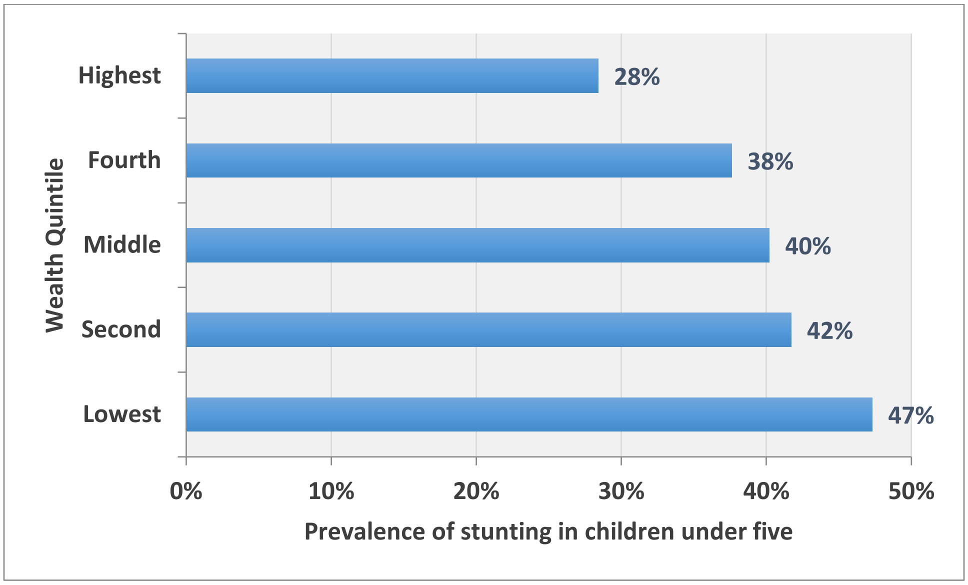
Figure 4. Poverty Rates for 2007 and 2010 and Stunting Rates for 2007 and 2013–14



Data Sources: Poverty rates from World Bank 2012b; stunting rates from DHS.
Note: The data shown in the keys for the panels of Figure 4 are as follows: Poverty rates for 2007: dark blue = (70,80]; medium blue = (60,70]; pale blue = (50,60]; white = (40,50]. Poverty rates for 2010: dark blue = (79,83]; medium blue = (72,79]; pale blue = (64,72]; white = (24,64]. Stunting rates for 2007: very dark blue = (55,60]; dark blue = (50,55]; medium blue = (45,50]; pale blue = (40,45]; white = (35,40]. Stunting rates for 2013–14: dark blue = (34,49]; medium blue = (40,43]; pale blue = (36,40]; white = (36,36].

Rates of childhood stunting also vary with income, although poverty is not the only explanation for undernutrition in Zambia. Stunting rates in the bottom three quartiles are higher than 40 percent, while these rates are 28 percent in the richest quartile (Figure 5). Nevertheless, it is noteworthy that over one-quarter of children in the richest are stunted. This shows that while poverty is associated with stunting, other factors are also at play. Non-food factors, such as disease, optimal feeding and caregiving practices have a major role to play in causing malnutrition.

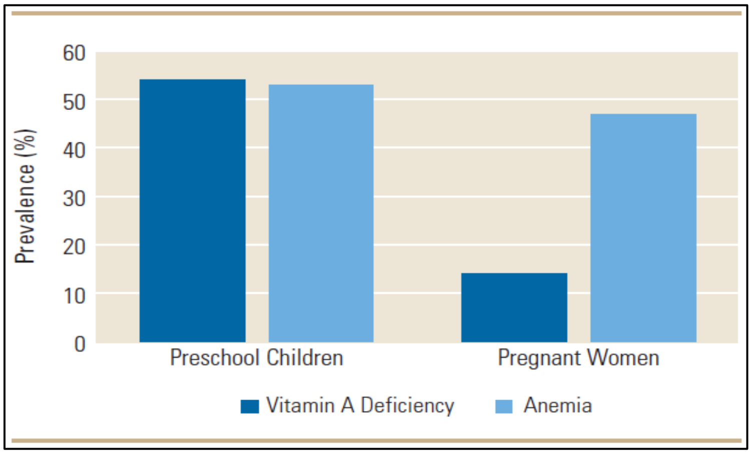
Figure 5. Prevalence of Stunting Among Children under Five by Wealth Quintiles in Zambia, 2013–14



Source: DHS 2013–14.

Vitamin and mineral deficiencies (*hidden hunger*) are also pervasive in Zambia. As shown in Figure 6, over 54 percent of children under five and 13 percent of pregnant women in Zambia were deficient in vitamin A during 1993–2003, the most recent time period for which data are available (World Bank 2011). Vitamin A deficiency increases child mortality, increases vulnerability to infectious diseases such as measles, and can lead to blindness among children under five years old (Mayo-Wilson et al. 2011). Based on the 2013–14 Demographic and Health Survey (DHS), 77 percent of children aged 6–59 months received vitamin A supplementation in the previous 6 months, up from 60 percent in 2007. In addition, the data from 1993–2003 show that about half of young children and pregnant women in Zambia were anemic. Although data on current levels of anemia are not available, the 2103–14 DHS reported that about half of children aged 6–23 months consumed iron-rich foods in the previous 24-hour period. The share of households that consumed iodized salt in 2013–14 was 96 percent (DHS 2013–14). Overall, it is estimated that Zambia loses $186 million annually to vitamin and mineral deficiencies (World Bank 2011).

Figure 6. Vitamin A Deficiency and Anemia in Zambia, 1993–2003



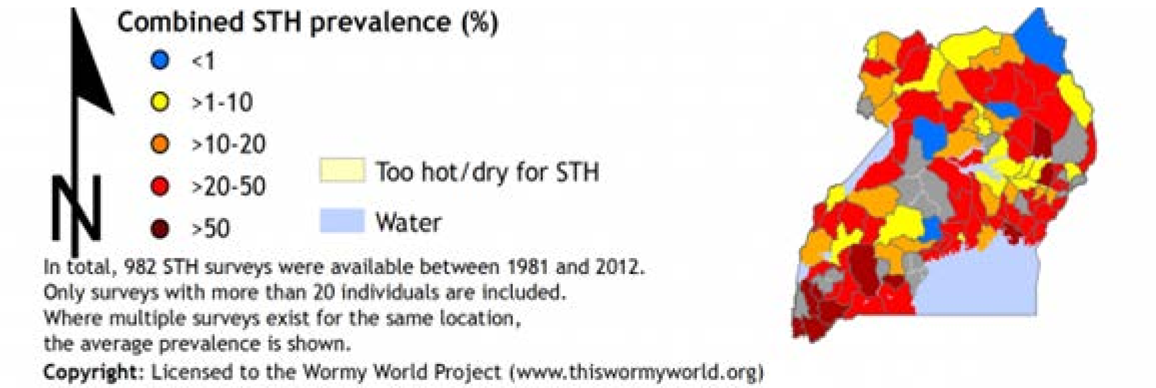
Source: WHO Global Database on Child Growth and Malnutrition.

Another health burden in Zambia is the high levels of aflatoxins, which are naturally occurring carcinogenic byproducts of common fungi on crops such as maize and groundnuts. Although there are no prevalence data for Zambia, experts consider aflatoxin contamination to be extensive. Evidence from other countries shows that high aflatoxin consumption can lead to liver cirrhosis (Kuniholm et al. 2008) and liver cancer in adults (Abt Associates 2014). Further, it is widely understood that there is a relationship between aflatoxin exposure and child stunting, although the evidence base for this relationship is still tentative and it has not yet been adequately quantified in the published literature (Unnevehr and Grace 2013; Abt Associates 2014).

Approximately 12,700 children under five die each year in Zambia from diarrhea. Over half of these deaths are directly attributed to poor water, sanitation, and hygiene (WHO 2009). Diarrheal episodes exacerbate the relationship between malnutrition and infection because children tend to eat less, absorb fewer nutrients, and exhibit reduced resistance to infections. Prolonged diarrheal episodes lead to impaired growth and development (Ejemot et al. 2008). Poor sanitation is also a contributing factor—through its impact on malnutrition rates—to other leading causes of child mortality including malaria, acute respiratory infections, and measles.

Parasitic intestinal worms are considered to be widely prevalent in Zambia, although no national-level prevalence data are available. A summary of all survey data of helminth infections in Zambia from 1983 through 2007 shows a wide range of infection rates, with the majority having a prevalence of over 20 percent, as depicted in the red-colored areas in Figure 7 (Global Atlas of Helminth Infections 2014). One recent study of the Kafue District in the Lusaka Province found a soil-transmitted helminth (STH) infection rate of 18 percent among preschool children (Siwila et al. 2010). The high rates of anemia among children in Zambia also point to a significant problem with STH. In the short term, helminthic infections potentially cause anemia and increase morbidity, undernutrition, and impairment of mental and physical development (Hotez et al. 2008). In the long term, infected children are estimated to have an average IQ loss of 3.75 points per child and they earn less as adults (43 percent) than those who grow up free of worms (Bleakley 2007).

Figure 7. Prevalence of Parasitic Intestinal Worms in Zambia between 1981 and 2012



Source: Global Atlas of Helminth Infections 2014.
Note: STH = soil-transmitted helminths.

THE IMPORTANCE OF INVESTING IN NUTRITION

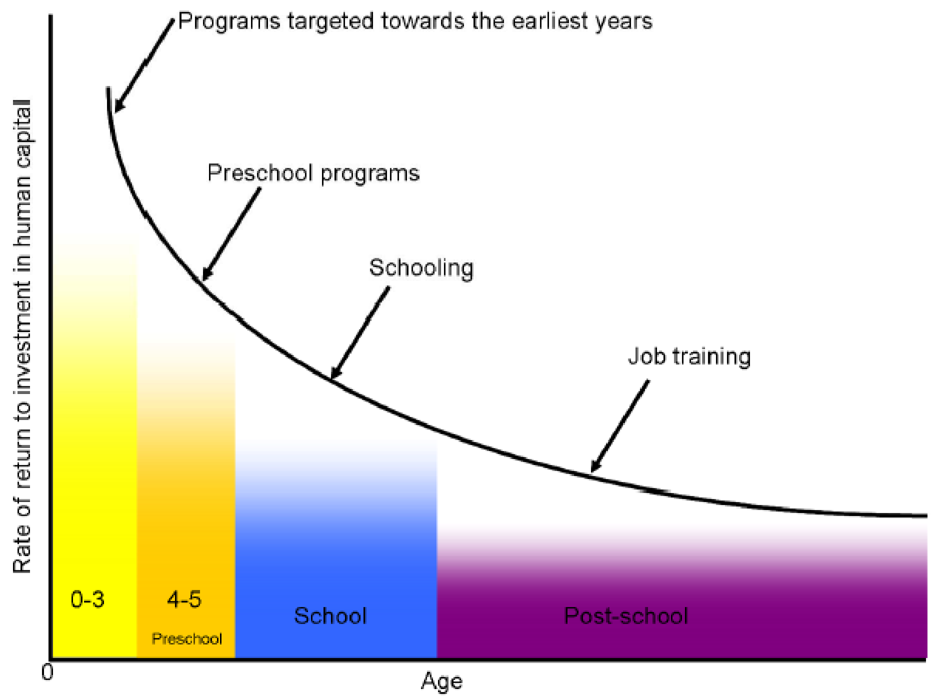
Undernutrition is an underlying cause of approximately half the deaths in children under five and one-fifth of maternal deaths in developing countries. The joint effect of suboptimum breastfeeding and fetal growth restriction in the neonatal period alone contributes 1.3 million deaths or 19 percent of all deaths of children under five (Black et al. 2013). Undernourished children are more likely to die from common childhood illnesses such as diarrhea, measles, pneumonia, malaria, or HIV/AIDS.

Those malnourished children who survive face long-lasting health and schooling consequences, including cognitive deficits and poorer schooling outcomes. Children with impaired cognitive skills have lower school enrollment, attendance, and graduation, which in turn results in lower productivity, earnings, and economic well-being. Stunted children lose 0.7 grades of schooling and are more likely to drop out of school. An adequate intake of micronutrients—particularly iron, vitamin A, iodine, and zinc—is critical for growth and cognitive development. Iodine-deficient children lose on average 13 IQ points, and iron deficiency anemia reduces performance on tests by 8 IQ points, making these children less educable and less productive in the long run (World Bank 2006). Behrman et al. (2009) showed improved schooling and test scores from food supplementation in early childhood.

Malnutrition costs developing countries billions of dollars in lost revenue through reduced economic productivity, particularly through lower wages, lower physical capability, and more days away from work as a result of illness. At the individual level, childhood stunting is estimated to reduce a person’s potential lifetime earnings by at least 10 percent (World Bank 2006). Other studies have shown that a 1 percent loss in adult height results in a 2 to 2.4 percent loss in productivity (Strauss and Thomas 1998; Caulfield et al*.* 2004). In addition, micronutrient deficiencies in childhood and adulthood have tremendous economic cost for both individuals and countries. Childhood anemia alone is associated with a 2.5 percent drop in adult wages. Anemia in adults has been estimated to be equivalent to 0.6 percent of GDP; this estimate goes up to 3.4 percent when including the secondary effects of retarded cognitive development in children (Horton 1999). Horton and Ross (2003) estimate that eliminating iron-deficiency anemia would result in a 5 to 17 percent increase in adult productivity. Annually Zambia loses over $186 million in GDP to vitamin and mineral deficiencies alone (World Bank 2013). The economic costs of undernutrition have the greatest effect on the most vulnerable in the developing world. A recent analysis estimates these losses at 11 percent of GDP in Africa and Asia each year (Horton and Steckel 2013)—equivalent to about $149 billion of productivity losses.

Because most of the detrimental effects of malnutrition occur in the first 1,000 days of a child's life, , the window of opportunity for preventing these effects is the before the child is two years of age. After that age, most actions are too little, too late, and too expensive (World Bank 2006; Black et al. 2008, 2013). Figure 8 shows that the rates of return from human capital (including nutrition) investments are highest for programs targeting the earliest years, since these investments build a foundation for future learning and productivity, prevent irreversible losses, and lock in human capital for life (Heckman and Masterov 2004).

Figure 8. Rates of Return to Investment in Human Capital



Source: Heckman and Masterov 2004.
Note: Age refers to the child's age from birth, depicted in years for infancy and preschool, then in aggregate for school age and adulthood.

Malnutrition and poverty are interrelated and exacerbate each other. A recent study (Hoddinott et al. 2011) concluded that individuals who are not stunted at 36 months are one-third less likely to live in poor households as adults. Poverty increases the risk of malnutrition by lowering poor households' purchasing power, reducing access to basic health services, and exposing these households to unhealthy environments, thereby compromising food intakes (both quality and quantity) and increasing infections. Poor households are also more likely to have frequent pregnancies, larger family sizes with high dependency ratios, more infections, and increased health care costs. Conversely, malnutrition causes poor health status, poor cognitive development, and less schooling, resulting in in poor human capital and long-term productivity losses.

Nutrition interventions are consistently identified as cost-effective development actions, and the costs of scaling up nutrition interventions are modest. Global benefit-cost ratio of micronutrient powders for children is 37 to 1; of deworming it is 6 to 1; of iron fortification of staples it is 8 to 1; and of salt iodization is 30 to 1 (World Bank 2010).

A recent World Bank study estimated that investing in nutrition can increase a country's GDP by at least 3 percent annually (World Bank 2010). The same study estimated these costs at $10.3 billion per annum globally, to be financed through domestic public and private sector and donor resources. These investments would provide preventive nutrition services to about 356 million children, save at least 1.1 million lives and 30 million DALYs, and reduce the number of stunted children by about 30 million worldwide. Bhutta et al. (2013) came up with similar estimates. In another study, Hoddinott, Rosegrant, and Torero (2012) estimate that, for just $100 per child, interventions including micronutrient provision, public provision of complementary food for the prevention of moderate acute malnutrition, treatments for worms and diarrheal diseases, and behavior change programs could reduce chronic undernutrition by 36 percent in developing countries. Clearly there is huge potential pay-off for dedicating more resources to the scale-up of evidence-based, cost-effective nutrition interventions.

A Multisectoral Approach for Improving Nutrition

The determinants of malnutrition are multisectoral. Therefore, to successfully and sustainably improve nutrition outcomes, a multisectoral approach is needed. At a proximate level, access to food, health, hygiene, and adequate child care practices is key to reducing malnutrition. At a more distal level, poverty, women's status, and other social factors play an important role. It has been demonstrated that direct actions taken to address the proximate determinants of malnutrition can be further enhanced by action on some of the more distal levels. For example, programs supporting improved infant and young child feeding practices will be more effective if they are complemented with programs to address gender issues by reducing women's workloads, thus allowing women more time for child care. Similarly, conditional cash transfer programs that target the poor, if designed appropriately, have the potential not just to address poverty but also to increase demand for nutrition services and good nutrition behaviors.

