Review Article

The economic consequences of malnutrition in Cambodia, more than 400 million US dollar lost annually

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Background: Cambodia is among the 28 worst countries globally with the highest rates of childhood malnutrition. The aim of the assessment was to apply published evidence associating malnutrition and a variety of functional consequences to project economic implications of this high rate of childhood malnutrition. Such information is vital to advocate for appropriate programs and action plan to reduce malnutrition (from severe stunting to micronutrient deficiencies). **Methods**: This exercise used a "consequence model" to apply these "coefficients of loss" established in the global scientific literature to Cambodia health, demographic and economic data to develop a national estimation of the economic losses link to malnutrition. **Results**: The impact of the indicators of malnutrition analysed represent a burden to the national economy of Cambodia estimated at more than $400 million annually -2.5% of GDP. Micronutrient deficiencies suggest deficits in the quality of the diet - representing a national burden of more than $200 million annually while breastfeeding behaviours account for 6% of the burden. 57% of the losses emerge from indicators measured in children, while 43% of losses are from indicators independent of childhood measurements - indicators of maternal behaviour along with maternal and adult nutrition. **Conclusions**: Given the low cost of interventions and the high baseline losses, investment in nutrition programs in Cambodia is likely to offer high returns and attractive benefit cost ratios. Since nearly half the losses are determined prior to the birth of the child, this has implications for targeting and timing of programs.

Key Words: malnutrition, Cambodia, stunting, micronutrient, behaviour

INTRODUCTION

With economic growth and development in the past decade, poverty has steadily declined from 47% of the population in 2003 to 30% in 2007 and 20% in 2011.[1] During the same period, Cambodia made important progress towards improving the health of its women and children.[2-4] For example, between 2005 and 2010, the under-five mortality rate decreased from 124 per 1,000 live births in 2000 to 54 deaths per 1,000 live births and the maternal mortality ratio in Cambodia significantly declined over the last 5 to 10 years (from 472 per 100,000 live births in 2005 to 206 per 100,000 live births in 2010).

Unfortunately, at 40%, Cambodia has the 28th highest prevalence of short (stunted) children in the world.[5] The 2010 Cambodia Demographic and Health Survey (CDHS4) also showed that 28% of children are underweight. This is strong evidence that the nutritional status of children is not improving. Cambodian women are also susceptible to malnutrition as nearly 60% of women between 15 and 49 are anaemic and 20% too thin according to the latest DHS,[4] conditions that increase the risks of complications during birth and lead to low birth weight babies.

Regardless of the recent attention in the national policy dialogue and strategies, the nutrition agenda remains under-resourced both by the government and donors, constraining to the much needed scale-up of a life-cycle approach and more particularly towards the 1,000 days window. The aim of the assessment was to examine the economic implications of malnutrition in Cambodia and secure general consensus on the need to invest on nutrition.

METHODS

The assessment explored the economic losses associated with 13 nutrition indicators via 4 discrete pathways: i) mortality and disability in children with consequent lost

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value of a future workforce (Pathway #1), ii) child cognition deficit resulting in inferior school performance and adult productivity (Pathway #2), iii) current value of depressed productivity in working adults including tax losses for government (Pathway #3) and iv) current value of excess and preventable healthcare and welfare utilization (Pathway #4). The same methodology was used in several countries such as Laos and Albania.[6,7] Those nutrition indicators are described in Table 1 and are divided into three groups: i) Four indicators for pregnant women, ii) Seven indicators for children under 5 years of age and iii) Two indicators for adults.

For each indicator, the scientific literature has developed substantial evidence defining higher risks of mortality, morbidity, deficits in mental development, physical performance and/or on-the-job productivity-expressed as relative risk (RR) or deficit (%). As no national data was available for Cambodia, the excess mortality from specific infections such as diarrhoea, respiratory disease, measles and other infections, was derived from WHO Child Mortality by Cause 2000-2010 data.[8] For pathway #1, to estimate the number of death attributable to different indicators the following algorithm was used:[6,7]

Number of death attributed = Population attributable risk x Mortality in risk group affected with:

- Population attributable risk: the Population Attributable Risk (PAR) is a function of the prevalence of the nutrition indicator along with the severity of the mortality risk as expressed by the Relative Risk (RR). It is calculated with the following formula: (Prevalence x (RR-1)) / (1+ (Prevalence x (RR-1))).
- Mortality in risk group affected: number of deaths per year based on national data.

