



WORKING PAPER

The Economic Consequences Of Malnutrition in Lao PDR: A Damage Assessment Report

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1. Background & Rationale

Freedom from hunger, an essential component of MDG 1, is defined as an environment “people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.”¹ Current scientific understanding of malnutrition has expanded beyond clinical conditions like kwashiorkor and nutritional marasmus to recognize that this visible form of malnutrition represents “the small tip of the iceberg.... only 1-5% of the burden of malnutrition.”²

Widespread malnutrition is consequence as well as a cause of poverty. Poverty and undernutrition are locked in a vicious cycle of increased mortality, poor health, and retarded cognitive and physical growth, diminished learning capacity and ultimately lower work performance, productivity and earnings. As this vicious cycle threatens health and survival, it simultaneously erodes the foundation of economic growth - people’s strength and energy, creative and analytical capacity, initiative and entrepreneurial drive. Extensive evidence demonstrates that undernutrition in young children has consequences not only for health and survival but also for physical and intellectual growth, school performance and adult productivity. Therefore, achieving reduction in the prevalence of malnutrition can substantially reduce this national burden as well as generate human and social capital to fuel economic development.

When indicators of suboptimal child nutrition are widespread, the aggregate burden on national economic growth can be significant. Data from the Lao Social Indicator Survey 2011 (LSIS) and the National Nutrition Survey of 2006 (NNS) suggest nearly 2 million Lao citizens, mainly women and children, suffer some form of undernutrition – and cannot achieve their full potential as students, workers, citizens and parents. The 10 indicators of undernutrition summarized in Table 1 suggest undernutrition represents a significant public health problem according to WHO criteria – and indicates a heavy burden on the human, social and economic development of Lao PDR.

Table 1: Summary of 10 Key Nutrition Indicators in Lao PDR from LSIS 2011 and NNS 2006

Nutrition Indicator	Risk Group	National Prevalence (%)	Estimated 000/yr Affected	Risk or Deficit
Underweight	Children 6-59 months	17-29%	260	Mortality
Stunting	Children 6-23 months	44.2%	132	Retarded Development
Low Birth Weight	Infants < 1 month	14.8%	23	Mortality, Morbidity,
Anemia	Children 6-23 months	52.8%	180	Mental Development
	Working Age Women	36.2%	728	Work Performance,
	Working Age Men	9.1%	142	Work Performance
	Anemia in Pregnancy	36.2%	57	Mortality
Vitamin A Deficiency	Children 6-59 months	30%	275	Mortality
Sub-Optimal Breastfeeding	Children <24 months	48-67%	158	Mortality and Morbidity
Birth Defects (NTD)	All Births		.2	Mortality and Disability

¹ World Food Summit, 1996 United Nation’s Food & Agricultural Organization, Food ftp://ftp.fao.org/es/esa/policybriefs/pb_02.pdf

² Latham, Michael, Human Nutrition in the Developing World, *Food and Nutrition Series - No. 29* FAO 1997

The scientific literature has developed substantial evidence defining heightened mortality or morbidity risks as well as mental development and physical performance deficits associated with each of these 10 indicators – expressed as relative risk (RR) or deficit (%). This analysis uses a “consequence model” to apply these “coefficients of loss” established in the global scientific literature to Lao health, demographic and economic data to develop a national Damage Assessment Report (DAR) via an algorithm shown in Table 2 below. The DAR is a rough scenario describing the magnitude of the national burden emerging from the status quo of these 10 indicators. This simultaneously defines the significant national development benefits of simple, feasible and cost effective interventions to lower the burden.

Table 2 DAR Algorithm to Project Economic Losses from Individual Indicators												
Number w/ Indicator		Average Earnings		Labor Force Participation		Average Work-Life		Coefficient Risk-Deficit		Discount for NPV		Annual Loss
Prevalence (%) x population of Risk Group	X	\$1244/y	X	All: 77.9% Male:79.5% Female:76.5%	X	All: 39y Male: 38y Female: 9y	X	RR or % from Literature	X	@ 3%	=	Net Present Value (NPV) of Loss \$/yr

These economic, demographic and labor data points were gathered from official national statistical sources and applied as follows:

- Prevalence taken from LSIS 2011 and NNS 2006 are applied to population or size of risk groups reported by or derived from Lao Statistics Bureau website.³
- In a nation where “own production”, subsistence agriculture and in-kind payments represent a significant portion of individual income, official wage data may be misleading. Average annual earnings potential is estimated as follows.
 - 2011 GDP reported by the World Bank of \$8.3 billion.⁴
 - Labor, not capital or rents, are sensitive to changes in nutrition status. Labor share of GDP is estimated at 60%.⁵
 - This derived labor share GDP is divided by the estimated population of 15-64 year old adults, the working age population, to derive average annual earnings of \$1244/year.
- Average annual earnings are corrected by labor for participation rates reported by the World Bank for 2011: 77.9% over-all rate including 79.5% for males and 76.5% for females.⁶
- Average time engaged in the labor force or “working life” is assume to begin at 15 years of age and extend to the WHO Healthy Life Expectancy - of 53 for males, 54 for women and 54 over-all.⁷ This suggests an average work-life of 38-39 years depending on gender.

³ <http://www.nsc.gov.la/>

⁴ <http://www.worldbank.org/en/country/lao>

⁵ Average Argentina, Brazil, Chile, China, Costa Rica, Kenya, Mexico, Namibia, Oman, Panama, Peru, Republic of Korea, Russia, South Africa, Thailand and Turkey in Figure 32 of Global Wage Report 2012/13, Wages and equitable growth International Labour Organization 2013.

⁶ <http://www.worldbank.org/en/country/lao>

⁷ <http://www.worldlifeexpectancy.com/healthy-life-expectancy-by-gender>

- Projected earnings losses of today’s children stretch far into the future. The earnings “stream” does not begin until the child enters the work force and stretches 54 years in the future. Net Present Value (NPV) is used to estimate the value future lost productivity in present currency. Discount rate used to calculate Net Present Value is taken as 3%, recommended by the World Bank for social investment.⁸ This social discount rate is not related to inflation but merely reflects the subjective time preference for current consumption over future consumption or savings.⁹ This enables a lifetime average of 39 years of future earnings to be expressed as a current annualized economic loss.¹⁰ This represents only a fraction of “gross” earnings.

The DAR assesses the magnitude of consequences from these 10 nutrition indicators via 4 discrete pathways to economic loss:

- Mortality and disability in children with consequent lost value of a future workforce (NPV).
- Child cognition deficit resulting in inferior school performance and adult productivity (NPV).
- Current value of depressed productivity in working adults.
- Current value of excess and preventable healthcare and welfare utilization.

The sections that follow present these 4 pathways to national economic loss for each of the 10 nutrition indicators presented in Table 1.

Caveat to the Damage Assessment Report Methodology

Converting indicators of malnutrition to economic activity and attaching a monetary value to that economic activity travels a long and winding road. First, monetizing the consequences of malnutrition is dependent on a relatively thin evidence base, complex methodologies and national health, demographic and economic statistics of uneven quality. Second, many factors beyond individual physical and intellectual potential determine earnings or work performance. Work place incentives, available technology and sense of opportunity all effect how increased human potential translates into actual improved productivity. Finally, benefits of improved nutrition extend beyond the workplace to a range of “voluntary” activities including parenting and household activities to educational improvement, entrepreneurial pursuits and community participation. In a world where improvement in nutrition, health and subsequent productivity will emerge mainly from individual choices and behaviors, the significance of these “voluntary” activities cannot be overstated. However, these are not captured in the DAR which focuses on monetary earnings only. For all these reasons and more, the margin of error is large and the calculations should be considered as an order of magnitude. These are projections to focus and facilitate policy discussion and present a solid and conservative case for policy discussion. Therefore, data judgments or assumptions consciously and consistently “biased” to minimize the impact of malnutrition. Consequently, conclusions drawn may be considered conservative low-end estimates.

