Economic Benefits of Flour Fortification in Egypt: Applying Global Evidence To the National Environment

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I. Background

Rationale

Micronutrient malnutrition as a result of inadequate intake and absorption of vitamins and minerals is a serious public health in Egypt. "The enormous impact of micronutrient deficiency is largely invisible. Silently, micronutrient deficiencies trap people, communities and entire countries in a cycle of poor health, poor educability, poor productivity and consequent poverty, often without the victims ever knowing the cause.[1]" Because micronutrient deficiencies are a "hidden hunger," policy makers do not generally view these deficiencies in vitamins and minerals as impediments to economic growth.

Between 2000 and 2005 levels of anemia in Egypt almost doubled.[2] To address these and other urgent vitamin and mineral nutrition deficits in the national diet, the Government of Egypt, supported by United Nations and other international organizations, adopted policies to increase access to iron and other micronutrients in commonly consumed foods. In 2009, the Government of Egypt began scaling up the fortification of baladi bread with iron and folic acid in order to reduce the prevalence of anemia and folic acid deficiency. This paper aims to provide a general estimate of the magnitude of costs and benefits involved in implementing this national flour fortification program in Egypt.

General Methodology

Micronutrient malnutrition erodes the foundation of economic growth - people's strength and energy, creative and analytical capacity, initiative and entrepreneurial drive. The scientific literature has developed "coefficients of loss," evidence-based estimates of health risks and functional deficits associated with iron and folic acid deficiency. Based on these "coefficients of loss," this paper ventures to quantify the health and economic consequences of iron and folic acid deficiencies by applying this best evidence from the scientific and economic literature to national health, demographic and economic environment. Projecting the economic benefits of flour fortification in reducing the impacts of anemia and folic acid deficiency in Egypt based on a two-step algorithm shown below.

Overview of the Analysis Process										
Baseline Economic Loss	X	Projected Effectiveness of fortification	X	Projected Coverage	=	**Projected Improvement or Benefit**	/	Cost of Fortification	=	**Benefit Cost Ratio**
$/yr		%		%		$/yr		$/yr		#

<u>Baseline Economic Losses:</u> Consequences of anemia and folic acid deficiencies are measured via four distinct pathways.

- Mortality and disability in children and consequent forgone income from future employment. This analysis will be applied to both iron and folic acid deficits.
- Deficits in children's cognitive development resulting in inferior school performance and depressed future productivity. This applies to anemia only.
- Depressed productivity in working but anemic adults. This applies to anemia only.

- Excess healthcare and welfare expenses resulting from folic acid deficiency. Although "there is evidence that sufficient iron is essential for immune function… the

[1] Vitamin and Mineral Deficiency Global Progress Report, UNICEF, 2004
[2] Demographic and Health Survey of 2000 and 2005.

evidence from experimental trials does not suggest that iron supplementation reduces morbidity." [3] Therefore, in this analysis this pathway will apply to folic acid only.

Effectiveness, Coverage and Benefit: Together, industrial fortification level and individual flour consumption define the added "dose" of iron and folic acid provided. This added dose, along with evidence from other fortification programs, allows for general estimates for effectiveness - defined as improvement among consumers of fortified flour. Estimates for market coverage of fortified flour along with the effectiveness parameter enable a general calculation of benefits from flour fortification - defined as reductions from baseline losses. The following algorithm is used to project the magnitude of reduction in current prevalence and the presumed parallel reduction in economic losses.

Benefits Algorithm				
Effectiveness	x	*Market Coverage*	=	% Reduction in Baseline Loss

Benefit Cost Ratio: Cost of national flour fortification is based on the current costs of the baladi bread fortification as reported by government, international organizations and the milling sector. Benefits and costs are projected over 10-years. Inflation is assumed to impact the both the cost of inputs to flour fortification as well as a key indicators of benefit such as the average wage. Since these two factors may simply balance each other out, there is no adjustment for inflation in the study.

II. Defining Baseline Economic Losses

The algorithm for defining baseline economic losses is provided in the graphic below.

Calculation for Projection of Economic Losses											
Risk Group Population	X	Prevalence of Condition	=	**Population with Deficit**	X	Economically Active Population	X	Average Annual Wage	x	Coefficient Of Loss	=	**Lost Productive Activity**
#		%		#		**# or %**		LE		%		**LE/yr**

Monetizing the productive potential of individuals is based on a range of national demographic, labor and health statistics – as well as some key assumptions in cases where data is not available. These, along with coefficients of loss, will be reviewed in the individual sections that follow. Key national statistics are reviewed below.

