Opportunities for Investments in Nutrition in Low-income Asia

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Abstract. *This paper examines the opportunities for nutritional investments in nine low-income Asian countries, where current levels of malnutrition are high and declining only slowly. Income growth alone is not sufficient to reduce malnutrition. The economic costs of malnutrition in the region are high, accounting for as many as 2.8 million child deaths and 65,000 maternal deaths annually. Productivity losses can be conservatively estimated to be at least 2-3 percent of GDP annually. Nutrition investments are very cost-effective. Micronutrient interventions and breastfeeding promotion are as cost-effective as basic child survival initiatives, and education/ supplementation programs are as cost-effective as antenatal care. Priority interventions in the region include: strengthening monitoring of salt iodization (and extension of the program to Cambodia); extension of coverage of vitamin A mass dose, establishing vitamin A fortification programs, and enforcing existing legislation; establishing iron fortification and intensifying coverage of iron supplementation to pregnant women; promotion of best practice in breastfeeding; water and sanitation investments in selected regions; and building on successful community-based nutrition programs.*

Introduction

Low-income Asia contains three quarters of the world's malnourished children, or 125 million of the estimated 167 million malnourished in 1995, using weight-for-age (ACC-SCN 1996). South Asia alone is home to half of the world's malnourished children, and another quarter of them are in Southeast Asia and the People's Republic of China (PRC). From the experience of other countries, we know that malnutrition will tend to decline if incomes rise, but

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that much faster progress can be made if there are investments in nutrition programs. There is also sufficient experience from existing programs to know how to make cost-effective investments.

There are strong reasons why governments should invest in nutrition, rather than leaving it solely to households and parents. First, nutrition, like education, is a very long-term investment. Capital markets are imperfect and do not finance this type of investment, particularly since there is no collateral. Hence investments by the poor in nutrition are likely to be too low, even if the households know that the returns are high. Second, parents are likely to underinvest in nutrition of girls, particularly in those countries in Asia where sons and daughters-in-law (but not daughters) take responsibility for their parents in old age. Lack of investment in girls' nutrition helps to transmit poverty intergenerationally, since stunted women have smaller babies. Finally, there are information gaps. The academic community only recently became fully aware of the importance of several micronutrients, and parents in developing countries may not have this information. Although the last problem can be overcome with public education policies, the first two represent market failures requiring government intervention.

This paper focuses on low-income Asia. The countries included are those in South Asia (Bangladesh, India, Nepal, Pakistan, and Sri Lanka), plus the PRC and the group of countries formerly included in Indochina (Cambodia, Laos, and Viet Nam). Myanmar and Bhutan are excluded due to lack of data, and we do not cover the low-income former Soviet Union countries. The nine countries included represent 86 percent of the total population of Asia (excluding central Asia). The eight middle-income economies, which are not covered, include the four "tigers" and the four "baby tigers" (Indonesia, Malaysia, Philippines, and Thailand). The following section discusses some of the human and economic costs of malnutrition in low-income Asia. General guidelines on cost-effectiveness of nutrition investments are then examined, and existing nutrition programs in low-income Asia are surveyed. The final sections discuss how to strengthen and complement existing investments in nutrition, and present conclusions. Throughout, we draw heavily on the country studies prepared for the ADB/UNICEF Regional Technical Assistance (RETA) Project (AERC 1998, Administrative Staff College of India 1998, Cambodia 1998, Chinese Academy of Preventive Medicine 1997, Institute of Nutrition and Food Science et al. 1998, Marga Institute 1998, National Institute of Nutrition 1998), hereafter referred to as the country studies.

The Existing Nutrition Situation in Low-income Asia

South Asia and Southeast Asia have the highest rates of child malnutrition in the world (ACC-SCN 1996). Although the rates have been slowly declining, in South

Asia this decline halted in the first half of the 1990s. The rates of decline in South and Southeast Asia are insufficient to reach the World Summit goals of halving child malnutrition by the year 2005. (Only the PRC, where nutritional status is already better, is likely to achieve this goal). In South Asia, malnutrition rates are higher than would be expected given food availability and per capita GNP, a phenomenon sometimes termed the "Asian enigma" (Ramalingaswami et al. 1994). In the seven low-income Asian countries included in the Project, there are some 120 million malnourished children, or 75 percent of the world's total (Mason, Hunt et al. 1999, Figure 2).

Rates of micronutrient malnutrition in low-income Asia are also very high. In South Asia, around 60 percent of pregnant women are anemic, and the rate is not much lower for infants and children (Mason et al. 1999, Table 4). Clinical signs of vitamin A deficiency are evident in 0.5-1.4 percent of the population surveyed (usually school-age children), and subclinical deficiency (based on low serum retinol) was found in 8-26 percent of preschool children (Mason, Hunt et al. 1999, Table 3). Iodine deficiency is also a serious problem, and country surveys indicate prevalence rates ranging from below 10 percent to over 50 percent (Mason, Hunt et al. 2001, Table 5).

These levels of malnutrition entail very high human and economic costs. One indicator of the human costs is elevated death rates. Studies suggest that protein-energy malnutrition (PEM) and vitamin A and iron deficiency are all associated with higher infant and child death rates. We know that the relative risks of mortality for children increase exponentially with protein-energy malnutrition. Compared to normal children, the relative risks are 2.5 for children who are 70-79 percent of median weight-for-age, 4.6 for children who are 60-69 percent of the median, and 8.4 for children who are less than 60 percent of the median (Pelletier et al. 1994). Using these relative risks, malnutrition is associated with 2.8 million child deaths per year in low-income Asia (51 percent of child deaths). If PRC is excluded from the comparison, then malnutrition is associated with 56 percent of child deaths in the region (Table 1). Note that in these calculations, we assume that the relative risks of malnutrition below six months are the same as for the 6-59 month age group, since data on child nutritional status and mortality rates by country are not readily available for the 0-5 and 6-59 month age groups separately. Iron deficiency anemia is estimated to be associated with 23 percent of maternal deaths (Ross and Thomas 1996). Thus of the estimated 286,000 maternal deaths per year in the region, an estimated 65,000 are attributable to iron deficiency anemia (Table 1).

Table 1: **Estimates of Excess Mortality Attributable to Malnutrition**

Country	# Child Deaths /yr, '000	# Due to Moderate/ Severe Malnutrition	# Maternal Deaths/ yr, '000	# Due to Anemia
Bangladesh	327	215	24.3	5.6
Cambodia	63	39	33.0	7.6
PRC	970	287	19.6	4.5
India	2,810	1,730	139.3	32.0
Laos	30	17	1.5	0.3
Nepal	95	51	12.5	2.9
Pakistan	687	367	17.1	3.9
Sri Lanka	6	3	4.0	0.9
Viet Nam	92	53	33.0	7.6
Total	5,080	2,762	286.2	65.3

Sources: Author's calculations, using data in appendix tables 1 and 2, and information on relative risks from Pelletier et al. (1994) and Ross and Thomas (1996).

