

Improving the efficiency of nutrition investments for better outcomes in Sierra Leone: results of an allocative efficiency analysis using Optima Nutrition

Prepared by Jonathan Akuoku (World Bank), Kazumi Inden (World Bank) and Kofi Amponsah (World Bank), in collaboration with the Directorate of Food and Nutrition (DFN) of the Ministry of Health and Sanitation, Sierra Leone

Key messages

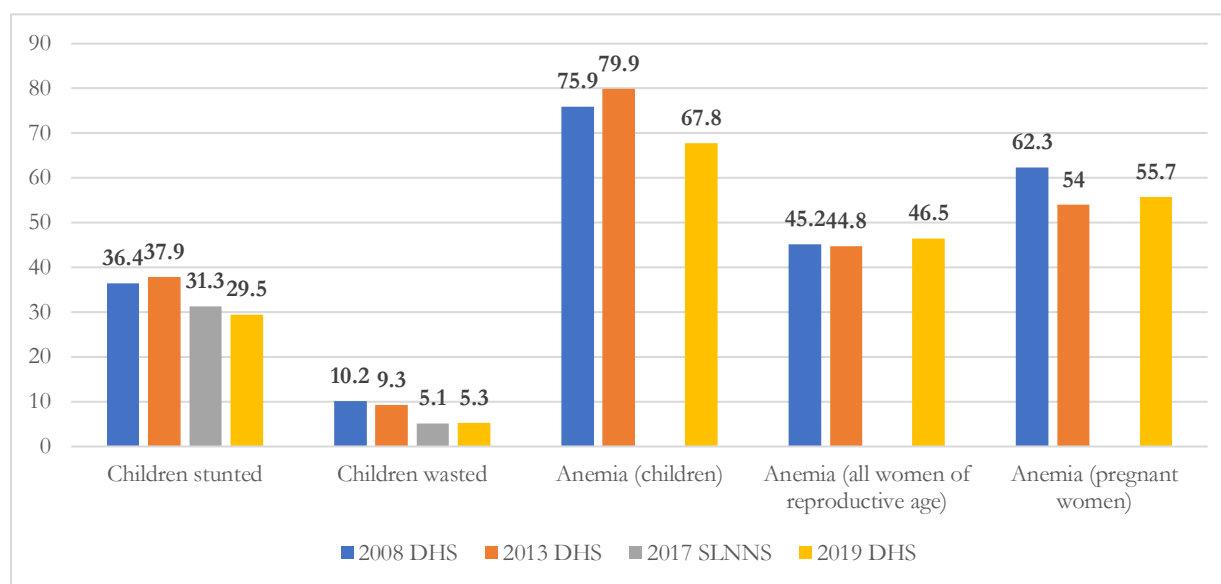
- Reducing malnutrition is of high national priority in Sierra Leone, yet progress toward reducing stunting and wasting have fallen short of national targets. Results from the 2019 DHS show stunting prevalence at 29.5% and wasting prevalence at 5.3%, representing high and medium levels of public health significance, respectively.
- The Optima Nutrition model was used to estimate the potential impact of optimizing allocation of different budget envelopes to nutrition-specific interventions:
 - Existing funding of US\$12m per year;¹
 - The total estimated US\$26.9m per year needed to scale up nutrition-specific interventions in the Multi-sector Strategic Plan to Reduce Malnutrition in Sierra Leone 2019-2025; and
 - Only the additional US\$14.9m per year needed to reach the funding target for scaling up nutrition-specific interventions in the Multi-sector Strategic Plan.
- The modeling results show that the greatest incremental impact could be achieved simply **by optimizing the existing spending**. Between 2020 and 2025, optimizing the current estimated US\$12m per year allocated to a set of nutrition-specific interventions¹ will result in the following additional gains:
 - 8,200 fewer children who are stunted by age 5;
 - 4,400 fewer cases of child wasting; and
 - 5,700 fewer child deaths.
- Optimizing the budget allocation would involve the following:
 - Diverting funding from balanced energy protein and iron and folic acid supplementation for pregnant women, along with public provision of complementary foods and zinc + oral rehydration solutions for treatment of diarrhea in children.
 - Reallocating these funds to achieve full coverage of facility based infant and young child feeding education and counseling, vitamin A supplementation in children, treatment of severe acute malnutrition, oral rehydration solution for treating diarrhea, intermittent presumptive treatment of diarrhea in pregnancy, and kangaroo mother care support and training. Additional resources would be allocated to increase the coverage of long-lasting insecticide-treated bed nets.
- Increasing the available **budget to the levels proposed in the Multi-sector Strategic Plan** resulted in modest additional improvements in stunting, wasting, and child mortality outcomes. Compared with continued current allocations:
 - Optimizing the total US\$26.9m per year will result in 11,700, 4,400, and 6,400 fewer cases of stunting, wasting, and child deaths, respectively.
 - Optimizing only the additional US\$14.9m needed to reach the funding target for nutrition-specific interventions in the Multi-sector Strategic Plan will result in 11,000, 4,400, and 7,300 fewer cases of stunting, wasting, and child deaths, respectively.
- By 2025, the stunting and wasting prevalence were estimated to be:
 - 28.8% and 5.4% if current budget allocation was maintained
 - 27.5% and 4.9% if the current budget allocation was optimized.
 - 26.8% and 4.8% if the total US\$26.9 million per year for nutrition-specific interventions proposed in the Multi-Sector Strategic Plan was optimized.
 - 26.9% and 4.8% if only the additional US\$14.9 million needed to reach the funding target for nutrition-specific interventions in the Multi-Sector Strategic Plan was optimized.
- If iron-folic acid was replaced with multiple micronutrient supplementation for pregnant women, there would be 24,000 fewer cases of anemia among pregnant women.
- Applying the results of this analysis requires dialog among stakeholders on how progress can be made toward achieving the optimized budget allocations.