Population of Risk Groups:

- Annual Births: CAPMAS data for 2007 is assumed to increase through 2009 along with the average birth rate increase from 2001-2007 of 1.99% as reported by UNDP. Therefore, the 2007 figure is adjusted upwards to 2.118 million births annually.

- Population of children less than 15 years of age: The 24.278 million children reported by CAPMAS 2007 are assumed to increase by the population growth rate of 1.99%.

[3] Stoltzfus et al, Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004

- Economically Active Adults: CAPMAS 2009 Q3 reports a labor force of 25.203 million with women representing 23.3%. Therefore, iron deficiency anemia rates and coefficients of loss will be applied to 5.872 million women and 19.331 men who are considered to be employed. The combined economically active population is 51.7% calculated from PRB 2009.[4]

	CAPMAS 2009 Q 3		**Employed**
	Women	Men	
Employed Q 4 2008 (MOP)	5,872,299	19,330,701	25,203, 0000
% Employed by Sex	23.3%	76.7%	

Average Annual Wage:

- Average Annual wage of LE 13,104 is calculated from weekly earnings of LE 252 reported MOP for Q4 2008. This represents about 43% of GDP per capita (PPP). There are other sources for this parameters and it is expected that his estimate will be adjusted during reviews of this paper.

- Childhood productivity deficits are not felt until children enter work force, as much as 15 years in the future. Therefore a Net Present Value (NPV) is calculated based on a discount rate of 5%, a bit higher than the 3% discount rate recommended by the World Bank for social investments.[5] Analysis at 3% and 7% discount rates is provided in an Annex to this paper. The social discount rate is not related to inflation but merely reflects the subjective time preference for current consumption or savings over future consumption or savings.[6]

- No information was identified on average age of entry and exit into the workforce. The analysis will assume, on a provisional basis, an average 45 year work life with average work force entry at 16 years of age.

Prevalence of Anemia vs. Iron Deficiency Anemia:

The causation of anemia is multi-factorial and includes malaria, hookworm and HIV and well lack of dietary iron and other micronutrient deficiencies (such as folic acid and vitamin A deficiencies). Only iron deficiency anemia (IDA) will be responsive to addition of dietary iron via fortification. Globally, WHO estimates about 60% of anemia is from iron deficiency.[7] However, little data was identified describing the proportion of anemia caused by iron deficiency in Egypt. Given the lack of comprehensive national data, the proportion of anemia caused by iron deficiency among adults was based on a range of data including:

- Rates of malaria, the second most common cause of anemia, are very low in Egypt.

[4] Personal communication Dr Heba Nassar
[5] World Bank, Development Report 1993: Investing in Health. Oxford University Press World Bank. (1993)
[6] Ross et all, Calculating the Consequences of Micronutrient Malnutrition on Economic Productivity, Health and Survival, AED 2003
[7] Global Burden of Disease Update, WHO, 2004

- Some literature suggests that rates of hookworm in Egypt may range up to 17% in some rural areas.[8] However, the intensity of these parasitic infections is quite low. A recent parasite control project suggests rates of about 5%.[9]

- A recent report estimates the total HIV cases at 3,735. Therefore, HIV is not a significant contributor to rates of anemia in Egypt.[10]Little national data was identified for B-thalessemia which, among other symptoms, results in mild anemia. One survey suggests about 10% of the population with thalessemia, with about half showing signs of mild anemia.[11] A report from WHO EMRO reports B-thalessemia rates for 6 countries in the region ranging from 3-4.6%.[12]

- While no national data was identified, vitamin A deficiency is not considered a severe public health problem in Egypt, with surveys suggesting less than 10% prevalence of low serum retinol.[13]

- Folic acid deficiency, which was identified as the cause of 18.7% of anemia among Egyptians in a small and non-representative clinical study, will be addressed via the fortification program.[15]

NNI Survey Preliminary Results & Analysis[14]

	Anemia (Hb)	***ID (Serum Ferritin)***	***ID as % Anemia***
Preschool	42%	38%	90%
School	38%	30%	79%
Average	40%	34%	85%

- Preliminary results from a soon-to-be-published NNI survey comparing rates of low hemoglobin (an indicator of all anemia) and serum ferritin (an indicator of iron deficiency) suggests that about 85% of anemia among Egyptian children less than 15 years of age may be from iron deficiency.[16]

While the data is thin, based on this range of inputs, this analysis will provisionally project that anemia 80% in adults and children is related to their iron deficiency.