Recent meta-analyses have concluded that subclinical vitamin A deficiency is a far more important factor in child mortality than was previously realized. (Meta-analysis is a technique used to pool the information from several clinical studies, since these studies frequently have small sample sizes). It is estimated that the relative risk of mortality for a child with subclinical deficiency is 1.75 times that for a nondeficient child (Ross 1996). If subclinical deficiency is 10 percent throughout the entire region, then 0.36 million child deaths per year could be averted with a successful program of vitamin A supplementation. Ten percent is likely to be a conservative estimate of the extent of subclinical deficiency.

The economic costs associated with malnutrition are also very high. Studies suggest that protein-energy malnutrition and iron and iodine deficiency entail productivity losses. Malnutrition is associated with lost productivity in adults. Adults who are stunted or anemic have lower productivity, most noticeably in (but not restricted to) manual work. Cognitive losses associated with protein-energy malnutrition in childhood, with childhood iron-deficiency anemia, and with being born to a mother with goiter, are more or less irreversible by the time a child reaches school. These cognitive losses are associated with lower productivity in adulthood. Malnutrition also entails wasted resources in the health and education systems. Children who are malnourished have greater needs for health care, and are more likely to repeat school years or to drop out of school.

Even with conservative assumptions, the productivity losses associated with protein-energy malnutrition are very high (Table 2). A 1 percent deficit in adult height was found to be associated with a 1.38 percent reduction in agricultural wages in the Philippines (Haddad and Bouis 1991), and with a 0.3 percent decrease in rural wages in Pakistan (Alderman et al. 1996). This implies that adults who were moderately malnourished as children would be 2-6 percent less productive, and those who were severely malnourished 2-9 percent less productive, than their counterparts who were not malnourished. Studies suggest that iron deficiency anemia is associated with a 17 percent loss of productivity in heavy manual labour, and 5 percent in light blue-collar work (studies cited in Ross and Horton 1998).

The losses due to cognitive impairments resulting from childhood malnutrition are more pervasive but more difficult to quantify (Table 2). Estimates suggest that protein energy malnutrition in childhood is associated with a 15 point decrease in IQ, which in turn is associated with a 10 percent drop in earnings and hence productivity (Selowsky and Taylor 1973). Similarly, childhood anemia is associated with a decrease in score on cognitive tests of about one half of one standard deviation, which in turn is associated with a 4 percent decrease in hourly earnings (Ross and Horton 1998). The average productivity loss per child born to a mother with goiter is estimated as 10 percent (Ross 1997, based on a 3.4 percent chance that the child is a cretin with zero economic productivity, a 10.2 percent chance that the child has a severe cognitive impairment, associated with a 25 percent loss of productivity, and an 86.4 percent chance of mild cognitive impairment with a 5 percent loss of productivity).

Table 2: **Summary of Productivity Losses Associated with Malnutrition**
(percent)

Type of Malnutrition	**Current Losses (Manual Labor)**	**Losses based on Childhood Malnutrition (Cognitive)**
Protein-energy malnutrition	2-6 (moderate stunting) 2-9 (severe stunting)	10
Iron deficiency	17 (heavy labor) 5 (blue-collar)	4
Iodine deficiency	n/a	10
Vitamin A deficiency	n/a	n/a

Sources: See discussion in text; Appendix Table 2.

Making estimates of the overall economic costs of malnutrition is difficult. One has to take different prevalences of anemia in men and women into account, for example, and their different levels of participation in market economic activity and in heavy manual labor. Economic calculations are based only on market economic activity and exclude nonmarket losses although these may be socially very valuable. The calculations also require estimating the degree to which different conditions overlap, for example the degree of overlap between those adults who are currently anemic and hence less productive in manual labour, and adults who are stunted and therefore less productive in manual labour. Similarly there is undoubtedly an overlap between children who are currently deficient in iron and those who are stunted. It is even harder to estimate the overlap between those adults who are currently anemic, and adults who suffered either protein-energy malnutrition or iron-deficiency anemia as children that affected their cognitive development and hence adult productivity. (We would expect a high degree of overlap between stunting in adults and childhood stunting in those same individuals). The usual bias is to be as conservative as possible and assume the maximum amount of overlap, such that the estimates of productivity losses are lower bounds.

Table 3 provides some estimates of the costs of malnutrition (based on lost productivity) estimated as a percentage of GDP for selected countries in the region. Even with conservative assumptions, the losses may exceed 2 or 3 percent of GDP, and substantially more if longer duration cognitive effects are included. Tables 1-3 show that the human and economic costs of malnutrition in low-income Asia are so high that investments in nutrition are a very important priority.

Table 3: **Estimates of Productivity Costs of Malnutrition, Selected Countries, as Percent of GDP**

	Losses of Adult Productivity		
Country	**Stunting**	**Iodine Deficiency**	**Iron Deficiency**
India	1.4	0.3	1.25
Pakistan	0.15	3.3	0.6
Viet Nam	0.3	1.0	1.1

	Losses Including Childhood Cognitive Impairment Associated with Iron Deficiency	
Country	**Cognitive Only**	**Cognitive plus Manual Work**
Bangladesh	1.1	1.9
India	0.8	0.9
Pakistan	1.1	1.3

Sources: Calculations for adult productivity from Administrative Staff College (1998), AERC (1998) and Horton (1998); cognitive impairments from Ross and Horton (1998). The data for India from Administrative Staff College are the “low scenario” and are about half the size of the “moderate scenario” losses, and only one-third the size of the “high scenario” losses.

Cost-effectiveness of Investments in Nutrition

Studies suggest that nutrition investments can be quite inexpensive and replicable on a national scale. Table 4 presents the unit costs of various nutrition interventions, which suggest that, with the exception of feeding and food subsidy programs, the costs are modest. However, unit cost information alone is not enough for policy analysis. Impact data is also necessary. The most comprehensive recent study of cost-effectiveness of health interventions in developing countries (Jamison et al. 1994, summarized in World Bank 1993) analyzed 52 health interventions, including nine with a main focus on nutrition. Six of the nutrition interventions ranked among the 22 most cost-effective interventions (breastfeeding promotion, salt iodization, sugar fortification with vitamin A, semiannual mass dose of vitamin A, iodine injections for pregnant women, and daily oral iron for pregnant women), costing less than $25 per Disability Adjusted Life Year (DALY) saved. The other three nutrition interventions ranked in the six next most cost-effective interventions (costing $25-75 per DALY: these included improved weaning practices for children, food supplements for children, and food supplements for pregnant women).

Table 4: **Approximate Unit Costs of Interventions with Effects on Malnutrition**

Intervention	**Cost/Beneficiary/Year (US$)**
Micronutrient fortification	
Iodine	0.05
Iron	0.09
Vitamin A	0.05-0.15
Micronutrient supplementation	
Iodine	0.50
Iron (per pregnancy)	1.70
Vitamin A	0.20
Mass media education programs	0.20-2.00
Breastfeeding promotion	2.00-3.00
Education programs (home gardening, growth monitoring, etc.)	5.00-10.00
Community-based nutrition programs	
Less intensive	2.00-5.00
More intensive	5.00-10.00 and up
Feeding programs (per ‘000 cals/day)	70.00-100.00
Food subsidy programs (per ‘000 cals/day)	36.00-170.00

Sources: This table is table 6 in Horton (1999). Breastfeeding promotion: Horton et al. (1996). Less intensive community-based programs: Horton (1999). More intensive community-based programs: Mason (1998). Other programs: Horton (1992). Examples of less intensive programs with some reported effectiveness include BIDANI (Philippines: $2/child), PANP operated by Save the Children in Viet Nam ($4/child), and a UNICEF pilot project in Viet Nam ($2.60/child). See Horton (1999) for references and examples of more intensive programs that are reported as effective including TINP ($12/child: see Ho 1985).