Box 2: Nutrition-Specific and Nutrition-Sensitive Interventions Distinguished

Nutrition-specific interventions address the immediate determinants of child nutrition, such as adequate food and nutrition intake, feeding and caregiving practices, and treating disease. Examples include:

- Community nutrition programs
- Micronutrient (e.g., vitamin A) supplementation
- Deworming

Nutrition-sensitive interventions are delivered through the agriculture; education; and water, sanitation, and hygiene sectors and have the potential to have an impact on nutrition outcomes more indirectly than nutrition-specific interventions. Examples include:

- Biofortification (e.g., vitamin-A rich sweet potato or cassava)
- Conditional cash transfers
- Water and sanitation sector infrastructure improvements

Although the health care sector is key in delivering *nutrition-specific* interventions to the poor (such as vitamin A supplementation and deworming), multisectoral *nutrition-sensitive* actions through the agriculture sector and social protection, water and sanitation, and poverty reduction programs have the potential to strengthen nutritional outcomes in several ways (Box 2). Examples of these include (1) improving the context in which the nutrition-specific interventions are delivered—for example, through investment in food systems, empowerment of women, and equitable education; (2) integrating nutrition considerations into programs in other sectors as delivery platforms (such as conditional cash transfer programs) that will potentially increase the scale and coverage of nutrition-specific interventions; and (3) by increasing policy coherence through government-wide attention to policies or strategies and trade-offs, which may have positive or unintended negative consequences for nutrition. The synergy with other sectors is critical to breaking the cycle of malnutrition and sustaining the gains from direct nutrition-specific interventions (World Bank 2013).

Guidance on costing for nutrition-sensitive interventions is currently very limited for at least two reasons. First, evidence of the effectiveness of nutrition-sensitive interventions with respect to nutritional outcomes is limited. Second, compared with nutrition-specific interventions, estimating and attributing the costs of nutrition-sensitive interventions is quite complex since these interventions have multiple objectives and improved nutrition outcomes is only one of them. Notwithstanding these limitations, the availability of costing information is crucial to assess the cost-effectiveness of these interventions. This series of papers on nutrition interventions makes a first-ever attempt to address these issues.

We identify and cost seven selected nutrition-sensitive interventions that are relevant for scale-up in the Zambian context, for which there is evidence of the positive impact on nutrition outcomes, and for which there is some cost information. These include three interventions delivered through the agriculture sector—vitamin A biofortification of orange maize and sweet potato, aflatoxin reduction through biocontrol intervention, and promotion of diet diversity through agriculture extension workers—and four delivered through the education sector—school-based deworming, school-based treatment of bilharzia, school-based promotion of good hygiene, and school feeding. Other potential nutrition-sensitive interventions include the reduction of women's workloads through appropriate technologies in agriculture, social safety nets and conditional cash transfers targeted to the poor and designed to have an impact on nutrition outcomes, and water and sanitation programs that reduce the exposure to infections and childhood diseases. However, because of data unavailability or the absence of delivery platforms, these interventions were not included. Cost and benefit estimates (where possible) for the seven nutrition-sensitive interventions described here are presented in Part II.

Biofortification has the potential to reduce micronutrient deficiencies in a highly cost-effective manner. Biofortification uses plant breeding techniques to enhance the micronutrient content of staple foods; in Zambia the focus is on fortifying maize with beta-carotene, which the body converts to vitamin A. The crossbreeding process causes the maize to take on an orange color. Over 60 percent of the total area planted in major crops in Zambia has been planted in maize and maize dominates the Zambian diet, accounting for more than half of available energy. A recent study by HarvestPlus that ranked countries according to their suitability for investment in biofortification interventions identified Zambia as a "top priority" country in its ability to benefit from the biofortification of maize (Asare-Marfo et al. 2013). A more recent ex-ante cost study of high vitamin A maize in Zambia suggests that the cost per DALY averted is considered cost-effective, but requires a long-term commitment for implementation (Fiedler and Lividini forthcoming). In another analysis, Fiedler and Lividini show how high vitamin A maize biofortication is a key component in addressing vitamin A deficiency in Zambia in a cost-effective way (Fiedler and Lividini 2014).

Based on analysis from other countries, biocontrol of aflatoxins has the potential to reduce aflatoxins in maize and groundnuts by at least 80 to 90 percent (Bandyopadhyay and Cotty 2013). Field testing of biocontrol products in Burkina Faso, Kenya, Nigeria, and Senegal, although not formally published, is producing extremely positive results. The method involves a single application of a product (aflasafe™) containing strains unique to that country. The U.S. Agency for International Development (USAID) is currently supporting a project on the mitigation of aflatoxin in maize and groundnuts in Zambia (2012–15) (USAID Zambia 2011). During 2012, researchers from the International Institute of Tropical Agriculture (IITA), the Zambia Agriculture Research Institute (ZARI), and the National Institute of Scientific and Industrial Research (NISIR) developed nonpoison forming strains of fungi to test in the field. In January 2013, the Zambian aflasafe™ began being applied to fields in the Eastern Province of Zambia (IITA 2013). IITA recommends that farmers apply aflasafe™ -Zambia 30 to 40 days after planting and at a rate of 10 kg/ha for optimum efficacy (IITA 2014).

Research from other countries has shown the success of agricultural programs to promote diet diversity in improving nutrition and feeding practices of young children. The promotion of diet diversity includes the delivery of basic food security and nutrition messages around specific crops via agricultural extension agents. The approach is most effective if messages are targeted toward the farmers growing the crop, and packaged together with delivery of seeds or other pertinent information about the crop, including storage and food preparation methods. In many contexts, it is usual for such a worker to talk to farm households about both food production and consumption decisions. Given the reality that food security and nutrition messages are most likely to be delivered effectively by and to women, it is important to employ female extension workers in contexts where the social norm prevents women from interacting with non-family males.

School-based deworming has been proven to be an efficient and cost-effective intervention to address health and nutrition outcomes in other settings, with cost per DALY averted estimated at $4.55 (J-PAL 2012). Delivering deworming tablets through schools is inexpensive because it uses existing infrastructure and delivery platforms in schools and community links with teachers. Teachers need only minimal training to safely administer the tablets, so their workloads are not significantly increased. On the other hand, the benefits of school-based deworming are enormous. Bi-annual deworming significantly boosted school attendance and reduced self-reported illness and anemia, while providing modest gains in height-for-age Z-scores (J-PAL 2012). Evidence from India also suggests that deworming has the potential to reduce cases of childhood stunting and underweight (Awasthi et al. 2013). In the long term, deworming improved self-reported health, increased total schooling years, and raised earnings by 20 percent (Baird et al. 2011). In Zambia, a USAID-supported program called Changes2 was implemented in 2005–09; this program trained teachers in school-based deworming in four southern provinces. Zambia hopes to expand this program to provide semi-annual deworming to all primary and secondary students.

Improved hygiene behaviors through school-based promotion of handwashing and other good hygiene behavior could decrease the risk of stunting in one in three children. Correct handwashing at critical times can reduce the severity of diarrhea by 42 to 47 percent, lower the incidence of diarrhea for children by 53 percent, and reduce the incidence of acute respiratory infections by 44 percent in Nigeria (where the World Bank conducted a study on the impact of poor sanitation; World Bank 2012a)—thereby reducing child stunting. A recent campaign (WASH) to promote handwashing with soap in primary schools in China, Colombia, and Egypt demonstrated significant reduction in absenteeism related to diarrhea and respiratory illness (UNICEF 2012). A study in Brazil showed a relationship between the effects of early childhood diarrhea on later school readiness and school performance, revealing the potential long-term human and economic costs of early childhood diarrhea (Lorntz et al. 2006).

The effectiveness of promoting good hygiene behavior in schools is demonstrated by the long-term impact and broad effect of good hygiene on communities. Schools are ideal settings for hygiene education: children can learn and sustain lifelong proper hygiene practices through peer-to-peer teaching, classroom sessions with focused training materials, and role playing or interactive songs. A study on the long-term effects of hygiene education programs for both adults and children found that hygiene behaviors are sustained beyond the end of an intervention. The study also found that educated students can also influence family members by sharing this information, which may in turn affect behavior change at the community level (Bolt and Cairncross 2004).

National and Partner Efforts to Address Malnutrition in Zambia

Nutrition interventions in Zambia are coordinated by the National Food and Nutrition Commission (NFNC), which has set out an initiative to expand nutrition interventions during 2011–15 (NFNC of Zambia 2012). This Five-Year National Food and Nutrition Strategic Plan (NFNSP) 2011–15 is Zambia's first multisectoral response to combat malnutrition. It focuses on 10 key strategic directions related to improving food and nutrition, with a major focus on strengthening and expanding interventions to promote the First 1000 Most Critical Days Programme that prevents stunting in children less than two years of age.

Major external support for nutrition comes from the U.K. Department for International Development (DFID), the European Union (EU), Irish Aid, teh Swedish International Development Cooperation Authority (Sida), the World Bank, and the Global Agriculture and Food Security Programme (GAFSP) (REACH 2014). DFID, Irish Aid, and Sida support a program managed by CARE to support the government’s First 1000 Most Critical Days Programme. The World Bank will soon support the Health Services Improvement project, which has a component to improve primary health care, including a plan to scale up high-impact nutrition interventions (World Bank 2013). The EU supports a focus on maternal and child care at the district level. (Appendix 1 provides a detailed list of donor activities.)

Several partners are working to improve nutrition by investing in the agricultural sector. The EU is supporting conservation agriculture with a nutrition component (REACH 2014). The GAFSP supports a food security and nutrition program. HarvestPlus is also active in Zambia, developing and disseminating a variety of vitamin A–rich maize that is intended to provide 50 percent of mean requirements for vitamin A requirements (Fiedler and Lividini 2014, forthcoming). USAID is supporting a program to reduce aflatoxins in maize and groundnuts and thereby improve nutritional status (USAID 2011; IITA 2013, 2014).

PART II – COSTED SCALE-UP SCENARIOS: RATIONALE, OBJECTIVES, METHODOLOGY, AND RESULTS

RATIONALE AND OBJECTIVES OF THE ANALYSIS

The overall objective of this costing analysis is to support the Government of Zambia in developing a costed scale-up plan for nutrition. It will provide the government with the tools it needs to leverage adequate resources from domestic budgets as well as from development partners in support of the costed scale-up plan. Within this context, the objectives of this analysis are as follows:

- To estimate scale-up costs in Zambia for a set of well-proven nutrition-specific interventions that have the potential to be scaled up through tested delivery mechanisms
- To conduct a basic economic analysis to calculate the potential benefits and cost-effectiveness associated with the proposed scale-up
- To propose a series of scenarios for a costed scale-up plan that rolls out this package of nutrition-specific interventions in phases, based on considerations of impact, geography, implementation capacity, and cost
- To explore initial costs for a limited number of nutrition-sensitive interventions through the agriculture, education, and water and sanitation sectors

Although the economic arguments for increasing investments in nutrition are sound, one of the first questions raised by key decision makers in any country is "How much will it cost?" In 2010, the World Bank spearheaded a study called *Scaling Up Nutrition: What Will It Cost?* to answer that question at the global level. The analysis estimated the level of global financing required to scale up 10 evidence-based nutrition-specific interventions in 36 countries that account for 90 percent of the world's stunting burden and 32 smaller countries that also have a high prevalence of undernutrition. The results of the study highlighted the global financing gap, underscored the importance of investing in nutrition at the global level, and laid out a methodology for estimating the costs of nutrition-specific interventions. However, these global estimates did not capture the nuances and context in each country, nor were these estimates contextualized to every individual country's policy and capacity setting or its fiscal constraints. This report builds on the early work to address this gap and contextualize the cost estimates for Zambia.

The multisectoral approach requires nutrition-sensitive approaches or interventions that can be delivered through other sectors. As discussed above, globally there is currently very limited guidance on costing for nutrition-sensitive interventions. Therefore this report provides an exploratory analysis to be used primarily to engage other sectors in planning for improved nutritional outcomes. This initial exercise will contribute to a broader discussion about methodological and other issues for costing nutrition-sensitive interventions, and will thereby encourage the formulation of standard definitions, methodologies, and guidance for costing these interventions in the future.

SCOPE OF THE ANALYSIS AND DESCRIPTION OF THE INTERVENTIONS

The costed scale-up plan is presented in two sections. The first section presents estimated costs and benefits for the set of 10 nutrition-specific interventions that have strong evidence of impact and were included in the World Bank's *Scaling Up Nutrition* report (2010) and are delivered primarily through the health sector. These interventions and the associated target population and current coverage for each intervention are specified in Table 1.

The nutrition-specific interventions considered are a modified package of the interventions included in the 2008 and 2013 *Lancet* series on Maternal and Child Undernutrition, tailored to the Zambian context. These 10 interventions are based on current scientific evidence and there is general consensus from the global community about their impact. Some interventions—such as deworming and iron-fortification of staple foods—that were included in the 2008 *Lancet* series but not listed in the 2013 *Lancet* series are included here because they remain relevant to Zambia. Others—such as calcium supplementation for women and prophylactic zinc supplementation—are excluded because delivery mechanisms are not available in client countries, including Zambia, and/or there are no clear WHO protocols or guidelines for large-scale programming. In other cases, there are limited capacities for scaling up the interventions. Only those nutrition-specific interventions that are relevant to the Zambian context and that have strong evidence of effectiveness, a WHO protocol, and a feasible delivery mechanism for scale-up are included in the proposed scale-up package below. As this evidence base grows, other interventions can be added over time.

Table 1. Nutrition-Specific Interventions Delivered Primarily Through the Health Sector

Intervention	Description	Target population	Current coverage
Breastfeeding and complementary feeding promotion	Behavior change communication focusing on optimal breastfeeding and complementary feeding practices	Children 0–23 months of age	Negligible
Vitamin A supplementatio n (children	Semi-annual doses	Children 6–59 months of age	76.50%
Therapeutic zinc supplementatio n with ORS (children)	As part of diarrhea management with ORS	Children 6–59 months of age	Negligible
Multiple micronutrient powders (children)	For in-home fortification of complementary food (60 sachets between 6 and 11 months of age, 60 sachets between 12 and17 months of age, and 60 sachets between 18 and 23 months of age).	Children 6–23 months of age who are not receiving complementary foods	0.00%

Deworming (children)	Two rounds of treatment per year	Children 12–59 months of age	59.80%
Iron-folic acid supplementation (pregnant women)	Iron-folic acid supplementation during pregnancy	Pregnant women	95.40%
Iron fortification of staple foods (general public)	Fortification of wheat flour with iron	General population	0.00%
Salt iodization (general public)	Iodization of centrally-processed salt	General population	95.60%
Complementary food for the treatment of moderate acute malnutrition (children)	Provision of a small amount (~250 kilocalories per day) of nutrient-dense complementary food for the treatment of moderate malnutrition (moderate acute malnutrition and/or moderate stunting)	Twice the prevalence of underweight (WAZ < −2) among children 6–23 months of age*	Negligible
Community-based treatment of severe acute malnutrition (children)	Includes the identification of severe acute malnutrition, community or clinic-based treatment (depending on the presence of complications), and therapeutic feeding using ready-to-use therapeutic food	Incidence (estimated as twice the prevalence) of severe wasting (WHZ <−3) among children 6–59 months of age	15.64%

Note: ORS = oral rehydration salts; WHZ = weight-for-height Z-score.

The analysis in the following section focuses on nutrition-sensitive interventions that are relevant to the Zambian context and that have the potential to have an impact on nutrition outcomes. A description of these interventions, associated target populations, and responsible sectors are listed in Table 2. As discussed above, the evidence base for nutrition-sensitive interventions is not as strong as it is for nutrition-specific interventions. Therefore, these estimates are exploratory and are limited to six potential interventions relevant to the Zambian context that can be scaled up and have potential for impact on nutrition outcomes. Additional interventions were not included in these initial estimates because their impact on nutrition is yet to be clearly documented (Masset et al. 2011; Ruel et al. 2013; World Bank 2013), because this is an exploratory instead of an exhaustive effort, or because they were not considered relevant to the needs of Zambia. Furthermore, cost attribution is complex because these nutrition-sensitive interventions are designed for multiple purposes.

Table 2. Multisectoral, Nutrition-Sensitive Interventions: An Exploratory Process

Intervention	Description	Target Population	Potential for impact
Interventions to be delivered through the agricultural sector			
Biofortification of orange maize and orange sweet potato	Promote use of vitamin A-rich maize and vitamin A-rich sweet potato	General population	Increase in vitamin A intakes and improve vitamin A status (Hotz 2012a, 2012b)
Aflatoxin control for maize	Promote use of biocontrols such as aflasafe™ for maize and groundnuts	General population	Improve child nutrition status (stunting) and reduce morbidity (Khlangwiset and Wu 2011)
Promotion of diet diversity	Promote diet diversification and nutrition messages to farmers growing crops through agricultural agents	General population	Improve consumption and nutrition impact in home gardening (Chakravarty 2000)
Interventions to be delivered through the education sector			
Deworming for school-aged children	Distribution of mebendazole/ albendazole to school-aged children and training to school teachers, community workers, and health workers	School-aged children	Reduce anemia and morbidity, improve cognitive outcomes (Miguel and Kremer 2004)
Promotion of good hygiene behaviors	Hygiene education program to teach healthy practices in schools	School-aged children	Improve child nutrition outcomes (stunting) (Spears 2013)
Treatment for bilharzias	School-based treatment	School-aged children	Reduce anemia and morbidity, improve cognitive outcomes (Miguel and Kremer 2004)
School feeding	School-based meal provision	School-aged children	Some evidence of improved nutritional status (World Bank 2012)

**Low income* is defined as those living under the poverty line.

Estimation of Target Population Sizes, Current Coverage Levels and Unit Costs

Target population estimates are based primarily on demographic data obtained from the population projection derived from the Population Census 2010 (see Appendix 2). The prevalence of child stunting (height-for-age Z-score <−2), underweight (weight-for-age Z-score <−2), and severe wasting (weight-for-height Z-score <−3) among children under five years of age in each province were obtained from the Zambia 2013–14 DHS.