Caveats:
Converting indicators of malnutrition to economic activity and attaching a monetary value to that economic activity travels a long and winding road. Many factors beyond human potential determine earnings or work performance. Work place incentives, available technology and sense of opportunity all effect how increased potential translates into improved productivity and earnings.

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[8] Lawless, et al, Intestinal Parasites in an Egyptian Village, *Parasitology Department, Naval Medical School, NNMC Bethesda, Maryland* and Kunt et al Comparison of Helminth and Protozoan Infections in Two Egyptian Villages, *Fuad I Research Institute for Tropical Diseases,Cairo, Egypt*
[9] Personal communication, WFP
[10] *EU News Network,* Egypt HIV Cases Jump Six-Fold, January 01, 2010
[11] El-Beshlway et al, Thalessemia Prevalence in Egypt, Egypt Pediatric Research, May 1999, volume 45, Issue 5
[12] Dr Hussein A. Gezairy, Regional Director, WHO Regional Office for the Eastern Mediterranean Region Screening programs for Haemoglobinopathies globally and in the Middle East Region, Power Point Presentation to 1stPan-Middle East Conference on Haemoglobinopathies Damascus, Syria1 -2 May 2009
[13] WHO Vitamin and Mineral Deficiency Database, http://www.who.int/nutrition/databases/micronutrients/en/index.html
[14] NNI, unpublished , 2009
[15] Salah, N. Et al Prevalence and type of anaemia in young Egyptian patients with type 1 diabetes mellitus , Eastern Med Health Journal Volume 11 Nos 5 & 6 September , 2005
[16] Unpublished, NNI,

Benefits of improved iron and folic acid 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. In Egypt with a very low rate of female economic participation, particularly in manual labor, this approach tends to devalue to impact of their anemia on national economic development.

Because of these limitations as well as in some cases the lack of up-to-date comprehensive national data, conclusions drawn in this analysis does not capture the full human, social and economic impact of anemia and folic acid deficiency in Egypt. It paints only general a picture on an order of magnitude.

III. Economic Impact of Iron Deficiency Anemia in Children:

When a large sector of a nation's young people cannot develop to their full cognitive potential and take only limited advantage of their educational and related opportunities, the aggregate affect is substantial national economic loss. As Egypt's economy shifts to a more service and knowledge-based work force work, the ability to adapt and acquire skills becomes increasingly important to national economic growth.

- ***The Global Evidence and Coefficient of Loss for Anemia in Children***

A range of evidence links anemia in children to future productivity deficits as adults. The evidence shows a direct link of anemia-related cognitive development deficits with future earnings as well as an indirect relationship mediated by educational opportunity:

- Anemia and Cognitive Development: A review of observational studies concluded anemic children score 0.5 to 1.5 standard deviations lower on intelligence tests.[17] A parallel body of literature documents the positive impact of iron intervention on cognitive scores, generally ranging from 0.5 to 1 SD.[18] The *Journal of Nutrition* found, "available evidence satisfies all of the conditions needed to conclude that iron deficiency causes cognitive deficits and developmental delays.[19]"

- Anemia and School Performance: Substantial literature links anemia and the ability of children to capitalize on educational opportunities. In addition to diminished cognitive ability, lack of energy undermines an anemic child's ability to concentrate and participate in learning experiences. A recent study linked anemia with significantly reduced school attendance.[20]

- Cognitive Scores and Future Earnings or Productivity: The association of childhood cognitive scores and productivity has been extensively documented. A recent review of the global literature by Galal et al linking cognitive test scores and earnings

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[17] Pollitt, Ernesto Relationship Between Undernutrition and Behavioral Development in Children, Journal of Nutrition, August, 1995 Volume 125 Number 8s
[18] Annex 7 provides descriptions and sources for a number of individual studies
[19] Haas, J. and Brownlie T., Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research to Determine a Causal Relationship[1] *Journal of Nutrition.* 2001;131:676S-690S
[20] Bobonis et al, Anemia and School Participation, Journal of Human Resources, Feb 2006

concludes that a "0.25 SD increase in IQ… would lead to a 5%-10% increase in wages."[21]