These data suggest that micronutrient programs rank very high in cost-effectiveness, since they have low unit costs and their effects can be dramatic. Education programs to change behavior (for example education of mothers accompanying growth monitoring, or to promote breastfeeding) can be equally cost-effective, if well designed. Feeding programs are in the next most cost-effective group of programs, as long as they are highly targeted and accompanied by strong complementary investments in nutrition education. Finally, credit programs or other programs that improve the access of poor households to resources can improve nutrition, although the effects may take some time. However, since the nutrition effects are more indirect, there are few, if any, good studies of the cost-effectiveness for nutritional outcomes of these complementary investments.

More detailed studies give guidance as to how to design the most cost-effective programs. Studies of micronutrient interventions suggest that supplementation programs for micronutrients are around ten times more costly than fortification programs (for iron and iodine see Levin et al. 1990). Hence fortification would be the program of choice unless the target group is small (i.e., less than 10 percent of the population) and deficiencies in the nontarget population were not important. Supplementation would be the program of choice, for example, for supplying folic acid to pregnant women.

There are also practical and logistical issues in micronutrient programs. For example, in Asia, iron fortification of cereals (one of the most important methods used in developed countries) is feasible for wheat-based diets but not cost-effective for rice-based diets. Fortification of vegetable oil with vitamin A is cost-effective in South Asia, but not in Southeast Asia and PRC, where purchases of vegetable oil are much lower. In all countries, there are remote regions that are not tied in to national food markets and are very hard to reach through national-level fortification programs. Here, supplementation might be a viable alternative.

Studies suggest that interventions for protein-energy malnutrition are more cost-effective at early ages (e.g., Taylor et al. 1984 for Narangwal, India). Feeding programs for school-age children do not feature as a cost-effective intervention in the World Bank study (Jamison et al. 1994), although feeding integrated with micronutrient supplements and deworming is cost-effective for this age group (del Rosso and Marek 1996). One finding emphasized in the country studies is that low birth weight is critically important in child malnutrition, particularly in South Asia and Viet Nam. Programs aimed at preschool children have to be complemented with programs aimed at pregnant women, and maybe even at female adolescents. This is a particularly difficult issue, given the weakness of primary health care and antenatal care in many low-income countries in Asia. Primary health care systems are relatively good in Sri Lanka, Viet Nam, and PRC (as reflected in the lower maternal and child death rates in Appendix Table 1), but they are weak in the other countries in South Asia and in Cambodia and Laos. The patterns in antenatal care are similar. Whereas

90 percent of women in Sri Lanka receive antenatal care, and 60 percent in Viet Nam, the figure is only 24 percent in Bangladesh and even lower in Pakistan (country studies). Good primary health care systems alone are not sufficient to reduce malnutrition, which remains high in Sri Lanka and Viet Nam. However, the absence of good primary health care systems in the other countries makes it more difficult—and probably more expensive—to improve nutrition. This suggests that different kinds of nutrition strategies may be required in the two groups of countries.

Existing Nutrition Investments in Low-income Asia

In most countries in low-income Asia, nutrition is an important component of national development plans. In some countries, there are separate National Plans of Action on Nutrition (Viet Nam, Sri Lanka, Cambodia, India), and these are frequently in place in middle-income Asian countries (Philippines, Thailand). In other cases, there may be a separate nutrition unit within the Ministry of Planning (Pakistan). Nevertheless, given the intersectoral nature of nutrition problems, progress has been less rapid than desired and most countries other than PRC are unlikely to reach the goal of halving childhood malnutrition by the year 2005.

Tables 2.1 and 2.2 in Mason, Hunt et al. (2001) provide information on existing investments in programs to address general malnutrition and micronutrient malnutrition, respectively. Tables 5 and 6 here provide information on the coverage of breastfeeding promotion programs and complementary efforts to reduce poverty and improve water and sanitation.

Table 5: **Breastfeeding Promotion Initiatives as of 1997 in Low-income Asia**

Country	**Interventions**
Bangladesh	Medium compliance with BM code, legislation 1984, 1993; 20% of targeted hospitals and maternity centers are baby-friendly (139 hospitals)
Cambodia	Weak compliance with BM code; no baby-friendly hospitals
PRC	Medium compliance with BM code; 6312 hospitals baby-friendly in 1995
India	Good compliance with BM code, legislation 1992, 1993; 1017 hospitals baby-friendly
Laos	Medium compliance with BM code, legislation 1993; 4 hospitals baby-friendly
Nepal	Good compliance with BM code, legislation 1992, 1994; 7 hospitals baby-friendly
Pakistan	Weak compliance with BM code. 35 hospitals baby-friendly (out of 62 district and 22 divisional hospitals): however vast majority of births occur outside hospitals
Sri Lanka	Good compliance with BM code; 97 hospitals baby-friendly; 85% of births occur in government institutions
Viet Nam	Medium compliance with BM code, legislation 1994; 23 hospitals baby-friendly, another 70 have received training (out of 63 provincial and 583 district hospitals)

Note: Countries with good compliance with the code have enacted legislation as suggested in the international code; countries with medium compliance have enacted weaker or partial legislation; countries with weak compliance may have voluntary measures or measures still in draft.

BM = Breastmilk

Sources: RETA country studies; additional information from UNICEF (1997a, 1997b). Ratings by UNICEF.

Table 6: **Selected Investments Complementary to Nutrition in Low-income Asia**

Country	Investments
Bangladesh	97% of households have safe water, 48% have sanitary latrines Poverty alleviation efforts include rural development (including food for work), vulnerable group development projects, microcredit
Cambodia	36% of households have safe water, 14% have sanitary latrines Village development is a high priority (UNICEF, UNDP, WFP, World Bank Integrated Social Fund, NGOs involved); half of Public Investment Program is allotted to water, sanitation, education; 20% of households are headed by women; 47% of women are illiterate
PRC	67% of households have safe water, 24% have sanitary latrines Existing provincial and municipal/commune level development plans often include nutrition; government safety nets include urban food subsidies
India	81% of households have safe water, 29% have sanitary latrines Public Distribution Scheme for food, not well targeted to improving nutrition; midday meal program for schoolchildren; many integrated development schemes; food for work programs are important (particularly in selected states)
Laos	52% of households have safe water, 28% have sanitary latrines
Nepal	63% of households have safe water, 18% have sanitary latrines
Pakistan	74% of households have safe water, 47% have sanitary latrines NGOs involved in poverty alleviation projects
Sri Lanka	53% of households have safe water, 61% have sanitary latrines 70% of population covered by oral rehydration treatment; transfers to poor account for 6.7% of GDP; programs include Samurdhi (foods stamps, kerosene stamps, midday meal), Janasivaya (gives cash and loans to very poor)
Viet Nam	43% of households have safe water 22% have sanitary latrines; VAC program (animal/fish husbandry and gardening) strong but small-scale; Women's Union strong and of potential value in improving women's status

Sources: RETA country studies, except UNICEF (1997c) for data on water and sanitation, which is derived from Table 7.