Data on current coverage levels for interventions were obtained from various sources. Current coverage levels for community nutrition programs for behavior change communication, zinc supplementation, multiple micronutrient powders for children to fortify homemade complementary food, maternal multiple micronutrients supplementation, iron fortification of staple foods, and public provision of complementary food for the prevention of moderate acute malnutrition were set to 0 percent either because interventions were not being implemented or because coverage was very minimal or reliable data were not available. Coverage data for vitamin A supplementation, deworming, iron-folic acid supplements for pregnant women, and households consuming adequately iodized salt were obtained from the Zambia 2013–14 DHS.[2] Finally, the Ministry of Health provided data on the number of children treated for severe acute malnutrition where programs for integrated management of acute malnutrition are in operation. The estimates of the current incidence of severe acute malnutrition and moderately acute malnutrition, underweight, and stunting (which were used to classify the provinces according to levels of stunting) were all obtained from the Zambia 2013–14 DHS.

Whenever possible, the unit costs of the nutrition-specific interventions were estimated using programmatic data provided by the Ministry of Health and local implementing partners based on program experience. For some of the interventions, the delivery cost from the district plan (Kaputa and Mumbwa) was used as estimates for the unit cost at district level, which then combined with national-level data to obtain full estimates of intervention costs. The estimated unit costs and the delivery platforms are listed in Table 3. In cases where the intervention was not yet implemented or local data were not available, the global unit cost estimate from the World Bank (2010) was used. A complete index of data sources and relevant assumptions for these interventions is provided in Appendix 3.

Table 3. Unit Costs and Delivery Platforms Used to Estimate Nutrition-Specific Intervention Costs

Intervention	Unit cost (US$) per beneficiary per year	Delivery platform
Breastfeeding and complementary feeding promotion	4.99	Community and facility nutrition programs
Vitamin A supplementation	0.94	Biannual campaign with deworming and prophylactic zinc supplementation
Therapeutic zinc supplementation with ORS	0.90	Health system delivery
Multiple micronutrient powders	3.60	Community nutrition programs
Deworming	1.10	Biannual campaign with vitamin A and prophylactic zinc supplementation
Iron-folic acid supplementation	2.11	Health system delivery during first antenatal care visit

[2] After discussion with the NFNC, it was decided to use the DHS data because they represent uptake of micronutrient supplements, which may not necessarily be captured in the programmatic data.

Iron fortification of staple foods	0.16	Market-based delivery
Salt iodization	0.05	Market-based delivery
Complementary food for the treatment of moderate acute malnutrition (children)	87.50	Community nutrition programs
Community-based treatment of severe acute malnutrition	120.00	Primary health care and community nutrition programs

Note: ORS = oral rehydration salts.

For nutrition-sensitive interventions in the agriculture sector, the unit costs were estimated using programmatic cost data from Zambia with the exception of aflatoxin control, which comes from Nigeria. The unit costs and the delivery platforms are listed in Table 4. The unit costs for biofortification of orange maize and orange sweet potato are composed of two main elements: the cost of the seeds and the cost of the promotion. Estimates of seed costs come from HarvestPlus and estimates of promotion activity costs come from the Ministry of Health. The unit cost does not include research and development or adaptive breeding activities since these phases were already completed. The unit cost for aflasafe™ per hectare comes from the International Institute for Tropical Agriculture (IITA) in Nigeria (Bandyopadhyay 2013) and is considered a best approximation of costs for Zambia. This cost estimate includes material and distribution costs. The unit cost for the promotion of diet diversification comes from the Ministry of Agriculture, which estimates the total cost for promotional activities through the agriculture sector for each district: assuming 20,000 farmers per district, that yields a unit cost of $2.10 per farmer.

Unit costs for interventions in the education sector come mostly from the Ministry of Education. The unit costs for school-based deworming, school-based treatment of bilharzias, and school feeding intervention used in the calculation are obtained from the Ministry of Education. The major cost components for deworming are human resources, surveillance and mapping, non-donated drugs, advocacy, infrastructure and logistics, and implementation and management. No unit cost estimates are available for school-based promotion of good hygiene for Zambia, so the unit cost of $2 per student, obtained from the UNICEF report (2012) on WASH in schools, is used as a proxy. This includes the cost of capacity building, monitoring, advocacy, and social mobilization.

Table 4. Unit Costs and Delivery Platforms Used to Estimate Selected Nutrition-Sensitive Intervention Costs

Intervention	Unit cost (US$) per benefit unit per year	Delivery platform
Interventions delivered through the agriculture sector		
Biofortification of vitamin A-rich (orange) maize	426.52 per hectare	Agriculture production
Biofortification of vitamin A-rich (orange) sweet potato	229.52 per hectare	Agriculture production
Aflatoxin control through biocontrol application (aflasafe™)	15.60 per hectare	Agriculture production
Promotion of diet diversity	2.10 per farmer	Agriculture extension services
Interventions delivered through the education sector		
School-based deworming	0.09 per student	School-based deworming distribution
School-based promotion of good hygiene	2.00 per student	School-based hygiene education campaign
School-based treatment of bilharzias	0.27 per student	School-based deworming distribution
School-based feeding	17.00 per student	School-based meal provision

Estimation of Costs and Benefits

The *program experience* methodology employed in *Scaling Up Nutrition. What Will It Cost?* (World Bank 2010) is used for calculating the cost of scaling up in Zambia. This approach generates unit cost data that capture all aspects of service delivery (e.g., costs of commodities, transportation and storage, personnel, training, supervision, monitoring and evaluation, relevant overhead, wastage, etc.) for each intervention from actual programs that are already in operation in Zambia and considers the context in which they are delivered. Another commonly used method is the *ingredients approach* in which selected activities are bundled into appropriate delivery packages (for example, number of visits to a health center) (see, e.g., Bhutta et al. 2013). Although the program experience approach tends to yield cost estimates that are higher than the ingredients approach, these estimates more accurately reflect real programmatic experience, including inefficiencies in service delivery. It should, however, be noted that the calculated costs are reported in financial or budgetary terms. They do not capture the full social resource requirements, which account for the opportunity costs of the time committed by beneficiaries accessing the services.

We calculate the annual public investment required to scale up the interventions as follows:

$$Y = (x_1 + x_2) - x_3$$

where:

Y = annual public investment required to scale up to full coverage[3]
x_1= additional total cost to scale up to full coverage
x_2= additional cost for capacity development, M&E, and technical assistance
x_3= cost covered by households living above poverty line for selected interventions

Appendix 4 describes the methodology in detail.

The expected benefits from scaling up nutrition interventions are calculated in terms of (1) DALYs averted, (2) number of lives saved, (3) cases of childhood stunting averted, and (4) increased program coverage. To calculate the number of DALYs, we use the method employed by Black et al. (2008) to estimate the averted morbidity and mortality from scaling up different nutrition interventions. The method uses population attributable fractions (PAF) based on the comparative risk assessment project (Ezzati et al. 2004; Ezzati et al. 2002) to estimate the burden of infectious diseases attributable to different forms of undernutrition using most recent *Global Burden of Disease Study* (IHME 2010). The estimation of DALYs averted is limited to 8 of the 10 interventions in the package.[4] Appendix 5 describes the detailed methodology for estimating DALYs. The projected number of lives saved and cases of childhood stunting averted is calculated using the Lives Saved Tool (LiST), which translates measured coverage changes into estimates of mortality reduction and cases of childhood stunting averted. Because of the limitations of LiST, it was possible to estimate the lives saved for only seven interventions,[5] and the cases of child stunting averted for five interventions.[6] Appendix 6 describes the methodology for the LiST estimates. The increased program coverage is calculated by subtracting the current coverage rate from full coverage and multiplying this difference by the size of the target population for each intervention.

The measures for cost-effectiveness of nutrition-specific interventions are calculated in terms of *cost per DALY averted, cost per life saved,* and *cost per case of stunting averted*. Estimates of benefits were combined with information on costs to produce the cost-effectiveness measures for each intervention as well as for the overall package of intervention. The evaluation of the cost-effectiveness ratio in terms of DALYs averted is based on the categorization used by WHO-CHOICE (Choosing Interventions that are Cost-Effective):[7] an intervention is considered to be "very cost-effective" if the range for the cost per DALY averted is less than GDP per capita;[8] "cost-

---

[3] *Full coverage* is defined as 100 percent of the target population for all interventions except for community-based treatment of severe acute malnutrition, for which full coverage is assumed to be 80 percent.

[4] Because of limitations in the estimation tool, it was not possible to calculate estimates for two interventions: iron fortification of staples and salt iodization.

[5] The seven interventions are breastfeeding and complementary feeding promotion, vitamin A supplementation, therapeutic zinc supplementation with oral rehydration solution, iron-folic acid supplementation, maternal multiple micronutrient supplementation, the public provision of complementary food for the prevention of moderate acute malnutrition, and community-based management of severe acute malnutrition.

[6] The five interventions are breastfeeding and complementary feeding promotion, vitamin A supplementation, iron-folic acid supplementation, maternal multiple micronutrient supplementation, and the public provision of complementary food for the prevention of moderate acute malnutrition.

[7] Information on the cost-effectiveness thresholds used by WHO-CHOICE can be found at http://www.who.int/choice/costs/CER_levels/en/

[8] Zambia GDP per capita in current U.S. dollars was $1,540 in 2013 (World Bank 2014).

effective" if it is between one and three times GDP per capita; and "not cost-effective" if it exceeds three times GDP per capita (WHO 2014).

Cost-benefit analysis is based on the estimated economic value of the benefits attributable to nutrition-specific interventions. In order to arrive at a dollar value for the impact on mortality and morbidity of a one-year investment in reaching full national coverage, we use estimates of the number of lives saved and the reduction in stunting prevalence produced by the LiST tool. Consistent with the methodology used to quantify the benefits of health and nutrition interventions in Stenberg et al. (2014), a statistical life year saved is valued as equivalent to gross national income (GNI) per capita; this is considered to be a conservative measure because it accounts for only the economic, not the social, value of a year of life. In order to estimate the value of the reduction in stunting, we follow the methodology used in Hoddinott et al. (2013), which values a year of life lived without stunting.[9] Future benefits are then age-adjusted and discounted at three potential discount rates (3, 5, and 7 percent) in order to arrive at their present value. The present value of future benefits is then compared with the annual public investment required, which allows us to estimate the net present value (NPV) and internal rate of return of the investment. A detailed explanation of the benefit estimation methodology can be found in Appendix 7.

The annual increase in economic productivity over the productive lives of beneficiaries attributable to each package of interventions is calculated based on the same estimates of future benefits. Although these benefits occur several years after the investment, we assume that they serve as an approximation of the present value of economic productivity lost each year as a result of mortality and morbidity that would otherwise be prevented by scaling up nutrition interventions. Values presented are taken from a year in which all beneficiaries have reached productive age.

The approach for estimating the potential costs and benefits of nutrition-sensitive interventions differs from the methodology used for nutrition-specific interventions. Similar to nutrition- specific interventions, the total cost for scaling up the interventions is calculated by multiplying the unit cost by the target population (either local Zambian unit costs or regional unit costs are used, depending on availability). However, since most nutrition-sensitive interventions have multiple objectives, it is not always feasible to attribute the nutrition-related benefits to the overall costs of the interventions. Because these constraints limit the accuracy of cost-effectiveness estimates, we instead rely on secondary sources and published literature when available, with cost-effectiveness presented in terms of cost per DALY averted.

Scenarios for Scaling Up Nutrition Interventions

When estimating the costs and benefits of scaling up nutrition interventions, we begin with estimates for scaling up all 10 interventions to full national coverage, followed by estimates for various scale-up scenarios. The full-coverage estimates can be considered the medium-term policy goal for the Government of Zambia, but resource constraints will likely limit the government's ability to achieve full national coverage in the short term. Therefore we also propose four scenarios for prioritizing the scale-up of nutrition interventions over a short-term time frame of five years:

---

[9] Hoddinott et al. (2013) assume that stunted individuals lose an average of 66 percent of potential lifetime earnings.

- Scenario 1: Scale up by province
- Scenario 2: Scale up by intervention
- Scenario 3: Scale up by province and intervention
- Scenario 4: Scale up by varying program coverage

Within each scenario we consider variations and analyze their cost-effectiveness in terms of cost per DALY averted, cost per life saved, and cost per case of childhood stunting averted. After our initial analysis, we present the most attractive scale-up scenarios and discuss them in more detail.

Full coverage is defined as 100 percent of the target population for all interventions except the treatment of severe acute malnutrition, for which full coverage is assumed to be 80 percent. This definition is consistent with the methodology used in World Bank (2010) and is based on the reality that few community-based treatment programs have successfully achieved more than 80 percent coverage at scale. Under Scenario 4 we also propose several “partial coverage” scenarios that reduce coverage targets.

PART III – RESULTS FOR NUTRITION-SPECIFIC INTERVENTIONS

Total Cost, Expected Benefits, and Cost Effectiveness

The total additional public investment required to scale up 10 nutrition-specific interventions from current coverage levels to full coverage at the national level in Zambia is estimated to be $40.5 million annually (Table 5). This cost includes the additional cost of scaling up all 10 interventions across the entire country ($46.1 million per year) plus additional resources for monitoring and evaluation (M&E), operations research and technical support, and capacity development for program delivery (estimated at $5.0 million). Of this total amount of $51.2 million, part of the costs for iron fortification, multiple micronutrient powders for children, salt iodization, and the public provision of complementary foods for moderate acute malnutrition could be covered from private resources from households above the poverty line (estimated at $10.7 million), which leaves a financing gap of $40.5 million for a full scale-up nationwide.

Table 5. Estimated Annual Cost of Scaling Up Nutrition-Specific Interventions to Full Coverage

Intervention	Annual Cost (US$ millions)
Breastfeeding and complementary feeding promotion (children)	5.7
Vitamin A supplementation (children)	0.6
Therapeutic zinc supplementation with ORS (children)	2.3
Multiple micronutrient powders (children)	2.3
Deworming (children)	1.0
Iron-folic acid supplementation (pregnant women)	0.05
Iron fortification of staple foods (general public)	2.2
Salt Iodization (general public)	0.03
Public provision of complementary food for prevention of moderate acute malnutrition (children)	23.0
Community-based treatment of severe acute malnutrition (children)	8.9
Total cost for scaling up all 10 interventions	46.1
Capacity development for program delivery	4.1
M&E, operations research, and technical support	0.9
Household contributions from private resources	,<10.7>
ANNUAL PUBLIC INVESTMENT REQUIRED	40.5

The expected benefits from scaling up these 10 nutrition-specific interventions across the entire country are enormous (Table 6). Once the interventions are scaled up to 100 percent, 112,545 DALYs and 2,859 lives would be saved annually, while 62,195 cases of stunting among children under five would be averted annually. Program coverage is assumed to expand as follows:

- 1.1 million families with children 0–23 months of age would be reached by community programs for breastfeeding and complementary feeding promotion
- 601,000 children 6–59 months of age would receive twice-yearly doses of life-saving vitamin A supplementation
- 2.6 million children 6–59 months of age would receive zinc supplementation as part of diarrhea management
- 640,000 children 6–23 months of age would receive vitamins and minerals through multiple micronutrient powders
- 909,000 children 12–59 months of age would receive deworming medication
- 24,000 additional pregnant women would receive iron-folic acid tablets as part of their antenatal care
- 14.0 million people would be able to consume staple foods fortified with iron
- 617,000 people who do not currently use iodized salt would be able to obtain it
- 263,000 children 6–59 months of age would be treated for severe acute malnutrition using community-based management practices
- 95,000 children aged 6–23 months of age would receive a small amount of nutrient-dense complementary food for the prevention or treatment of moderate malnutrition

Table 6. Estimated Annual Benefits for Scaling Up 10 Nutrition-Specific Interventions to Full Coverage

Intervention	Number of beneficiaries covered	DALYs averted[a]	Lives saved	Number of stunting cases averted
Breastfeeding and complementary feeding promotion (children)	1,147,221	16,019	334	21,292
Vitamin A supplementation (children)	601,814	6,321	155	5,043
Therapeutic zinc supplementation with ORS (children)	2,560,912	31,968	960	—
Micronutrient powders (children)	640,203	—	—	—
Deworming (children)	908,835	3,035	—	—
Iron-folic acid supplementation (pregnant women)	23,935	264[b]	6	280
Iron fortification of staple foods (general public)	14,024,707	—	—	—
Salt iodization (general public)	617,087	—	—	—
Public provision of complementary food for	262,988	28,898	475	56,872

prevention of moderate acute malnutrition (children)				
Community-based treatment of severe acute malnutrition (children)	95,062	42,992	1,293	—
Total when all interventions implemented simultaneously[c]	—	112,545	2,859	62,195

Note: ORS = oral rehydration salts; — = not available.
a. DALY estimates in this study are neither discounted nor age-weighted, in line with the methodology used in the IHME Global Burden of Disease 2010 and the WHO Global Health Estimates 2012. For more information on the methodology used to calculate DALYs averted, see Appendix 5.
b. DALY estimates for iron-folic acid supplementation are calculated for DALYs averted among pregnant women. They do not include the DALYs averted among children born to mothers who received these supplements.
c. The total of the interventions implemented simultaneously does not equal to the sum of the individual interventions. This is because some interventions affect nutrition outcomes via similar pathways, causing their combined impact to be different than the individual sums.