Based on a comprehensive range of literature from child psychology, nutrition and economic science, Ross and Horton concluded that IDA related development deficits in less than 5 years old children are associated a 4% drop in earnings.[22] The authors cite several studies suggesting that nutrition related improvements in cognitive measures persist into adolescence and calculate a correlation coefficient 0.62–0.65 from young children ages 6 to 8 with teenagers 17 years.[23] Therefore, the original 4% deficit is corrected by a factor of 0.62 to arrive at a 2.5% decrease in wages for children less than 15 years of age.[24] This recognizes the diminishing but still significant impact of anemia on cognitive development and school performance of older children. Moreover, this recognizes that to "lock-in cognitive gains due to iron interventions in earlier years, iron status needs to be protected throughout childhood and school years. This 2.5% coefficient of loss is used in this analysis.[25]

Prevalence of Anemia in Children:
Prevalence of anemia in children less than 15 years of age is set a 40% based on preliminary findings of a recent as yet unpublished NNI survey. This figure is simply an average of 42% anemia found among pre-school children and 38% among school children.[26] It should be noted that the rate found by NNI is lower than the 48% prevalence reported by DHS 2005. Moreover, DHS 2005 finds anemia rate of 51% among the lower 80% of income groups, the targets for baladi bread fortification. The lower NNI figures are used in this analysis. As indicated earlier this paper assumes 80% of anemia to iron deficiency – and therefore the remaining 20% is excluded from the analysis because they are assumed not to benefit from flour fortification.

Calculating For Earnings Lost Due to Cognitive Deficits of Children
Based on the 40% anemia prevalence, 7.7 million children under 15 years of age suffer IDA. Among this cohort, modest 2.5%/yr productivity deficits, on average about LE 40 per child per year, accumulate with a significant national impact. Gross earnings deficit over a 45 year work life totals LE 3.9 billion annually. However, the NPV discounted at 5% projects annual depressed national productivity at about LE 1 billion per year. The calculation assumes an average 7.5 year lag until entry into the workforce and the beginning of the earnings stream.

Calculation of Net Present Value of Future Earnings Loss from Today's Anemic Children

Children Iron Deficiency Anemia		Average Annual Wage All Sectors		Labor Force Participation Rate		Coefficient of Loss		Discounting @ 5% for 45 years earnings after 7.5 year delay		Net Present Value of Losses
	X		X		X		X		=	
7,768,901		LE 13,104		51.7%		2.5%/15yrs		25.7%		LE1,021,522,229

A 10 year projection is shown below.

Projection for 10 Year Losses with 1.9%/Yr Growth in Cohort of Children Less than 15 Years of Age

Year	LE	Year	LE

[21] Osman M. Galal et al *Proceedings of the International Workshop on Articulating the Impact of Nutritional Deficits on the Education for All Agenda*, Food & Nutrition Bulletin Vol. 26, no. 2 (Supplement 2), June 2005
[22] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[23] Pollitt et al. 1995 and Jensen, 1980 in Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[24] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[25] It should be noted that these deficits apply to all children classified as anemia and takes into account differences in severity of the anemia.
[26] Need information to attribute to NNI

2009	1,021,522,229	2014	1,028,328,708
2010	1,022,879,911	2015	1,029,695,437
2011	1,024,239,398	2016	1,031,063,982
2012	1,025,600,691	2017	1,032,434,345
2013	1,026,963,794	2018	1,033,806,531
		Total	**10,276,535,027**

IV. Anemia in Adult Workers

Weakness, fatigue and lethargy brought on by anemia result in measurable productivity deficits in manual labor sector. This depressed work performance will be concentrated in Egypt's agriculture, mining and manufacturing and electricity sectors.

Global Evidence and Coefficient of Loss

A substantial literature shows the negative impact of anemia on indicators work performance. Ability to sustain moderate-to-heavy physical labor involving strength, endurance and aerobic capacity is compromised 10-75%.[27] Studies in the real workplace support these laboratory findings. In Indonesia, the output of iron supplemented rubber tree tappers involved in heavy manual labor was 17% higher than non-supplemented co-workers.[28] There is also evidence anemia impairs less physically demanding work in "blue collar labor" or manufacturing jobs.[29] Three studies measuring productivity of supplemented female cotton mill workers in China, jute mill workers in Indonesia and cigarette rollers in Indonesia found 5% improvement in work output.[30] [31] [32] Deficits of 5% for manual labor and 17% for heavy manual labor will be used in the analysis.