⁸ World Bank, Development Report 1993: Investing in Health. Oxford University Press World Bank 1993

⁹ Ross et al, Calculating the Consequences of Micronutrient Malnutrition on Economic Productivity, Health and Survival, AED 2003

¹⁰ Formula used to calculate the NPV: (# in Risk Group w/ Deficiency X Deficit Coefficient X Labor Participation Rate) X Present Value (Discount Rate, Work Life, Annual Wage) – Present Value (Discount Rate, Years until Workforce Entry, Annual Wage) / # Annual Cohort in Risk Group

2. Child Mortality Attributable to Malnutrition

Malnutrition is rarely specified as a cause of death. However, the close association of malnutrition, infection, disease and premature death of children has been extensively documented with a range of data demonstrating that globally malnutrition is the underlying cause of about 45% of all child deaths.¹¹ Of the estimated 156 thousand children born annually in Lao, more than 12 thousand die before their 5th birthday. 86% of deaths are during the first year of life – and about half during the first month. The estimates of child mortality attributed to malnutrition in LAO PDR are based on specific mortality rates in Lao children. Official figures as well as derivations used in the DAR are shown in Table 3.

Age Segment	Rate/1000	Estimated 2013	Source
Under 5 Mortality	79	12,339	LSIS @ 156,195 births/year
Infant Mortality/1000	68	10,621	LSIS @ 156,195 births/year
Neonatal < 1 month	32	4,998	LSIS @ 156,195 births/year
Post-Neonatal 1-12 months	36	5,623	Infant minus Neonatal
Infant: 1-5 months		2,812	50% Post Neonatal – 562 deaths/month
Infant: 6-11 Months		2,812	50% Post Neonatal -468 deaths /month
Child: 1 -5 years		1,718	Under Five minus Infant Mortality
Early Neonatal @ 74% of Neonatal	24	3,699	Calculated from WHO 2005 ¹²
Still Births	32	4998	Calculated from WHO 2005 ¹³
Perinatal		8,697	Early Neonatal plus Stillbirths

How many of these deaths can be associated with malnutrition in children and their mothers? The sections that follow apply coefficients for higher risk of mortality found in the scientific literature to 5 individual indicators of malnutrition to paint a general picture of child mortality that can be attributed to current prevalence of malnutrition in Lao PDR. The general methodology is outlined in Table 4.

Prevalence Indicator		Relative Risk of Mortality	=	PAR: Population Attributable Risk ¹⁴	X	Mortality in Risk Group Affected	=	# Deaths/yr Attributed To Indicator*
From National Statistics	X	From Global Literature		Fraction (%) of Risk Group Affected		From National Child Mortality Statistics		

¹¹ Robert E Black, Cesar G Victora, Susan P Walker, Zulfiqar A Bhutta, Parul Christian, Mercedes de Onis, Majid Ezzati, Sally Grantham-McGrego, Joanne Katz, Reynaldo Martorell, Ricardo Uauy, and the Maternal and Child Nutrition Study Group Maternal and child undernutrition and overweight in low-income and middle-income countries The Lancet, June 6, 2013

¹² http://www.wpro.who.int/health_research/documents/dhs_hr_health_in_asia_and_the_pacific_10_chapter_5_mortality.pdf

¹³ IBID

¹⁴ 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: $(Prevalence * (RR - 1)) / (1 + (Prev * (RR - 1)))$.

2.1 Underweight

Measurement of weight-for-age (HAZ) in the LSIS suggests ~330 thousand children 6-59 months of age are either moderately or severely underweight.¹⁶ These children face a significant elevated risk of premature death. A recent meta-analysis found that the RR of death for underweight children compared to normal weight children was 10 times for severe underweight (<3 SD), 2.5 times for moderately underweight (<2 SD), and 1.8 times for mildly underweight (<-1SD).¹⁷ Data from LSIS does not include mildly underweight children and therefore are not included in this analysis.

Table 5 Relative Risk of Mortality for Underweight Children < 5 yrs Causes¹⁵

	Severe < 3 SD	Moderate <2 – 3 SD	Mild < 1-2 SD
Overall	9.7	2.5	1.8
Diarrhea	9.5	3.4	2.1
Pneumonia	6.4	1.3	1.2
Malaria	1.6	1.2	0.8
Measles	6.4	2.3	1.3

Table 6: Mild and Moderate Underweight¹⁸

Age Segment	%< 2 SD
0-5 months	5.5
6-11 months	21.1
12-23 months	39.1
24-35 months	38.1
36-47 months	35.8
48-59 months	36.6
Average < 59 months	37.4

Since the risk of mortality is dramatically different as infants grow into pre-school ages, two parallel calculations are run – one for a cohort of ~78 thousand children ages 6-11 months and another for ~837 thousand children 6-59 months. We exclude children > 6 months, comprising >60% of child mortality, because according to LSIS prevalence of underweight is relatively low, ~5% before climbing to 21% during the 6-11 month period and 36-39% from 1-5 year old children.

Table 7 and 8 outline parameters used to calculate PAR for severe and moderate underweight separately for both age groups. PARs ranging from 20-41% are applied to the estimated deaths in each age segment suggesting total of nearly 2,500 deaths per year due to underweight among children 6-59 months.

Table 7: Projection of Mortality Attributed to Underweight in Children `1-5 months

Prevalence of Condition	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Deaths in Children 1-5 months	=	Annual Deaths Attributed
Moderate: 17.4%		2.5		20.7%		2,812		582
Severe: 3.6%		9.7		23.9%			671	

Table 8 Projection of Mortality Attributed to Underweight in Children `6-59 months

Prevalence of Condition	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Deaths in Children 6-59 month	=	Annual Deaths Attributed
Moderate: 29.4%		2.5		30.6%		1,718		526
Severe: 8%		9.7		41%			705	

¹⁵ Robert E Black, Lindsay H Allen, Zulfiqar A Bhutta, Laura E Caulfield, Mercedes de Onis, Majid Ezzati, Colin Mathers, Juan Rivera, Maternal and child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, January 17, 2008

¹⁶ Lao PDR National Nutrition Survey, UNICEF, NCD, 2010

¹⁷ Ibid

¹⁸ LSIS 2011

2.2 Low Birth Weight

14.8% of an estimated 156 thousand births in Lao PDR resulted in low birth weight, weighing less than 2500 grams.¹⁹ While national data does not categorize these ~23 thousand cases by severity, based on global estimates by Black et al, we project 88% or 20,422 of these low birth weight infants weighed 2000-2499 g and 11.7% or 2,694 weighed < 2000 g.²⁰ This extrapolation an incidence of 13.1% of births 2000-2499 grams and 1.7% < 2000 grams. These ~23 thousand babies are at higher risk of mortality during the neonatal period (1st month of life). A recent meta-analysis pooling 11 studies concludes that compared to normal weight babies, infants weighing 1500–1999 g were 8.1 times more likely to die and those weighing 2000–2499 g were 2.8 times more likely to die during the first month of life.²¹

Table 9 Extrapolation from Global Low Birth Weight Analysis by Black et al 2008

	Global Analysis	Calculated Proportion for Lao
2000-2499 g	9.55%	88.3%/20,422
1500-1990g	1.26%	11.7%/2694

As shown in Table 10, the RR mortality risks of 2.8 and 8.1 together with the derived prevalence rates for the two categories of low birth weight result in PARs of 11% and 19% suggesting that of 4998 neonatal current deaths, nearly 1500 represent this high risk 23 thousand low birth weight babies.

Table 10: Projection of Mortality Attributed to Low Birth Weight

Prevalence of Condition	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Deaths Neonatal Deaths	=	Annual Deaths Attributed
2000-2499g: 13.1%		2.8		19.1%		4,998		952
< 2000 g:1.73%		8.1		10.9%			545	

The association of maternal nutrition and low birth weight is strong. Indicators of maternal nutrition status including body mass index, mid upper arm circumference and iron status strongly predict low birth weight. One meta-analysis that included 11 trials identified a significant 20% reduction in low birth weight associated with antenatal iron folic acid supplementation.²² Nevertheless, not all births < 2500 grams can be confidently attributed to maternal nutrition status. The Lao NNS 2006 found about 60% of women had either low BMI or iron status, representing the top-end of potential low births weights attributable to maternal nutrition status. In recognition of the potential error band and in order to project conservatively, we apply half this number or 30% for attribution of nutrition related mortality from low birth weight – lowering our projection to 443 deaths.