Background

Achieving proper nutrition for infants and mothers leads not only to better health outcomes but also increased cognitive capacity among children, better learning outcomes, and increased adult productivity and earning potential². Improving nutrition outcomes for children is of high national priority in Sierra Leone. The National Food and Nutrition Security Strategic Implementation Plan (NFNSIP) 2013-2017, the first national multisectoral plan aimed at addressing malnutrition, was a key component of Sierra Leone's poverty reduction strategy³. Nutrition has also formed a key part of other national sectoral strategies and policies⁴. While addressing malnutrition was elevated on the government's agenda, insufficient progress has been made to achieve national targets for stunting and wasting among children under 5.

Figure 1 shows trends in selected nutrition indicators for women and children. After slightly increasing between 2008 and 2013, stunting prevalence significantly declined between 2013 and 2019. Similarly, wasting significantly declined between 2013 and 2019 after stagnating at alarming levels between 2008 and 2013. These remain at medium to high levels of public health concern⁵, and fall short of the targets set in the NFNSIP by 2017 (stunting – 28.5%, wasting – 4.8%).

Figure 1: Trends in stunting, wasting, and anemia among children and anemia among women in Sierra Leone



Anemia remains high and of severe public health significance⁶ among both children and women, although iron deficiency accounts for a minor proportion of anemia. According to an analysis of the 2018 Sierra Leone Micronutrient Survey, prevalence of iron-deficiency anemia is 6.1% among women of reproductive

¹ In the analysis, it was assumed that resources can be reallocated from the following interventions: balanced energy protein supplementation, iron and folic acid supplementation for pregnant women, infant and young child feeding (IYCF) in facility, IYCF in community, oral rehydration salts (ORS) for diarrhea treatment, zinc + ORS for diarrhea treatment, treatment of severe acute malnutrition, and vitamin A supplementation.

² Hoddinott, John, et al. "The economic rationale for investing in stunting reduction." *Maternal & child nutrition* 9 (2013): 69-82.

³ Government of Sierra Leone. *National food and nutrition security implementation plan, 2013-2017*.

⁴ Government of Sierra Leone. *Multi-sector strategic plan to reduce malnutrition in Sierra Leone*.

⁵ De Onis, Mercedes, et al. "Prevalence thresholds for wasting, overweight and stunting in children under 5 years." *Public health nutrition* 22.1 (2019): 175-179.