Anemia Women: Lower 80% SES	
Income Quintile	Anemia %
5	41
4	40.8
3	37.7
2	40.7
Average Lower 80%	**40.05**
1	37

Prevalence of Anemia in Working Adults:

Anemia prevalence among women in the 80% lower income groups targeted by the baladi fortification program is ~40%. [33] With no available data on anemia in adult men, the model assumes prevalence of 1/3rd the rate in women or ~ 13%. As indicated earlier, although the data is thin, iron deficiency anemia is presumed to be 80% of all anemia.

Segmenting the Workforce to Include only Manual Labor

Productivity deficits are applied only to those engaged in manual labor – where aerobic capacity, endurance and strength play a role in work performance. White collar administrative, intellectual and other employment requiring no physical exertion is expressly excluded from the analysis. Total number of workers in manual labor is calculated from CAPMAS reports of employment by sector and sex for 2006 as shown in the table below.

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[27] Celsing F., Blomstrand E., Werner B., Pihlstedt P., Ekblom B. Effects of iron deficiency on endurance and muscle enzyme activity in man. Med. Sci. Sports Exerc. 1986;18:156-161

[28] 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

[29] 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

[30] 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

[31] 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

[32] Unturo J., Gross R., Schultink W., Sediaoetama D. The association between BMI and haemoglobin and work productivity among Indonesian female factory workers. Eur. J. Clin. Nutr. 1998;52:131-135

[33] DHS 2005

Methodology and Rough Estimates of Workforce Employed I Manual Labor								
Employment by Economic Sector	**CAPMAS Employment by Sector[34]**		**General Estimation Manual Labor by Sector**		**CAPMAS: Labor Segmentation by Sector & Sex**		**Calculated Sex Segmentation of Labor Force**	
	# Employed		**Estimated Manual[35]**	**Manual % by Sector**	**Male**	**Female**	**Male**	**Female**
	# 000	%	%	%	# 000	# 000	%	%
Agriculture	5427	27.0%	99.0%	26.7%	3692.0	1680.7	18%	8%
Mining	105.5	0.5%	99.0%	0.5%	94.5	9.9	0%	0%
Manufacturing Industries	2652.5	13.2%	90.0%	11.9%	2160.9	226.4	11%	1%
Electricity	152	0.8%	75.0%	0.6%	87.4	26.6	0%	0%
Water	130	0.6%	75.0%	0.5%	96.3	1.2	0%	0%
Construction & building	1580	7.9%	99.0%	7.8%	1544.2	20.0	8%	0%
Transportation	811.8	4.0%	33.0%	1.3%	258.0	9.9	1%	0%
Communication	160	0.8%	33.0%	0.3%	41.5	11.3	0%	0%
Suez canal	16.2	0.1%	25.0%	0.0%	3.9	0.2	0%	0%
Internal trade	1825	9.1%	5.0%	0.5%	79.9	11.3	0%	0%
Financial	152	0.8%	5.0%	0.0%	5.8	1.8	0%	0%
Insurance	70	0.3%	5.0%	0.0%	3.1	0.4	0%	0%
Restaurants & hotels	345	1.7%	5.0%	0.1%	13.2	4.0	0%	0%
Real estate activities :	664	3.3%	5.0%	0.2%	29.1	4.1	0%	0%
Government services	4726	23.5%	5.0%	1.2%	107.8	128.5	1%	1%
Education, health, services	1303	6.5%	5.0%	0.3%	36.5	28.6	0%	0%
Grand Total	20120			51.8%	8,254.	2,165.	**41.0%**	**10.8%**

Based on the segmentation in the table above, 41% of employed males and only 10.8% of employed women are engaged in manual labor requiring physical exertion and stamina. When applied to the over-all rate of economic activity of 23% for women and 77% for men, this indicates nearly 4 million employed workers currently suffering the productivity deficits from iron deficiency anemia. The coefficients of deficit will only be applied to these workers. There is no data to allow segmentation of heavy manual labor from light manual labor. The analysis will assume that 10% of female and 20% of male manual laborers are engaged in heavy physically exerting manual work.

Averages Wages

Unlike the analysis for children which applies the over-all average wage, the calculation for adults applies specifically to manual labor. Wages in manual labor are estimated LE 12,092/yr based on CAPMAS reported manufacturing and agriculture sector wages in 2006 and adjusted for 17% inflation in the following 3 years.

	Weekly Wages CAPMAS 2006		**Calculated**	
Employment 2007	**Public**	**Private**	**Average Weekly**	**Average Annual`**
Manufacturing	304	153	228.5	11,882
Agriculture	211	127	169	8,788

[34] http://www.mop.gov.eg/English/Employment.htm
[35] The proportion of manual labor within each sector is only roughly estimated based on discussions with stakeholders.

