

Annex 2

Calculations of costs and benefits from the country studies

Cost-benefit calculations were done in the country studies [1–7], in most cases using the simulations from PROFILES*, as follows :

- » the strategies, described in chapter 4, build on current programs and are costed from the line items of proposed activities taking account of existing structures and considerations of expenditures likely to be considered reasonable;
- » the likely impact in terms of reduction in general and micronutrient malnutrition is largely unknown (see discussion below); in some cases they are set to the goals (e.g., 50% reduction in underweight) but this is not linked to a known relation to the program activities;
- » the benefits are calculated as saving a portion of the losses due to malnutrition predicted in the previous step, using the PROFILES default coefficients except for Sri Lanka (where independent estimates were made);
- » with discounting, these two are compared to give a benefit:cost ratio.

Overall, these calculations appear to give attractive returns to the proposed investments in economic terms, and this is intuitively correct. However, the whole process is based on so many assumptions that, while detailed analysis is avoided here, some delving into the underlying calculations seems necessary to get a sense of their credibility. In summary, it is concluded that, on one hand, biases in the calculations may make the conclusions over-optimistic in the short-term, and particularly favorable to micronutrient programs; on the other hand altering the assumptions in the direction likely to nearer reflect reality increases the calculated returns in the long-run, in part because preventing general malnutrition in early childhood has a persistent effect through life.

* PROFILES is a computer-based simulation package designed to illustrate the effects of malnutrition and the benefits of improving nutrition [8]; the methods are similar to those in the World Bank publication [9].

The costs of malnutrition

The direct productivity effects of malnutrition are on the capacity to perform physical work and earn higher wages. Protein-energy malnutrition (PEM), stunting and iron-deficiency anemia (IDA) reduce both. Improvements in PEM improve wages through increases in weight-for-height, while improvements in iron increase the capacity to perform moderate to hard labor with related increases in wages. These effects have been demonstrated in Indonesia, Philippines, India, and other countries [10].

The indirect effects on productivity are on cognitive ability and achievement, through impacts on psychomotor skills, development quotients for infants, and intelligence quotients for both preschool and school-age children. Iodine-deficiency disorders (IDD), protein-energy malnutrition, and iron deficiency have substantial negative impacts on developmental capacities of children, probably in that order of significance. In high-risk populations with a large goiter incidence, IDD depresses average intelligence by 13 IQ points [11]. Salt iodization programs throughout Asia are rapidly eliminating that gap, but much work remains to be done in terms of program coverage and product quality. Iron deficiency depresses psychomotor skills and intelligence, and only some of the effects are reversible [12]. On the other hand, appropriate complementary feeding for children under two years of age has a remarkable effect on stunted children of impoverished background, especially when combined with early cognitive stimulation [13]. Additional effects are included in the calculations from effects of malnutrition on health and survival.

Further evidence suggests that small children are usually born from small mothers, and both are caught up in an inter-generational cycle of poverty and malnutrition. Underweight or very thin children are susceptible to much higher risk for developing chronic diseases in mid-life, including cardiovascular diseases, hypertension, and diabetes [14]; combined with poor adult diets the risk is likely to be even greater. Proper

nutrition for the mother and young infant could avert a substantial disease burden across the life cycle of the next generation. However, inter-generational effects are not presently captured in the loss estimates calculated by this method.

Program costs in relation to impact

As discussed earlier, there is some concern that the cost estimates (summarized in the second column of table A2.1) are too low to have a major impact in some

of the proposals. If the relation between input and impact is non-linear, as is likely, then either further targeting of the same resources, or increasing the budget estimates, would be required.

In two proposals, from Bangladesh and Sri Lanka, the estimates of the likely reduction in malnutrition (underweight prevalence) are in line with the present limited experience of program impacts, suggesting a reduction of 1 or 1.5 percentage points per year (pp/yr), added to an underlying trend of 0.5 to 1.0 pp/yr reduction, to give a reduction of 20 pp over the 10 year term—a very worthwhile gain, and one

TABLE A2.1. Estimated costs (US\$) and benefits of proposed programs from the country reports