⁶ World Health Organization. *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity*. No. WHO/NMH/NHD/MNM/11.1. World Health Organization, 2011.

age and 3.8% among children⁷. Among children, malaria and inflammation have been identified as the main causes of anemia. While these also represent significant risk factors for anemia among women in Sierra Leone, other factors may also play a role.

The Multi-sector Strategic Plan to Reduce Malnutrition in Sierra Leone 2019-2025 (the Plan) continues the high-level focus on nutrition in Sierra Leone and seeks to build upon the experiences and challenges encountered in implementing the first NFNSIP to advance a multisectoral approach for and realize further reductions in malnutrition. Among other objectives, the Plan targets reducing stunting prevalence to 25% and wasting prevalence to below 5% by 2025. Estimates from the plan indicate that US\$161 million over six years (or US\$26.9m/year) will be needed to scale up cost-effective nutrition-specific interventions, vastly greater than current estimated allocations to these interventions. In an environment of limited resources and continued reductions in donor funding for nutrition, it is vital that resources are allocated most efficiently to achieve the greatest impact. The Optima Nutrition model, a tool for allocative efficiency analysis in nutrition, was created to address such a need.

The Optima Nutrition model

The Optima Nutrition model is a quantitative tool to support allocation decisions under constrained nutrition budgets⁸. It can provide advice to assist governments with allocation of current and projected budgets across cost-effective nutrition interventions in order to achieve the best outcomes for stunting, wasting, anemia, and mortality. The model can be of value to stakeholders in several ways: (i) determining optimal allocation of nutrition budgets for different levels of funding; (ii) projecting medium to long-term impacts of current investments; and (iii) providing confidence to stakeholders that funding is being used in a way to maximize impact. The model takes as input country-specific health and demographic data, the burden of malnutrition, coverage and costs of available nutrition interventions, and outcome objectives informed by national plans and stakeholder consultations. With these inputs, the model uses a mathematical optimization algorithm to incrementally shift budgets across interventions until it finds a combination that achieves the best outcome based on the given objectives.

Data inputs

Demographic and health data

Country-specific data for this analysis were drawn from the most recent available sources. This includes the 2019 Sierra Leone Demographic and Health Survey⁹ (health facility attendance, unmet need for family planning, age distribution of pregnant women, birth spacing, child and maternal mortality rates, stillbirth rates, diarrhea incidence, breastfeeding distribution, and nutritional status distributions), the 2015 Population and Housing census¹⁰, the World Bank poverty estimates¹¹, the Global Burden of Disease 2017 results tool (child causes of death distribution)¹², the Ministry of Health and Sanitation (MoHS) (distribution of causes of maternal mortality)¹³, and Lee et al (birth outcome distribution)¹⁴. When

⁷ Wirth, James P., et al. "Anemia, micronutrient deficiencies, and malaria in children and women in Sierra Leone prior to the Ebola outbreak-findings of a cross-sectional study." *PLoS One* 11.5 (2016): e0155031.

⁸ Pearson, Ruth, et al. "Optima Nutrition: an allocative efficiency tool to reduce childhood stunting by better targeting of nutrition-related interventions." *BMC Public Health* 18.1 (2018): 1-12.

⁹ Statistics Sierra Leone (Stats SL) and ICF. 2020. Sierra Leone Demographic and Health Survey 2019. Freetown, Sierra Leone, and Rockville, Maryland, USA: Stats SL and ICF

¹⁰ Statistics Sierra Leone. 2016. 2015 Population and Housing Census

¹¹ The World Bank. 2021. World Development Indicators database, (Accessed 28 January 2021).

¹² Institute for Health Metrics and Evaluation. 2020 'GBD Results Tool.' Global Health Data Exchange. Seattle WA: University of Washington. Available from <http://ghdx.healthdata.org/gbd-results-tool> (Accessed 28 January 2020)

¹³ Directorate of Reproductive & Child Health, Ministry of Health and Sanitation [Sierra Leone]. (2017). Maternal Death Surveillance and Response: Annual Report 2016. Freetown: MoHS

¹⁴ Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, Adair L, Baqui AH, Bhutta ZA, Caulfield LE: National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. *The Lancet Global Health* 2013, 1(1):e26-e36.

necessary, the DHS datasets were reanalyzed to obtain values for specific age distributions required by the model.