Average Manual Labor 2006				10,335
Adjusted 17% Inflation 2006-2009				12,092

Calculation of National Productivity Loss

Of 49 million working age adults with 13 million considered anemic, a 5% work performance deficit analysis is only applied to 3.9 million who are defined as working in some form of manual labor. At an average LE 12 thousand per year wages, productivity deficits are calculated at LE 659 million annually. Additional deficits of 12% are applied to the 10% of women and 20% of male laborers assumed to be employed in heavy manual work - totaling another LE 287 million annually (for a total deficit of 17% in heavy manual labor). The total projected deficit attributed to working adults with iron deficiency anemia is some LE 910 million annually.

Calculation of Net Present Value of Future Earnings Loss from Anemia in Adult Manual Workers

Risk Group Population	X	Prevalence of Condition	=	Population with Deficit	X	Coefficient of Loss	X	Average Annual Wage	=	Lost Productive Activity
#		%		#		%		LE		**LE/yr**
25,203,000		40% women 13% men		Women: 1,881,4857 Men: 2,064,519		5% Manual 17% Heavy		12,092		909,640,585

3. Maternal Anemia and Perinatal Maternal mortality:

Global Evidence and Coefficient of Loss

Improving maternal iron status is generally recognized as an essential component to improving birth outcomes. During pregnancy the need for iron increases significantly and prevalence of anemia rises in parallel, threatening the health and survival of both mother and child. Worldwide anemia is associated with 115,000 maternal deaths and 591,000 perinatal deaths annually.[36] A recent meta-analysis quantified the association of anemia during pregnancy with perinatal death (mortality in the weeks just prior or after birth), concluding that where malaria is not a significant threat, perinatal mortality decreases 16% for every 1 gram per deciliter increase in hemoglobin - a relative risk of 0.84 used in this analysis. [37] [38]

Prevalence of Anemia in Pregnancy and Attributable Perinatal Deaths

No comprehensive data on anemia in pregnancy has been identified. However, a substantial sub-set of pregnant women surveyed in DHS 2005 suggest 34.2% were anemic. While this rate is curiously lower than the general prevalence for women, possibly as a result of iron folate supplementation, since no other data was available this will be used temporarily in the analysis. This 34% rate indicates approximately 750 thousand infants are born annually to anemic women, with risks to health and survival of both mother and child.

DHS 2005 also found perinatal death rate of 22.9/1000 for all pregnancies. The lower 80% income quintiles, suffer a higher rate of 24.93/1000 births. In the opinion of several stakeholders, these rates seem high and were therefore averaged with the CAPMAS/MOH which reports a much lower neonatal death rate of 9.6/1000. The compromise number of 17.26/1000 is used in this analysis.

[36] Stoltzfus et al, Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004
[37] Ibid
[38] A similar risk for maternal death (RR .8) has been found and is projected within the analysis. However, this is not monetized. but for a number of reasons will not be calculated as part of an economic analysis.

Extrapolating Hemoglobin (Hb) from Prevalence Rates of Anemia in Pregnant Women
Based on anemia prevalence of 34.2% among pregnant women, mean hemoglobin is calculated at 11.6 gram per deciliter. In contrast, mean hemoglobin in the absence of iron deficiency, is calculated at 12.8 grams per deciliter. [39] The resulting difference of 1.21 gram per deciliter applied to relative mortality risk of 0.84 for each added gram per deciliter yields a 14% Population Attributable (PAR). The PAR is applied to 36.1 thousand annual perinatal deaths to attribute about 5 thousand annual deaths to the mother's anemia.

Calculating Value of Lost Workforce due to Perinatal Deaths
While the loss is immeasurable, in economic terms these 5 thousand annual deaths simply represent a lost future workforce valued at about LE 244million/yr. This represents NPV at a discount rate of 5% over a 45 year work-life with earnings delayed for 15 years. As a point reference, the gross earnings loss over 45 years with no discounting totals more than LE 1.58 billion, about 15% of the discounted value. This cold and hard financial calculation, shown in the table below, values each lost life at about LE 46.9 thousand. [40]

Calculation of Net Present Value of Future Earnings Loss from Perinatal Mortality