Then for all pathways, the general algorithm mixing global and national parameters were applied[6,7] to each of the 13 nutrition indicators:

Annual loss = Indicator (prevalence or number of death)[4,9,10] x Average earnings x Labour force participation x Average work-life x Coefficient risk-deficit x Net person value with:

- Average earnings: $US1253/year; based on $177 per month per household and average number of workers per household which was estimated at 1.7.[11]
- Labour force participation: all: 84.4%, male: 88.8% and female: 80.4%.[11]
- Average work-life: average time engaged in the labour force or "working life" assumes beginning work at 15 years and extending to the full life expectancy: all: 47 years, male: 45 years and female: 49 years.
- Net person value: Net Present Value (NPV) is a subjective factor used to define the value of future goods or services and express that value in current currency. To calculate this NPV of lost future earnings due to the various indicators of malnutrition, we used a 3% discount rate, recommended by the World Bank[12] for social investments. As a sensitivity parameter, a 7% discount rate is also used as recommended by other organizations. The formula used was the following: NPV= (# in Risk Group w / Deficiency x Deficit coefficient x Labour participation rate) x Present value (discount rate, work life, and annual wage) – Present value (discount rate, years until workforce entry, annual wage) / # Annual cohort in risk group.
- Coefficient risk-deficit: see Table 2 for relative risk and Table 3 for coefficient risk deficit.[13-21]

All losses are expressed as dollars per year in depressed or lost economic activity. Pathway #4, represents actual family resources and government budgets currently expended for health care services. Pathway #3 describes lower levels of productivity of today's adults working with at less than their optimal efficiency. Pathways #1 and #2 attempt to capture the future productivity or earnings deficit emerging from child mortality or the life-long deficits projected from malnutrition in childhood.

RESULTS

Pathways #1: child mortality attributable to malnutrition

This pathway compiles the coefficients of risk for mortality for specific nutrition indicators found in the global scientific literature (including maternal nutrition, suboptimal breastfeeding practices, anthropometric indicators, and micronutrient deficiencies) to paint a general picture of child mortality that can be attributed to current prevalence of malnutrition in Cambodia. After statistical adjustment, 6,170 deaths of children under 5 years of age are attributed to maternal malnutrition, underweight and wasting, suboptimal breastfeeding or micronutrient defi-

Table 1. Summary 10 nutrition indicators: cases and risk groups derived from DHS 2010[4]

Risk group	Nutrition indicator	Prevalence (%)	Cases or at risk (000)	Risk or deficit
388 thousand pregnant women	Low body mass index	19	73.9	Infant and maternal mortality
	Short stature	6	24.5	
	Anaemia	53	204.9	
	Folic acid deficiency	50	194.4	
1.6 million children <5 years of age	Suboptimal breastfeeding	26	202.2	Mortality & morbidity
	Low weight for height	44	628.3	Mortality
	Low weight for age	60	856.7	
	Low height for age	65	928.1	Growth, development & productivity
	Vitamin A deficiency	22	318.4	Mortality
	Zinc deficiency	52[6]	742.5	Mortality & morbidity
	Anaemia: childhood	34	482.7	Growth, development & productivity
3.3 million adults	Anaemia: women	44	2,445	Strength, endurance and productivity
	Anaemia: men	17[7†]	850.5	

[†]Based on ratio of male to female anaemia found in Vietnam survey.