Intervention costs and coverage

The World Bank and the Directorate of Food and Nutrition (DFN) of the MoHS collaborated on a costing study between October 2019 and February 2020. This included in-country data collection supervised by the DFN and with support of a consultant, follow-up by email and other means, and conference calls with stakeholder to present the summarized costing information for validation.

For each intervention, an “ingredients-based” or “bottom-up” approach as used to estimate direct costs such as consumable commodities and staff time. For non-direct or program costs, a “program experience” or “top-down” approach was undertaken. Such an approach entails the use of program data on the total expenditures and the total beneficiaries reached by an intervention in a fixed time period to estimate the unit cost of delivering the intervention per beneficiary. When program data was unavailable or incomplete, informed estimates based on feedback from stakeholders were used. In instances where it was not possible to estimate direct costs using a bottom-up approach, we used a top-down approach for the total costs (both direct and program), or estimates based on the available literature and consultation with stakeholders.

Baseline coverage of interventions were estimated based on the 2019 DHS, through review of program documentation, and during consultations with stakeholders. Table 1 presents a summary of intervention cost and coverage data to be used in this analysis.

Table 1: Intervention unit cost and baseline coverage

Intervention	Unit cost (US\$)	Coverage (%)
Balanced energy protein supplementation	131.5	8.5
Cash transfers (nutrition-sensitive)	18	0
Delayed cord clamping	0.65	15
Family planning	34.78	50.2
IFA supplementation for pregnant women (health facility)	4.54	27.7
Infant and young child feeding (IYCF) education (community + media)	2.46	100
Infant and young child feeding (IYCF) education (health facility)	2.04	77.5
Intermittent presumptive treatment of malaria in pregnancy (IPTp)	4.56	73
Kangaroo mother care	0.55	9
Long-lasting insecticide-treated bed nets (LLIN)	2.32	33.4
Magnesium sulphate for treatment of pre-eclampsia	56.49	31.9
Magnesium sulphate for treatment of eclampsia	56.49	31.9
Micronutrient powders (i.e. iron sprinkles)	20.4	0
Multiple micronutrient supplementation	5.2	0
Oral rehydration salts (ORS)	1.06	36.3
ORS + Zinc	1.48	49.7
Public provision of complementary foods (WFP’s “fortified blended foods”)	145.07	6.5
Treatment of severe acute malnutrition (SAM)	114.48	74
Vitamin A supplementation	0.63	69.4

Modelled scenarios

For this analysis, we have estimated optimized budget allocations with the combined objective of maximizing the number of alive, non-stunted children and minimizing the number of wasted children, two key strategic objectives in the 2019-2025 plan. Analysis was conducted for 4 different budget scenarios for a 5-year period (2020-2025):

1. Only the existing budget¹⁵ for nutrition-specific interventions is available to the reallocated;
2. The full estimated cost of nutrition-specific interventions in the multisectoral plan is available for reallocation;
3. Only the difference in 1 and 2 (the budget gap for nutrition-specific interventions) is available for reallocation. Existing budgets will not be reallocated (no intervention will have its budget reduced); and
4. The three budget scenarios above but with the addition of 3 interventions not currently implemented at scale in Sierra Leone: nutrition-sensitive cash transfers, multiple micronutrient supplementation for pregnant women, and micronutrient powders for children.

Results

Current funding scenario

Table 2 presents the distribution of current funding for interventions in the model¹⁶. An estimated US\$12 million/per year is available to be reallocated across the set of available interventions. At current allocations, 23% of the allocable budget is used for diarrhea treatment (ORS alone and ORS + zinc) and 28% for IYCF at community and facility levels. The two most expensive interventions, balanced energy protein supplementation for pregnant women and public provision of complementary foods for children, both targeting poor households, make up 30% of the allocable budget. If current allocations are maintained through 2025, the model estimates that cumulatively, 392,400 children turning age 5 will be stunted, 40,500 children turning age 5 will be wasted, and there will be 138,800 child deaths.