Perinatal Death due to Iron Deficiency Anemia	X	Average Annual Wage	X	Labor Force Participation Rate	X	Coefficient of Loss	X	Discounting @ 5%: Proportion Gross Lifetime Earnings	=	Net Present Value of Losses
5.188[41]		13,104		51.7%		100%		15.4%		**243,790,305**

4. Folic Acid Related Neural Birth Defects

Global Evidence and Coefficient of Loss
Neural Tube Defects (NTD), spina bifada and anencephaly, are a significant cause of death and disability throughout the world. The March of Dimes Global Burden of Birth Defects estimated almost 324,000 yearly NTD births worldwide. Using these estimates, a recent review calculated that more than 200,000 are likely preventable with folic acid.[42]

Incidence of NTDs
No nationally representative figures exist for the incidence of spina bifada and anencephaly in Egypt. The March of Dimes average global is 2.45 NTDs per 1000 live births.[43] However, a number of studies suggest "the incidence of NTDs among Egyptians is unusually high."[44] While these may not be nationally representative, for the purposes of this study, the incidence of NTDs will be taken as 3.77 per thousand found by Temtamy et al in a review of several thousand births in 3 Egyptian hospitals.[45] Based on this rate we project nearly 8000 annual birth defects.

Mortality from NTDs

[39] Presuming normal distribution in the population
[40] The calculation is: 2.5%* Anemia Prevalence* Economic Activity*(PV(0.05,45,-Average Wage)-PV(0.05,16,-Average Wage)
[41] Based on PAR of 14.2% applied to 36.57 thousand perinatal deaths.
[42] Bell KN, Oakley GP, Jr. Tracking the prevention of folic acid-preventable spina bifida and anencephaly. Birth Defects Res A Clin Mol Teratol 2006;76:654-7.
43 Bell, K and Oakley G Update on prevention of folic acid-preventable spina bifida and anencephaly, Birth Defects Research Part A: Clinical and Molecular Teratology, VL: 85 NO: 1, PG: 102-107 YR: 2009
44 Teebi A, Farag, T Genetic disorders Among Arab Populations, Oxford University Press, 1997
45 Temtamy et al EMHJ, 1998 Anencephaly only

Those with limited access to sophisticated medical care face high probability of death in infancy. Therefore, the 64% of infants not born in a medical facility and presumably no access to special care are assumed to die.[46 47] For the remaining cases born in health facilities, the result is severe or moderate disability. However, no official statistics have been identified to segment these 3 outcomes - death, severe disability and moderate disability. The table below outlines the estimates and assumptions used in the analysis based on the opinion of the director and staff of El Galla Hospital in Cairo. Costs of the various surgical procedures are estimated based only on the incremental costs to the health care facility and do not include the full costs of treatment including payment of medical personnel, use of medical facilities and other institutional fixed expenses.

General & Rough Estimates for Segmentation of NTD Outcomes and Associated Costs			
Segmentation Rationale	**Deaths**	**Number and Cost**	
	#/yr	# /yr	Cost LE/yr
All children with no access to medical care will die. According to the DHS 2007 36% of children are not delivered in a medical facility.	2,876		
Of 64% of children born with NTDs in medical facilities, all are incubated for an average of 5 days at a cost of LE 500 per day.		5112	2,500
Of children born within medical facilities it is estimated that about one half die within two weeks of delivery.	2,556		
Of the surviving children born in medical facilities (50% or 64% or 32% of total cases) 60% undergo a serious corrective surgeries.		1,534	25,000
Of the surviving children born in medical facilities (50% or 64% or 32% of total cases) 40% undergo moderately complex procedure		1,022	3,000
Mortality for children undergoing serious surgery estimated at 50%.	767		
Annual rehabilitation and Care for Survivors of Serious Surgery		767	20,000
	6,199		

Based on the segmentations shown above, we estimate about 6200 annual deaths and nearly 2 thousand cases of moderate and severe lifetime disability. It should be noted that these are only rough estimations for the total number of cases, the segmentation by severity of case, and costs involved in treatment.

Calculating Value of Lost Workforce, Medical Care and Other NTD Associated Costs

The economic impact of NTD's on health care and rehabilitation costs depends on access, utilization and cost of medical facilities. The more care, the higher the chances of survival, the greater the economic impact. In the United States lifetime medical and rehabilitation was estimated at $258 thousand per child in 1992 while the cost in Chile was estimated at $120,000 in 2003.[48 49] As shown in the table below, the very rough estimates for the economic burden of surgeries, rehabilitation and care for surviving cases in Egypt used in this analysis are much lower. However, the true cost is probably substantially higher since these are unit costs based on incremental expenses estimated by staff of El Galla Hospital and not full institutional costs including salaries, overhead and other costs.