Table 2. Relative risk of mortality

	Relative risk			
Child mortality associated to maternal nutrition status[11-13*]				
Anaemia	1.25			
BMI<18.5	1.71			
Height<145 cm	2.20			
Neonatal mortality attributed to low birth weight[14]				
2,000-2,499 g	2.80			
<2,000 g	8.10			
Post neonatal mortality attributed to low birth weight[14]				
Post neonatal mortality	1.98			
Mortality associated with severe, moderate and mild wasting and underweight[13,15]				
	Wasting	Underweight		
Pneumonia among children with anthropometric indicator z score<-3SD	9.7	10.1		
Pneumonia among children with anthropometric indicator -3SD<z score<-2SD	4.7	3.1		
Pneumonia among children with anthropometric indicator -2SD<z score<-1SD	1.9	1.9		
Diarrhoea among children with anthropometric indicator z score<-3SD	12.3	11.6		
Diarrhoea among children with anthropometric indicator -3SD<z score<-2SD	3.4	2.9		
Diarrhoea among children with anthropometric indicator -2SD<z score<-1SD	1.6	1.7		
Measles among children with anthropometric indicator z score<-3SD	9.6	7.7		
Measles among children with anthropometric indicator -3SD<z score<-2SD	2.6	3.1		
Measles among children with anthropometric indicator -2SD<z score<-1SD	1	1		
Other among children with anthropometric indicator z score<-3SD	11.2	8.3		
Other among children with anthropometric indicator -3SD<z score<-2SD	2.7	1.6		
Other among children with anthropometric indicator -2SD<z score<-1SD	1.7	1.5		
Infant morbidity by breastfeeding behavior[15]				
	0-6 months		6-24 months	
	Predominant	Partial	None	None
Diarrhoea	1.26	1.68	2.65	2.07
ARI	1.79	2.07	1.79	1.17
Infant mortality by breastfeeding behavior[32]				
	0-6 months		6-24 months	
	Predominant	Partial	None	None
Diarrhoea	2.28	4.62	10.5	2.10
Pneumonia	1.75	2.49	15.1	1.92
All mortality	1.48	2.85	14.4	3.68
Diarrhoea and measles mortality associated with vitamin A deficiency[13]				
Diarrhoea and measles mortality	1.32			
Mortality associated to zinc deficiency[13]				
ARI	1.96			
Diarrhoea	2.01			
Mortality associated to Neural Tube Defects (NTD)				
NTDs	80% of 2 births out of 1,000 births			

*The numbers refer to references in the reference section.

ciencies. This represents 60.4% of all childhood mortality in Cambodia. More than half the attributed deaths are not associated with quantity of food or lack of calories but rather food quality, child care behaviours and the nutrition status of the mother (see Figure 1). Presuming an entry into workforce at average of 15 years of age, the total economic losses from emerging child deaths total is approximately 88.7 million USD (using the discount rate 3%).

Pathways #2: depressed future productivity of children

This pathway focuses on childhood anaemia and stunting-indicators strongly associated with slow growth and depressed cognition. According to Cambodian data, stunting represents a yearly economic loss of 128.3 million USD due to depressed work performance and productivity in the agriculture, service and industry sectors. An additional 52.7 million USD and 780,000 USD are lost due respectively to anaemia and NTD, corresponding to a total of 181.7 million USD.

Table 3. Coefficient risk-deficit on economic losses

	Coefficient risk-deficit (%)
Economic loss from stunting[16,17]	
Stunting and productivity at school	19.8
Moderate stunting and direct earning	6.0
Severe stunting and direct earning	8.6
Economic loss from childhood anemia[18]	
Child hood anemia	2.5
Economic loss from neural tube defects†	
Moderate disability	50
Severe disability	100
Economic loss from adult anemia[19]	
Manual labor	5
Heavy manual labor	17

†Given the lack of information, a personal estimation has been made.

Pathways #3: depressed current productivity: anaemia in adult workers

Weakness, fatigue and lethargy brought on by anaemia results in measurable productivity deficits in the manual labour. After corrections for general labour participation and estimates for proportion employed in manual labour, the 5% productivity deficit is applied to 308,000 anaemic women workers and 83,000 anaemic men workers - with an additional 12% deficit for those assumed to be engaged in heavy manual labour.[20] Projected losses of approximately USD 89 per year per anaemic worker add up to an estimate of 138.3 million USD in depressed productivity of manual labourers with anaemia - a significant burden on the current expansion of agriculture and industry sectors in Cambodia.

