

Burden of Disease Reduction and Cost-Effectiveness of Biofortification in Combating Zinc Malnutrition: A Synthesis of the Evidence

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INTRODUCTION

As the fifth top ranking factor contributing to the burden of disease in the developing world, Zn deficiency is increasingly acknowledged as one of the most serious public health challenges (WHO 2002). Meta-analysis findings have linked Zn deficiency to the morbidity and mortality of children younger than five through significantly increased risk to diarrhea, pneumonia and malaria. The average global prevalence of Zn deficiency was estimated at 31% with the most severe burden of disease for diarrhea and pneumonia due to Zn deficiency found in Africa and South Asia (Caulfield and Black 2004). Zinc has also been associated with adverse functional outcomes resulting from stunting during early childhood (Stein et al. 2005).

This paper presents a synthesis of the ex ante impacts, including reduction of burden of disease, and cost-effectiveness, of Zn biofortification in seven countries (Bangladesh, India, Pakistan, Philippines, Northeast Brazil, Honduras, Nicaragua) and crops (beans, rice, wheat) that are targeted under HarvestPlus. The results provide evidence on whether biofortification can be a useful approach to combating Zn deficiency and identify the conditions under which is it most likely to be successful.

METHODS

An increasingly popular measure for quantifying the burden of disease is the “disability-adjusted life year” or DALY (Murray and Lopez 1996). The DALYs enable the aggregation of morbidity and mortality outcomes as well as providing a way to “add up” the burden of temporary illness (such as diarrhea) with more permanent ones (such as blindness) to result in a single index.

Since Zn-dense crop varieties have not yet been released, any evaluation of impacts is necessarily an analysis of ex ante impacts; that is, the potential effect of varieties with increased Zn levels on health status. We utilize the DALYs framework in quantifying the burden of current micronutrient deficiency (status quo) and the potential impact of biofortification on the reduction of the burden of disease. The difference in DALYs (or DALYs saved) are then a direct metric for analyzing the benefits of biofortification. By incorporating information on expected costs of biofortification, including research and development, adaptive breeding and dissemination and maintenance costs, costs per DALYs saved and the cost-effectiveness of biofortification can also be estimated.

The adaptation of this approach to the specific context of micronutrient malnutrition necessitated additional modifications in terms of the level of disaggregation incorporated in determining the functional consequences of Zn deficiencies for specific target groups. Expert opinion was solicited from nutritionists to detail specific outcomes that are attributable to Zn

deficiency, and only those outcomes for which there is research-based evidence from meta-analyses in the health literature are included.

The extent to which a food-based intervention such as biofortification can help ameliorate micronutrient deficiencies also depends heavily on level of consumption of the staple food crop, processing losses between the harvest and the plate, expected increase in micronutrient content, share of biofortified staples in production and consumption, and dose-response to increased nutrient intakes. These factors are incorporated into the estimated model through the use of primary and secondary data, expert opinion, and experience with the spread and diffusion of other modern varieties in these countries.

RESULTS AND DISCUSSION

Findings suggest that 0.1% of the population in the Philippines and 0.3 to 0.4% of the population in South Asia suffer the consequences of Zn deficiency on an annual basis. The overwhelming brunt of the burden is borne by infants under the age of 1. The reduction in the DALY burden of Zn deficiency from biofortified beans ranges between 3 to 20% in Latin America. A much greater reduction is seen from rice and wheat biofortification in Asia, with a 15 to 46%-reduction with high-Zn rice in Bangladesh and a 5 to 33%-decrease with high-Zn wheat in Pakistan.

Biofortification is extremely cost-effective in South Asia, with cost per DALY saved lower than \$10 even in the pessimistic scenario for both wheat and rice. Costs per DALY saved with beans in Latin America are higher, but still cost-effective in the optimistic scenario. It is only in the pessimistic scenario that costs per DALY saved exceed \$196 by a wide margin.

Table 1. Cost per DALY saved and benefit-cost ratios with Zn biofortification under pessimistic and optimistic scenarios.

	Cost per DALY saved (US\$)		Benefit-cost ratios	
	Optimistic	Pessimistic	Optimistic	Pessimistic
<u>Beans</u>				
Honduras	48.50	422.80	16	2
Nicaragua	208.40	1880.30	4	<1
Northeast Brazil	95.10	799.00	8	1
<u>Rice</u>				
Bangladesh	1.70	6.10	590	163
India	1.10	3.30	894	308
Philippines	7.00	46.30	144	22
<u>Wheat</u>				
India	1.20	7.10	807	141
Pakistan	4.50	33.90	222	29

CONCLUSIONS

This paper presents, for the first time, evidence from a range of countries and crops that biofortification can significantly impact the burden of Zn malnutrition and that it does so in a cost-effective manner, with most costs per DALY reported falling in a highly cost-effective category.

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