¹⁹ LSIS 2011

²⁰ Black et al Maternal & child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, Jan 17, 2008

²¹ IBID

²² Imdad A, Bhutta ZA. Routine iron/folate supplementation during pregnancy. Paediatr Perinat Epidemiol 2012; 26 (S1): 168–77

2.3 Perinatal Mortality Attributed to Anemia in Pregnancy

Perinatal death, defined as number of stillbirths plus deaths during the first week of life, is a major cause of child death in Lao PDR. Applying estimates made for Lao in WHO's *Health in Asia and the Pacific*, a rate of stillbirth at 32/1000 and early neonatal mortality (1st week) at 74% of neonatal deaths, perinatal mortality is estimated at nearly 8700. A recent meta-analysis including 10 individual studies quantified the often observed association of anemia during pregnancy with perinatal death concluding that where malaria is not a significant threat, as is most often the case in Lao PDR, perinatal mortality decreases 16% for every 1 gram per deciliter increase in the mother's hemoglobin (Hb) - a protective RR of 0.84 per gram Hb.²³

There is no recent data on the prevalence of anemia or iron deficiency anemia among pregnant women. For the purpose of this analysis, the DAR uses data for all women of reproductive age found in the Lao NNS 2006, 36.2% - a conservative approach since iron needs rise dramatically during pregnancy and iron status often deteriorates. The NNS further found iron deficiency anemia among women at 14.6% - suggesting 40% of anemia is from lack of iron - and therefore sensitive to nutrition interventions providing dietary iron. Using an algorithm developed in WHO Global Burden of Disease, the model calculate mean hemoglobin level of 12.5 g/dL at current anemia prevalence and mean hemoglobin of 12.9 g/dL in the theoretical absence of iron deficiency, leaving a 0.41 g/dL deficit in mean hemoglobin. As shown in Table 11 below, this 0.41 g/dL deficit along with the RR of 0.84 per 1g/dL enables calculation of a PAR of 7% which is applied separately to estimated stillbirths and early neonatal deaths to project 605 perinatal deaths attributed to maternal anemia. A parallel analysis for maternal mortality with an established RR 0.71 per g/Hb was applied to the maternal mortality rate reported by LSIS to suggest 13.4% of maternal death Lao is associated with maternal anemia.²⁴

Table 11 Projection of Perinatal Mortality Attributed to Maternal IDA

Prevalence of Condition (IDA)	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Perinatal Deaths	=	Annual Deaths Attributed
Deficit 0.74 g/dL Hb		0.84/1g/DI Hb		7%		Stillbirths: 4998		347
						Neonatal: 3699		257
Deficit 0.41 g/dL Hb		0.71 /1g/DI Hb		13.2%		Maternal Death: 558		74

2.4 Mortality Attributed to Sub-Optimal Breastfeeding

Evidence from both developing and developed countries shows the critical lifesaving significance of exclusive breastfeeding during the first 6 months.²⁵ A recent meta-analysis including studies from multiple counties concluded that the increased mortality risk for non-breastfed versus exclusively

²³ Stoltzfus RJ, Mullany L, Black RE. Iron deficiency anaemia. In: Ezzati M, Lopez AD, Rodgers A, Murray CLJ, eds. Comparative quantification of health risks Geneva: World Health Organization, 2004: 163–209.

²⁴ Black et al Maternal & child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, Jan 17, 2013

²⁵ Bernardo L. Horta, Rajiv Bahl, José C. Martines, Cesar G. Victora, Evidence on the long-term effects of breastfeeding, Systematic Reviews and Meta-Analysis, WHO 2007

breastfed babies ranges from RR 10.53 for diarrhea, RR 15.13 for pneumonia and RR 14.4 from all causes.²⁶ The risks were lower, but still significant for predominant and partial breastfeeding - ranging from RR 1.48 to 2.28. After the first 6 months, babies who are not breastfed also face higher risk of mortality than partially breastfed infants – though these risks not as acute as during the first 6 months, ranging from RR 1.52 to RR 3.68.

Table 12 Relative Risk Infant Mortality by Breastfeeding Behavior²⁷

	0- 6 months			6-23 months
	Predominant	Partial	None	None
Diarrhea	2.28	4.62	10.53	2.83
Pneumonia	1.75	2.49	15.13	1.52
All Mortality	1.48	2.85	14.4	3.68

As indicated in Table 13, LSIS found about half of Lao infants were exclusively breastfed during the first month and at the end of 5 months this drops to about one-quarter. LSIS does not include partial breastfeeding with about twice the risk of mortality as predominant breastfeeding. Though there is reason to believe that a that a significant number of infants categorized as predominant in the LSIS are in fact partial breastfeeding, in order to ensure no over-estimation, the categories as reported by the LSIS are not adjusted to reclassify any predominant cases as partial.

Table 13 Breastfeeding Behaviors in Lao PDR, from LSIS 2011

Age Group	Exclusive	Predominant	No Breastfeeding
1 month	52%	44%	4%
at-5 month	27%	63%	10%

Since prevalence of suboptimal breastfeeding varies significantly within this time period and since infant mortality rates are very different in the neonatal and post-neonatal period, projections are made separately for these two age groups. In addition, since preliminary results showed an exceedingly high PAR, the RR used in the analysis were adjusted to the low-end of the Confidence intervals for all-cause mortality found in the meta-analysis – namely RR 1.13 rather than 1.48 for predominant and 6.09 rather than 14.4 for no breastfeeding.

Table 14 below shows separate mortality projections for children less than one month of age and children 1-5 months totaling more than 2,300 deaths – about 22% of all infant mortality.

Table 14: Table 6 Projection of Mortality Attributed to Suboptimal Breastfeeding

Prevalence of Condition		Relative Risk Mortality		Population Attributable Risk		Annual Deaths in Risk Group		Attributed Deaths/Yr
< 1m: 44% Predominant		1.13		5.4%		4998 Neonatal Deaths		270
< 1m: 5% No Breastfeeding	X	6.09	=	18%	X		=	898
1-5m 63% Predominant		1.13		7.6%		2812 Deaths from 1-5 months		213
1-5m: 10% No Breastfeeding		6.09		33.7%				948

²⁶ Robert E Black, Lindsay H Allen, Zulfiqar A Bhutta, Laura E Caulfield, Mercedes de Onis, Majid Ezzati, Maternal and child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, Lancet January 17, 2008

²⁷ IBID

2.5 Mortality Attributed to Vitamin A Deficiency (VAD)

Vitamin A deficiency has been attributed to poor intake of vitamin A-rich foods such as liver, eggs, meat, green and yellow vegetables. Inadequate intake of vitamin A compromises the immune system, leading to risks of common illnesses progressing to more severe forms, including death. The risks are especially high during periods of rapid physical growth, and consequent increases in nutritional requirements, as in pregnancy and early childhood. Since 1993 and as recently as 2011, a number of randomized controlled trials have examined the effect of vitamin A supplementation and fortification on the survival of children aged 6-59 months showing a mortality reduction of 23%-30%.²⁸ This establishes risk of death at RR of 1.75.²⁹

There is no recent data on vitamin A deficiency among Lao children. The 2000 National Health Survey indicated the prevalence of vitamin A deficiency was 45%, with 7% having a severe deficiency.³⁰ Since 2000 this intake may have improved marginally, in part due to modest coverage of vitamin A capsules has been undertaken by the GoL along with support from UNICEF. This twice annual coverage is far from universal, with a recent survey finding coverage as low as 18%.³¹ In order to recognize the possibility of reduced national prevalence and enable a conservative analysis of the current national impact of VAD, we rates found in 2000 have been lowered one-third, leaving a prevalence rate of 30%. As indicated in Table 15 below, a RR of mortality of 1.75 and an assumed prevalence of 30% yield a PAR of 18.4%. This is applied separately to the estimated 2812 late infant deaths and 1718 deaths in children ages 1-5 years to project a total of 832 deaths attributed to VAD – about 7% of total child mortality in Lao PDR.