Table 2: Current distribution of allocable budget to nutrition-specific interventions

Intervention	Budget (US\$ estimated)	Share of total
Balanced energy-protein supplementation	1,588,000	13.3%
Iron and folic acid supplementation (IFAS) for pregnant women (health facility)	249,000	2.1%
IYCF (health facility)	673,000	5.6%
IYCF (community + media)	2,759,000	23.1%
Oral rehydration salts	931,000	7.8%
Public provision of complementary foods	1,994,000	16.7%
Treatment of SAM	1,465,000	12.2%
Vitamin A supplementation	529,000	4.4%
Zinc + ORS for diarrhea treatment	1,779,000	14.9%

Allowing the model to reallocate budgets across interventions results in greater impact on outcomes and thus improves the allocative efficiency of the existing budget. An optimized budget will involve reallocating funds from balanced energy protein supplementation (BEPS), public provision of complementary foods (PPCF), and zinc + ORS. These funds would be used to achieve full coverage (95%) of facility based IYCF, vitamin A supplementation, treatment of SAM, ORS, IPTp, and kangaroo mother care. Coverage of LLINs will also be expanded from 33.4% to 67.1%. Table 3 summarizes optimized intervention coverage and changes in budget allocations.

IYCF and vitamin A supplementation are very low-cost interventions with significant impact on improving breastfeeding and reducing the risk of diarrhea, both important factors for reducing stunting and

¹⁵ The existing budget is estimated by multiplying the current coverage of an intervention by the estimated unit cost.

¹⁶ This excludes allocations to delayed cord clamping, family planning, IPTp, kangaroo mother care, magnesium sulphate for eclampsia, and magnesium sulphate for pre-eclampsia as these were assumed to be funded outside the nutrition budget and thus their budgets cannot be reallocated to other interventions.

mortality. LLINs and IPTp reduce the risk of malaria during pregnancy, and therefore the risk of anemia among pregnant women. This in turn reduces the risk of small or preterm births, significant risk factors stunting, wasting, and mortality. Improving the coverage of treatment of SAM, while expensive, will reduce both wasting and mortality. PPCF and BEPS are the two most expensive interventions, and in the context of the current available budget, are less cost-efficient at achieving impact.

Table 3: Optimized coverage and change in budget allocation of existing funding

Intervention	Current coverage	Optimized coverage	Change in budget allocations (US\$ millions)
Balanced energy-protein supplementation	8.5%	0.0%	-1.59
Delayed cord clamping	15.0%	15.0%	0.00
Family planning	50.2%	50.2%	0.00
IFAS for pregnant women (health facility)	27.7%	0.0%	-0.25
IPTp	73.0%	95.0%	0.25
IYCF (facility)	77.5%	95.0%	0.15
IYCF (community + media)	95.0%	95.0%	0.00
Kangaroo mother care	9.0%	95.0%	0.01
Long-lasting insecticide-treated bed nets (LLIN)	33.4%	67.1%	2.67
Mg for eclampsia	31.9%	31.9%	0.00
Mg for pre-eclampsia	31.9%	31.9%	0.00
Oral rehydration salts	36.3%	95.0%	1.50
Public provision of complementary foods	6.5%	0.8%	-1.76
Treatment of SAM	74.0%	95.0%	0.42
Vitamin A supplementation	69.4%	95.0%	0.20
Zinc for treatment + ORS	49.7%	5.0%	-1.60

Budget based on the total estimated US\$26.9m per year needed to scale up nutrition-specific interventions in the Multi-sector Strategic Plan to Reduce Malnutrition in Sierra Leone 2019-2025

In a scenario where the full budget for nutrition-specific interventions, estimated at US\$26.9 million/year in the national strategic plan, was available to be optimized across interventions, additional impact on stunting, wasting, and child deaths could be realized. In this optimization, funds will be diverted from BEPS, IFAS for pregnant women, and ORS for diarrhea treatment. Instead, the optimization would prioritize full coverage (95%) of facility based IYCF, vitamin A supplementation, LLINs, treatment of SAM, zinc + ORS, IPTp, and kangaroo mother care. With the expanded budget envelope, coverage of PPCF would also be scaled up, from 6.5% to 39.4%, and standalone ORS would be defunded in favor of zinc + ORS. Table 4 summarizes optimized intervention coverage and changes in budget allocations under this scenario.