Pathways #4: excess healthcare expenditures

Malnutrition in children contributes to impaired immunity and infection. Consequently, malnourished children may suffer more frequent or more severe illness (such as ARI or diarrhoea) which in turn translates into increased utilization and expense of health services. [4,22,23] Inadequate breastfeeding practices, low birth weight, zinc deficiencies and NTDs between 0-23.9 months, respectively are responsible for approximately 2,300,000 million cases triggered by several diseases (including 910 cases of NTDs, 9,744 cases of low birth weight, 1,600,000 cases of diarrhoea and 700,000 ARI seen at facility level) which are estimated to cost families and government 1.9 million USD, 600,000 USD, 7.5 million USD and 30,000 USD, losses corresponding to a total of 10.03 million USD.

The impact of the indicators of malnutrition analysed in the report represent a burden to the national economy of Cambodia estimated at more than $400 million annually -2.5% of GDP. This figure is comprised of qualitatively different kinds of loss as measured via 4 pathways (see Table 4). The base analysis reported above uses a 3% discount rate to develop the NPV, as recommended by the World Bank's World Development Report. As indicated in Figure 2, applying a higher 7% discount rate shrinks the value of child survival and future productivity from $270 million to about $100 million per year – and consequently the projected annual burden to the Cambodian economy drops to about $250 million annually, 1.5% of GDP.

DISCUSSION

In Cambodia, 1.5-2.5% of the GDP is and will be lost every year due to malnutrition indicators if nothing is done. Similar findings were observed in neighbouring countries using the same methodology. For example in Laos, the burden on national economy of Lao PDR may be at least $200 million annually, representing about 2.4% of GDP (using only 10 indicators over the 13 used in Cambodia).[6] In Albania, the burden of malnutrition on national economy was less but it already cost $107 million annually representing about 0.7% of GDP.[7]

Severe acute malnutrition is the most dangerous form of malnutrition. Even if in Cambodia less than 5% of the $400 million in annual economic burden is associated with acute malnutrition requiring clinical life-saving medical care, it is essential to continue the effort.

Most of the projected losses are linked to hidden malnutrition identified by blood analysis, anthropometric measurements or indicators of feeding and care behaviours. 57% of the losses emerge from indicators measured in children, while 43% of losses are from indicators independent of childhood measurements - indicators of maternal behaviour along with maternal and adult nutrition (anaemia in adults, maternal nutrition, breastfeeding, folic acid deficiency). Since nearly half the losses are determined prior to the birth of the child, this has implications for targeting and timing of nutrition programs. While all programs to improve child nutrition target both mothers and their young children, this indicates a large burden and emphasises the need to target women independently - during pregnancy and pre-pregnancy periods, for instance during secondary school, during routine child and maternal contacts with the health care system as well as via the workplace and the media.

The economic perspective outlined in this study suggests that strategic planning for effective nutrition intervention recognize that: i) more than half the losses attributed to malnutrition are associated with feeding behaviour and food quality, and not only quantity of food and ii) nearly half the losses attributed to malnutrition emerge from maternal, adult and inter-generational factors.