Table 15 Projection of 6-59 month Mortality Attributed to VAD

Prevalence of Condition	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Perinatal Deaths	=	Attributed Deaths/Yr
30%		1.75		18.4%		6-11m: 2812		516
						12-59: 1718		316

2.6 Folic Acid related Neural Tube Defects:

Neural Tube Defects (NTD) including serious birth defects such as spina bifida and anencephaly are a significant cause of death and disability worldwide. A Cochrane review including five trials of folic acid (a synthetic form of folate) supplementation identified a 72% reduction in the risk of neural tube defects.³² A more recent systematic review had much the same findings and estimated that in 2005, 56 000 deaths worldwide were attributable to insufficient dietary folic acid.³³ While there is no data on the incidence of NTDs in Lao, a review by the March of Dimes, global birth defects prevention NGO, suggested 374

²⁸ Beaton GH, Martorell R, Aronson K, et al. Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries—Paper no 13. Toronto, ON: International Nutrition Program, 1993; Fawzi WW, Chalmers TC, Herrera MG, et al. Vitamin A supplementation and child mortality. *JAMA* 1993; **269**: 898–903; Mayo-Wilson E, Imdad A, Herzer K, et al. Vitamin A supplements for preventing mortality, illness, and blindness in children aged under 5: systematic review and meta-analysis. *BMJ* 2011; Imdad A, Yakoob MY, Sudfeld C, et al. Impact of vitamin A supplementation on infant and childhood infant and childhood mortality *BMC Public Health* 2011;

²⁹ Burkhalter, Barton R., Victor M. Aguayo, Serigne M. Diene, Margaret B. Parlato, and Jay S. Ross *PROFILES: A Data-Based Approach to Nutrition Advocacy and Policy Development. BASICS/ USAID* 1998

³⁰ Health Status of the People in the Lao PDR, National Institute of Public Health of the Ministry of Health, January 2001

³¹ Multiple Indicator Cluster Survey (MICS) 3, Ministry of Health of the Government of the Lao PDR, National Statistical Centre (NSC) of the Committee for Planning and Investment, UNICEF, 2006

³² De-Regil LM, Fernandez-Gaxiola AC, Dowswell T, et al. Effects and safety of periconceptional folate supplementation for preventing birth defects. *Cochrane Database Syst Rev* 2010; 10: CD007950.

³³ Blencowe H, Cousens S, Modell B, et al. Folic acid to reduce neonatal mortality from neural tube disorders. *Int J Epidemiol* 2010;

cases annually.³⁴ Global data suggest NTDs occur at a rate of 1-2 per 1000. We apply a mid-point of 1.5/1000 births to estimate 234 cases, a lower number than the March of Dimes. Given the seriousness of NTDs and high case fatality rate for births outside a facility and without access to pediatric neurosurgery, we speculate 90% of these infants die, with survivors living with a lifelong disability.

2.7 Summary of Child Mortality Attributed to 5 Malnutrition Indicators

Table 16 below summarizes findings of proportion of child mortality in Lao attributable to child and maternal nutrition based on an individual indicator by indicator analysis projecting more than 6.9 thousand deaths of children from the perinatal period until 5 years of age. However, during the neonatal period, infancy 1-5 months, and period of 1-4 years, this includes multiple and over-lapping risks. For example, some children may suffer both VAD and underweight or low birth weight and suboptimal breastfeeding. Since there is no data on how many children suffer these multiple risks, the DAR uses a formula to develop “hybrid” PAR adjusting for multiple parallel risks as recommended by Rockhill et al to statistically correct for any potential “double-count.”³⁵ This adjustment reduces the attributed child mortality to 6016, ~1/3rd of all 17,338 deaths estimated from the perinatal period till 5 years.³⁶

Perinatal	Individual Analysis	Adjusted Multiple Risks
Maternal Anemia (Stillbirths)	347	
Maternal Anemia (Early Neonatal)	257	
Perinatal Deaths	605	605
Neonatal Period		
Low Birth Weight	443	408
Folic Acid associated Birth Defects	211	195
Sub Optimal Breast Feeding	1,168	1078
Neonatal Deaths	1,821	1680
Infant: 1-6 Month		
Sub Opt BF	1,161	
Deaths in infant 1-5 months	1,161	1161
Infant 6-11 Months		
Underweight	1,252	1009
VAD	516	416
Deaths in infant 6-11 months	1,769	1426
Child 12-59 months		
Underweight	1,231	911
VAD	316	233
Deaths in Children 1-4 years	1,546	1144
Total Deaths from Perinatal to 5 years of Age	6,902	6016
Proportion all 17,338 deaths < 5 yrs including and Stillbirth	40%	35%

³⁴ Calculated from March of Dimes, Report on Global Birth Defects, Appendix B, 2001

³⁵ Rockhill et al, Use and Misuse of Population Attributable Fractions, American Journal of Public Health, January 1988,

³⁶ Calculations for multiple exposure adjustment provided in Annex 1

2.8 Estimating Value of Workforce Lost to Child Mortality

The value of this loss is immeasurable. What is the national economic loss that can be attributed to premature deaths 6016 of infants and children? The DAR takes a discounted net present value (NPV) of future lost earnings discounted at 3% and at constant 2013 levels. The NPV includes a delayed earnings stream that presumes entry into the workforce at average of 15 years of age – a delay ranging from 15 years for perinatal and neonatal deaths to 13 years for the 1-4 year old cohort. Further, this cold economic perspective attributes an economic value only to the 78% who participate in the labor force. In other words, this economic calculation attributes no value at all to ~22% of these child deaths who are not projected to participate in the labor force and be economically active.³⁷

At a 3% discount rate, the NPV of a lifetime of lost potential future earnings from emerging from an estimated 6016 children indicates economic losses from child mortality totaling ~\$70 million. At about \$11.5 thousand per life, this methodology does not reflect to true loss. As shown in Table 17 below, when the discount rate to calculate the NPV is set at 7% , the value is more than cut in half. Life is very sensitive to discount rates. Clearly, this methodology does not begin to measure the value of human life.

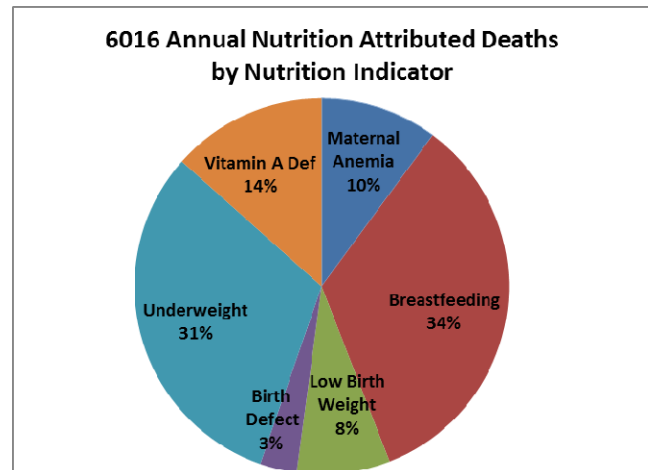
Table 17 Algorithm Used for Value of Lost Workforce due to Child Mortality								
Child Deaths Attributed to Malnutrition	X	Average Wage	X	Labor Force Participation Rate	X	NPV: 39 yr Work life w/delayed earning stream ³⁸	=	Net Present Value of Losses (\$000,000)
6016		\$1244		77.9%		@ 3%		\$69.4
						@ 7%		\$27.5

³⁷ The formula is (6016 Deaths X 77.9%) X (PV(39 yrs x \$1244/yr @ 3%)) - (PV(13-15 yrs x \$1244 @3%))

³⁸ Delay in earnings stream varies slightly with estimates at 15 years for deaths in peri and neonatal; 14.5 years for and early infancy; 14 years for late infancy and 13 years for 1-4 years olds.

2.9 Perspectives on the Attributions for child Mortality

It's important to note that nutrition related deaths are only in part associated with lack of staple foods like rice that are usually used as benchmarks of food security. While the causes of underweight, which represent about 1/3rd of the attributed losses, include lack of sufficient quantity of food (calories) this indicator is associated with a range of causes including – initial birth come, infection, lack of hygiene and suboptimal breastfeeding. However, the other indicators are not associated with lack calories or food quantity but rather food quality, child care behaviors and the nutrition status of the mother.