	Estimated program budget (US\$ million/yr—usually 10 yr plan)	Estimated total annual losses due to malnutrition	Reduction in malnutrition considered due to program expenditure	Hence losses avoided, which are equated to benefits (B), compared with costs (C)
Bangladesh	GEN: BINP \$5.4m rural \$62.1m urban \$21.8m (tabs 4.9–4.11) Total \$89.2 m/yr (\$5/child/yr)	Total \$2.3 billion [1, p. 101]	65% underweight prevalence reduced to 50% in 10 yr, 1.5 pp/yr (23% in 10 yr)	Calculated as \$530m in yr 10 (B); e.g., yr 10–20, \$5,300m, compared with \$890m total expenditure in yr 1–10 (C) (ratio=6.0)
India	Gen: \$1,380m/yr Vitamin A/iodine/iron \$200m/yr (\$11/child/yr)	Gen: \$8.1b VAD:\$0.4b IDD: \$1.5b IDA: \$6.3b [3, tabs 14.10–13] Total \$16.3b	25% reduction/yr in prevalence	Ratios calculated as B:C = 3.8, but basis unclear [13, p. 148]
Pakistan	Gen: \$46m/yr Vitamin A + iron \$5m/yr (tabs 5.5–5.8) (\$2/child/year)	\$166m/yr (\$71m underweight, \$94m stunting, [4, p. 4–10]) VAD: \$26m IDD: \$68m IDA: \$28m	Gen: 50%/10yr in underweight + stunting 100% reduction 100% reduction 50% reduction	B:C 3.2 B:C 33.6 B:C 4.1 B:C 3.5
Sri Lanka	Total: \$9m/yr (\$3/child/yr)	\$100m/yr [6, p. 126]	Additional 1pp/yr underweight reduction, equivalent to 30% over 10 yr due to program	At 30 yr, discounted present value of benefit = \$250m, cost = \$190m, ratio = 1.3
Cambodia	Total: \$9m/yr (\$6/child/yr)	NA	In 10 yr PEM 50% VAD 100% IDD 100% IDA 50%	B:C given as: PEM 5.5 IDD 11.5 IDA 10.6
Vietnam	Total: \$5m/yr (\$0.4/child/yr)	NA	100% reduction	Default costs B:C given as PEM 8.6 IDD 12.0 IDA 5.4

Note: Pakistan, Cambodia, and Vietnam estimates are directly from PROFILES [8]; Pakistan and Cambodia use costs from proposed program budget, with PROFILES default benefits; Vietnam also uses PROFILES costs.

GEN = general malnutrition (assessed as child underweight prevalence); PEM = protein-energy malnutrition; VAD = vitamin A deficiency; IDD = iodine-deficiency disorders; IDA = iron-deficiency anemia.

that is credible with a highly effective program. This amounts to a 25 to 30% reduction in the prevalence of underweight in the 10 years: nearing the declared goals of 50% reduction. In the other proposals (except from India) the expected reduction is simply set to the goals of 50% reduction of underweight. For vitamin A and iodine deficiency the goal is elimination (100% reduction), and for iron deficiency 50% reduction. These data are summarized in the fourth column of table A2.1.

The key point here is that the projected reductions, from which the benefits are calculated, have to be related to the program proposals. In the cases of Bangladesh and Sri Lanka they are optimistic guesses—which is better than simply taking default values—but no relationship of input to output has been systematically used. In the others this relationship is not established. In the guidelines for the RETA project (see Annex 1) a rule-of-thumb, that US\$5 to \$15/child/year additional expenditure might be expected to lead to an additional 1 to 2 pp/yr reduction in underweight prevalence was suggested if no other basis for calculation existed. This is approximately what was used in the Sri Lanka and Bangladesh studies (at the optimistic end of this range), but not in the others. The conclusion is that most estimates of the expected impact in terms of underweight prevalence reduction (see table A 2.1) are generally not based on any established relationships; they seem likely to be considerable overestimates for the proposed level of effort; and therefore probably should not be used in the benefit:cost calculations.

Benefit calculations

The issue of estimating benefits is quite separate from that of nutrition impact, involving ascribing economic (or other) losses to malnutrition, hence benefits gained when these losses are decreased by reducing malnutrition. Moreover part of these losses and gains are in the future, through the calculated enhanced productivity of people who were better nourished in childhood, for example, so that some discounting calculation is applied—although this is a minor question with the others.