Table 4: Optimized coverage and change in budget allocation based on strategic plan total cost for nutrition-specific interventions

Intervention	Current coverage	Optimized coverage	Change in budget allocations (US\$ millions)
Balanced energy-protein supplementation	8.5%	0.0%	-1.59
Delayed cord clamping	15.0%	15.0%	0.00
Family planning	50.2%	50.2%	0.00
IFAS for pregnant women (health facility)	27.7%	0.0%	-0.25
IPTp	73.0%	95.0%	0.25
IYCF (facility)	77.5%	95.0%	0.15
IYCF (community + media)	95.0%	95.0%	0.00
Kangaroo mother care	9.0%	95.0%	0.01
Long-lasting insecticide-treated bed nets (LLIN)	33.4%	95.0%	4.87
Mg for eclampsia	31.9%	31.9%	0.00
Mg for pre-eclampsia	31.9%	31.9%	0.00
Oral rehydration salts	36.3%	5.0%	-0.80
Public provision of complementary foods	6.5%	39.4%	10.08
Treatment of SAM	74.0%	95.0%	0.42
Vitamin A supplementation	69.4%	95.0%	0.20
Zinc for treatment + ORS	49.7%	95.0%	1.62

Budget based on only the additional funds US\$14.9m per year needed to reach the funding target for scaling up nutrition-specific interventions in the Multi-sector Strategic Plan

In a third scenario, we assumed that only the additional funds needed to cover the gap between current estimated expenditure and the National Strategic Plan’s cost for nutrition-specific interventions would be allocable across interventions. In this instance, no intervention would lose funding but shall be allocated additional funds through the optimization. Optimizing the additional US\$14.9 million/year required to funding target in the National Strategic Plan will result in prioritizing full coverage of facility based IYCF, vitamin A supplementation, LLINs, treatment of SAM, zinc + ORS, IPTp, and kangaroo mother care. PPCF would also be scaled up from 6.5% to 30.8% coverage.

Table 5: Optimized coverage and allocation of additional funds to reach the National Strategic Plan estimate for nutrition-specific interventions

Intervention	Current coverage	Optimized coverage	Additional allocations (US\$ millions)
Balanced energy-protein supplementation	8.5%	8.5%	0.00
Delayed cord clamping	15.0%	15.0%	0.00
Family planning	50.2%	50.2%	0.00
IFAS for pregnant women (health facility)	27.7%	27.7%	0.00
IPTp	73.0%	95.0%	0.25
IYCF (facility)	77.5%	95.0%	0.15
IYCF (community + media)	95.0%	95.0%	0.00
Kangaroo mother care	9.0%	95.0%	0.01
Long-lasting insecticide-treated bed nets	33.4%	95.0%	4.87
Mg for eclampsia	31.9%	31.9%	0.00
Mg for pre-eclampsia	31.9%	31.9%	0.00
Oral rehydration salts	36.3%	36.3%	0.00
Public provision of complementary foods	6.5%	30.8%	7.44
Treatment of SAM	74.0%	95.0%	0.42
Vitamin A supplementation	69.4%	95.0%	0.20
Zinc for treatment + ORS	49.7%	95.0%	1.62

Table 6 summarizes the incremental impact of each of the three budget scenarios described earlier. Estimates of impact are based on comparisons of outcomes from the scenario in which the current budget allocations remain unchanged through the projection period of 2020-2025. Optimizing allocation of the current budget results in the largest incremental gain, with 8,200, 4,400, and 5,700 fewer cases of stunting, wasting and child deaths, respectively. The National Strategic Plan budget (US\$26.9 million/year) more than doubles the available allocable budget yet results in modest additional gains across the three outcomes. Restricting reallocation to only the additional funds needed to reach the cost of nutrition specific interventions in the strategic plan (US\$14.9 million/year) results in slightly fewer stunting cases averted but more child deaths averted.