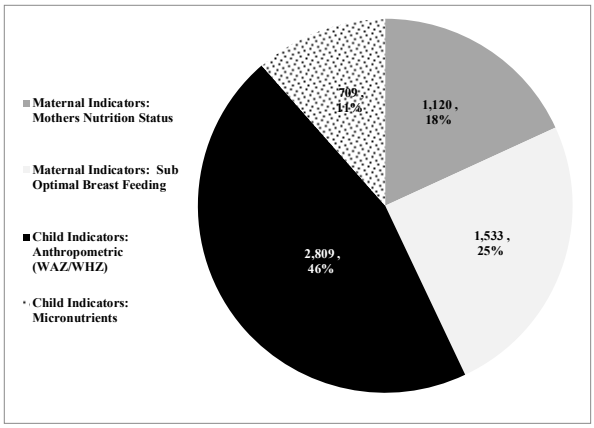

Figure 1. Child mortality by indicator

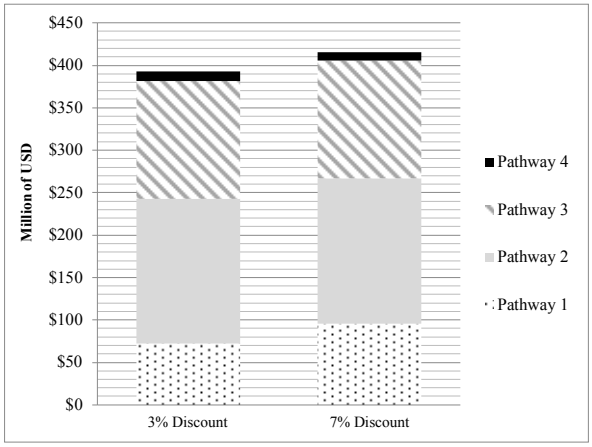

Figure 2. Impact of discount rate on economic burden of malnutrition

Table 4. Summary economic consequences for all indicators net present value at 3% (adjusted for multiple risks in million USD)

Indicators	Pathway #1	Pathway #2	Pathway #3	Pathway #4	Total	
Maternal nutrition	$9.70	-	-	$0.60	$10.2	2.4%
Suboptimal breastfeeding	$21.7	-	-	$1.90	$23.6	5.6%
Wasting (WHZ)	$18.8	-	-	-	$18.8	4.5%
Stunting (HAZ)	-	$128	-	-	$128	30.6%
Underweight (WAZ)	$22.3	-	-	-	$22.3	5.3%
Zinc deficiency	$5.70	-	-	$7.50	$13.2	3.2%
Vitamin A deficiency	$4.60	-	-	-	$4.60	1.1%
Childhood anaemia	-	$52.7	-	-	$52.7	12.6%
Birth defects	$5.90	$0.78	-	$0.03	$6.70	1.6%
IDA in adults	-	-	$138	-	$138	33.0%
Annual total	$88.7	$182	$138	$10.0	$419	100%

To improve the quality of the diet, a set of interventions such as dietary diversity, supplementation and fortification have been recognized as effective. According to the World Bank, scaling up core micronutrient interventions in Cambodia to prevent deficiencies would cost less than US$6 million per year[23] and will allow savings of more than US$169 to 200 million per year which is 59.9-86.7% of the total burden depending on the interest rate (158-191 million due to anaemia, 1.7-4.6 million USD due to vitamin A deficiency and 9.5-13.2 million USD due to zinc deficiency). The Government of Cambodia has recognized the importance of food fortification as one strategy for improving the nutrition quality of its population and calls for action on food fortification within the 2008-2013 Strategic Framework for Food Security and Nutrition. To this effect various initiatives have been undertaken including the issuance of a Government Proclamation for official label/logo to be used for iron fortified fish sauce and soy sauce products nationwide.[24] As highlighted by Theary et al, even if standard exists, mandatory legislation has not yet been enacted and therefore could delay the roll-out of fortified food vehicles as only a few industry partners may be willing to voluntarily fortify[24] even at a small cost 2 cents USD/L.[24] However, it is essential before scaling-up iron fortification or supplementation to investigate the factors that might predispose them to anaemia with particular emphasis on the role of genetic Hb disorders, iron and vitamin A deficiency, and infections. Recent studies showed that thalassemia and hemoglobinopathies are a significant health burden in the region.[25] If the government also decided to promote mandatory legislation for vegetable oil with vitamin A (13.5 ppm of RE), such an initiative would add less than 0.2 cents USD/L which is minimal. This fortification would provide 17.5% of WHO estimated average requirements for a woman of reproductive of age[26] and other potential vitamin such as vitamin D.[27]