For the package as a whole, the total cost per DALY averted is estimated to be $410, the total cost per life saved is estimated to be $16,126, and the total cost per case of stunting averted is estimated to be $741 (Table 7).[10] Variation in cost-effectiveness among the interventions is high, with costs per DALY averted ranging from $72 for zinc supplementation to $796 for the public provision of complementary foods. Overall, these cost estimates translate into an increase in annual public resource requirements of $14.42 per child. This compares favorably to global estimates of $30 per child calculated in World Bank (2010).

All 10 proposed nutrition-specific interventions are “very cost-effective” according to the WHO/CHOICE criteria (WHO 2014). As shown in Table 7, these 10 intervention are “very cost-effective” in that the cost per DALY averted is below the Zambian GDP per capita of $1,540 in 2013 (World Bank 2014). Although public provision of complementary food for the prevention of moderate acute malnutrition is cost-effective with the cost per DALY averted estimated of $796, it is the least cost-effective of the 10 interventions considered. In countries such as Zambia where fiscal and capacity constraints limit scale-up, the public provision of complementary foods may be a lower priority. Issues of governance, accountability, and supply logistics will further constrain the scale-up of the public provision of complementary foods.

[10] For the total cost per benefit unit, we divide the total annual program cost for all 10 interventions (excluding M&E, and capacity development costs, but before subtracting household contributions) by the benefits estimates available. Because of limitations of the LiST tool, DALYs averted estimates are available for only 7 interventions, lives saved estimates are available for 6 interventions, and stunting reduction estimates are available for 4 interventions.

Table 7. Cost-Effectiveness of Scaling Up 10 Nutrition Interventions to Full Coverage, US$

Intervention	Cost/DALY averted		Cost/life saved	Cost/case of stunting averted
	Zambia	Global		
Breastfeeding and complementary feeding promotion (children)	357 [a]	53–153	17,140	269
Vitamin A supplementation (children)	89 [a]	3–16	3,628	112
Therapeutic zinc supplementation with ORS (children)	72 [a]	73	2,401	—
Micronutrient powders (children)	—	12.2	—	—
Deworming (children)	327 [a]	—	—	—
Iron-folic acid supplementation (pregnant women)	188 [a]	66–115	8,290	178
Iron fortification of staples (general public)	—	—	—	—
Salt iodization for general population	—	—	—	—
Public provision of complementary food for prevention of moderate acute malnutrition (children)	796 [a]	500–1,000	48,455	405
Community-based treatment of severe acute malnutrition (children)	207 [a]	41	6,867	—
Total when all interventions implemented simultaneously[b]	**410** [a]	—	**16,126**	**741**

Note: ORS = oral rehydration salts; — = not available.
a. Very cost-effective according to WHO-CHOICE criteria (WHO 2014).
b. The total of the interventions implemented simultaneously does not equal to the sum of the individual interventions. This is because some interventions affect nutrition outcomes via similar pathways causing their combined impact to be different than the individual sums.

Potential Scale-Up Scenarios

Scenario 1: Scaling Up by Province

Table 8 shows the estimated costs and benefits of scaling up the 10 nutrition-specific interventions by province. The provinces are grouped according to the rate of stunting prevalence in 2013–14: those with higher prevalence (stunting over 40 percent) and those with lower prevalence (stunting between 35 and 39 percent). The lack of wide variation in stunting rates across provinces, combined with the fact that provinces in the lower prevalence category have (collectively) a greater population and therefore a higher total number of stunted children, means that it is hard to prioritize some provinces over others, as demonstrated in Table 8. Concentrating on the five highest prevalence provinces would require $20.7 million and avert over 58,000 DALYs and save over 1,200 lives, whereas addressing stunting in the lower prevalence provinces would cost $19.8 million and avert almost 70,000 DALYs and save over 1,500 lives.

Table 8. Scenario 1: Cost and Benefits of Scaling Up 10 Nutrition-Specific Interventions by Province

Province	Annual public investment (US$, millions)	Annual benefits	
		DALYs averted	Lives saved
Higher prevalence (over 40% stunting) [a]	$20.7	58,405	1,274
Rural lower prevalence (35–39% stunting) [b]	$9.2	26,743	581
Urban lower prevalence (35–39% stunting) [c]	$10.5	43,128	970
Total when all interventions implemented simultaneously	**$40.5**	**112,545***	**2,859***

Note: Cells in red indicate recommended interventions under this scenario.
a. Central, Eastern, Luapula, Muchinga, and Northern provinces
b. Northwestern, Southern, and Western provinces
c. Copperbelt, Lusaka,
* The total of the interventions implemented simultaneously does not equal to the sum of the individual interventions. This is because some interventions affect nutrition outcomes via similar pathways, causing their combined impact to differ from the individual sums.

Concentrating only on the higher stunting prevalence provinces would increase program coverage as follows:

- 0.5 million families with children 0–23 months of age would be reached by community programs for breastfeeding and complementary feeding promotion
- 0.3 million children 6–59 months of age would receive twice-yearly doses of life-saving vitamin A supplementation
- 1.1 million children 6–59 months of age would receive zinc supplementation as part of diarrhea management
- 0.3 million children 6–23 months would receive vitamins and minerals through multiple micronutrient powders
- 0.4 million children 12–59 months would receive deworming medication;
- 0.01 million pregnant women would receive iron-folic acid tablets as part of their antenatal care
- 6.2 million people would be able to consume staple foods fortified with iron
- 0.3 million people who do not currently use iodized salt would be able to obtain it
- 0.1 million children aged 6–23 months of age would receive the public provision of a small amount of nutrient-dense complementary food for the prevention of moderate malnutrition

- 0.04 million children 6–59 months of age would be treated for severe acute malnutrition using community-based management practices

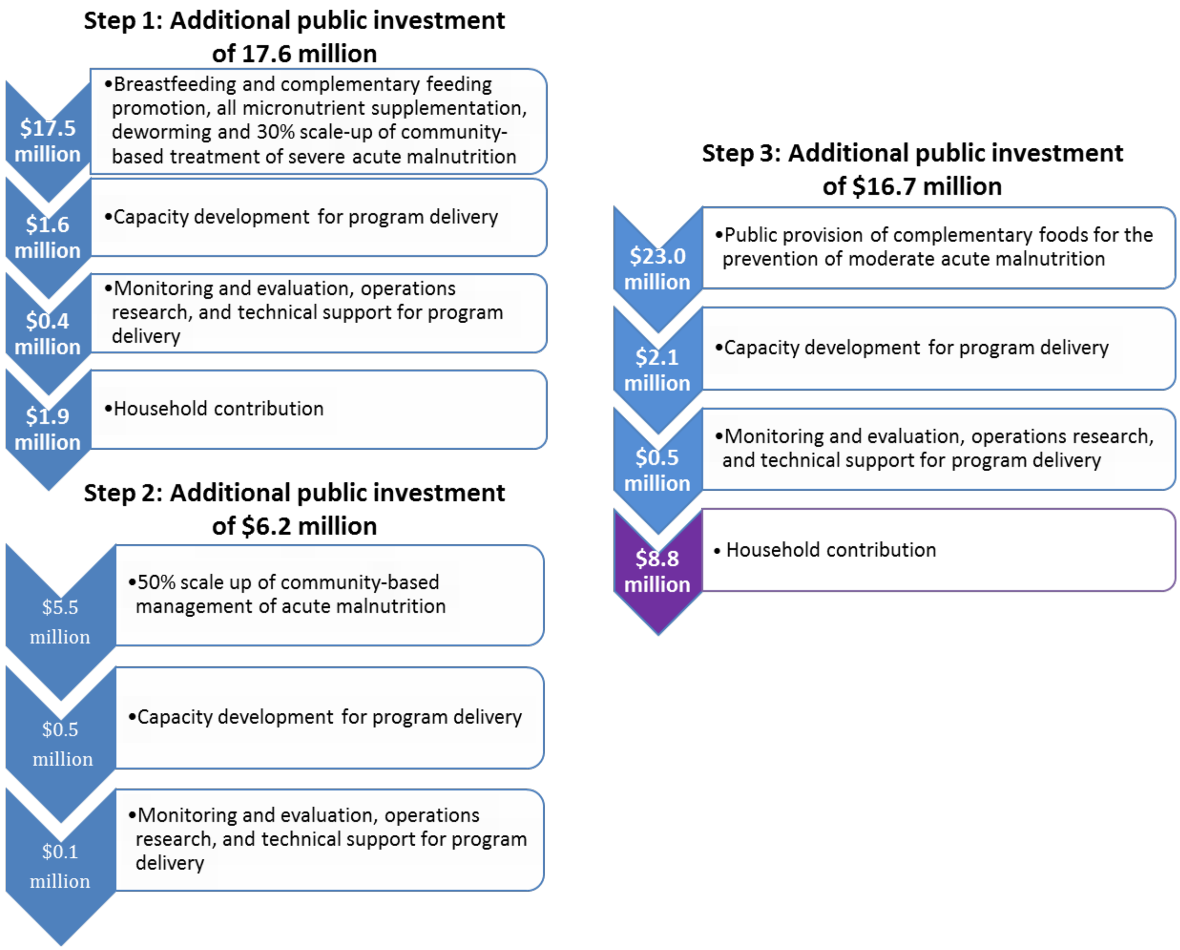
Scenario 2: Scaling Up by Intervention

Scenario 2 is based on a stepwise scale-up by intervention. The primary considerations for choosing the interventions in each step are cost effectiveness, recommended phasing of interventions, implementation capacity, and delivery mechanisms. The proposed plan for a stepwise scale-up by intervention is summarized below and illustrated in Figure 9.

- **Step 1** focuses on a package of primarily preventive interventions that can be scaled up quickly, either with existing capacities or with modest investment in capacity-building for community nutrition programs for breastfeeding and complementary feeding promotion and child health days. It also includes community-based treatment of severe acute malnutrition at 30 percent coverage. The cost of Step 1 is $17.6 million. An additional $1.6 million for capacity development and $0.4 million for monitoring and evaluation, operations research, and technical support is budgeted, which brings the total cost of Step 1 to $19.5 million. The portion of scale-up costs that could be covered by households above the poverty line is estimated at $1.9 million. **Therefore the total public investment required for Step 1 is estimated at $17.6 million**.
- **Step 2** includes the costs of a full scale-up of treatment for severe acute malnutrition from a base of 30 percent in Step 1 to 50 percent coverage, with the assumption that additional implementation capacities are built in Step 1. The estimated cost of this scale-up is $5.5 million. We also include an additional $0.5 million for capacity development and $0.1 million for monitoring and evaluation, operations research, and technical support in Step 2, which brings the total **public investment required for Step 2 to $6.2 million**. (There is no household contribution for this intervention.)
- **Step 3** adds scaling up of the public provision of complementary foods to prevent and treat moderate malnutrition among children under two years of age. The total cost of this intervention is $23.0 million. We also include an additional $2.1 million for capacity development and $0.5 million for monitoring and evaluation, operations research, and technical support. Of the total cost of $25.5 million, an estimated $8.8 million could be resourced from private resources in households above the poverty line. This brings **the estimated public investment required for Step 3 to $16.7 million**.

Step 3 interventions are assigned the lowest priority for the following reasons: (1) the 2013 *Lancet* nutrition series concluded that there are no additional benefits to public provision of complementary foods beyond those provided by dietary counseling and education; (2) at $796 per DALY averted, the public provision of complementary foods for the preventions of moderate acute malnutrition is not as cost-effective as other key interventions (as discussed above); (3) the total cost of complementary foods is overwhelming and accounts for more than half cost of the total cost of scaling up all interventions, while the benefits as estimated lives saved or DALYs averted are lower than other interventions; (4) governance, accountability, supply-chain, and logistics are key challenges associated with large-scale food distribution. The estimated benefits do not outweigh these risks, and the costs are high when compared with other interventions. Under these circumstances, rapid scale-up is neither feasible nor recommended.

Figure 9. Scenario 2: Stepwise Scale-Up by Intervention



Note: There is no household contribution for Step 2 interventions.

The preferred scale-up scenario would be to scale up Step 1 and Step 2 interventions, requiring an annual public investment of $23.7 million. As shown in Table 9, this would avert 99,379 DALYs and save 2,358 lives. It would also provide the following additional program coverage:

- 1.1 million families with children 0–23 months of age would be reached by community programs for breastfeeding and complementary feeding promotion
- 601,000 additional children 6–59 months of age would receive twice-yearly doses of life-saving vitamin A supplementation
- 2.6 million children 6–59 months of age would receive zinc supplementation as part of diarrhea management
- 640,000 children 6–23 months of age would receive vitamins and minerals through multiple micronutrient powders
- 909,000 million children 12–59 months of age would receive deworming medication
- 24,000 million pregnant women would receive iron-folic acid tablets as part of their antenatal care
- 14.0 million people would be able to consume staple foods fortified with iron
- 617,000 people who do not currently use iodized salt would be able to obtain it

- 95,000 children 6–59 months of age would be treated for severe acute malnutrition using community-based management practices

Table 9. Scenario 2: Costs and Benefits of Scaling Up Nutrition-Specific Interventions by Intervention

Interventions	Annual public investment (US$, millions)	Annual benefits	
		DALYs averted	Lives saved
Step 1: Community nutrition programs, all micronutrient and deworming interventions, 30% of community-based treatment of severe acute malnutrition	$17.6	73,234	1,617
Step 2: 50% of community-based treatment of severe acute malnutrition	$6.2	26,145	741
Subtotal (step 1 and 2 interventions when implemented simultaneously)[a]	**$23.7**	**99,379**	**2,358**
Step 3: Public provision of complementary food for the prevention of moderate malnutrition	$16.7	28,898	467
TOTAL when all interventions implemented simultaneously[a]	$40.5	**112,545**	**2,859**

Note: Cells in red indicate recommended interventions under this scenario.
a. The total of the interventions implemented simultaneously does not equal to the sum of the individual interventions. This is because some interventions affect nutrition outcomes via similar pathways, causing their combined impact to be different than the individual sums.

Scenario 3: Scaling Up by Province and by Intervention

Scenario 3 is a hybrid of Scenarios 1 and 2 and proposes the scaling up by province and by selected interventions as listed in Table 10 below. **The preferred scenario is to scale up Step 1 and Step 2 interventions in provinces where stunting rates exceed 40 percent (the higher prevalence provinces). This requires an annual public investment of $10.8 million and averts 45,056 DALYs and saves 1,042 lives (Table 11).**

Scenario 3 would provide the following program benefits:

- 0.5 million families with children 0–23 months of age would be reached by community programs for breastfeeding and complementary feeding promotion
- 0.2 million children 6–59 months of age would receive twice-yearly doses of life-saving vitamin A supplementation
- 1.1 million children 6–59 months of age would receive zinc supplementation as part of diarrhea management

- 0.2 million children 6–23 months of age would receive vitamins and minerals through multiple micronutrient powders
- 0.4 million children 12–59 months of age would receive deworming medication
- 0.01 million pregnant women would receive iron-folic acid tablets as part of their antenatal care
- 6.2 million people would be able to consume staple foods fortified with iron
- 0.3 million people who do not currently use iodized salt would be able to obtain it
- 0.04 million children 6–59 months of age would be treated for severe acute malnutrition using community-based management practices

Table 10. Scenario 3: Costs of Scaling Up Nutrition-Specific Interventions by Province and by Intervention, US$ millions

Intervention/Province	Higher prevalence provinces[a]	Rural and Urban lower prevalence provinces[b]
Step 1 interventions: Community nutrition programs, all micronutrient and deworming interventions, 30% of community-based treatment of severe acute malnutrition	$8.1	$9.5
Step 2 interventions: 50% of community-based treatment of severe acute malnutrition	$2.7	$3.5
Step 3 interventions: Public provision of complementary food for prevention of moderate acute malnutrition	$9.9	$6.9

Note: Cells in red indicate recommended interventions under this scenario.
a. Central, Eastern, Luapula, Muchinga, and Northern provinces.
b. Copperbelt, Lusaka, Northwestern, Southern, and Western provinces.

Table 11. Scenario 3: Costs and Benefits of Scaling Up Nutrition-Specific Interventions by Intervention and Province

Interventions and provinces	Annual public investment (US$, millions)	Annual benefits	
		DALYs averted	Lives saved
Step 1 and 2 interventions in higher prevalence provinces[a]	$10.8	44,056	1,042
Step 1 and 2 interventions in rural and urban lower prevalence provinces[b]	$12.9	55,323	1,316
Step 3 interventions in all provinces	$16.7	28,898	467
TOTAL when all interventions are implemented simultaneously[c]	**$40.5**	**112,545**	**2,859**

Note: Cells in red indicate recommended interventions under this scenario.
a. Central, Eastern, Luapula, Muchinga, Northern provinces.
b. Copperbelt, Lusaka, Northwestern, Southern, Western provinces.
c. The total of the interventions implemented simultaneously does not equal to the sum of the individual interventions. This is because some interventions affect nutrition outcomes via similar pathways causing their combined impact to be different than the individual sums.

Scenario 4: Scaling up by varying program coverage

As discussed above, the previous scenarios assume full program coverage. Scenario 4 allows for partial coverage rates as a way to scale-up to the eventual full coverage scenario (Table 12).