The larger problem here is that the empirical relationship between malnutrition, productivity, and future income (adding in those who survive as well as those whose abilities are increased) is hardly known. The multi-step calculations multiply one average (and uncertain) value by others, ranges not being used, and give results whose error bands, if they were or could be estimated, would be very large. Added to this, there are conceptual issues, such as direction of causality. For instance, it is not clear that the observation that taller people earn more is because they are taller; it could also be that better-off parents are able to help

their children get higher paying jobs, not least through education.

This discussion is not intended to suggest that there are not great benefits, including economic, from improving nutrition. What is clear on close examination is that they are much more uncertain than indicated in some of the reports. If confidence intervals in this alone were assessed, the B:C ratios shown in column 5 of table A2.1 would be large—at a guess a B:C quoted as 3.5 could be at least from 1 to 10.

The reason for this is in part that PROFILES was originally designed as an illustrative tool for advocacy purposes. It was intended to show vividly, to the non-specialist, how malnutrition causes substantial losses, which it undoubtedly does, and illustrate some 'what ifs,' like what if malnutrition was halved. It was not intended as a direct input to benefit-cost analysis, but was used as such. Application of the methods of benefit calculation, and then introducing costs and impact (e.g., as described in [9]) is of doubtful value at least at this stage of the planning process. The conclusion is that the benefit estimates should be taken for what they were intended—as illustrations of possible benefit for advocacy purposes—but not then be multiplied/divided by other uncertain numbers to give a ratio of unknown accuracy.

Benefit-cost ratios

Given the uncertainties in the costs, in the likely program impacts hence proportion of losses that become benefits, and in the calculation of benefits themselves, the estimated benefit:cost ratios should be treated with great caution. This applies to the estimates for general and for micronutrient malnutrition. The ratios as calculated in the country studies are shown in column 5 of table A2.1. Except for Sri Lanka, they derive from the PROFILES calculations, thus the apparent consistency of B:C ranging from 3 to 6 largely reflects the PROFILES assumptions. (If the actual reduction in malnutrition was a more realistic 25% rather than the 50% assumed, these B:C ratios would be 1.5 to 3, still a good investment (see chapter 5, table 5.1.) The case of Sri Lanka is interesting as it is based on a new independent calculation. The authors show some restraint in not giving actual ratios in the report—the figures in the Sri Lanka cell were chosen from several given, and the ratio of 1.3 was calculated for this overview, not by the Sri Lankan authors.

The figures relating benefits to savings in table 5.1 are calculated simply by cumulating the annual savings, assuming that benefits persist, and comparing these with cumulated costs through time. This gives the ratios in columns H and I of table 5.1. The estimates can be done discounting the costs and benefits, although this does not alter the overall conclusions (see table A2.2). Here the case of Bangladesh is recalculated

TABLE A2.2. Values of expenditure on nutrition programs and benefit from reduced losses due to malnutrition, discounted at 5% per year, calculated for Bangladesh, in US\$ millions

	US\$ million per year									Total over 10 yr
	1	2	3	4	5	6	7	9	10	
Expenditure										
Annual	89.00	89.00	89.00	89.00	89.00	89.00	89.00	89.00	89.00	
Total	84.76	80.72	76.88	73.22	69.73	66.41	63.25	57.37	54.64	687.23
Benefit										
Annual	53.90	107.80	161.70	215.60	269.50	323.40	377.30	485.10	539.00	
Total	51.33	97.78	139.68	177.37	211.16	241.33	268.14	312.70	330.90	2,122.25
Benefits:expenditure ratio	0.61	1.21	1.82	2.42	3.03	3.63	4.24	5.45	6.06	3.08

Note: Expenditures and benefits discounted (at 5% per annum) according to the formula in [9, p. 58].

for a 5% discount rate. The ratios of benefit to cost are similar, around 3.0 cumulated over 10 years, and the estimated benefit:cost ratio can be seen to be better than one after the second year.