- Vitamin A deficiency reflects low quality of diet rather than lack of sufficient quantity of food. Vitamin A is available mainly in animal products and to some extent fruits and vegetables – and not offered by rice, cassava or other staple grain and root foods.
- About ¼ of the losses attributed to child mortality are associated only with maternal status and not with nutrition of child infant – namely low birth weight delivery, perinatal deaths from maternal anemia, birth defects associated with folic acid deficiency.
- Another 1/3rd of deaths are linked exclusively with maternal behavior, lack of optimal breastfeeding.

Therefore, significantly reducing this burden of childhood deaths will involve a comprehensive set of interventions beyond ensuring access to increasing quantities of staple foods.

3. Depressed Future Productivity of Children

Malnutrition coincides with many health and economic deprivations which affect child growth and development. Isolating the “nutrition factor” or the “child development factor” is complicated by countless interactions of nutrition, nature and nurture. However, there is substantial evidence that after correction for poverty and associated environmental threats, nutrition has independent and additive impacts on child growth, cognition and development.³⁹ This in turn is linked to future earnings and productivity as an adult via a long line of economic scholarship and evidence.⁴⁰

Undernutrition diminishes children’s cognitive development through physiological changes, by reducing the ability to participate in learning experiences, or both. Even in mild or moderate cases, malnourished children score poorly on tests of cognitive function, psychomotor development and fine motor skills. With lower activity levels, they interact less frequently with their environments and thus fail to acquire physical and intellectual skills at normal rates. In large part these early childhood deficits determine their ability to capitalize on educational opportunities and later employment opportunities, resulting in an adult productivity deficit.

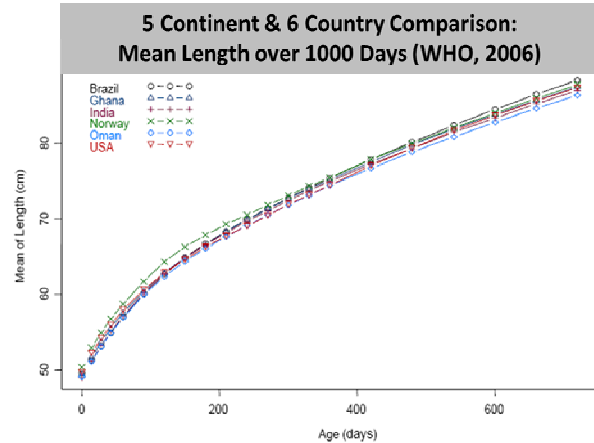
This analysis focuses on childhood anemia and stunting - indicators strongly associated with slow growth, depressed cognition, inferior school performance and reduced future earnings. At current prevalence rates for these two indicators, possibly three-quarters of Lao’s population of children 6-24 months will not have the opportunity to grow to their full physical, intellectual and productive potential.

³⁹ Grantham- McGregor et al, Developmental Potential in the first 5 Years for Children in Developing Countries, The Lancet, Vol 369, 2007

⁴⁰ Behrman (1993), Behrman and Deolalikar (1989), Deolalikar (1988), Foster and Rosenzweig (1993), Glick and Sahn (1997), Haddad and Bouis (1991), Schultz (1996), Strauss and Thomas (1998) and Thomas and Strauss (1997) Behrman (1993), Behrman and Deolalikar (1989), Deolalikar (1988), Foster and Rosenzweig (1993), Glick and Sahn (1997), Haddad and Bouis (1991), Schultz (1996), Strauss and Thomas (1998) and Thomas and Strauss (1997)

3.1 Stunting or Small Stature

Children who fall more than 2 standard deviations below an international reference population developed by WHO are considered to be low height for age (HAZ), or stunted.⁴¹ Findings from well-nourished populations consistently show that in a range of nations and ethnic groups, grow at very close to the same trajectory. As shown in the attached figure from WHO Assessment of linear growth in well-nourished children from birth to 1000 days in Brazil, Ghana, India, Norway, Oman and USA shows that there is some minor some variation, the growth curves across the world are very similar.⁴² If in well-nourished populations there is no average difference in length among countries, “being short” only has negative effects when there is malnutrition.



Stunting is a general marker of the cumulative effects of chronic malnutrition in childhood – one result of the all too common combination of inadequate diet, infection, and suboptimal child care. Stunted children suffer low physical activity, impaired motor and mental development, lowered immune competence, greater severity of infections and increased mortality.⁴³ Stunting has a number of life-long consequences – and after 2 years of age there is limited possibility of “catch-up growth” to reverse the consequences of early childhood stunting.⁴⁴ A number of studies have documented the association between stunting and future productivity via 3 pathways.

- *An association with lower cognition which in turn is linked to lower earnings as adults:* Numerous studies have directly associated stunting with lower test scores for childhood cognition. A recent pooled analysis from 5 countries concluded that “being moderately or severely stunted was associated with lower scores for cognition in every study and the effect size varied from 0.4 to 1.05 SD.”⁴⁵ This magnitude of deficit is linked with 5-20% lower earnings as adults.
- *An indirect association mediated by school participation and performance.* Substantial evidence shows stunted children start school later, progress through school less rapidly and have lower over-all schooling attainment. A review of evidence from 79 countries concluded “for every 10% increase in stunting, the proportion of children reaching the final grade of primary school dropped by 7.9%.”⁴⁶ Most recently, an authoritative review in the Lancet concluded that after statistically correcting for poverty, stunted children suffer a combined grade attainment and

⁴¹ Bulletin of the World Health Organization, Vol 83, No 3, Geneva, Mar 2005

⁴² WHO Multicentre Growth Reference Study Group, Assessment of Linear Growth Difference Among Populations, Acta Paediatrica. 2006 450:56-65

⁴³ Martorell, R. The role of nutrition in economic development. Nutr. Rev. 54: S66-S71(1996)

⁴⁴ IBID

⁴⁵ Psacharopoulos G, Patrinos H. Returns to investment in education: A further update. Educ Econ 2004; 12:111-34.

⁴⁶ Ibid

school performance deficit of 2.91 years - with each year predicting decreased future wages of 8.3%.⁴⁷

- *A direct association between lower adult height and reduced earnings.* Direct observations of the links of stunting with future productivity deficits provide more modest scenario for economic losses. An examination of nutrition/productivity links using wage rates in urban Brazil using four variables (height, BMI, per capita energy consumption and per capita protein intakes) found only height was a significant determinant of wages.⁴⁸ A number of studies, controlling for a variety of characteristics, document a direct association between lower adult height and reduced earnings.⁴⁹ Two widely noted studies ventured specific estimates of lower earnings among stunted manual laborers. An analysis of wages in urban Brazil, Strauss et al estimated that a 1% increase in height leads to a 2-2.4% increase in wages or earnings.⁵⁰ Among sugar cane workers in the Philippines, Haddad & Bouis estimated that an individual 15 cm taller than average could be expected to earn 13% more, suggesting wages earned workers rose 1.38% for every 1% increase in height.⁵¹

The DAR considers two approaches to quantifying the economic impact of stunting in Lao PDR. A global literature review of losses from both grade attainment and school performance in the Lancet concludes that a stunted child suffers a “total percentage loss of adult yearly income” of 19.8%. Table 18 below, uses this “coefficient of deficit” along with LSIS finding that 44% of children 6-24 months fall < 2 SD below international reference standard age for height, to calculate an NPV for lost future productivity may rise as high as \$194 million annually.,

Table 18 Projecting Economic Loss from Stunting via Schooling Methodology

Number w/ Deficit or Risk	X	Average Earnings	X	Labor Force Participation	X	Average Work-Life	X	Coefficient Risk-Deficit	X	Discount for NPV	=	Annual Loss
131,568		\$1244/y		All: 77.9%		All: 39y		19.8%		@ 3% 14yr delay		NPV \$193.7 million/yr