Table 12. Full and Partial Program Coverage Targets

Intervention	Percent of target population covered by Year 5	
	Full coverage (Scenarios 1, 2, and 3)	Partial coverage (Scenario 4)
Community programs for growth promotion	100	80
Vitamin A Supplementation	100	100
Therapeutic zinc Supplementation with ORS	100	80
Micronutrient powders for children	100	80
Deworming	100	100
Iron-folic acid supplementation for pregnant women	100	80
Maternal multiple micronutrient supplementation	100	80
Iron fortification of staple foods	100	80
Salt iodization	100	80
Public provision of complementary food for prevention of moderate acute malnutrition	100	50
Community-based treatment of severe acute malnutrition	80	50

The first possibility (4a) under Scenario 4 would scale up all interventions to the partial coverage levels and would require total annual public investment of $24.7 million (Table 13). This scenario would avert 73,805 DALYs, save 1,893 lives and avert 33,619 cases of stunting among children under five.

Table 13. Scale up Possibilities Considered Under Scenario 4

Scale up option	Annual public investment (US$, millions)	Annual benefits	
		DALYs averted	Lives saved
Scenario 4a: All interventions in all provinces at partial coverage rates	$24.7	73,805	1,893
Scenario 4b: Step 1 and Step 2 interventions in all provinces at partial coverage rates	**$11.2**	**69,184**	**1,659**

Note: Cells in red indicate recommended interventions under this scenario.

Scenario 4b would scale up all interventions except the public provision of complementary foods in all provinces. This would require an annual public investment of $11.2 million, and would also avert 69,184 DALYs, save 1,659 lives and avert 22,076 cases of stunting among children under five. This option would provide the following program benefits:

- 1.1 million children 6–59 months of age would receive twice-yearly doses of life-saving vitamin A supplementation
- 0.6 million families with children 0–23 months of age would be reached by community programs for breastfeeding and complementary feeding promotion
- 2.6 million children 6–59 months of age would receive zinc supplementation as part of diarrhea management
- 0.6 million children 6–23 months of age would receive vitamins and minerals through multiple micronutrient powders
- 0.9 million children 12–59 months of age would receive deworming medication
- 14.0 million people would be able to consume staple foods fortified with iron
- 0.6 million people who do not currently use iodized salt would be able to obtain it
- 0.1 million children 6–59 months of age would be treated for severe acute malnutrition using community-based management practices

Cost-Benefit Analysis of All Scenarios

When considered in terms of cost-effectiveness (cost per benefit unit) and total resources required, Scenarios 2 and 4b stand out as the most attractive. Table 14 presents a comparison of the costs and benefits of the scenarios considered in this analysis. Based on cost per DALY averted, the two most cost-effective scenarios (2 and 4b) both involve scaling up nine of the 10 interventions. The excluded intervention is the public provision of complementary foods for the prevention of moderate acute malnutrition, which is not nearly as cost-effective as the other nine interventions. Scenario 4b is the most cost-effective, with a cost per DALY averted of $166, and would scale up the nine interventions to partial coverage levels nationwide. This scenario would require $11.2 million annually and would avert over 69,000 DALYs, save almost 1,700 lives, and prevent over 22,000 cases of stunting. Although Scenarios 2 and 3 are equally cost-effective, at a cost of about $230 per DALY averted and $9,750 per life saved, Scenario 2 would provide benefits nationwide, making it more politically feasible. This option would require a larger annual public investment of $23.7 million, but would also avert over 99,000 DALYs and save over 2,300 lives. The choice between these two scenarios will mainly depend on the level of resources Zambia is able to leverage for nutrition interventions.

Table 14. Costs and Benefits of All Scenarios

Scenarios	Annual public investment (US$, millions)	Annual Benefits			Cost per Benefit Unit		
		DALYs averted	Lives saved	Cases of stunting averted	Cost/ DALY averted	Cost/ life saved	Cost/ case of stunting averted
Full coverage	$40.5	112,545	2,859	62,195	$410	$16,126	$741
Scenario 1	$20.7	58,405	1,274	—	$370	$16,947	—
Scenario 2	**$23.7**	**99,379**	**2,358**	**—**	**$232**	**$9,739**	**—**
Scenario 3	$10.8	44,056	1,042	—	$231	$9,756	—
Scenario 4a	$24.7	73,805	1,893	33,619	$374	$14,574	—
Scenario 4b	**$11.2**	**69,184**	**1,659**	**22,076**	**$166**	**$6,933**	**—**

Note: Cells in red indicate recommended interventions under this scenario.
— = not available.

Estimated Costs over a Five-Year Scale-Up Period

Until this point in the analysis, the costs are presented assuming scale-up over a one year. However, recognizing that a slower, incremental scale up may be more feasible, we also estimate the cost for scaling up selected scenarios over a five-year time frame (Table 15). A five-year scale up of all 10 interventions nationwide is estimated to cost $134.5 million, whereas Scenario 2 would require an investment of $70.8 million and Scenario 4b would require $34.7 million. Interventions are assumed to scale from current coverage as follows: 20 percent of scale up in Year 1, 40 percent in Year 2, 60 percent in Year 3, 80 percent in Year 4, and 100 percent in Year 5. For these calculations, we consider the expenditures on capacity development and system strengthening required to scale to full coverage to be a fixed cost, with some additional funds allocated to refresher training and rehiring in the years after scale has been reached. Thus, the average annual amount spent on capacity development is allocated across the five years, rather than increasing in proportion to coverage as is the case with the other costs.

Table 15. Scale Up over Five Years for Selected Scenarios (US$, millions)

Scenario	Year 1 (20% coverage)	Year 2 (40% Coverage)	Year 3 (60% coverage)	Year 4 (80% coverage)	Year 5 (100% coverage)	Total Scale Up Costs Over 5 Years
Scale up of all 10 interventions nationwide	6.8	16.8	27.6	37.0	46.4	**$134.5**
Scenario 2	$4.8	$9.5	$14.2	$18.9	$23.6	**$70.8**
Scenario 4b	$2.2	$4.5	$7.0	$9.3	$11.7	**$34.7**

Note: Expenditures on capacity development and system strengthening required to scale to full coverage treated as a fixed cost, with some additional funds allocated to refresher training and rehiring in the years after scale has been reached.

Estimated Economic Benefits and Economic Analysis

A high burden of malnutrition negatively impacts a nation's human capital. An investment in improving nutrition outcomes among Zambian children is therefore also an investment in the country's economic future. The two main ways in which malnutrition affects economic productivity are increased mortality and morbidity—in other words, lives lost and years lived with a disease or disability. For the purposes of this analysis, we estimate the potential economic benefits of scaling up nutrition interventions in terms of lives saved (reduction in mortality) and cases of stunting averted (reduction in morbidity). Because each life lost results in one less citizen contributing to the nation's economy, and because stunted children tend to earn and consume less, these impact estimates help us to arrive at approximations of the return on investment attributable to the scale-up of a particular package of interventions.

The economic benefits of investing in these effective nutrition interventions are tremendous (Table 16). Scaling up all 10 interventions nationwide could produce an annual increase of $915 million in national economic productivity over the productive lives of the children affected. Investing in the lower-cost Scenario 4a would also produce an annual increase, of $496 million, in national economic productivity over the lives of the children affected. (Because of methodological limitations, we were not able to calculate the increases in economic productivity for the other scenarios.)

These estimates of economic benefits are based on a conservative methodology that does not necessarily account for all of the potential benefits associated with improving nutrition outcomes among Zambian children. For example, these figures do not account for future growth in GDP per capita, which would also be expected to increase with improved nutritional outcomes. Furthermore, it is likely that these estimated increases in GDP would also improve equity in Zambia because productivity among the poor would benefit the most from improved nutritional outcomes.

Our analyses also show that these nutrition interventions are excellent economic investments (Table 16). Because an increase in the assumed discount rate reduces the present value of future benefits, we present the results using three possible discount rates: 3, 5, and 7 percent. Both scenarios show highly positive net present values across this range of discount rates, indicating that they are an excellent economic investment. In addition, each of the scenarios would yield a highly positive internal rate of return, another indicator that it is an excellent economic investment.

Table 16. Estimated Economic Benefits and Economic Analysis of Selected Scenarios

Economic measure	Full scenario	Scenario 4a
Annual increase in economic productivity[a]	$915 million	$496 million
Internal rate of return	31.5%	30.6%
Net present value (US$, billions) at 3% discount rate	$13.8	$7.5
Net present value (US$, billions) at 5% discount rate	$7.6	$4.1
Net present value (US$, billions) at 7% discount rate	$4.4	$2.4

Note: Because of methodological limitations of the LiST tool, this analysis is limited to scenarios that include all 10 interventions nationwide.
a. Annual increase in productivity over the productive lives of the beneficiaries.

Financing Nutrition in Zambia

The cost-effectiveness analysis presented here identifies an annual financing gap of at least $11.2 million (Scenario 4b) to $23.7 million (Scenario 2). This is above and beyond the $15.6 million of government and donor funds currently financing nutrition interventions in Zambia (Table 17). Some of the donor contributions, especially the $7.5 million from the United States, may be overestimated. The government budget for 2013 appropriated $1.5 to nutrition interventions. This is an increase of only $300,000 over the previous year and represents only 2 percent of the additional resources needed for even the most modest scale-up scenario.

Some preliminary information is available regarding donor pledges for 2014 to 2016; this information suggests that more than $37 million is pledged for this three-year period (Table 18).[11] This represents a dramatic increase and will go a long way toward financing the needed interventions. Nevertheless, it will not cover both the current expenditures (about $16 million per year) and the additional resources needed for either of the most cost-effective scenarios identified in this analysis: Scenario 2 ($23.7million per year) or Scenario 4b ($11.2 million per year). It will therefore be essential to leverage additional government resources for nutrition interventions, rather than continued exclusive reliance on donor aid.

[11] The nutrition portion of the European Union budget has not yet been finalized and therefore is not included in this figure.

Table 17. Estimated Annual Allocations for Nutrition, 2012

Source of financing	Estimated allocations for 2012 (US$, millions)
United States	7.5
DFID	5.2
Government of Zambia	1.5*
UNICEF	1.0
Irish Aid	0.7
World Food Programme	0.04
Total available financing	**15.6**

Sources: Scaling Up Nutrition 2014 for all figures except Government of Zambia, which is from Zambia Civil Society Scaling Up Nutrition Alliance 2014.
*Denotes budget for 2013.

Table 18. Estimated Donor Funding for 2014–16

Donor	Estimated allocations for 2014–2016 (€, millions)
European Union	€50 for health and nutrition (≈US$62.5 million)
SUN Funding (DFID, Irish Aid, and Sida)	US$29 million
USAID (for both FY 2014 and 2015)	US$7.6 million

Uncertainties and Sensitivity Analyses

Because actual unit costs may differ from our estimates, it is important to consider the effects of both an increase and a decrease in these costs on the overall price of the interventions. This uncertainty is greatest for higher-cost interventions, and less significant for those with lower costs. For example, given the prevalence of information on and experience with less expensive micronutrient and deworming interventions, there is a higher degree of certainty around their estimated costs and financing needs. On the other hand, the costs of community nutrition programs can vary greatly depending on their context, the intensity of behavior change campaigns, the number of community health workers employed, and the amount of incentives provided to them—all of these affect unit costs. Finally, there is very little information concerning the costs of public provision of complementary foods for prevention of moderate acute malnutrition. In Zambia, there is no delivery mechanism that can be used as a reference for the public provision of complementary foods, while unit costs depend on the type of food provided as well as the choice of targeting method. Other factors, such as widespread governance concerns and diversion of the food, also need to be considered. In order to account for these uncertainties, we perform a partial sensitivity analysis that describes the impact of variation in unit costs while holding other variables constant. These results are presented in Appendix 8.

PART IV – RESULTS FOR NUTRITION-SENSITIVE INTERVENTIONS

We present cost-benefit estimates for four nutrition-sensitive interventions delivered through the agriculture sector and four delivered through the education sectors. Table 19 summarizes the cost of scaling up these interventions and, when available, DALYs averted and cost per DALY averted.

Table 19. Preliminary Results for Costing Nutrition-Sensitive Interventions

Intervention	Annual cost (US$, millions)	DALYs averted	Cost/DALY averted (US$)
	Delivered through the agriculture sector		
Biofortification of vitamin A-rich (orange) maize	20.8	1,208,012 [a]	$24[a]
Biofortification of vitamin A-rich (orange) sweet potato	11.2	343,750 [b]	$32[b]
Aflatoxin control through biocontrol application (aflasafe™)	22.7	511,628[c]	$43[c]
Promotion of diet diversity	3.4	—	—
TOTAL for agriculture	**58.1**	—	—
	Delivered through the education sector		
School-based deworming	0.3	—	$4.6[d]
School-based promotion of good hygiene	7.0	—	—
School-based treatment of bilharzias	0.3	—	—
School-based feeding	14.6	—	—
TOTAL for education	**22.2**	—	—

Note: — = not available.
a. Based on estimates for Zambia (Fieldler and Lividini 2014).
b. Based on ex-ante global estimates (Meenakshi et al. 2010).
c. Based on estimates from Nigeria (Khlangwiset 2011).
d. Cost per DALY averted based on a similar program with similar costs in Kenya (J-PAL 2012).

NUTRITION-SENSITIVE INTERVENTIONS DELIVERED THROUGH THE AGRICULTURE SECTOR

The estimated total cost of scaling up biofortification of vitamin A-rich (orange) maize is $20.8 million and of vitamin A-rich (orange) sweet potato is $11.2 million. This is based on the assumption that 50,000 hectares of each breed would be planted in Zambia. Cost per DALY averted for vitamin A-rich maize is estimated at $24 for Zambia, resulted in an estimated 1,208,012 DALYs averted (Fiedler and Lividini 2014). Ex-ante global estimates for vitamin A-rich sweet potato are estimated at $32 (Meenakshi et al. 2010). Meenakshi and colleagues also estimated benefit-cost ratios for maize in Ethiopia and Kenya of between 2 (a pessimistic estimate) and 47 (an optimistic one), and benefit-cost ratios for sweet potato in Uganda of between 17 and 58 (Meenakshi et al. 2010*)*. Taken together, these benefit estimates suggest large potential benefits from biofortication in Zambia. Nevertheless, these interventions are much more costly than the nutrition-specific interventions discussed in the previous section.

The total cost of scaling up aflatoxin reduction through biocontrol of maize is estimated to be $22.7 million. The cost calculation uses the unit cost of aflasafe™ biocontrol developed by IITA and tested in Nigeria, with a cost per hectare of approximately $15.6, including material and distribution costs (Bandyopadhyay 2013). Crop area is based on the FAO's 2010 projections of Zambia maize planting area, which is estimated at a little over a million hectares. It is assumed that aflasafe™ will be applied to all maize fields.[12] The estimated DALYs averted for biocontrol is estimated at 511,628 and assumes a cost per DALY averted of $43 (Khlangwiset 2011). No estimations are currently available for lives saved through aflatoxin control.

NUTRITION-SENSITIVE INTERVENTIONS DELIVERED THROUGH THE EDUCATION SECTOR

The cost of scaling up both school-based deworming and school-based treatment for bilharzia is estimated to be $570,000 annually. The unit cost for deworming ($0.09) and treatment for bilharzia ($0.27) used in the calculation is obtained from Ministry of Education. For deworming, the unit cost estimate compares well with regional estimates of delivery cost in schools for Ghana (Guyatt et al. 2003). The major cost components are human resources, surveillance and mapping, non-donated drugs, advocacy, logistics and implementation, and management. The estimated target population for school-based deworming is 3.5 million school-aged children (6–15 years old) enrolled in primary and secondary schools; current coverage is assumed to be negligible.

The cost of scaling up school-based promotion of handwashing and good hygiene behavior is estimated to be $7 million. Although the promotion of water, sanitation, and hygiene (WASH) in schools normally includes sustainable, safe water supply points, handwashing stands, and sanitation facilities, the costing includes only the component for hygiene education. The target population is 3.5 million school-aged children (6–15 years old) enrolled in primary and secondary schools; current coverage is assumed to be negligible.

The cost of scaling up school-based feeding program is estimated to be us $14.6 million. The unit cost per child is estimated at $17 and is obtained from Ministry of Education. The school-based feeding program is part of School Health and Nutrition program and is expected to reach 860,000 students.

COMPARING NUTRITION-SPECIFIC AND NUTRITION-SENSITIVE INTERVENTIONS

Overall, the nutrition-sensitive interventions considered here are much more costly than the nutrition-specific interventions discussed in the previous section, with the exception of school-based deworming. For example, the biofortification and aflatoxin reduction costed for the agriculture sector would cost more than all of the nutrition-specific interventions proposed under

[12] Most maize in Zambia is consumed by humans, but some is also consumed by livestock. We were not able to estimate how many hectares produce maize for human consumption versus other purposes, so we estimate the cost for all hectares of maize production.

Scenarios 2 and 4b. In addition, the evidence base demonstrating effectiveness in improving nutrition through nutrition-sensitive interventions is significantly weaker than that for nutrition-specific interventions. Taking these two factors together—the costly nature of the interventions and the weaker evidence on effectiveness—we conclude that more pilot projects are needed before prioritizing scarce resources for the nutrition-sensitive interventions considered here. The exception is school-based deworming interventions, which are highly cost-effective and relatively low cost.