Other aspects of the cost-benefit relationship can be examined and have significant policy implications. One concerns the relative characteristics of investing in improved child growth, and in controlling micronutrient deficiencies. If an intervention prevents growth failure and the associated developmental faltering at critical early stages in a child's life, then the child after (say) five years of age is set and moves into the future with his/her potential intact. The interventions then benefit the next cohort. Even if the intervention ceases, the good is done and the benefit will persist into adulthood [15], as well as for the next generation. If the intervention continues for the next cohort, that benefit is accumulated with the first, again even if the intervention then stops. This contrasts with control of iron deficiency, for example, where the deficiency returns if the intervention stops, and the benefit is only seen with continuing expenditure. The benefits thus accumulate differently for the two situations. Interventions for general child growth and development are more expensive than micronutrient deficiency control. Thus micronutrient deficiency control appears to have a higher benefit/cost when this is estimated in the short term—in fact the benefit/cost does not change year-to-year as estimated in the PROFILES model for the reason given above: the intervention is needed continuously to get the benefit. The result is that the benefit from general malnutrition interventions looks much better after 10 or 20 years, because of this different cumulative characteristic. This is in line with intuition that, after some time, a more costly but persistent intervention will be a better investment than a reversible one.

This can be illustrated with a rough simulation as shown in table A2.3, which is based on the calculations in several of the country studies, using the Bangladesh data for guidance. Nonetheless the figures are hypothetical and are meant only to illustrate the

point; they are discounted at 5% per year. The simulation assumes that interventions to improve general malnutrition (or PEM) assessed by growth failure may be more expensive, but that the effects persist from the time that growth failure is prevented (e.g., even if the intervention then ceased). The calculations are in the first rows of table A2.3. The benefit:cost ratio here is about 2.5 over 10 years of project implementation, quite similar to the values in table 5.1 discussed earlier.

In the second part of the simulation, a less-expensive micronutrient intervention (at 20% of the cost of the first one) is assumed to bring similar benefits to begin with, but these are taken to be reversible: if the intervention ceases the deficiency returns, as would happen in reality, although certain benefits would also persist (like preventing mental retardation from *in utero* iodine deficiency). Still the second scenario explores the case of reversible effects from cheaper interventions, similar in some ways to micronutrient programs. Here the benefit:cost ratio remains the same through time, becoming the same annually as for PEM by year five, and cumulating to a similar level through year 10; by year 10 the annual return is greater for the persistent effect. (The calculations in the second part are very much like PROFILES outputs.)

The point made in this simulation is that with benefits accumulating with a persistent effect, like for PEM and growth (or general malnutrition), the cumulative benefit per cost increases through time. An investment in this aspect of malnutrition makes sense in a perspective of 10 years or more: precisely as an investment approach should. On the other hand, the micronutrient interventions are attractive from the start, not only as relatively low cost—much less than US\$1/capita/year—but as having clear and measurable benefits. The benefit/cost remains similar through time, but they remain worthwhile at any time.

This argues for a mixed approach: both general malnutrition and micronutrient deficiencies should be addressed, albeit with different expectations in a time perspective.

TABLE A2.3. Simulation of costs and benefits if benefits accumulate from one-time input (persistent effect) compared with if they are reversible

	Year: US\$ millions				Total over 10 years, US\$ millions
	1	2	5	10	
Persistent effect (e.g., PEM/growth)					
Benefit in year	50	100	250	500	
Benefit in year, present value discounted at 5%	47.6	90.7	195.9	307.0	1,968.7
Expenditure in year	100	100	100	100	
Expenditure in year, present value discounted at 5%	95.2	90.7	78.4	61.4	772.2
Benefit:cost ratio	0.5	1.0	2.5	5.0	2.55
Reversible effect (e.g., micronutrient deficiencies)					
Benefit in year	50	50	50	50	
Benefit in year, present value discounted at 5%	47.6	45.4	39.2	30.7	386.1
Expenditure in year	20	20	20	20	
Expenditure in year, present value discounted at 5%	19.1	18.1	15.7	12.3	154.4
Benefit:cost ratio	2.5	2.5	2.5	2.5	2.5

Notes:

1. Expenditures for persistent effect (e.g., PEM/growth) are set at US\$100 million/yr, similar to the Bangladesh proposal (see table 5.1, US\$89 million/yr); benefits from reduced losses are also based on Bangladesh calculations, starting at US\$50 million in the first year and cumulating.
2. Expenditures for reversible effect (e.g., micronutrient deficiencies) are taken as 20% of overall budget; benefits per year taken to be the same as for PEM, but not persistent.
3. Discounting uses the formula in ref. 9, p. 58.

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