The second approach is based on direct observations of Haddad et al that wages earned workers rose 1.38% for every 1% increase in height. This finding together with figures found standard growth reference charts suggest that severe stunting (> -3 SD) represents a 6.25% reduction in height and moderate stunting (-2 to -3 SD) represents a 4.375% deficit.⁵² Multiplying these percentage height deficits by the assumed loss of 1.38% productivity suggests severely stunted children suffer a productivity loss of 8.6% while moderate stunting results in about a 6% future deficit. These coefficients are applied to the data for severe and moderate stunting reported by LSIS 2011 in Table 19 below indicating NPV of annual loss amounting to ~\$70 million annually. Given the wide variation in these two

⁴⁷ Grantham- McGregor et al, Developmental Potential in the first 5 Years for Children in Developing Countries, The Lancet, VOI 369, 2007;

⁴⁸ (Haddad & Bouis 1991)

⁴⁹ Behrman (1993), Behrman and Deolalikar (1989), Deolalikar (1988), Foster and Rosenzweig (1993), Glick and Sahn (1997), Haddad and Bouis (1991), Schultz (1996), Strauss and Thomas (1998) and Thomas and Strauss (1997)

⁵⁰ Thomas & Strauss et al Health and wages: evidence on men and women in urban Brazil, Journal of Development Economics, 1997; 77:15

⁵¹ Haddad, L et al The Impact of Nutritional Status on Agricultural Productivity: Wage Evidence from the Philippines, Oxford Bulletin of Economics & Statistics, Vol 53 February, 1991, 45-68 1991

⁵² Burkhalter, Barton R., Victor M. Aguayo, Serigne M. Diene, Margaret B. Parlato, and Jay S. Ross *PROFILES: A Data-Based Approach to Nutrition Advocacy and Policy Development*. BASICS/ USAID 1998

approaches, both using evidence based assumptions, the DAR will take forward the lower figure found in Table 19 in order to ensure that economic losses from stunting are not over-estimated

Table 19 Projecting Economic Loss from Stunting via Direct Observation of Earning Methodology												
Number w/ Deficit or Risk		Average Earnings		Labor Force Participation		Average Work-Life		Coefficient Risk-Deficit		Discount for NPV		Annual Loss
Moderate: 25.4%/75,691	X	\$1244/y	X	All: 77.9%	X	All: 39y	X	6.038%	X	@ 3% With 14 yrs delay	=	NPV \$69.8 million/yr
Severe: 18.8%/55,877											8.625%	

3.2 Anemia in Children:

A range of evidence links iron status in children to cognitive and development deficits and to lower future earnings. These are summarized below.

- A *Journal of Nutrition* review of the literature documents the positive impact of iron intervention on cognitive scores, generally ranging from 0.5 to 1 SD and concluded that “available evidence satisfies all of the conditions needed to conclude that iron deficiency causes cognitive deficits and developmental delays.”⁵³
- A recent review from child psychology, nutrition and economic science, concluded that development deficits related to iron status in children less than 5 years old children are associated a 4% drop in earnings.⁵⁴ Several intervention studies show that iron supplementation in children < 5 years led to cognitive improvements which were sustained into adolescence with a correlation coefficient 0.62.⁵⁵ Therefore, the DAR corrects the 4% deficit by a factor of 0.62 to arrive at a 2.5% decrease in future earnings and productivity.⁵⁶

Data on iron status and anemia among children in Lao is scarce. The recent Maternal and Young Child Security Initiative (MYCNSIA) combined data from 2 sources, the national LSIS and a supplementary survey conducted in 3 provinces from 2011-2012. This provides the most recent and reliable data for anemia in Lao children. MYCANSIA found about 40% of children < 5 years of in the survey provinces suffered anemia. However, among children in the very sensitive development growth stages of 6-23 months anemia rates were considerable higher, averaging 52.8%. The DAR apply this prevalence rate to the national population of children 6-24 months indicating more than 157 thousand anemic children suffering current cognitive development deficits and future earnings deficits. As outlined in Table 15, this suggests an NPV for future productivity deficits in these 157 thousand children total \$29 million

⁵³ Haas, J. and Brownlie T., Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research *Journal of Nutrition*. 2001;131

⁵⁴ Horton & Ross The Economics of Iron Deficiency *Food Policy* 28 (2003) 51–75

⁵⁵ Pollitt et al. 1995 and Jensen, 1980 in Horton & Ross The Economics of Iron Deficiency *Food Policy* 28 (2003) 51–75

⁵⁶ Horton & Ross The Economics of Iron Deficiency *Food Policy* 28 (2003) 51–75

annually. The lifetime deficit for each child is about \$185, but given the high prevalence of anemia and large numbers of children affected, this relatively modest individual deficit accumulates with significant impact on the national economy.

Table 20 Projecting Economic Loss from Childhood Anemia												
Number w/ Deficit or Risk		Average Earnings		Labor Force Participation		Average Work-Life		Coefficient Risk-Deficit		Discount for NPV		Annual Loss
52.8%/ 157,279	X	\$1244/y	X	All: 77.9%	X	All: 39y	X	2.5%	X	@ 3% With 14 yrs delay	=	NPV \$29 million/yr

3.3 Long Term Disability from Folic Acid Related Neural Tube Defects

No data was identified on chances of survival for the estimated 234 annual cases of folic acid related birth defects such as spina bifida and anencephaly. Given lack of access to pediatric neuro-surgery, the DAR speculates a 90% fatality rate, this leaves about 23 surviving case with lifelong disability and a projected 100% loss of productivity. Since this is a speculative number, and results in the same 100% loss as mortality, these projected earnings losses from these cases are included in the previous mortality analysis.

4. Depressed Current Productivity: Anemia in Adult Workers

Although the Lao MDGs, National Nutrition Policy and this analysis focuses mainly on malnutrition in pregnant and children, widespread anemia among adults may result in current work performances deficits - and losses to the national economy. In addition to the potential impact on national economic development, the inter-generational links of mother and child associated with child nutrition indicators – including birth outcome, underweight, stunting and others – suggest that undernutrition among adult women may be an intergeneration link and an important component of the national burden of malnutrition.

Weakness, fatigue and lethargy brought on by anemia results in measurable productivity deficits in the manual labor. Aerobic capacity, endurance and energy efficiency are compromised 10-50%.⁵⁷ A substantial literature shows the negative impact on indicators of work performance. The output of iron supplemented rubber tree tappers involved in heavy manual labor in Indonesia was found 17% higher than non-supplemented co-workers.⁵⁸ There is also evidence anemia impairs less physically demanding work in “blue collar labor” or manufacturing not requiring significant physical exertion.^{59 60 61} Based on an extensive review of the literature, Ross & Horton estimate a 5% deficit among all manual or “blue collar” manufacturing work and an additional 12% loss for heavy manual labor such as agriculture and construction.⁶²

The Lao National Nutrition Survey of 2006 established national prevalence of anemia at 36.2% for reproductive age women – more than half a million women of working age.⁶³ While there is no available data on anemia or iron deficiency in Lao men, it stands to reason that this condition exists – but at a much lower level than in women. For the sake of this analysis we will assume anemia in men at one-quarter the female rate – or ~9%.⁶⁴

While there is reason to believe anemia has a negative impact on all kinds of work performance, including “white collar” jobs, the published evidence is limited to “blue collar” or manual work requiring physical exertion. As with previous analysis, productivity deficits are only applied to individuals participating in the labor force (79.5% of men and 76.5% of women). However, for adult anemia the DAR applies an additional screen to include only to individuals in manual labor - not to administrative, managerial, education and other “white collar” jobs. The manual labor share of employment is estimated from the findings in 4th Lao Expenditure and Consumption Survey (LECS4) which estimates “total hours worked in different sectors as percent of total hours.” As shown in the Table 21 below,

⁵⁷ Celsing F., Blomstrand E. Effects of iron deficiency on endurance and muscle enzyme activity *Med. Sci. Sports Exerc.* 1986;18:156-161

⁵⁸ Basta S. S., Soekirman D. S., Karyadi D., Scrimshaw N. S. Iron deficiency anemia and the productivity of adult males in Indonesia. *Am. J. Clin. Nutr.* 1979;32:916-925

⁵⁹ Li R., Chen X., Yan H., Deurenberg P., Garby L., Hautvast J.G.A.J. Functional consequences of iron supplementation in iron-deficient female cotton workers in Beijing, China. *Am. J. Clin. Nutr.* 1994;59:908-913