Community-based interventions are the most expensive and involve the most administrative effort, in terms of replication on a national scale. India, Sri Lanka, and Viet Nam have the largest existing national programs in low income Asia. India's Integrated Child Development Services (ICDS) program covers approximately 80 percent of all blocks (administrative units), but a lower proportion of the target population. It includes growth monitoring and a massive supplementary feeding component, and costs $150 million per year (Administrative Staff College 1998). Sri Lanka has nutrition-promotion activities (growth promotion, targeted supplementary feeding and some nutrition education) linked into its Maternal and Child Health services, and apparently succeeds in weighing over 80 percent of infants (but only about 20 percent of preschool children). Likewise, the targeted supplementary feeding program covers about half of pregnant women, one third of lactating mothers and two thirds of infants 7-12 months, and past internal evaluations and rapid appraisals suggest there is evidence of improvements in nutritional status after participation in these programs although no formal evaluations are available (Marga

Institute 1998). Finally, the program of the Committee for the Protection and Care of Children (CPCC) in Viet Nam currently covers 20 percent of the population, and includes growth monitoring, supplementary feeding, micronutrients (a limited amount of iron supplements for pregnant women and a vitamin A mass dose program that is not part of CPCC), and nutrition education. The program costs $2.2 million per year, or $0.83 per child, or $12.30 per malnourished child (National Institute of Nutrition 1998). The PRC also has province level programs for nutrition improvement. Community-level programs in these four countries provide a foundation for strengthening, improvement, and an increase in coverage to 100 percent of the target group. These countries (with the exception of India) have well-functioning primary health care systems, as evidenced by their superior performance on child and maternal mortality rates (Appendix Table 1).

The other low-income countries in Asia have much more limited existing community-level nutrition programming, and suffer from the additional disadvantage that they also lack well-developed primary health care systems (Bangladesh, Cambodia, Laos, Nepal, and Pakistan). Establishing national-scale community-level nutrition programs will be much more challenging in this environment. Antenatal care is also lacking in those countries with insufficient primary health care. Addressing the problems of low birth weight is very hard in the absence of an antenatal care network.

Seven of the nine low-income countries have existing legislation on breastmilk substitutes (Pakistan and Cambodia being the exceptions). All except Cambodia have some baby-friendly hospitals promotion, and have made an encouraging amount of progress (20 percent of targeted hospitals in Bangladesh, 44 percent in Pakistan, and 3 percent in Viet Nam are already baby-friendly, and many more have commenced training; see Table 5). The main issue here, however, is that, except in Sri Lanka, the vast majority of births in low-income Asia occur outside hospitals. Thus baby-friendly hospital initiatives need to be complemented by education initiatives at the community level. One advantage in the region is that levels of breastfeeding are high (although the duration for exclusive breastfeeding tends to be too short, and other practices, such as withholding colostrum, are not ideal).

Despite the problems, there are a number of examples of successful and cost-effective community-based programs at pilot scale in the countries lacking existing national programs, as described in the country studies. These could be used as a basis for scaling up, at costs ranging from $2 to $10 per child per year. Although these expenditures are modest, it should be borne in mind that the average per capita health expenditure in the PRC is only about $11 and about $21 in India (public and private expenditures combined; World Bank 1993). Hence these programs need to be targeted, whether geographically or by other means, unless significant local resources can be mobilized. Thailand provides an excellent example of the success possible when communities are mobilized (Tontisirin and Gillespie 1999).

In the area of micronutrients, much remains to be done. Programs on iodine are furthest ahead, in that salt iodization is mandatory in almost all countries in the region (with the exception of Cambodia), however, monitoring capability needs strengthening. Even though the technical requirements are modest, governments do not have the capability to monitor food fortification at the local level. In Pakistan for example, local-level testing of iodized salt by the public was encouraged with the distribution of testing kits. However, salt iodization in Pakistan is the responsibility of a nongovernment organization. Another issue is the provision of additional iodine in areas where iodine deficiency is endemic and iodized salt is not available. In the PRC, UNICEF has experimented with iodine drips in irrigation systems.

Progress has been more limited with vitamin A. Some of the South Asian countries require fortification of vegetable oil with vitamin A (mandatory in India and Pakistan, and some oil is fortified in Bangladesh), but monitoring and hence compliance are weak. Vegetable oil is not as suitable a fortification vehicle in Southeast Asia and PRC due to different consumption patterns. Bangladesh and India have national semiannual mass dose programs, but in Bangladesh these programs reach mainly children one year and younger (through the EPI), and in India reach 25 percent of the target group. Nepal also has a mass dose program. In Cambodia, there is a vertical program, but it only delivers one dose per year instead of the recommended two. In Viet Nam, the mass dose program is still only at pilot scale, and such a program does not exist in the other countries.

There has been least progress on iron fortification and supplementation, despite the very high levels of anemia. National-level fortification does not exist in the region, although India is currently testing iron-fortified salt. Several countries (including Bangladesh, Cambodia, and Pakistan) make some attempts at supplementation for pregnant women, but coverage is low (only 1 percent of the target population in Bangladesh).

We used the PROFILES model (described in detail in the Appendix) to estimate the benefit-cost ratios for hypothetical nutrition intervention programs in seven low-income Asian countries (Table 7), and the cost per death-averted (Table 8). The underlying parameters for the countries are given in Appendix Table 3, and the program costs in Appendix Table 4. The program analyzed is a hypothetical one, the same across all countries, incorporating intensive education and breastfeeding promotion, salt iodization, vitamin A mass dose and (for pregnant women) iron supplementation, which is phased in gradually over nine years in order to achieve the World Summit for Children goals by the tenth year. Current and future costs and benefits are analyzed (discounting the future at 3 percent, which is the usual rate for investments in the social sector). We do not attempt to analyze the benefit-cost ratio for iron fortification (which would be feasible in some countries for a portion of their population). We also do not consider variation in unit costs of interventions by country due to lack of data. However it is the author's judgment that unit costs would likely be higher in the countries without preexisting primary health care systems (Bangladesh, Cambodia, parts of India, Pakistan, Laos, and Nepal).

Table 7: **Benefit-cost Ratios for Nutrition Investments using PROFILES Methodology**

Deficiency	**Bangladesh**	**Cambodia**	**PRC**	**India**	**Pakistan**	**Sri Lanka**	**Viet Nam**
Iodine	13.48	12.43	7.50	2.70	28.67	6.88	11.98
PEM	3.65	5.46	2.37	4.72	5.01	1.58	8.57
Iron	3.94	5.28	3.59	4.10	0.87	10.25	6.12
Total	7.16	7.23	4.53	3.98	8.32	5.45	8.89

Source: Author's calculations using PROFILES software as described in Ross (1997). Calculations were done using common (default) values of costs of nutrition interventions, and country data on prevalences, death rates, and economic variables (see Appendix Table 3). The benefit-cost ratio is calculated for an intervention, phased in over nine years, which aims to halve the prevalence of selected nutritional deficiencies.