PART V: LIMITATIONS

Service delivery assumptions. These analyses focus on the costs of delivering direct nutrition services using services modalities currently in place or that have the potential to be delivered at scale. Where programs did not exist at scale, service delivery assumption were made for the purpose of modeling scale-up costs. However, such decisions need to be reviewed and modified based upon the discretion of implementing agencies. Efficiency gains could potentially be made using alternative service delivery channels.

Our cost estimates are based on a number of assumptions regarding the supply of nutrition services and interventions. First, we assume supply is the limiting factor and that additional demand-generation activities are not necessary to stimulate the consumption of direct nutrition interventions; improving the quality and availability of supply-side will be sufficient to increase coverage to desired levels. This may not be true, particularly for interventions such as rice fortification and the promotion of optimum infant and young child feeding, where non-costed promotion efforts may be necessary to stimulate consumption. Second, we assume that the capacity to absorb the additional financing and scale up the intervention either exists currently or will be developed in the future. Further assessments of health system capacity—in terms of infrastructure, supply chain effectiveness, and human resources for health—are needed to determine whether this is indeed the case. Specifically, as a result of the absence of a human resource time use study, we are limited in our assumption of the incremental nature of the human resource costs included in our estimates.

Assumptions about unit costs. We have assumed that the average unit cost will not change over the next 10 years. It is possible that the delivery of certain services will improve over time thanks to economies of scale, increased efficiency in service delivery, cheaper technologies and products, or other factors. It is also possible that, as the coverage increases, reaching the last 20 percent or 10 percent of beneficiaries will be more expensive and have higher marginal cost. Empirical literature on the over-time changes in the service delivery cost of nutrition interventions is very limited and it is impossible to determine which of the potential cost escalation or de-escalation scenarios are more realistic. Given this level of uncertainty, we selected to assume no changes in service deliver cost.

Cost-benefit and cost-effectiveness calculations. Although this analysis compares effectiveness and cost-effectiveness of different interventions, it does not address various different service modalities options for delivering a specific intervention. Such analysis is beyond the scope of this report. However, it would be very important for planning the expansion of nutrition interventions in Zambia. For example, a study by Puett et al. (2013) showed that outpatient treatment of severe acute malnutrition using ready-to-use therapeutic foods is much more cost-effective than the traditional inpatient treatment. Further analyses comparing cost-effectiveness of different service delivery platforms should be conducted.

Different data sources are used to generate costs versus benefits, which may result in an overstatement of the benefits per dollar spent. Impact analyses using the LiST model use effect estimates from controlled clinical or community trials. During such trials, the delivery of the interventions is closely monitored and supervised and, consequently, services delivered are of very high quality (for example, they exhibit high fidelity with guidelines and protocols, are delivered by highly trained staff, and so forth). The real-life, large-scale programs are likely to be less effective than that of controlled trials. Therefore, the results presented above are likely to be overestimating the cost-effectiveness and economic benefits of the interventions. Nevertheless, given the absence of more accurate data from large-scale national programs, our estimates can be interpreted as reasonable upper-bound estimates. On the other hand, the economic benefits presented, based largely on mortality, morbidity, and cognitive deficits avoided in children under age five, do not include benefits from reductions in anemia and micronutrient deficiency resulting from the fortification of staples in the general population. Therefore, it is likely that the benefits are, in fact, underestimated.

Scope of the analysis. Finally, even though this report focuses almost exclusively on direct nutrition interventions, the causes of malnutrition are multisectoral, so any longer-term approach to improving nutrition outcomes must also include nutrition-sensitive interventions. An important next step will be to extend the cost-effectiveness analysis to nutrition-sensitive interventions implemented outside of the health sector. More robust data on nutrition-sensitive interventions are needed to do this.

PART VI – CONCLUSIONS AND POLICY IMPLICATIONS

Systematic costing of highly effective nutrition interventions is important for priority-setting, resource mobilization, and advocacy. Combining costing with estimates of impact (in terms of lives saved, DALYs averted, and cases of stunting averted) and a cost-effectiveness analysis will make the case for nutrition stronger and will aid in priority-setting by identifying the most cost-effective packages of interventions in situations where financing is constrained. This will potentially be a powerful evidence-based advocacy tool for policy makers (i.e., the Ministry of Finance) when making budget allocations because it provides useful evidence on what the government can "buy" (in terms of lives saved, DALYs averted, or cases of stunting averted) given available resources.

Reaching full national coverage would be expensive and would require a significant increase in the amount of public resources devoted to nutrition in Zambia. Because it is unlikely that the government or its partners will find the $40.5 million annually necessary to reach full national coverage for all nutrition-sensitive interventions, it is important to consider scenarios that make the most of the resources available. Therefore, the findings and recommendations presented here are based on cost-benefit analyses that can help policy makers to prioritize the allocation of resources more effectively so as to achieve maximum impact. The scenario recommended in this report represents a compromise between the need to increase coverage and the constraints imposed by limited resources and capacities.

Scaling up the nine most cost-effective interventions (excluding the public provision of complementary foods) nationwide at either full or partial coverage levels (Scenarios 2 and 4b, respectively) is the most advantageous way to scale up when considered in terms of resource requirements and cost-effectiveness (cost per benefit unit). Scenario 4b is the most cost-effective in terms of cost per DALY averted of $166, and it is also the least costly overall ($11.9 million). It would avert over 69,000 DALYs and save over 1,600 lives. However, Scenario 4b would only scale up interventions to partial coverage levels. Scenario 2 requires more resources ($23.7 million) but is also cost-effective ($232 cost per DALY averted) and scales up all nine interventions to full coverage levels nationwide. Scenario 2 also provides more benefits: over 99,000 DALYs averted and 2,300 lives saved.

Although this report focuses extensively on nutrition-specific interventions, the causes of malnutrition are multisectoral and therefore any longer-term approach to improving nutrition outcomes must also include nutrition-sensitive interventions. This analysis takes an innovative approach to nutrition costing by not only estimating the costs and benefits of nutrition-specific interventions but also exploring costs for a selected number of nutrition-sensitive interventions implemented outside of the health sector. We have identified seven candidate nutrition-sensitive interventions with high impact potential for Zambia: the biofortication of vitamin A-rich maize and sweet potato, aflatoxin control in maize, promotion of diet diversity, school-based deworming, school-based promotion of good hygiene, school-based treatment of bilharzias, and school-based feeding. The most promising of these is school-based deworming, which is very cost-effective and requires fewer resources than the other nutrition-sensitive interventions considered here. However, these interventions are just a starting point, and as the government begins to develop a multisectoral nutrition policy, it would be useful consult across sectors and ministries in order to identify other possible nutrition-sensitive interventions that are cost-effective.

Overall, these findings point to a powerful set of nutrition-specific interventions and a candidate list of nutrition-sensitive approaches that represent a cost-effective approach to reducing the high levels of child malnutrition in Zambia. Most of the malnutrition that occurs in the first 1,000 days of a child's life is essentially irreversible. Investing in early childhood nutrition interventions therefore offers a window of opportunity to permanently lock in human capital.

APPENDIXES

Appendix 1: Partners Collaborating on Nutrition in Zambia

Donor	Program	Amount in US$ millions	Coverage	Status
Government	• Social protection through cash transfer programs	-—	50 districts	Ongoing
DFID, Irish Aid, Sida	• First 1000 Most Critical Days Programme • 60% of the funds support government-supported programs on both national and subnational levels	$27 managed by CARE of which $17 is for nutrition	14 districts	Ongoing
World Bank	• Maternal Child and Neonatal Health through the MOH and MCDMCH	$67 of which $24 is directed toward strengthening basic health services including nutrition interventions	4 provinces	To start in July
European Union	• Millennium Development Goal initiative, to be implemented by UNICEF, WHO, UNFPA • Focus on maternal and child health care at district level	50 million euros (US$68)	11 districts	Inception stage
	• Support to FAO for conservation agriculture	11 million euros (US$15)	31 districts	Inception stage
	• EDF 11- 2014–20	110 million euros (US$150)	N/A	Design stage

	• Conservation agriculture with a built in nutrition element			
Global Agriculture and Food Security Programme (GAFSP)	• Agriculture investment plan • Food security and nutrition	31	6 districts	

Source: REACH 2014.
Note:
DFID = Department for International Development (U.K.)
EDF = European Development Fund
FAO = Food and Agriculture Organization of the United Nations
MCDMCH = Ministry of Community Development, Mother and Child Health
MOH = Ministry of Health
UNFPA = United Nations Population Fund
UNICEF = United Nations Children’s Fund
WHO = World Health Organization

APPENDIX 2: TARGET POPULATION BY PROVINCE

Province	Children 0-23 months to cover under the community nutrition programs (1)	Children 6–59 months not covered by vitamin A supplementation (2)	Children 6–59 months to cover under therapeutic zinc supplementation with oral rehydration salts (3)	Children 6–23 months not covered by multiple micronutrient powders (4)	Children 12–59 not covered by deworming (5)	Pregnant women not receiving iron-folic acid supplementation (6)	Population not using fortified foods (7)	Population not consuming iodized salt (8)	Children 6–23 months to receive complementary feeding (9)	Children 6–59 months not treated for severe acute malnutrition (10)
Central	114,255	69,628	255,049	62,426	87,136	2,073	1,396,765	54,474	27,525	6,856
Copperbelt	182,263	66,725	406,860	103,028	97,337	3,224	2,228,150	89,126	40,465	17,088
Eastern	140,859	77,666	314,436	82,507	141,013	2,939	1,721,993	70,602	28,389	7,396
Luapula	82,647	36,160	184,490	37,478	55,375	2,774	1,010,352	69,714	27,588	18,287
Lusaka	205,512	108,726	458,759	126,201	172,122	2,423	2,512,370	100,495	35,595	17,726
Muchinga	67,643	39,562	150,999	36,639	56,653	1,902	826,936	25,635	16,615	2,537
Northern	101,828	61,601	227,309	49,704	84,883	3,833	1,244,845	94,608	30,464	5,346
North-Western	48,193	24,528	107,580	27,470	42,832	874	589,154	20,031	10,472	5,241
Southern	126,368	67,137	282,089	73,422	98,117	1,777	1,544,844	83,422	26,066	4,739
Western	77,653	46,456	173,342	41,327	67,179	1,867	949,298	6,645	19,808	7,280
NATIONAL	**1,147,221**	**601,814**	**2,560,912**	**640,203**	**908,835**	**23,935**	**14,024,707**	**617,087**	**262,988**	**95,062**

Sources and Notes:

Column 1: Population Census 2010 (Children 0–23 months); **Column 2:** Population Census 2010 (Children 6-–59 months), Vitamin A coverage from DHS 2013-14; **Column 3:** Population Census 2010 (Children 6–59 months); **Column 4:** Population Census 2010 (Children 6–23 months), Percent < −2 WAZ from DHS 2013-14; **Column 5:** Population Census 2010 (Children 12–59 months), Deworming coverage from DHS 2013-14; **Column 6:** Population Census 2010 and Pregnancy Rate of 3.71%, iron-folic acid supplementation coverage from DHS 2013-14; **Column 7:** Population Census 2010 (Total population); **Column 8:** Population Census 2010 (Total population), Percent of households consuming iodized salt from DHS 2013-14; **Column 9:** Population Census 2010 (Children 6–23 months), Percent < −2 WAZ from DHS 2013-14; **Column 10:** Population Census 2010 (Children 6–59 months), Percent < −3 WHZ from DHS 2013-14, SAM treatment coverage (16%) from the Zambian Ministry of Health. This represents the total population of children 6–59 months not treated for severe acute malnutrition although we only expect to reach 80 percent of this population.

APPENDIX 3: DATA SOURCES AND RELEVANT ASSUMPTIONS FOR UNIT COSTS IN ZAMBIA

Intervention	Costed delivery platform	Unit cost (US$ per beneficiary per year)	Source	Assumptions
Community nutrition programs growth promotion (children)	Community nutrition programs	$7.25	MOH 2013; NFNC 2013; Mumbwa District Nutrition Plan 2013	Calculated based on district work plan and combined with central-district level budget (MOH, Mumbwa district budget). Focus is on exclusive breastfeeding, infant and young child complementary food, and hygiene practices, among others.
Vitamin A supplementation (children)	Child Health Weeks	$ 0.94	MOH 2013; Fiedler et al. 2013	Supplements are distributed through biannual maternal, newborn and child health weeks, with overhead costs (for planning, advocacy, social mobilization, health worker and volunteer training, monitoring, supervision) shared with other interventions
Therapeutic zinc supplementation with ORS (children)	Primary health care and community nutrition program	$0.90	MOH 2013	Assuming diarrhea three episodes/year and each required 12 tablets for treatment
Multiple micronutrient powders for children (children)	Community nutrition programs	$3.60	UNICEF 2013	Estimates based on micronutrient powder trial currently underway managed by UNICEF
Deworming (children)	Child Health Weeks	$1.10	MOH 2013; Fiedler et al. 2013	Supplements are distributed through biannual MNCH weeks, with overhead costs (for planning, advocacy, social mobilization, health worker and volunteer training, monitoring, supervision) shared with other interventions

Intervention	Costed delivery platform	Unit cost (US$ per beneficiary per year)	Source	Assumptions
6. Iron-folic acid supplementation of pregnant women	Primary health care and community nutrition programs	$2.11	MOH 2013; NFNC 2012	Assume daily IFA supplements for last two trimesters of pregnancy (about 180 tablets) delivered through primary health care and child health weeks; includes cost of prenatal visits and of supplement.
7. Iron fortification of staple foods (general public)	Market-based delivery system	$0.16	Fiedler 2013	Based on total annual capital and recurrent costs divided by total population
8. Salt iodization (general public)	Market-based delivery system	$0.05	Horton et al. 2010; Aminu 2013	Global estimate is used; no specific information on is Zambia available
9. Public provision of complementary food for prevention of moderate acute malnutrition (children)	Community nutrition programs	$87.50	WFP 2013	Based on a ration of 200 grams per day
10. Community-based treatment of severe acute malnutrition (children)	Primary health care and community nutrition programs	$120.00	MOH 2013	Calculated from MOH budget

Appendix 4: Methodology for Estimating Costs for Zambia

The following steps lay out the methodology used to estimate costs for each intervention:

1. Describe each intervention
2. Define target populations for each intervention
3. Estimate the size of the target populations for each intervention in each province using the most current demographic data
4. Specify the delivery platform or channel(s) for each intervention, based on the country context and the accepted delivery modes
5. Identify data on the current coverage levels for each intervention in each province
6. Estimate the unit cost per beneficiary for each intervention from program experience in Zambia, whenever possible, and/or Africa region
7. Calculate additional costs of scaling up to full coverage by multiplying the unit cost for each intervention with the size of the "uncovered" target population for each intervention by province. The formula for calculation is:

$$x_1 = z_1(100 - z_2)$$

where:

x_1 = additional costs of scaling up to full coverage
z_1 = unit cost per beneficiary
z_2 = current coverage level (percentage)

8. Estimate additional resources for (1) capacity development for program delivery and (2) M&E, operations research, and technical support, estimated at 9 percent and 2 percent of total cost of interventions, respectively
9. Estimate a portion of the total cost that can be covered by private household resources. It is assumed that households above the poverty line could cover their own cost of iron fortification, multiple micronutrient powders, salt iodization. and complementary food from private resources
10. Calculate the annual public investment required to scale up these interventions to full coverage using the following formula:

$$Y = (x_1 + x_2) - x_3$$

where:

Y = annual public investment required to scale up to full coverage
x_1= additional total cost to scale up to full coverage
x_2= additional cost for capacity development, M&E, and technical assistance
x_3= cost covered by households living above poverty line for selected interventions

Full coverage is defined as 100 percent of the target population for all interventions except the treatment of severe acute malnutrition, which is set to 80 percent. This is consistent with World

Bank (2010) methods and is based on the reality that few community-based treatment programs have successfully achieved more than 80 percent coverage at scale.

Appendix 5: Methodology for Estimating DALYs for Zambia

The following steps were undertaken to estimate the impact in DALYs averted of implementing the various nutrition interventions:

1. Estimate the effectiveness of each intervention on mortality and morbidity for each targeted cause
2. Calculate the rate of YLL and YLD due to each cause-risk factor combination for the target population
3. Calculate the DALYs averted under current or counterfactual coverage scenario
4. Calculate the DALYs averted under the proposed intervention coverage scenario
5. Calculate the net DALYs averted by the proposed intervention

1. Estimate the effectiveness of each intervention on mortality and morbidity for each targeted cause

To estimate the effectiveness of the interventions, key articles by Black et al. (2013) and Bhutta et al. (2013) in the *Lancet* series on maternal and child undernutrition were first consulted. Additional literature searches for the latest evidence were conducted in the Pubmed online database and the Cochrane Library of systematic reviews and meta-analyses. Effectiveness figures that were reported as statistically significant were extracted and used for the calculations.

2. Calculate the rate of YLL and YLD

The WHO's 2012 Global Health Estimates (GHE 2012) data tables provide country-specific YLL and YLD rates for each cause of death or disease (WHO 2012b). GHE 2012 morbidity and mortality estimates were used in combination with country-specific population attributable fractions (PAF) from the *Global Burden of Disease* (IHME 2010). This assumes that the risk factor impacts on morbidity and mortality did not differ significantly between the two estimates.