⁶⁰ Scholz B. D., Gross R., Schultink W., Sastroamidjojo S. Anaemia is associated with reduced productivity of women workers in even less-physically-strenuous tasks. *Br. J. Nutr.* 1997;77:47-57

⁶¹ Unturo J., Gross R., Schultink W. Association between BMI and hemoglobin and work productivity among Indonesian female factory workers. *Eur. J. Clin. Nutr.* 1998;52:131-135

⁶² Ross L Horton S *The Economic Consequences of Iron Deficiency, Micronutrient Initiative* 1998

⁶³ Lao PDR National Nutrition Survey UNICEF/NCDC, 2010

⁶⁴ National data of anemia in men is scarce. The Philippines national survey finds anemia rates of 21% for women and 10% of men. We take one half of this proportion for this analysis.

based on the categories of work reported by LECS4, the DAR model assumes 72.2% of working women and 73.3% of working men are engaged in manual labor. While there is no data distinguishing normal manual labor from heavy manual labor (and the definition may be ambiguous), based on a global analysis done for the Copenhagen Consensus, we assume 15% of manual labor may be classified as heavy – and therefore subject to an additional 12% deficit.⁶⁵

	Female	Male
Agriculture	61.1	61.8
Mining	0.3	0.1
Food Processing	1.2	1.1
Textiles	3.2	3.3
Wood/Chemical	1.5	1.5
Equipment	1.8	1.3
Electricity	0.1	0.3
Construction	3	3.9
	72.2	73.3

Table 22 below shows calculations for national economic losses emerging from anemia among women and men employed in manual labor. After corrections for general labor participation and estimates for proportion employed in manual labor, the 5% productivity deficit is applied to 308 thousand women and 83 thousand men – with an additional 12% deficit for those assumed to be engaged in heavy manual labor. Since these are current losses no discounting is applied before reaching an estimate of \$55 million in depressed productivity of manual laborers with anemia.

Number w/ Deficit or Risk		Average Earnings		Labor Force Participation		Manual Labor %		Coefficient Deficit		Coefficient Deficit		Annual Loss
Female 15-64y 36.5%/557,180	X	\$1244/y	X	76.5%	X	72.2%	X	5% for Manual Labor	X	+12% for Heavy Manual Labor(15%)	=	\$55,147,273 /yr
Male: 15-64y: 9%/143,225				79.5%		73.3%						

5. Excess Healthcare Expenditures

Malnutrition in children contributes to impaired immunity and infection. Consequently, malnourished children may suffer more frequent or more severe illness which in turn translates into increased utilization of health services. This can generate a significant financial burden both on individual families as well as the health and medical system. While there are also significant opportunity costs to families involved in caring for sick children, only direct financial costs will be estimated in the DAR. While excess healthcare expenditures are measured for two indicators, there are doubtless countless cases of sickness associated with other nutrition indicators. However, evidence is not considered sufficiently robust or specific to quantify the impact of these other indicators.

⁶⁵ Sue Horton, Harold Alderman, Juan A. Rivera, *Hunger and Malnutrition*, Copenhagen Consensus, 2008

5.1 Excess Healthcare Costs Due to Suboptimal Breastfeeding

A long literature has documented the association of suboptimal breastfeeding and increased morbidity from acute respiratory infection (ARI) and diarrhea. For children 0-6 months, the most recent authoritative review in the Lancet finds that predominantly breastfed infants have a relative risk of 1.26 for diarrhea morbidity and the risk triples for those not breastfeeding at all. For ARI the relative risk of morbidity is 1.79 for partial breastfeeding while infants with no breastfeeding are twice likely to suffer respiratory disease.

Breastfeeding Behavior and Age Segment	Diarrhea Cases	ARI Cases
	RR	RR
0-6 months		
None	3.65	2.48
Partial	3.04	2.07
Predominant	1.26	1.79
6-23 months:		
None	1.2	1.17

To estimate the higher burden of diarrhea and ARI cases emerging wide spread suboptimal breastfeeding in Lao, the DAR make a series of assumption based on LSIS sample reporting cases of diarrhea or breastfeeding in the past 2 weeks. Assuming the two week time period reflects annual use, the percent reporting an episode is adjusted for annual cases per child (times 26 weeks). Since the sample was taken in the dry season when diarrhea and ARI typically decline, the resulting projection may be an under-estimate. Table 24 shows parameters for projection of 1.1 million annual cases of diarrhea and > 300 thousand cases of ARI.

Cohort < 6 months: 78,097	Diarrhea	ARI
% Had Episode in past 2 weeks (Dry Season)	11.4%	2.9%
Projected Episode per child over 52 weeks	2.964	0.754
Estimated Total Annual Cases	231,481	58,885
Cohort 6-24 months: 234,292		
% Had Episode in past 2 weeks	15.0%	4.0%
Projected Episode per child over 52 weeks	3.910	1.034
Estimate Annual Cases	916,086	242,193

How many of the estimated cases above can be attributed to the higher risks of morbidity related to the suboptimal breastfeeding behaviors among Lao mothers? Based on national prevalence of suboptimal breastfeeding along with the RR for elevated risk associated with each behavior and age segment, the calculation shown in Table 26 suggests PARs of 8-21% for Diarrhea and 7-57% for ARI. As shown in Table 26, these PARs are applied to the expected number of cases within each subgroup. For example, the cohort of 63% of children predominantly breastfeeding would be expected to represent 63% or 145,833 total diarrhea cases. The estimated cases of diarrhea attributed to suboptimal breastfeeding are derived by applying the PAR of 14% to this expected number of cases, 20,545 cases to this suboptimal

⁶⁶ Robert E Black, Lindsay H Allen, Zulfiqar A Bhutta, Laura E Caulfield, Mercedes de Onis, Majid Ezzati, Colin Mathers, Juan Rivera, Maternal and child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, Lancet Published Online January 17, 2008

breastfeeding behavior. Applying this methodology to all 3 relevant behaviors in both relevant age groups suggests more than 57 thousand cases of diarrhea and about 23 thousand cases of ARI can be attributed to suboptimal breastfeeding behaviors, in total about 80 thousand annual cases.

Table 25 Population Attributable Risk for Diarrhea and ARI from Suboptimal Breastfeeding Behaviors

	Suboptimal Breastfeeding	Diarrhea		ARI	
	Prevalence	RR	PAR	RR ARI	PAR
Infants < 6 months					
Predominant Breastfeeding	63%	1.26	14%	1.79	33%
No Breastfeeding	10%	3.65	21%	14.4	57%
Children 6-23 months					
No Continued Breastfeeding	44%	1.2	8%	1.17	7%

Table 26 Projections for Excess Cases of Diarrhea and ARI based on Population Attributable Risks

	Diarrhea		ARI	
	Expected Cases Proportional to Prevalence	Attributed Excess Cases	Expected Cases Proportional to Prevalence	Attributed Excess Cases
< 6 Months	Total: 231,481 cases		Total: 58,885 cases	
Predominant Breastfeeding	145,833 cases: 63%total	20,525	37,098 cases: 63% Total	12,328
No Breastfeeding	23,148 cases: 10% Total	4,849	5,889 cases: 10% total	3,372
6-23 Months	Total: 916,086 cases		Total: 242,193 cases	
No Continued Breastfeeding	398,554 case: 44% Total	31,903	105,369 cases: 44% Total	7,256
Total Cases		57,277		22,956

Establishing a financial cost for these 80 thousand annual cases of diarrhea and ARI requires several assumptions and derivations from available data. First, as indicated in Table 27 shows available LSIS on utilization of health care services. Not all cases result in health care seeking and only the proportion of cases actually seeking care or receiving medical services is counted as a cost. For ARI, utilization of health care services is based on the percent of cases seen in public or private health care facilities along with the proportion receiving medication. For diarrhea, LSIS data defines the proportion of cases receiving specific treatments. For example, 42% of diarrhea cases received Oral Rehydration Therapy (ORT) and 5% received some sort of injection. In both cases, we speculate a proportion of cases serious enough to be referred from the primary health care level to a hospital.