Table 8: **Cost per Death Averted for Nutrition Investments, Using PROFILES Methodology in US$**

Deficiency	**Bangladesh**	**Cambodia**	**PRC**	**India**	**Pakistan**	**Sri Lanka**	**Viet Nam**
PEM	150	103	591	149	175	1,112	298
Iron	4,971	9,659	48,445	7,467	14,820	93,714	48,862
Vitamin A	116	161	229	237	76	493	282

Source: Author's calculations using PROFILES software as described in Ross (1997).

In interpreting the results, it is important to bear in mind that two of the interventions (intensive education to reduce stunting and iron supplementation) each have two outcomes (productivity gains and deaths-averted), and two have only one outcome modelled (productivity losses in the case of iodine fortification, and deaths-averted in the case of vitamin A supplementation). We have not attempted to assign a dollar value to deaths-averted, and hence it is not possible to compare different interventions with different outcomes.

The calculations suggest that nutrition interventions have benefits that exceed costs (Table 7), with the one exception of iron supplementation in Pakistan (where women's labor force participation is very low, and hence effects on marketed output are small; this is not to suggest that iron fortification in Pakistan is not socially valuable, simply that its effects are not captured by market-based indicators). Iodine fortification has the highest benefit-cost ratio of all interventions in all countries except India (where the goiter figures are suspiciously low).

The benefit-cost ratios vary quite widely. It should be borne in mind that the prevalence of goiter varies by a factor of 6 across the countries included, that the prevalence of anemia varies by a factor of 2, and stunting is twice as prevalent in some countries as in others. Moreover, women's participation in agriculture in Cambodia and Vietnam is 7 times higher than in Pakistan. Child mortality rates are almost 9 times higher in Cambodia than in Sri Lanka, and maternal mortality rates are almost 9 times higher in Cambodia than in PRC. These enormous variations in the underlying parameters account for the observed variation in benefit-cost ratios.

Nutrition interventions also appear to be very cost-effective as public health interventions, when examining costs per death-averted (Table 8). Costs per death-averted by breastfeeding promotion/IEC are estimated as $100-$300 in the poorest countries (Bangladesh, Cambodia, India, and Viet Nam) and are also in the same range in Pakistan, which has surprisingly high levels of malnutrition given its higher per capita income. Estimated costs per death-averted for vitamin A mass dose are in the same range for all countries except for Sri Lanka, which has by far the lowest infant mortality rate in this group of countries. The estimated costs per death-averted for iron supplementation are markedly higher than for other interventions, because maternal death rates are lower than infant mortality rates (but note that iron supplementation also has effects on productivity). Comparing across countries, costs per death-averted are inversely related to levels of mortality.

The results again suggest that nutrition interventions in low-income Asia are a high priority in terms of high benefit-cost ratios, and low costs per death-averted. If program costs are identical across countries, then the countries where interventions are highest priority are those with highest current death rates and prevalences of nutritional deficiency (Bangladesh, Cambodia and Viet Nam, the poorest countries, and Pakistan, which has surprisingly poor human resource indicators given its level of income). India is also a high priority, although the prevalence figures for micronutrient deficiencies appear to be underestimates.

If costs for nutrition intervention programs are lower in countries with better primary health care systems, this would tend to improve the benefit-cost and cost-effectiveness ranking of PRC, Sri Lanka, and Viet Nam. However, we do not have good data on the variation of program costs across countries.

Nutrition improvements also require complementary investments (refer back to Table 6). Without investments in water and sanitation, children may lose the benefits of additional food intake due to parasite infestation and diarrhea. However, the costs of these investments per household are high. Water jars in areas where these are feasible can cost $10 per household, and latrines may cost $15 for the ceramic fixtures but closer to $100 per household if the cost of a structure is included (these figures are approximate, and based on experience in Thailand and Viet Nam). Safe water is available to 64 percent of households in Sri Lanka, 45 percent of households in Viet Nam, and 70 percent of urban (but only 20 percent of rural) households in Pakistan. The case of Bangladesh, however, indicates that safe water supply alone is not enough. Although safe water is almost universally available in Bangladesh, substantial education efforts are necessary to ensure that everyone uses it (especially children). Investments in sanitation lag. Fewer than half of all households in the nine countries have sanitary latrines (Sri Lanka is the only exception), and in six of the nine countries, fewer than one third of all households have sanitary latrines.

Poverty alleviation programs can also have important indirect effects on nutrition (refer back to Table 6). South Asia has in the past focused on public food distribution/ration schemes, which have been phased out in Bangladesh, Pakistan, and Sri Lanka (in Sri Lanka they were replaced by food stamps). There has been a growth in poverty alleviation efforts. Sri Lanka has fairly comprehensive national programs and Bangladesh has a heavy emphasis on credit, following several successful NGO-run schemes. Bangladesh and India have important food-for-work schemes. Integrated rural development schemes are a focus in Cambodia due to the overall deficiencies in infrastructure. One successful pilot program in Viet Nam is the VAC scheme (an acronym that stands for the Vietnamese words for animal and fish husbandry and gardening). Food subsidies remain important in urban PRC. All the countries have regions of particularly high need. In rural areas, these tend to be more remote and inaccessible and lacking in infrastructure, although other factors may also intervene. In Sri Lanka, the estate sector performs poorly with respect to nutrition. All of the countries (although to a lesser extent the PRC) also have urban slums, which are a high priority for intervention.

With respect to the status of women, the gap between education of women and men tends to be largest in the poorest countries, and there are cultural and religious factors (including inheritance and support in old age) which increase discrimination against women, particularly in parts of South Asia and PRC. In the Southeast Asian countries and parts of southern PRC, the issue is perhaps less the status of women, and more that women have very heavy responsibilities in agriculture that are associated with lower weight gain during pregnancy and with substitute childcare during busy agricultural seasons. Investments in poverty alleviation and in improving the status of women are long-term investments that will enhance the effectiveness of specific investments in improving nutrition; they are not substitutes for direct nutritional investments.

Thus countries in low-income Asia have begun to make the important investments necessary for nutrition improvement. Obstacles include: the costs (particularly for community nutrition programs and investments in water and sanitation), which are large relative to per capita income; administrative and technical capability (especially for micronutrients, where costs are less of an obstacle); and, in several countries, the weak primary health and antenatal care systems, without which encouraging community nutrition interventions will be more difficult and more costly. Some of the countries have existing nutrition investments which are not highly effective, such as large-scale public distribution systems, growth monitoring programs with limited impact, or programs focusing on older children rather than those under three years of age. These resources could be redirected to more effective programs.

Opportunities for Additional Investments

The previous section discussed existing investments and some of the gaps. This section focuses on the opportunities for investments, using also the information on costs and cost-effectiveness from above. We commence first with micronutrients and then move to investments that affect malnutrition more generally.

All countries in the group could use technical assistance and financial support to set up monitoring capability for micronutrients. Several countries have units, often with the Ministry of Industry, to monitor product standards (for example the Pakistan Standards Control Authority), but these units do not usually have the capability to monitor micronutrient fortification. The level of technical capability need not be very high (in Pakistan the NGO involved in salt iodization spent only modest amounts to distribute testing kits to the public), but some monitoring is essential. Similarly, investments in “social marketing” of fortification do not have to be very high (again, in Pakistan the amount involved was around $1.5m), but the benefits in terms of sustainability are important.