To calculate the rate of morbidity and mortality from a cause due to a specific risk factor, the first step is to calculate the PAF for the cause-risk factor combination. The PAF was extracted from the country-specific risk factor attribution table from the 2010 GBD data. This was done separately for YLL and YLD. In the second step, the country-specific YLLs and YLDs for the target population—in most cases children under five years old—were extracted from the GHE 2012 estimates. To calculate the YLL rate, the country-specific YLL is multiplied by the YLL PAF and then by 100,000. The final figure is divided by country-specific population of interest (usually children under five) to get the rate. The same final steps are followed to calculate the YLD, although instead multiplying country-specific YLDs by the YLD PAF. The population estimate for the rate calculation was extracted from GHE 2012.

YLL per 100,000 = (U-5_cause_total_YLL * YLL_PAF * 100,000)/U-5_ population
YLD per 100,000 = (U-5_cause_total_YLD * YLD_PAF * 100,000)/U-5_population

where:

U-5_population = the population of children under five

3. Calculate counterfactual DALYs averted

To calculate the DALYs averted if current intervention coverage were maintained, the following formula was used:

YLL = U-5_population_intervention_year * current_coverage
* intervention_mortality_reduction * YLL_rate

YLD = U-5_population_intervention_year * current_coverage
* intervention_morbidity_reduction * YLL_rate

DALY_current = YLL + YLD

4. Calculate total DALYs averted under intervention coverage

To calculate the potential DALYs averted under the intervention coverage, a similar formula as above was used:

YLL = U-5_population_intervention_year * intervention_coverage
* intervention_mortality_reduction * YLL_rate

YLD = U-5_population_intervention_year * intervention_coverage
* intervention_morbidity_reduction * YLL_rate

DALY_intervention = YLL+YLD

5. Calculate net DALYs averted

The potential net DALYs averted by the intervention is:

DALYs averted = DALY_intervention - DALY_current

APPENDIX 6: METHODOLOGY FOR ZAMBIA LIST ESTIMATES

The Lives Saved Tool (LiST) is a part of an integrated set of tools that comprise the Spectrum policy modeling system. These tools include DemProj for creating demographic projections; AIM to model and incorporate the impact of HIV/AIDS on demographic projections and child survival interventions; and FamPlan for incorporating changing fertility into the demographic projection. LiST is used to project how increasing intervention coverage would impact child and maternal survival. The table below summarizes data sources used for the Zambia LiST estimates.

Zambia LiST estimates	Data sources
Source	
First year population	UN World Population Prospects, 2012 Revision
Sex ratio at birth	UNData; http://data.un.org/Data.aspx?q=sex+ratio&d=PopDiv&f=variableID%3a52
Life expectancy	UN World Population Prospects, 2012 Revision
Family planning	
Unmet need	Bradley et al. 2012.
Total fertility rate	Population Reference Bureau's 2013 World Population Datasheet
Age-specific fertility rate	UN World Population Prospects, 2012 Revision
Health, mortality, economic status	
Vitamin A deficiency	Black et al. 2013
Zinc deficiency	Wessels and Brown 2012
Diarrhea incidence	Fischer Walker et al. 2012
Severe pneumonia incidence	Fischer Walker et al. 2013
Malaria exposure (women)	Guerra et al. 2008
Stunting distribution	LiST default; data have been calculated using DHS and MICS datasets
Wasting distribution	LiST default; data have been calculated using DHS and MICS datasets
Neonatal mortality	UN IGME 2013
Infant mortality	Population Reference Bureau's 2013 World Population Datasheet
Child mortality	UNICEF (2012 data)
Distribution of causes of death	Liu et al. 2012.
Maternal mortality ratio	WHO 2013
Household poverty status	World Bank 2012b, accessed 2014
Household size	LiST default; DHS and MICS Survey results

Once the demographic and health data have been updated, the coverage and scale-up plan for each intervention is introduced into LiST. LiST either can use a sequential method to calculate the impact of individual interventions or can calculate the simultaneous impact of a set of interventions implemented at the same time. The second, simultaneous method is likely to yield slightly lower estimates because interventions may have overlapping benefits. In this analysis we present the both the individual/sequential results of the individual interventions in the full coverage scenario (with totals calculated using the simultaneous method) and the simultaneous impact in the various scale-up scenarios.

Note on Estimates of Cases of Stunting Averted

In order to estimate the number of cases of under-five stunting averted attributable to the annual investment in the scaling up of nutrition interventions, we use LiST to model changes in the prevalence of stunting over five years, during which the interventions are projected to have reached 100 percent of the target population. Next, we model changes in the prevalence of stunting over five years with no scale-up of the interventions. We then take the difference between the estimated stunting prevalence in Year 5 with the scale up and the prevalence in Year 5 absent the scale-up, and multiply this percentage point difference by the total population of children under five years of age.

Our reason for using stunting prevalence in Year 5 relates to the assumptions built into the LiST model, which assumes that stunting is itself a risk factor for becoming stunted in the next time period. As a result, stunting prevalence remains flat during the first two years of the scale-up, before dropping precipitously until Year 5, after which the prevalence begins to level out. We assume that continuing investments in maintaining scale after Year 5 will serve to maintain the gains in stunting prevalence reduction, and therefore we present this reduction as a benefit attributable to a one-year investment in scaling up nutrition.

On the other hand, when estimating stunting reduction (and lives saved) attributable to a five-year scale-up plan, we model this scale-up directly in LiST and use the annual results over five years in our cost-benefit analysis. Using annual results over five years provides a more accurate portrayal of the direct benefits attributable to a five-year scale up plan, and it does not assume that the scale will necessarily be maintained following the end of the period covered in the plan.

APPENDIX 7: METHODOLOGY FOR ESTIMATING ECONOMIC BENEFITS

There is considerable debate in the literature regarding the best methodology for monetizing the value of a life saved. In this analysis, we focus solely on the economic value of a life year, which we measure as equal to GNI per capita. Other studies attempt to estimate the social value of a life year as well as its economic value; because we do not, we acknowledge that our results underestimate the true value of a life year saved.

Still, valuing years of life saved alone does not account for the economic benefits of reduced morbidity, which include the long-term, nonlethal impacts of malnutrition on individuals. Although there are a number of long-term impacts of nutritional deficiencies, we choose to focus on stunting because of the availability of country-specific impact estimates produced by the LiST tool.[13]

In order to estimate the economic value of a case of childhood stunting averted, we follow the methodology used in Hoddinott et al. (2013), who begin by assuming that stunted individuals lose an average of 66 percent of lifetime earnings, based on direct estimates of the impact of stunting in early life on later life outcomes found in Hoddinott et al. (2011).[14] This estimate for the effects of stunting on future consumption is used as a proxy for the effect of stunting on lifetime earnings. Additionally, Hoddinott et al. (2013) account for uncertainty by assuming that only 90 percent of the total gains will be realized, which we also include in our calculations. However, unlike those authors, we adjust our calculations to reflect the country's labor force participation rate.

For both lives saved and cases of stunting averted, the benefits of a five-year scale-up plan are attributed to a group of children that is assumed to enter the labor force at age 15 and exit the labor force at age 57, which is equivalent to life expectancy at birth in Zambia. Benefits from both stunting and lives saved are then multiplied by a lifetime discount factor (LDF) in order to obtain the present value of benefits incurred during the expected years of productivity (years between the age of entry into and exit from the workforce). The LDF is derived from three potential discount rates (3 percent, 5 percent, and 7 percent), an adjustment for age at the time of investment (for simplicity, we assume an average age of two years for all children), and the years of lifetime productivity expected. The LDF represents the years of productivity that are "counted" in the calculation, discounted back to their present value in the year in which the investment in nutrition is made. Because we assume an average age of two years for all beneficiaries, we use an LDF that assumes that these children will enter the labor force 13 years from the time of investment. Importantly, given the time frame considered under this analysis, we do not attempt to account for projected growth in the country's GDP and per capita incomes. This downward bias contributes to the conservative nature of our estimates.

The following equations are used to estimate (1) the economic value of lives saved (reduced mortality) and (2) increased future productivity (reduced morbidity):

---

[13] It should be noted that because stunting is just one of many long-term consequences of poor nutrition, actual economic benefits of improving nutrition may be much higher than estimated here.

[14] Hoddinott et al. (2011) provided direct estimates of the impact of stunting in early life on later life outcomes, which found that an individual stunted at age 36 months had, on average, 66 percent lower per capita consumption over his or her productive life.

1. *Present value of reduced mortality* = (*lives saved attributable to intervention scale-up*) *(*GNI per capita*) * *LDF*

2. *Present value of reduced morbidity* = (*cases of child stunting averted*) * (*coefficient of a deficit*) * (*percent of income actually realized*) * (*GNI per capita*) * (*LDF*)

where:

- Lives saved attributable to the intervention scale-up are estimated using the LiST tool.
- Cases of child stunting averted are calculated by subtracting the projected under-five stunting prevalence (%) after the interventions are scaled up calculated by LiST from the projected stunting prevalence under a scenario with no scale up and multiplying it by the total under-five population.
- The coefficient of deficit is equal to the reduction in lifetime earnings attributable to stunting.
- The lifetime discount factor (LDF) is used to discount future benefits to their value at the time of investment. It is derived from a discount rate, age at the time of investment and the estimated age of entry and exit into the workforce. The equation used to calculate the LDF is:

$$LDF = \sum_{t=13}^{t=T} \frac{1}{(1+r)^t}$$

where:

LDF = the lifetime discount factor

r = is the discount rate

t = the time period since the initial investment in scaling up the interventions (we assume that children are 2 years old at the time of investment and enter the labor force at 15 years old, which is reflected in the starting value for *t*)

T = the last time period before individuals exit the labor force (we assume individuals are out of the workforce at life expectancy at birth)

Note, the beginning time period *t* and ending period *T* is adjusted for each cohort based on the year of investment. For example, the first cohort is assumed to enter the labor force at time period *t*=13 and exit at time *T*, the second cohort is assumed to enter the labor force at time period *t*=14 and exit at time *T*+1, and so forth.

The following values and sources are used in our calculations:

Indicator	Value	Source
GNI per capita	US$1,480	World Bank 2013
Life expectancy at birth	57 years	World Bank 2012
Labor force participation rate	79%	World Bank 2012
Coefficient of deficit (stunting)	0.66	Hoddinott 2011
Actual gains realized	90%	Hoddinott 2013

To arrive at a net present value (NPV), we use the following equation:

$$NPV = \sum_{c=1}^{5} (PV\ of\ reduced\ mortality)_c + (PV\ of\ reduced\ morbidity)_c - \sum_{t=1}^{5} \frac{1}{(1+r)^t} (investment\ cost)_t$$

where *c* is the cohort group and *t* is the time period.

Finally, the annual addition to economic productivity is measured by taking the total economic benefits for the year in which all beneficiaries of the initial one-year investment have reached productive age. These benefits are not discounted back to their present value, as they are considered the annual opportunity cost of not investing in scaling up nutrition interventions. It should be noted that these benefits are derived from a progressive, five-year scale-up plan, and therefore subsequent investments that maintain the target scale will increase the total annual benefits as new beneficiaries are reached.

Appendix 8: Sensitivity Analysis

Full Coverage

Assumption change	Effect on total annual cost
Iron fortification of staple foods unit cost doubles	Increase from $48.7 million to $50.9 million
All micronutrient and deworming unit costs double	Increase from $48.7 million to $57.2 million
Community nutrition program unit cost doubles	Increase from $48.7 million to $57 million
Complementary food unit cost doubles	Increase from $48.7 million to $71.7 million
Community-based management of severe acute malnutrition unit cost doubles	Increase from $48.7 million to $57.6 million
Iron fortification of staple foods costs reduced by 50%	Decrease from $48.7 million to $47.6 million
All micronutrient and deworming unit costs reduced by 50%	Decrease from $48.7 million to $44.5 million
Community nutrition program unit cost reduced by 50%	Decrease from $48.7 million to $44.5 million
Complementary food unit cost reduced by 50%	Decrease from $48.7 million to $37.2 million
Community-based management of severe acute malnutrition unit cost reduced by 50%	Decrease from $48.7 million to $44.3 million

Partial Coverage

Assumption change	Effect on total annual cost
Iron fortification of staple foods unit cost doubles	Increase from $29.7 million to $31.5 million
All micronutrient and deworming unit costs double	Increase from $29.7 million to $36.7 million
Community nutrition program unit cost doubles	Increase from $29.7 million to $36.3 million
Complementary food unit cost doubles	Increase from $29.7 million to $41.2 million
Community-based management of severe acute malnutrition unit cost doubles	Increase from $29.7 million to $34.1 million
Iron fortification of staple foods costs reduced by 50%	Decrease from $29.7 million to $28.8 million
All micronutrient and deworming unit cost reduced by 50%	Decrease from $29.7 million to $26.1 million
Community nutrition program unit cost reduced by 50%	Decrease from $29.7 million to $26.3 million
Complementary food unit cost reduced by 50%	Decrease from $29.7 million to $23.9 million
Community-based management of severe acute malnutrition unit cost reduced by 50%	Decrease from $29.7 million to $27.4 million

REFERENCES

Abt Associates. 2014. *Country Assessment for Aflatoxin Contamination and Control in Nigeria*. January 8. Bethesda, MD: Abt Associates.

Asare-Marfo, D., E. Birol, C. Gonzalez, M. Moursi, S. Perez, J. Schwarz, and M. Zeller. 2013. “Prioritizing Countries for Biofortification Interventions Using Country-Level Data.” HarvestPlus Working Paper No. 11(October 2013). Washington, DC: HarvestPlus.

Awasthi, S., R. Peta, S. Raed, S. M. Richards, V. Pande, D. Bundy, and the DEVTA (Deworming and Enhanced Vitamin A) Team. 2013. “Population Deworming Every 6 Months with Albendazole in 1 Million Pre-School Children in North India: DEVTA, a Cluster-Randomized Trial.” *Lancet* 381(9876):1478–86.

Baird, S., J. H. Hicks, M. Kremer, and E. Miguel. 2011. “Worms at Work: Long-Run Impacts of Child Health Gains.” Working paper. Harvard University.

Bandyopadhyay, R. (International Institute for Tropical Agriculture plant pathologist). 2013. Personal communication cost per hectare of aflasafe™ (Nigeria).

Bandyopadhyay, R. and P. J. Cotty. 2013. “Biological Controls for Aflatoxin Reduction.” *2020 Focus Brief #20 (16)*. Washington, DC: International Food Policy Research Institute. http://www.ifpri.org/sites/default/files/publications/focus20_16.pdf

Behrman, J. R., M. C. Calderon, S. H. Preston, J. Hoddinott, R. Martorell, and A. D. Stein. 2009. “Nutritional Supplementation in Girls Influences the Growth of their Children: Prospective Study in Guatemala.” *American Journal of Clinical Nutrition* 90 (1):1372–9.

Bhutta, Z., T. Ahmed, R. Black, S. Cousens, K. Dewey, E. Giugliani, B. Haider, B. Kirkwood, S. Morris, H. Sachdev, and M. Shekar. 2008. “What Works? Interventions for Maternal and Child Undernutrition and Survival.” *The Lancet* 371:417–40.

Bhutta, Z. A., J. K. Das, A. Rizvi, M. F. Gaffey, N. Walker, S. Horton, P. Webb, A. Lartey, and R. E. Black for the Maternal and Child Undernutrition Study Group. 2013. “Evidence-Based Interventions for Improvement of Maternal and Child Nutrition: What Can Be Done and At What Cost?” *Lancet* 382 (9890): 452–77, Maternal and Child Nutrition series.

Black, R. E., L. H. Allen, Z. A. Bhutta, L. E. Caulfield, M. de Onis, M. Ezzati, C. Mathers, and J. Rivera for the Maternal and Child Undernutrition Study Group. 2008. “Maternal and Child Undernutrition: Global and Regional Exposures and Health Consequences.” *Lancet* 371 (9608): 243–60.

Black, R. E, C. G. Victoria, S. P. Walker, Z. A Bhutta, P. Christian, M. de Onis, J. Ezzati, S. Grantham-McGregor, J. Katz, R. Martorell, and R. Uauy for the Maternal and Child Undernutrition Study Group. 2013. “Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries.” *Lancet* 382 (9890): 427–51. Maternal and Child Nutrition series.

Bleakley, H. 2007. “Disease and Development: Evidence from Hookworm Eradication in the American South.” *Quarterly Journal of Economics* 122 (1):73–117.

Bolt, E. and S. Cairncross. 2004. *Sustainability of Hygiene Behaviour and the Effectiveness of Change Interventions: Lessons Learned on Research Methodologies and Research Implementation from a Multi-Country Research Study*. Delft, the Netherlands: IRC International Water and Sanitation Centre.

Bradley, S. E. K., T. N. Croft, J. D. Fishel, and C. F. Westoff . 2012. “Revising Unmet Need for Family Planning.” DHS Analytical Studies No. 25, ICF International, Caverton, MD.

Caulfield, L.E., M. de Onis, M. Blossner, and R.E. Black. 2004. “Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles.” *American Journal of Clinical Nutrition*. 80(1): 193-198.

Chakravarty, I. 2000. “Food-Based Strategies to Control Vitamin A Deficiency.” *Food and Nutr Bulletin* 21: 135–43.

DHS (Zambia Democratic and Health Survey). 2013-14. Zambia Demographic and Health Survey 2013-14. Rockville, MD: Zambia Central Statistical Office, Zambia Ministry of Health and ICF International. (Published in 2014.)

Ejemot, R., J. E. Ehiri, M. M. Meremikwu, and J. A. Critchley. 2008. “Hand Washing for Preventing Diarrhoea.” *Cochrane Database of Systematic Reviews* Issue 1.