Table 27 Data and Derivations for Health Care Utilization for Diarrhea and ARI Cases in Children < 24 months

Utilization and Cost estimates	Diarrhea	ARI	Source
Taken to Public Facility %		29%	LSIS
Taken to Private Facility %		11%	LSIS
Received Antibiotics or other pills	47%	48%	LSIS
Received Injections	5%		LSIS
ORT	42%		LSIS
Home and Other Treatment	10%		LSIS
Hospitalizations	1%	10%	Estimate

The second difficulty in making this analysis of excess costs attributed to breastfeeding behaviors is the cost per case or treatment is a speculative figure. Estimates for cost per case or treatment are ventured in the DAR based on rough estimates provided by Ministry of Health to the National Economic Research Institute. While understanding the degree of speculation involved, unit costs are ventured in Table 28 below.

Calculated Number of Treatments	Unit Cost	Background
Taken to Public Facility #	\$11.76	90,000 Kip/Consult
Taken to Private Facility #	\$23.53	Estimated 1 times Public Facility
Received Antibiotics or other pills	\$1.053	8000 Kip Full Course
Received Injections	\$7.89	5 Injections @ 8000 Kip
ORT	\$0.98	5 treatments @ 5000 Kip
Home and Other Treatment	\$2.6	Special foods, folk remedies etc.
Hospital Cost Per Day	\$26.32	200,000 Kip/dy
Average Hospital Days Diarrhea/ARI	2/4.7	2/3 rd MOH Maximum

Based on the data, derivations and speculations in Tables 24-28 above, the 80 thousand excess cases is adjusted to reflect those actually seeking care and then multiplied by the unit cost of the specified product or service to project an annual health care cost of more than half a million dollars annually due to the current prevalence of suboptimal breastfeeding practices in Lao.

	Attributed Cases Utilizing Health Services		Estimated Costs	
	Diarrhea	ARI	Unit Cost	Annual Cost
Taken to Public Facility #	-	6,585	\$11.76	\$77,474
Taken to Private Facility #	-	2,591	\$23.53	\$60,956
Received Antibiotics or other pills	26,900	11,126	\$1.05	\$40,028
Received Injections	3,062	-	\$7.89	\$24,170
ORT	24,215	-	\$0.98	\$23,740
Home and Other Treatment	5,863	-	\$2.63	\$15,428
Hospitalizations Diarrhea	573		\$52.89	\$30,297
Hospitalizations ARI		2,296	\$123.42	\$283,331
Total				\$553,389

5.2 Costs Associated with Low Birth Weight Deliveries

Of more than 23 thousand low birth weight deliveries in Lao, the DAR estimates 20,422 are infants weighing 2000-2499 grams while 2694 are severe cases weighing less than 2000 grams at birth.⁶⁷ Excess healthcare costs are estimated only for the 42% in health facilities, as reported by LSIS. Parameters used to estimate the added cost to health care system for 9,599 babies born in Lao health care facilities is shown in the table below. A rough speculation is also ventured made for modest financial costs that may fall on families due to low birth weight babies not delivered in a medical or health facility.

Percent Born in Facility	42%	LSIS
Added Days in Facility < 2000 Grams	4.69	2/3 rd of Maximum from MOH Guidelines
Added Days in Facility 2-2500 Grams	3.35	2/3 rd of Maximum from MOH Guidelines
Cost of Bed/ICU/Treatments for Mother Per Night	\$26	Reported by MOH
Post Maternity Care Visits for Mother and Child	3	Estimated by MOH
Cost Per Post Maternity Care Visit	\$3.95	Sick Child Visit @30,000 Kip
Born At Home	13,518	Derived from LSIS
Cost to Families Per Case	\$9	65000 Kip estimated by NERI/MOH Work Group

Based on the data and unit costs as well as speculations ventured above, low birth weight cases represent a financial burden of about \$1.1 million annually to Lao government and individual families.

Annual Cost Projections for LBW Cases	
1119 Babies > 2000g @ \$88.16 per case	\$138,089
8480 Babies 2000-2499g @ \$123.42	\$747,592
Follow-up Post natal care for 9,599 Facility born Babies	\$113,672
Speculated Family Costs for 13,518 Estimated Home Births	\$ 115,613
Annual Cost Projections for LBW Cases	\$ 1,114,966

⁶⁷ Based global analysis in Black et al Maternal & child undernutrition: global and regional exposures and health consequences Maternal and Child Undernutrition Study Group, Jan 17, 2008

6. Summary: National Economic Consequences of Child Malnutrition

At current prevalence for 10 indicators of malnutrition analyzed in the DAR, the burden on national economy of Lao PDR may be at least ~\$200 million annually, representing about 2.4% of GDP.⁶⁸

Individual analysis from mortality as well as lost productivity have been statistically adjusted to correct for possible “double counting” of children suffering more than one form of malnutrition. For example, the NPV for Lost Future Productivity is about 74% of the sum of the individual analysis for anemia and stunting in children 6-24 months of age to account for children who may be both anemic and stunted.

Almost three quarters of this \$200 million annual loss represents Net Present Value of future losses due to mortality, depressed cognitive development and consequent lost future work potential of children. Projecting economic losses from future productivity amongst children is very sensitive to the discount rate used in calculating the NPV. When a rate of 7% is used instead of the 3%, the total annual loss declines to \$113 million. While lost current productivity of adults and healthcare costs are not affected, the NPV of future losses from childhood risks and deficits declines dramatically – and represents less than half the total loss when this higher discount rate is applied.

Table 32 Summary Economic Consequences for All Indicators: \$000,000/yr

	Lost Workforce	Lost Future Productivity	Lost Current Productivity	Healthcare Costs	Total	
					\$000000/yr	%
Maternal Anemia	\$7.0				\$7.02	4%
Suboptimal Breastfeeding	\$23.6			\$0.6	\$24.13	12%
Low Birth Weight	\$5.6			\$1.1	\$6.70	3%
Birth Defect (NTDs)	\$2.2				\$2.2	1%
Childhood Anemia		\$21.5			\$21.53	11%
Stunting		\$51.4			\$51.42	26%
Underweight	\$21.7				\$21.69	11%
Vitamin A Deficiency	\$9.3				\$9.32	5%
IDA in Adults			\$55.1		\$55.15	28%
Annual Total	\$69.4	\$73.0	\$55.1	\$1.7	\$199.18	100%
	35%	37%	28%	1%	% of GDP \$8.3 billion	2.40%

Over the next decades, a growing Lao PDR economy will doubtless lower this human and financial burden. However, nutrition status will respond relatively slowly to economic growth. A recent World Bank analysis of malnutrition and economic growth in 79 countries concluded “that income growth can play an important role in malnutrition reduction, but that it is not enough. Increases in the number and

⁶⁸ GDP is the same total used to calculate individual earnings \$8,297,664,741

effectiveness of direct nutrition interventions have a crucial role to play if nutrition goals are to be met.”⁶⁹ According to the *Disease Control Priorities Project*, “Progress has been made in some areas, but the current magnitude of the problems and of the associated disease burden underscores the need for more investment in nutritional interventions.”⁷⁰

If malnutrition continues to drain the Lao economy on the magnitude of 2.5% of GDP, the ambitious national goal of 8% annual GDP growth will be more difficult to achieve and sustain. The DAR estimate describes the magnitude losses from malnutrition in order to spur policy discussion and ultimately secure investment in programs on a scale appropriate to the extent of the burden malnutrition. The “baseline losses” projected by the DAR indicate the potential for significant economic as well as human and social benefits that might be secured by investment in interventions to lower prevalence of these indicators of malnutrition.

⁶⁹ Harold Alderman, Simon Appleton, Lawrence Haddad, Lina Song and Yisehac Yohannes Reducing Child Malnutrition: How Far Does Income Growth Take Us? Centre for Research in Economic Development and International Trade, University of Nottingham CREDIT Research Paper No 105

⁷⁰ Laura E. Caulfield, Stephanie A. Richard, Juan A. Rivera, Philip Musgrove, and Robert E. Black, Stunting, Wasting, and Micronutrient Deficiency Disorders, *Disease Control Priorities in Developing Countries*, 2006