Stunting, an indicator of chronic malnutrition, is causing by itself 15% to 31% of the total burden depending on the interest rate (47 to 128 million USD/year). In Albania, stunting represented approximately 50% of the economic losses.[7] Buttha et al in the latest 2013 Lancet series[28] showed the linkages between the risk factors and stunting. For example, multiple micronutrient supplementation and balanced energy protein consumed by pregnant women has an effect on birth outcomes which will decrease the risk of being stunted.[29] The same link can be observed for zinc supplementation, complementary feeding, education and supplementation during the childhood. Therefore, investing in those strategies is essential in Cambodia. Hoddinott et al analysed in several countries, including Vietnam, the rational for investing in stunting reduction[30] and detailed the cost of several interventions. According to their cost,[29,30] the Cambodian government could invest for less than 12 million USD/year (9.3% to 25.5% of the yearly losses) in several impactful interventions to prevent stunting if well implemented and accepted: i) multiple micronutrient supplementation for mothers during pregnancy (6.15 USD/mother/year, total of approximately 2,460,000 USD), ii) therapeutic zinc supplementation for management of diarrhoea (5.90 USD/child/year, total of approximately 2,950,000 USD), iii) complementary feeding education (5.27 USD/child/year, total of approximately 2,545,410 USD), and iv) micronutrient powders distribution (7.98 USD/mother/year, total of approximately 3,999,000 USD).

In addition, though requiring more intensive investment and effort, a targeted intervention to provide complementary foods to the identified poor population (27% of the total number of households[31]) could have a profound impact on poor children's cognitive development and physical growth and therefore innovative food supplements should be explored.

Conclusions

Over the next decades, a growing Cambodian economy will doubtless lower the $250-400 million annual burden on national economic activity. However, nutrition status responds relatively slowly to economic growth. A recent World Bank analysis from 79 countries concluded "that income growth can play an important role in malnutrition reduction, but it is not enough. Increases in the number and effectiveness of direct nutrition interventions have a crucial role to play if nutrition goals are to be met".[32] Moreover, investments to reduce malnutrition do not only serve nutrition goals. If malnutrition continues to depress economic activity at 1.5-2.5% of GDP, Cambodia's ambitious national objective of 7% annual GDP growth will be more difficult to achieve and sustain. Investment in nutrition is an investment in achieving that national economic development goal.

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AUTHOR DISCLOSURES

Authors declare that there was not a conflict of interest in this paper and authors are not directly or indirectly affiliated with any profit making units that may create a conflict of interest.

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Review Article

The economic consequences of malnutrition in Cambodia, more than 400 million US dollar lost annually

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柬埔寨营养不良的经济后果：每年损失超过 4 亿美元

背景：柬埔寨是全球 28 个儿童营养不良发生率最高的国家之一。本文的目的是运用已发表的营养不良相关的证据及对各种功能的影响，来评估儿童营养不良高发率的经济影响。这些信息对提出合适的方案和行动计划来降低营养不良（从严重的发育迟缓到微量营养素缺乏）是至关重要的。**方法**：本研究用全球科学文献中关于柬埔寨人的健康、人口和文化的数据，使用“结果模型”，应用“损失系数”以评估国家与营养不良相关的经济损失。**结果**：据估计因营养不良指标的影响，柬埔寨国家经济负担每年增加 4 亿美元以上，约占国家 GDP 的 2.5%。微量营养素缺乏表明膳食质量差，每年给国家造成超过 2 亿的负担，其中母乳喂养行为占 6%。57%的损失来自儿童测量指标，其他 43%的损失来自独立于儿童测量的相关指标，如孕产妇的行为指标及孕产妇和成人的营养。**结论**：鉴于干预成本低、基线损失高，在柬埔寨投资营养计划有可能获得高回报和引人注目的收益成本比。由于将近一半的损失在孩子出生之前就决定了，这预示着项目投资的定位和时间应放在出生前。

关键词：营养不良、柬埔寨、发育迟缓、微量营养素、行为