Ezzati M., A. D. Lopez, A. Rogers, and C. J. Murray. 2004. *Comparative Quantification of Health Risks: The Global and Regional Burden of Disease Attributable to Selected Major Risk Factors.* Geneva: World Health Organization.

Ezzati M, A. D. Lopez, A. Rogers, S. Vander Hoorn, and C. J. Murray. 2002. “Selected Major Risk Factors and Global and Regional Burden of Disease.” *Lancet* 360: 1347–60.

Fiedler, J. and K. Lividini. 2014. “Managing the Vitamin A Program Portfolio: A Case Study from Zambia 2013–2042.” *Food and Nutrition Bulletin* 35 (1): 105–25.

Fiedler, J. and K. Lividini. Forthcoming. “Assessing the Promise of Biofortification: A Case Study of High Vitamin A Maize in Zambia.” Washington, DC: HarvestPlus.

Fischer Walker, C. L., J. Perin, M. J. Aryee, C. Boschi-Pinto, and R. E. Black. 2012. “Diarrhea Incidence in Low- and Middle-Income Countries in 1990 and 2010: A Systematic Review.” *BMC Public Health* 12: 220.

Fischer Walker, C. L., I. Rudan, L. Liu, H. Nair, E. Theodoratou, Z. A. Bhutta, K. L. O’Brien, H. Campbell, and R. E. Black. 2013. “Global Burden of Childhood Pneumonia and Diarrhoea.” *Lancet* 381 (9875): 1405–16

Global Atlas of Helminth Infections. 2014. Distribution of soil-transmitted helminthes survey data in Zambia. http://www.thiswormyworld.org/maps/2013/distribution-of-soil-transmitted-helminth-survey-data-in-zambia (accessed 28 April 2014).

Guerra, C. A., P. W. Gikandi, A. J. Tatem, A. M. Noor, D. L. Smith, and S. I. Hay. 2008. “The Limits and Intensity of *Plasmodium falciparum* Transmission: Implications for Malaria Control and Elimination Worldwide.” *PLoS Medicine* 5 (2): e38

Guyatt, H. L. 2003. “The Cost of Delivering and Sustaining a Control Programme for Schistosomiasis and Soil-Transmitted Helmithiasis.” *Acta Tropica* 86: 267–74.

Heckman, J. J. and D. Masterov. 2004. “The Productivity Argument for Investing in Young Children.” Technical Report Working Paper No. 5, Invest in Kids Working Group, Committee on Economic Development. Research supported by a grant from the NICHD (NIH R01-HD043411) and a grant from the Committee for Economic Development.

Hoddinott, J., H. Alderman, J. R. Behrman, L. Haddad, and S. Horton. 2013. “The Economic Rationale for Investing in Stunting Reduction.” *Maternal and Child Nutrition* 9 (Suppl. 2): 69–82.

Hoddinott, J., J. Maluccio, J. R. Behrman, R. Martorell, P. Melgar, A. R. Quisumbing, M. Ramirez-Zea, A. D. Stein, and K. M. Yount. 2011. “The Consequences of Early Childhood Growth Failure over the Life Course.” Discussion Paper 1073. International Food Policy Research Institute, Washington, DC.

Hoddinott, J., M. Rosegrant, and M. Torero. 2012. “Investments to Reduce Hunger and Undernutrition.” Challenge Paper prepared for the 2012 Copenhagen Consensus.

Horton S. 1999. “Opportunities for Investment in Nutrition in Low-Income Asia.” *Asia Development Review* 17: 246–73.

Horton S. and J. Ross. 2003. “The Economics of Iron Deficiency.” *Food Policy* 28 (1): 51–75.

Horton S. and R. Steckel. 2013. *“*Global Economic Losses Attributable to Malnutrition 1900–2000 and Projections to 2050.” In *The Economics of Human Challenges*, edited by B. Lomborg. Cambridge, U.K.: Cambridge University Press.

Hotez, P., P. J. Brindley, J. M. Bethony, C. H. King, E. J. Pearce, and J. Jacobson. 2008. “Helminth Infections: The Great Neglected Tropical Disease.” *The Journal of Clinical Investigation* 118 (4): 1311–21.

Hotz, C., C. Loechl, A. de Brauw, P. Eozenou, D. Gilligan, M. Moursi, B. Munhaua, P. van Jaarsveld, A. Cariquiry, and J. V. Meenakshi. 2012a. “A Large-Scale Intervention to Introduce Orange Sweet Potato in Mozambique Increases Vitamin A Intakes among Children and Women.” *British Journal of Nutrition* 108 (1): 163–76.

Hotz C., C. Loechl, A. Lubowa, J. K. Tumwine, G. Ndeezi, A. Nandutu Masawi, R. Baingana, A. de Brauw, J. V. Meenakshi, and D. O. Gilligan. 2012b. “Introduction of β-Carotene-Rich Orange Sweet Potato in Rural Uganda Resulted in Creased Vitamin A Intakes among Children and Women and Improved Vitamin A Status among Children.” *Journal of Nutrition* 142 (10): 1871–80.

IHME (Institute for Health Metrics and Evaluation). 2010. *Global Burden of Disease Study.* Institute for Health Metrics and Evaluation. http://www.healthmetricsandevaluation.org/gbd

IITA (International Institute of Tropical Agriculture). 2012. The aflasafe™ Zambia Journey: From the Field to the Lab and Back Again.” *IITA Annual Report.* http://wpar12.iita.org/?p=458

———. 2013. “In Zambia: Aflatoxins No More!” *IITA Annual Report.* http://wpar12.iita.org/?p=379

———. 2014. *Southern Africa Highlights*. http://www.iita.org/southern-africa-highlights

J-PAL (Abdul Latif Jameel Poverty Action Lab). 2012. “Deworming: A Best Buy for Development.” *J-PAL Policy Bulletin.* March. Boston, MA: Massachusetts Institute of Technology.

Khlangwiset, P. 2011. “Reducing the Risks of Aflatoxin Through Public Health Interventions.” Doctoral dissertation, Graduate School of Public Health, University of Pittsburg.

Khlangwiset, P. and Wu F. 2011. “Cost and Efficacy of Public Health Interventions to Reduce Aflatoxin-Induced Human Diseases.” *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*, July. 27 (7): 998–1014.

Kuniholm, M. H., O. A. Lesi, M. Mendy, A. O. Akano, O. Sam, A. J. Hall, H. Whittle, E. Bah, J. J. Goedert, P, Hainaut, and G. D. Kirk. 2008. “Aflatoxin Exposure And Viral Hepatitis in the Etiology of Liver Cirrhosis in the Gambia, West Africa.” *Environ Health Perspect,* 116 (11): 1553–57.

Liu, L., H. L. Johnson, S. Cousens, J. Perin, S. Scott, J. E. Lawn, I. Rudan, H. Campbell, R. Cibulskis, M. Li, C. Mathers, and R. E. Black. 2012. “Global, Regional, and National Causes of Child Mortality: An Updated Systematic Analysis for 2010 with Time Trends since 2000.” *Lancet* 379 (9832): 2151–61.

Lorntz, B. A. M. Soares, S. R. Moore, R. Pinkerton, B. Gansneder, V. E. Bovbjerg, H. Guyatt, A. M. Lima, and R. L. Guerrant. 2006. “Early Childhood Diarrhea Predicts Impaired School Performance.” *The Pediatric Infectious Disease Journal* 25 (6): 513–20.

Masset E, L. Haddad, A. Cornelius, and J. Isaza-Castro. 2011. *A Systematic Review of Agricultural Interventions that Aim to Improve Nutritional Status of Children*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Meenakshi, J., N. Johnson, V. M. Manyong, H. De Groote, J. Javelosa, D. Yanggen, F. Naher, C. Gonzalez, J. Garcia, and E. Meng. 2010. “How Cost-Effective Is Biofortification in Combating Micronutrient Malnutrition? An *Ex-Ante* Assessment.” *World Development* 38 (1): 64–75.

Miguel, E. and M. Kremer. 2004. “Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities.” *Econometrica* 72 (1): 159–217.

Mayo-Wilson, E., A. Imdad, K. Herzer, M.Y. Yakoob, and Z.A. Bhutta. 2011. “Vitamin A Supplements for Preventing Mortality, Illness, and Blindness in Children Aged under 5: Systematic Review and Meta-Analysis."*BMJ* 343 (2011). doi: http://dx.doi.org/10.1136/bmj.d5094

NFNC (National Food and Nutrition Commission of Zambia). 2011*. National Food and Nutrition Strategic Plan for Zambia 2011–2015 with a Multi-Sector Strategic Direction on First 1000 Most Critical Days to Prevent Child Stunting*. Lusaka: Government of Zambia.

———. 2012. *The First 1000 Most Critical Days Three Year Programme 2013-2015.* Lusaka: Government of Zambia. http://scalingupnutrition.org/wp-content/uploads/2013/04/Zambia_First-1000-Most-Critical-Days-Programme_2013-2015.pdf

Population Reference Bureau’s 2013 World Population Datasheet. http://www.prb.org/pdf13/2013-population-data-sheet_eng.pdf

REACH (Renewed Efforts Against Child Hunger and Malnutrition). 2014. “Zambia Exploratory Mission Debriefing.” Presentation at the debriefing meeting, Pamodzi Hotel, Lusaka, Zambia, April 11.

Ruel M. T. and H. Alderman for the Maternal and Child Undernutrition Study Group. 2013. “Nutrition-Sensitive Interventions and Programmes: How Can They Help to Accelerate Progress In Improving Maternal and Child Nutrition?” *Lancet* 382 (9891): 536–51. Maternal and Child Nutrition series.

SCN (Standing Committee on Nutrition). 2011. “Advocacy and Institutional Arrangements to Position Nutrition on the National Development Agenda: The Republic of Senegal Experience.” *SCN News* 39 (Supplement): 20–21.

Siwila, J., I. G. Phiri, H. L. Enemark, M. Nchito, and A. Olsen. 2010. “Intestinal Helminths and Protozoa in Children in Pre-Schools in Kafue District, Zambia.” *Trans R Soc Trop Med Hyg* 104 (2): 122–8.

Spears, D. 2013. “How Much International Variation in Child Height Can Sanitation Explain?” Policy Research Working Paper 6351, World Bank, Washington, DC.

Stenberg K. et al. 2014. "Advancing Social and Economic Development by Investing in Women's and Children's Health: A New Global Investment Framework." *The Lancet* 383 (9925): 1333–54. http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(13)62231-X.pdf

Strauss, J. and D. Thomas. 1998. "Heath, Nutrition and Economic Development." *Journal of Economic Literature*. 36(1):766-817.

SUN (Scaling Up Nutrition). 2013. "DRAFT Compendium of SUN Country Fiches (September 2013)." http://scalingupnutrition.org/wp-content/uploads/2013/09/130916Compendium2013-English.pdf

———. 2014. *Mobilizing Resources in Zambia*. Accessed May 27, 2014. http://scalingupnutrition.org/sun-countries/zambia/progress-impact/mobilizing-resourcesUNICEF (United Nations Children's Fund). 2012. *Water, Sanitation and Hygiene (WASH) in Schools.* New York: UNICEF.

United Nations, Department of Economic and Social Affairs. 2012. *UN World Population Prospects, 2012 Revision*. http://esa.un.org/wpp/

UNDP (United Nations Development Programme). 2012. *Human Development Reports. Table 1: Human Development Index and its Components.* http://hdr.undp.org/en/content/table-1-human-development-index-and-its-components

UNICEF (United Nations Children's Fund). 2012. *Water, Sanitation and Hygiene (WASH) in Schools.* New York: UNICEF.

UN IGME (United Nations Inter-agency Group for Child Mortality Estimation). 2013. *Levels & Trends in Child Mortality.* New York: UNICEF. http://www.childinfo.org/files/Child_Mortality_Report_2013.pdf

Unnevehr, L. and D. Grace, eds. 2013. "Aflatoxins: Finding Solutions for Improved Food Safety." 2020 Focus Brief #20. Washington, DC: International Food Policy Research Institute.

USAID (United States Agency for International Development). 2011. "U.S. Announces Support for the Africa-Led Partnership for Aflatoxin Control in Africa." Press Release. Friday, June 10. http://www.usaid.gov/news-information/press-releases/us-announces-support-africa-led-partnership-aflatoxin-control-africa

USAID Zambia. 2011. *Strategic Review: Feed the Future.* February 28. http://feedthefuture.gov/sites/default/files/resource/files/ZambiaFeedtheFutureStrategicReview.pdf

Wessels, K. R. and K. H. Brown. 2012. "Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting." *PLOS One* 2012 7 (11): E50568. doi:10.1371/Journal.Pone.0050568. Epub 2012 Nov 29.

WHO (World Health Organization). No date. 'Landscape Analysis on Countries' Readiness to Accelerate Action in Nutrition'. http://www.who.int/nutrition/landscape_analysis/en/

———. 2009. *Zambia Country Profile of Environmental Burden of Disease.* http://www.who.int/quantifying_ehimpacts/national/countryprofile/zambia.pdf?ua=1

———. 2012. *Global Health Estimates*. Geneva: WHO. http://www.who.int/healthinfo/global_burden_disease/en/

———. 2013. *World Health Statistics.* Geneva: WHO. http://www.who.int/gho/publications/world_health_statistics/EN_WHS2013_Full.pdf

———. 2014. *Cost-Effectiveness and Strategic Planning: Threshold Values for Intervention Cost-Effectiveness by Region*. Geneva: WHO-CHOICE (Choosing Interventions that are Cost-Effective) Program. http://www.who.int/choice/costs/CER_levels/en/

World Bank. 2006. *Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action.* Washington, DC: World Bank.

———. 2010. *Scaling Up Nutrition. What Will It Cost?* Washington, DC: World Bank.

———. 2011. *Nutrition at a Glance: Zambia*. Washington, DC: World Bank.

———. 2012a. "Do School Feeding Programs Help Children?" From Evidence to Policy, a note series on what works from the Human Development Network (January.) Washington, DC: World Bank.

———. 2012b. *World Bank DataBank,* Poverty headcount ratio at $1.25 a day (PPP) (% of population). Accessed 2014. http://data.worldbank.org/indicator/SI.POV.DDAY

———. 2013. *Improving Nutrition Through Multisectoral Approaches*. Washington, DC: World Bank.

———. 2014. *World Development Indicators*. http://databank.worldbank.org/data/ Accessed September 23, 2014.

Zambia, Republic of. 2011. *National Food and Nutrition Strategic Plan for Zambia 2011–2015: With a Multi-Sector Strategic Direction on First 1000 Most Critical Days to Prevent Child Stunting.* Lusaka, Zambia: Government of the Republic of Zambia. http://scalingupnutrition.org/wp-content/uploads/2013/02/Zambia_NFNC-Stratergic-Plan-2011-20151.pdf

———. 2013. "Southern African CAADP Nutrition Development Workshop." Unpublished Report of the Proceedings, Lusaka, Zambia.

Zambia, Ministry of Agriculture and Livestock. 2014. *National Agriculture Investment Plan (NAIP) 2014–2018: Under the Comprehensive Africa Agriculture Development Programme (CAADP),* May. Lusaka, Zambia: Government of the Republic of Zambia, Ministry of Agriculture and Livestock. http://www.gafspfund.org/sites/gafspfund.org/files/Documents/6.%20Zambia_investment%20plan.pdf

Zambia Civil Society Scaling Up Nutrition Alliance. 2014. Nutrition in the 2014 National Budget. Lusaka, Zambia.

This paper builds on global experience and Zambia's specific context to identify an effective nutrition approach along with costs and benefits of key nutrition interventions. It is intended to help guide the selection of the most cost-effective interventions as well as strategies for scaling these up. The paper considers both relevant "nutrition-specific" interventions, largely delivered through the health sector, and multisectoral "nutrition-sensitive" interventions, delivered through other sectors such as agriculture, education, and water and sanitation. We estimate that the costs and benefits of implementing 10 nutrition-specific interventions would require an annual public investment of $40.5 million and would avert over 112,000 DALYs, save over 2,800 lives, and prevent 62,000 cases of stunting. Economic productivity could potentially increase by $915 million annually over the productive lives of the beneficiaries, with an impressive internal rate of return of 32 percent. However, because it is unlikely that the Government of the Zambia or its partners will find the $40.5 million necessary each year to reach full coverage, we also consider scale-up scenarios based on considerations of their potential for impact, burden of stunting, resource requirements, and implementation capacity. The two scenarios that scale up the nine most cost-effective nutrition-specific interventions (excluding the public provision of complementary foods) are the most advantageous in terms of cost-effectiveness and resource requirements and would require $11 million to scale up to partial levels and $23 to scale up to full-coverage levels. Among the 8 nutrition-specific interventions we consider, school-based deworming is low cost and effective. The interventions we reviewed in the agriculture sector are expensive when compared to nutrition-specific interventions, although very little cost-effectiveness data are available for the nutrition-sensitive interventions to make careful comparisons. These findings point to a powerful set of nutrition-specific interventions and a candidate list of nutrition-sensitive approaches that represent a highly cost-effective approach to reducing child malnutrition in Zambia.

ABOUT THIS SERIES:

WORLD BANK GROUP
Health, Nutrition & Population

1818 H Street, NW
Washington, DC USA 20433

Telephone: 202 473 1000
Facsimile: 202 477 6391
Internet: www.worldbank.org
E-mail: feedback@worldbank.org