Initial investments involved in equipment for fortification can be relatively large, and here external support might be desirable. These costs were estimated for Pakistan as close to $1m for vitamin A (based on a cost of $7,000 per plant), and $9m for iron (based on a cost of $15,000 per plant, AERC 1998). However, it would probably be possible to reduce these costs substantially if the fortification machinery were made locally rather than imported. Once installed, however, as long as there is public acceptance, the consumer can bear the modest costs implied. For Pakistan, the annual costs were estimated as $0.09 per person per year for iron, $0.05 for vitamin A and $0.06 for iodine (AERC 1998).

Logistical considerations are also important for micronutrient fortification, the identification of an appropriate vehicle being one prime issue (see Lotfi et al. 1996 for further discussion). In cases where wheat flour is a staple (Pakistan, parts of Bangladesh and India, and urban areas in other countries) fortification of wheat flour with iron would be an obvious step. In other countries, investigation of suitable vehicles for iron fortification is necessary. Possible candidates include double fortification of salt (iron/iodine), soy sauce, etc. Even with iron fortification, supplementation for pregnant women will remain necessary, and should form one component of antenatal care. Legislation is also necessary to mandate levels of fortification.

In the case of iodine, salt iodization should be made mandatory in all remaining countries as soon as possible, and monitoring and enforcement improved. Special projects should continue in goiter-endemic areas not reached by iodized salt from the national market.

For vitamin A, a three-pronged approach is recommended. The first component is mass doses (semiannual), which can be integrated into maternal and child health care programs, and given to children below three years of age and to women immediately postpartum. (Given the risks of mass dose of vitamin A in women with undetected pregnancy, this is the safest way to reach women). Reaching infants at six months and one year is feasible in combination with EPI, and could be integrated with growth monitoring for children below three years of age. A second component of the approach would be fortification. In South Asia, establishing monitoring of existing fortification of vegetable oil would be helpful (this may require assistance with provision of fortification equipment), and possibly some small technical studies on optimal storage and packaging to maintain quality of the fortificant. Finally, a long-term solution is to promote the growth and consumption of foods rich in vitamin A, particularly among pregnant and lactating women, and small children. (We do not include here treatment of measles cases with vitamin A, since this is more a component of primary health care than a nutritional concern.) If successful programs for iron, iodine, and vitamin A can be established, other micronutrients may be included, particularly zinc, and in some areas of the PRC, vitamin D.

Turning now to programs with more general effects on nutrition, baby friendly hospital initiatives should continue and be extended to cover all hospitals. Although these only reach a minority of women in many countries, they are an important complement to initiatives at the community level. If richer, urban women are those who give birth in hospital, their behavior should act as a positive role model for other women in the country. Enacting legislation on breastmilk substitutes should be a priority in those countries without such legislation (Cambodia and Pakistan), as should be improving compliance in those countries with partially successful existing legislation (Bangladesh, PRC, and Laos).

Community-level initiatives require the most financial and administrative resources. As discussed above, countries in the region fall into two groups: those with strong primary health care/antenatal care, and those with weaker systems. In the former case, it is feasible to consider extending the system and intensifying nutrition activities, which could be achieved by training existing health workers, and recruiting nutrition workers and/or nutrition volunteers as for example in Thailand. The advantage is that existing health workers can provide support and supervision. This in turn requires investments in training, training materials, and initial equipment (scales), as well as recurrent expenditures (micronutrient supplements, deworming tablets in endemic areas, growth charts etc). Although the cost of supplies is very modest per child, nonetheless costs become very substantial at anything approaching national scale. Countries may wish to follow the approach adopted by Thailand (and also the PRC in the 100 counties model), and begin with the highest priority areas. Programs also necessarily differ between urban and rural areas. In urban areas, slums are a high priority, but it may be very hard to use volunteers in such areas. By definition, high priority rural areas are most likely to be remote or difficult to access, have dispersed populations, and lack basic facilities such as a local doctor, clinic, or school.

In countries without adequate primary health care and antenatal care, it is harder to imagine implementing community nutrition programs on a stand-alone basis. Cost-effectiveness data suggest that some primary health interventions (immunization against DPT, measles, TB, rotavirus and hepatitis B, treatment of measles with vitamin A, use of antibiotics for acute respiratory infection and ophthalmic ointment at birth), as well as micronutrient interventions have very high priority. Once these programs have been implemented, then interventions aimed at protein-energy malnutrition should be added, along with antenatal care. However, investing in primary health care, antenatal care, and community nutrition is relatively costly. In Bangladesh where primary health care is weak, the Bangladesh Nutrition Intervention Program costs $18/child (Mason, Hunt et al. 1999), likely in part because supervision and support from the primary health care system is not available. In countries without existing primary health care, nutrition interventions would have to be targeted to the most vulnerable population, rather than aiming for populationwide coverage.

In terms of complementary investments, additional investments in water and sanitation are vital in all countries. Some countries have identified regions where these are a particular bottleneck, for example in selected regions in the PRC (using factor analysis, Chen 1996), and in Viet Nam, often related to the use of human feces in agriculture. Cost-effective methods can be adapted from existing pilot projects. Viet Nam has innovative water tank and water jar schemes, wherein villages are provided with a rotating fund and with technical assistance to construct demonstration projects. Thailand also has similar experience.

These nutrition investments need to be complemented with poverty alleviation policies and with improvements in women's status. Smith and Haddad (1999) find that status of women (as measured by female education relative to male, and female life expectancy at birth relative to male) are two significant underlying determinants of malnutrition. Poverty alleviation and improvements in women's status are desired for other reasons and not only for their effects on nutrition. These policies are complements to—and not substitutes for—specific nutrition programs.

The literature provides some guidance on the size and duration of investments required. Since the investments have greatest effect on infants and young children, the main payoffs in productivity benefits will take 15-20 years to appear, although the benefits in decreased mortality should be seen within the first few years. The Thai experience suggests that such efforts over a 10-year period can achieve remarkable results. Note, however, that Thailand's economy was growing at almost 8 percent per annum in the 1980s, and that its per capita income even in 1980 was more than twice that of the richest of the nine low-income countries examined here. In slower growing countries, starting from a lower level of income, the nutritional investments might need to continue over a longer time (albeit perhaps targeted geographically rather than being national in scale).

Investments of the scale required are feasible. For comparison purposes, the World Bank (1993) estimates that EPI costs about $15 per "fully immunized child". Micronutrient interventions are of the order of $1-2 per person, and may be passed on to consumers in the case of fortification. Costs of community nutrition interventions vary. There are some programs in the range of $2-$5 which are thought to be effective (but for which no formal evaluation exists), and some in the $5-$10 per child range with demonstrated cost-effectiveness (Table 4). This suggests that if these programs are focused on children below two years of age (or possibly below three), and carefully targeted (for example geographically), they are affordable.

Are there existing expenditures on nutrition which can be reallocated? Some existing projects are not well designed and not as efficient at reaching their goals, and here some effort at assessing outcomes and redesigning interventions is desirable. Feeding programs overall need much work. Unless they are well targeted and combined with nutrition education (the Tamil Nadu Integrated Nutrition Project is a success story), they are not sustainable. These programs need to target education to parents, and to train primary caregivers to improve caring practices. Sometimes food is used as an incentive to improve attendance at health clinics. It might be more sustainable to use the food as payment in kind to train and maintain a network of community volunteers. In other cases, the motivation for a feeding program is clearly not nutrition but something else, for example, programs that provide lunch for girls to encourage their school attendance. These projects can be valid, although their primary rationale is not a nutritional one. However, it is apparent that additional resources need to be directed towards the improvement of nutrition, and the discussion above has demonstrated that such investments are highly cost-effective.