Table 6: Cumulative Impact of optimizing three budget envelopes on child nutrition and mortality outcomes from 2020-2025¹⁷

	Scenario 1: Optimized current spending	Scenario 2: Optimized estimated cost for nutrition-specific interventions in the National Strategic Plan	Scenario 3: Optimized additional funds needed reach funding target in National Strategic Plan
Funding (per year)	US\$12.0 million	US\$26.9 million	US\$14.9 million
Cases of stunting averted	8,200	11,700	11,000
Cases of wasting averted	4,400	4,400	4,400
Child deaths averted	5,700	6,400	7,300

¹⁷ Cases averted when compared with outcomes from continued current allocation of estimated spending on nutrition-specific interventions (US\$12 million/year).

The three scenarios would allow Sierra Leone to make greater progress toward achieving its national nutrition targets for stunting and wasting. Figure 2 and figure 3 present the expected trends in stunting and wasting prevalence in each of the scenarios. Based on the funding scenarios and available set of interventions, it is projected that some progress could be made toward achieving the national stunting target, but additional innovations may be needed to reach or exceed the target by 2025. For wasting, reallocating the current budget produces the greatest impact, and increasing the budget produces negligible gains.

Figure 2: Expected trends in stunting prevalence based on modeled scenarios

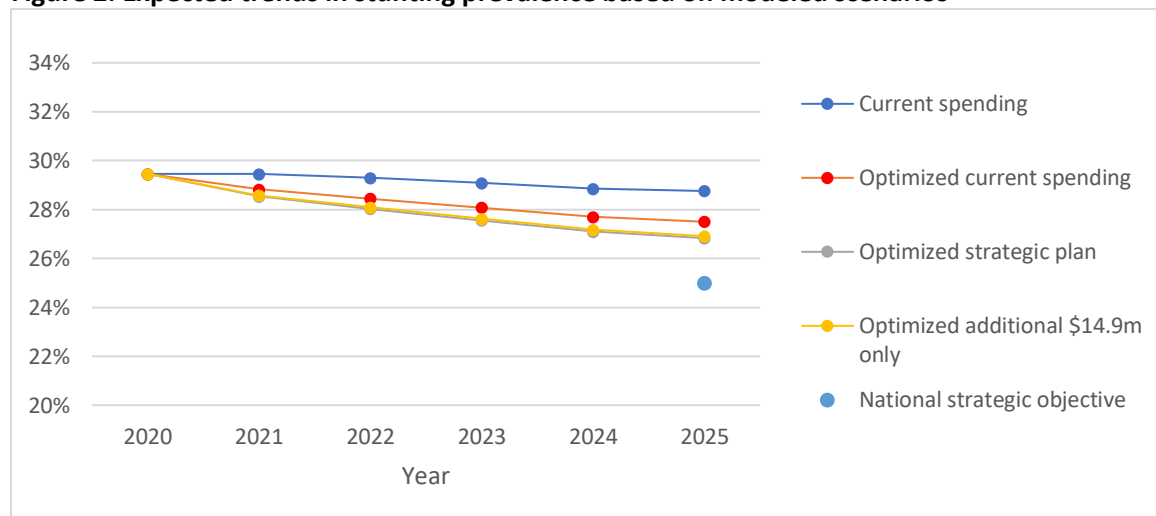
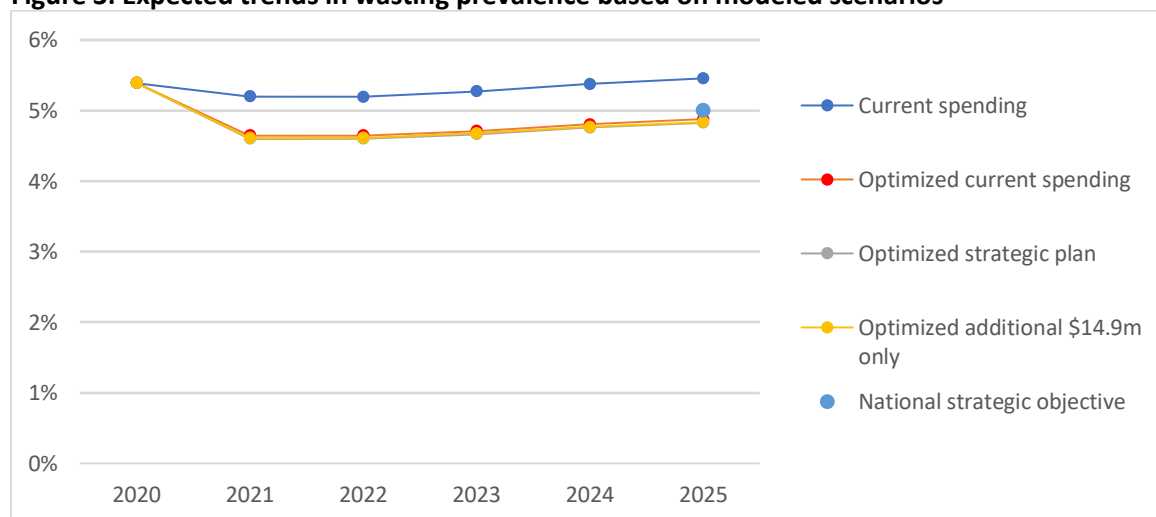