Conclusion

The "Asian enigma" need not remain an enigma. Much has been learned about how nutrition interventions can help the 125 million malnourished children in low-income Asia. It is not enough to rely on the growth of income to reduce malnutrition. The social costs of malnutrition are enormous. In low-income Asia, 2.6 million child deaths per year are associated with protein-energy malnutrition, 0.36 million child deaths per year with vitamin A deficiency, and 65,000 maternal deaths per year with iron deficiency anemia. We do not attempt to measure the economic costs of these deaths. The economic costs of reduced productivity are at a minimum 1-2 percent of GDP and likely more, since the most pervasive effects (associated with poor cognitive development of children) are hardest to quantify.

Nutrition interventions are highly cost-effective. Micronutrient fortification and supplementation are as urgent as primary health care. Once countries have implemented these minimal interventions, the next highest priority, along with basic antenatal care, is community-based interventions to reduce protein-energy malnutrition.

Low-income countries in Asia have begun to act on micronutrients, with the most progress on iodine, followed by vitamin A, and very little progress on iron. There are opportunities for investments in this area with very high pay-offs, both economic and social. All the countries have commenced baby-friendly hospital initiatives, which may be important for their demonstration effects since urban, more affluent women are the main group who give birth in hospitals. All but two of the countries have some legislation in place on breastmilk substitutes, with varying degrees of enforcement. At least three countries have begun to develop large-scale community-based nutrition initiatives (these three, with the partial exception of India and the addition of PRC, also have the best-developed primary health care systems). Other countries have successful pilot-scale projects that can be used for replication, but face the bigger challenge that their primary health care systems are weak and antenatal care scarcely exists. Investments in water and sanitation are key to improving nutrition in some specific regions. Long-term efforts in poverty alleviation, as well as improving the status of women, have important indirect benefits for nutrition. Intensification of all these efforts will be necessary if the World Summit for Children's goal of halving childhood malnutrition within ten years is to be reached.

Appendix
PROFILES: Calculating the Effects of Malnutrition on Economic Productivity, Health, and Survival

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General Approach

PROFILES is a process and a set of software tools designed to quantify the effects of malnutrition on a variety of outcomes of importance to policymakers. The development and use of PROFILES has been described recently elsewhere (Burkhalter et al. 1999). PROFILES requires the user to provide data on the prevalence of protein-energy malnutrition, vitamin A deficiency, goiter, and anemia in a variety of severity categories and demographic groupings. These data are usually obtained from representative national surveys, where available, or are estimated from other sources such as smaller surveys, scientific studies, or surveys in adjacent countries. A variety of other data such as employment rates, wages, baseline morbidity and mortality rates, costs of health care, exchange rates, etc. are also required. Coefficients used in the computational models (derived from the scientific literature) and demographic estimates (derived from current UN population projections) are provided in the spreadsheets.

The demographic, nutrition and other data for a particular country comprise a scenario, computed in this application over the 9-year period from 1997 to 2005. PROFILES estimates the benefits of a policy or program by comparing a scenario in which the rates of malnutrition remain unchanged over the course of the projection with another in which the proposed program or policy is implemented and malnutrition is reduced over the same period. These benefits are summed over the scenario and compared with the costs of the program to permit calculation of benefit-cost and cost-effectiveness ratios as presented in Tables 7 and 8. The PROFILES models used to generate these estimates are described below. Key assumptions regarding malnutrition prevalence and intervention costs are given in Appendix Tables 3 and 4, respectively.

Effects of Malnutrition on Productivity

PEM. Evidence for the relationship between protein-energy malnutrition (PEM) and productivity comes from an extensive literature spanning several fields including nutrition, physiology, economics, and history, reviewed by Martorell (1996). The underlying mechanism for the relationship between nutrition and productivity is not well-understood, but may be due to effects on internal organ systems and physiological functions, with height serving only as a marker for these less visible effects.

The model is derived from one first suggested by Pinstrup-Andersen et al. (1993). It predicts the productivity effects of moderate and severe stunting in the current two-year old population assuming that the percentage reduction in adult height is 4.375 percent and 6.25 percent for moderate and severe stunting, respectively, and for each percentage point reduction in adult height there is a 1.38 percent reduction in wages (Haddad and Bouis 1991). Since not all children will work in affected occupations (manual labor), the “effective employment rate” for this model is defined as the percentage of the population actually working in manual labor sectors (agriculture, forestry, and fisheries). This “effective employment rate” is intended to capture the labor force participation rate, the employment rate and the proportion of the labor force that is engaged in manual labor. This rate is further reduced by two thirds, since not all tasks within manual labor are assumed to be affected. Future wages are discounted at 3 percent per year, after adjusting for normal mortality at each year of life. Any effects due to mild stunting are not counted.

IDD. Iodine deficiency during pregnancy is known to hinder the development of the fetus, resulting in a broad spectrum of mental and physical impairments. Evidence from seven countries suggests that approximately 3.4 percent of all births to iodine deficient women are cretins and another 10.2 percent are mentally impaired (Clugston et al. 1987).

Although no studies have measured the productivity losses resulting from mental impairment due to iodine deficiency during pregnancy, Levin et al. (1993) estimate that cretins have no productivity and that the other severely mentally impaired persons (due to iodine deficiency) are 25 percent less productive relative to unaffected individuals. There is evidence that virtually all infants born to mothers with goiter suffer some intellectual handicap due to brain damage. The meta-analysis of Bleichrodt and Born (1994) suggests that there is an average 13.5 point reduction in IQ in iodine deficient communities. This is a communitywide impairment in intellectual functioning that must have serious productivity consequences for all but the least intellectually demanding tasks. For purposes of calculations here, we estimate that children born to mothers with goiter who are neither cretins nor severely impaired are 5 percent less productive than normal children. Considering that 13.5 points is a communitywide average, that it is equal to almost a full standard deviation in the distribution of normal IQ, and that we are applying this reduction only to children born to mothers with palpable goiters, the 5 percent reduction is probably a conservative estimate of the total impact of iodine deficiency on the productivity of children in affected communities.

The IDD-productivity model uses the total goiter rate as the proportion of newborn affected and divides these between cretins (3.4 percent), severely impaired (10.2 percent) and the rest (86.4 percent). For each of these groups of infants, the model assumes productivity losses of 100 percent, 25 percent and 5 percent, respectively. As for the PEM-productivity model, future wages are discounted at 3 percent per year, after adjusting for normal mortality at each year of life.

Anemia. Iron is a component of hemoglobin, the oxygen-carrying component of the blood. Low hemoglobin is therefore both an indicator of poor iron status and of low oxygen carrying capacity. Because of the importance of adequate blood oxygen levels for mental function, fetal development, and physical activity, iron deficiency anemia has a range of consequences on health, performance, and survival.

The model used here only estimates the effect of anemia on productivity in the adult female agricultural labor force. Levin et al. (1993) report that workers with iron deficiency anemia are less productive at physical labor than non-anemic workers, producing 1.5 percent less output for every 1.0 percent their hemoglobin is below standard. This conclusion is based primarily on a study in Indonesia by Basta et al. (1979) but is supported by an extensive literature (Levin et al. 1993). In the model used here, we use a more conservative estimate of the elasticity of productivity with respect to hemoglobin of 1.0, in acknowledgment of the methodological concerns of Behrman (1992).

To estimate the average severity of anemia, we assume that half of all anemic subjects have mild anemia, a third have moderate anemia and a sixth have severe anemia. This yields an average hemoglobin deficit (as a percent of the sex-specific standard) of about 11 percent. If the distribution of hemoglobin values in a particular country is known then this value can be calculated more precisely.

Effects of Malnutrition on Mortality

PEM. A meta-analysis of the findings of eight studies from five countries (Bangladesh, India, Malawi, Papua New Guinea, and Tanzania) by Pelletier et al. (1994) reveals that in children under five years of age, the risk of death increases exponentially as protein-energy malnutrition (as assessed by low weight-for-age) becomes more severe. Even though malnutrition prevalence, morbidity patterns, and mortality rates vary across countries, the same exponential relationship is consistently observed, suggesting an underlying biological relationship between malnutrition and mortality. Based on these findings, the model assumes that children with mild, moderate and severe malnutrition face, respectively, 2.5, 4.6 and 8.4 times the risk of dying as children with no malnutrition (Pelletier et al. 1994). The population attributable risk (PAR) for each severity category is calculated as a function of these relative risks and the prevalence of underweight in each severity category. To calculate the number of deaths attributable to malnutrition the spreadsheet multiplies the total PAR, summed across severity categories, by the number of deaths in children 6-59 months of age.

Vitamin A Deficiency. A meta-analysis of vitamin A supplementation trials concluded that children aged 6-59 months living in vitamin A deficient areas who received vitamin A supplements were, on average, 23 percent less likely to die than children not receiving supplements (Beaton et al. 1993). The model calculates vitamin A related deaths as a function of the relative risk of death for a child with vitamin A deficiency taken as 1.75 (Ross 1995), the prevalence of vitamin A deficiency, and the number of deaths in children 6-59 months old.

Anemia and Maternal Mortality. In their review of five Asian studies, Ross and Thomas (1996) estimate that about 23 percent of maternal deaths are attributable to anemia, either directly, or by contributing to the risk of death due to hemorrhage and other causes. In the spreadsheet model, maternal deaths due to anemia are calculated as a function of the number of births in a given year, the maternal mortality ratio, and the proportion of maternal deaths attributable to anemia (with 0.20 as the suggested default value for Asia). Not all anemia is due to iron deficiency. Therefore to estimate cost-effectiveness, assumptions must also be made at the program level about the expected impact of iron interventions on the prevalence of maternal anemia.

Appendix Table 1: **Selected Macro Indicators, Low-income Asia**

Country	GDP/Capita, 1995 US $	Population (million)	CBR per '000
Bangladesh	240	120	23.7
Cambodia	270	10	35.4
PRC	620	1,200	17.2
India	340	929	26.3
Laos	350	5	45.2
Nepal	200	21	39.6
Pakistan	460	130	38.6
Sri Lanka	700	18	17.8
Viet Nam	240	73	28.0

Sources: GDP, population from World Bank (1997); crude birth rate from UNDP (1997).

Appendix Table 2: **Protein-energy Malnutrition (Children <5) and Selected Mortality Rates, Low Income Asia**

Country	Moderate Malnutrition (%)	Severe Malnutrition (%)	Maternal MR (per '00,000)	Under 5 MR (per '000)
Bangladesh	35	21	850	115
Cambodia	33	7	900	174
PRC	16	–	95	47
India	32	21	570	115
Laos	28	12	650	134
Nepal	31	16	1,500	114
Pakistan	25	13	340	137
Sri Lanka	31	7	140	19
Viet Nam	34	11	160	45

Note: Severely malnourished is defined here as more than 3 standard deviations below the median weight for age, and moderately malnourished is between 2 and 3 standard deviations below the median.

Sources: Nutritional data from UNICEF (1997c); mortality rates (MR) from UNDP (1997).

Appendix Table 3: **Key Assumptions: PROFILES Calculations**

Variable	Bangladesh	Cambodia	PRC	India	Pakistan	Sri Lanka	Viet Nam
Prevalences (%)							
PEM mild	48.9a	35	20.4	48.6	36.3	34.2	41.4
PEM moderate	18.5a	16.6	4.3	18.4	11.5	7.2	11.2
PEM severe	6.5a	5.2	0.8	6.4	3.5	1.0	2.6
Stunting moderate	28a	26.2	17.7	27.1	21.9	15.3	29.5
Stunting severe	32a	29.8	12.7	35.8	30.3	5.1	17.4
Subclinical VAD	17	40	27.4	7f	30	30	10
Goiter	47	20	20.4	5f	30e	18.4	20
Anemia (pregnant women)	74	60	35	50	41	39	52.7
Anemia (nonpregnant women)	75	55	22.7	50	30	45	52.7
Rates							
MMR per ‘00,000	850b	452	82.1	570b	300	42.5	90
IMR per ‘000	85b	115	45.7	74b	90.5	17	38
Child DR per ‘000	115b	181	55.2	115b	117.4	22.2	68
Economic variables							
Employed population in agriculture (%)	38.0c	53.7c	42.6	37.5c	19.2	37.7	53
Employed population (%)	64.5c	72.5c	49.6	60.5c	40.4	88.4	73
Females employed in agriculture (%)	26.6c	53.7c	40.2	19.2c	7.3	37.7	53
Annual wage (US$)	264c	300	289	374d	788	339	263

Note: For definition of variables see Ross (1997).

Sources: Country studies, except:

a total (moderate+severe) from country study, allocated in same proportion as India.
b UNDP (1997).
c Labor force participation from World Bank (1997), agriculture share from UNDP (1997).
d Used 1.1 X per capita GDP (country data not readily available).
e Country PROFILES work uses 3% but this is likely to be visible goiter only.
f Figures from country study appear to be underestimates.

Appendix Table 4: **Costs for Hypothetical Nutrition Interventions, for PROFILES Calculations**

Type of Undernutrition/Intervention	Cost
Protein-energy malnutrition	
Breastfeeding promotion	$2.50/newborn/year
Intensive targeted growth promotion	$5/infant/year
Percentage of population needing intensive education campaign	20%
Iodine	
Fortification (whole population)	$0.04/capita/year
Capsules for pregnant women	$0.50/pregnancy/year
Intensive education campaign for iodized salt	$1million (whole country)
Iron	
Iron supplement (pregnant women)	$2.50/pregnancy
Vitamin A	
Twice-annual mass dose (children 3 and under) and women postpartum	$0.10/dose, i.e. $0.20/child/year and $0.10/birth

Sources: Costs are estimates, described in Ross (1997) and using Horton (1992). Costs of vitamin A mass dose were inflated to current dollar terms. Note that current costs in Viet Nam (supplement only but not distribution) are only $0.08/year (National Institute of Nutrition 1998).

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