Figure 3: Expected trends in wasting prevalence based on modeled scenarios



Alternative scenarios with expanded set of interventions (addition of MMS, MNP, and cash transfers)

The three budget scenarios were repeated to include additional interventions, which the Government of Sierra Leone and nutrition partners may be interested in supporting. These included the provision of multiple micronutrient supplementation to pregnant women (MMS), micronutrient powders for children (MNP) and nutrition-sensitive cash transfers. The cash transfer program was assumed to include complementary activities to reinforce proper nutrition and caring behaviors for mothers and their children. In the optimization results, only MMS was allocated funding while the other two remained

without funding. MMS replaced IFAS in the optimized budget and resulted in an additional 24,600 cases of iron-deficiency anemia averted among pregnant women. There were no significant differences in stunting, wasting, and child mortality outcomes when compared with the scenarios with fewer interventions.

Policy implications

With a wide menu of intervention options and limited resources, the Multi-sector Strategic Plan to Reduce Malnutrition in Sierra Leone 2019-2025 recognizes the need to prioritize which interventions would receive scarce nutrition resources. The results of this analysis indicate that prioritizing interventions for allocation of resources could lead to additional gains in nutritional outcomes and progress towards meeting the national targets for stunting and wasting. Even without additional funding, these impacts can be achieved by shifting resources from very expensive interventions such as balanced energy protein supplementation and public provision of complementary foods in favor of achieving full coverage of IYCF, vitamin A supplementation, treatment of SAM, ORS, IPTp, and kangaroo mother care. Funds should also be allocated to expand the coverage of LLINs. The government should also explore replacing IFAS with MMS for pregnant women due to its greater efficacy for improving birth outcomes, improving anemia status of pregnant women, and lowering mortality risk for infants.

Limitations

There are several limitations to this study that bear recognition when interpreting or applying the results:

- The effect sizes of interventions are based on global evidence derived from trials and systematic reviews. There is an inherent assumption that there is high quality implementation to achieve the expected levels of impact. Poor quality of implementation and other contextual factors may influence the possibility of achieving the expected outcomes.
- Assumptions about the accuracy of the costing exercise and estimates of intervention coverage have significant implications for the available budget used in the analysis.
- While the model has identified which allocations may lead to the best outcomes, it does not consider how feasible it may be to achieve these shifts in budget allocations. The important that progress is made toward attaining these optimal allocations and will require dialog among between government and other stakeholders.
- There may be ethical and other practical barriers to address when considering making certain reallocations.
- The determinants of malnutrition are multisectoral yet the Optima Nutrition, with some limited exceptions, focuses exclusively on nutrition-specific interventions as these have the strongest evidence base and effects data that can be quantitatively modeled. The tool can adapt as new evidence of effective interventions from other sectors evolve.

Acknowledgement

We acknowledge the contributions of all technical staff of Ministry of Health and Sanitation, its agencies and development partners who significantly enriched the outcomes of this study and take the results forward for actions. We specifically express our gratitude to the technical and financial support provided by the Government of Japan through the Japan Scale-Up Nutrition (SUN) Trust Fund for Advisory and Analytical Services.