Annual Estimated Costs Associated with the Burden of Folic Acid Deficiency	
Annual Direct Costs	

[46] Personal communication, Director. El Galla Hospital
[47] DHS 2005
[48] Bendich A, Mallick R, Leader S. Potential health economic benefits of vitamin supplementation. West j Med 1997 May; 166:306-312
[49] Flour Fortification with Iron, Folic Acid, and Vitamin B12 in the Americas, Regional Meeting October 9-10, 2003 – Santiago, Chile
Institute of Nutrition and Food Technology, University of Chile (INTA) Pan American Health Organization (PAHO/WHO), Centers for Disease Control and Prevention (CDC), March of Dimes (MOD), United Nations Children's Fund (UNICEF)
In the table below, the lost future productivity from mortality and 100% disability of severely disabled survivors is calculated with methodology earlier used in calculating NPV of perinatal death.

Cost of Incubation for NTDS	12,781,034
Cost of Major Surgery (NTDs)	38,343,101
Cost of Moderate Surgeries (NTDS)	3,067,448
Cost of Rehab and Care for Survivors (20 years NPV)	191,135,916
Total Direct Costs	**245,327,498**
NPV of Future Lost Productivity	
Deaths: NPV over 45 year worklife with average 7.5 year until entry into workforce	272,970,515
Lost Productivity Surviving Severe Cases	33,769,548
Total Future Productivity	**306,740,064**
Total NTDS	**552,067,562**

Based on projected growth in birth rate, the 10 year mortality and financial burden of folic acid deficiency related birth defects is shown in the table below.

10 Year Economic Losses Associated With Current Rates of NTDs

	Deaths	Annual Direct Costs	NPV Lost Productivity	Total Economic Burden
2009	6,199	*306,740,064*	*245,327,498*	*552,067,562*
2010	6,322	*312,855,283*	*250,218,387*	*563,073,669*
2011	6,448	*319,092,416*	*255,206,781*	*574,299,196*
2012	6,577	*325,453,893*	*260,294,624*	*585,748,517*
2013	6,708	*331,942,195*	*265,483,899*	*597,426,094*
2014	6,842	*338,559,847*	*270,776,629*	*609,336,476*
2015	6,978	*345,309,431*	*276,174,875*	*621,484,306*
2016	7,117	*352,193,575*	*281,680,742*	*633,874,317*
2017	7,259	*359,214,963*	*287,296,374*	*646,511,337*
2018	7,404	*366,376,330*	*293,023,961*	*659,400,291*
	67,855	3,357,737,996	2,685,483,770	6,043,221,766

5. *10 Year Summary of National Economic Losses*

Based on the analysis above, the best available global evidence applied to national health, labor and demographic data suggests depressed national economic activity of LE 28.9 billion over the next decade. Current and future productivity losses from adult anemia represent about 80% of these losses. Compared with many other countries, the proportion of losses from folic acid deficiency related conditions is relatively high due to the high incidence of birth defects. On the other hand, the results show proportionally lower losses from adult anemia relative to other national analysis, presumably due to the very low economic participation of women.

Summary 10 Year National Economic Burden

Year	*Perinatal Mortality*	*Adult Anemia*	*Childhood Anemia*	*Total IDA*	*Folic Acid NTDs*	*Total Projected Damage*
	Future Productivity	**Current Productivity**	**Future Productivity**			
	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr
2009	243.79	909.64	1,021.52	2,174.95	552.07	2,727.02
2010	248.65	927.78	1,022.88	2,199.31	563.07	2,762.38
2011	253.61	946.27	1,024.24	2,224.12	574.30	2,798.42

2012	258.66	965.14	1,025.60	2,249.40	585.75	2,835.15
2013	263.82	984.38	1,026.96	2,275.16	597.43	2,872.59
2014	269.08	1,004.00	1,028.33	2,301.41	609.34	2,910.75
2015	274.44	1,024.02	1,029.70	2,328.16	621.48	2,949.64
2016	279.92	1,044.43	1,031.06	2,355.41	633.87	2,989.29
2017	285.50	1,065.26	1,032.43	2,383.19	646.51	3,029.70
2018	291.19	1,086.49	1,033.81	2,411.49	659.40	3,070.89
	2,668.7	9,957.4	10,276.5	22,902.6	6,043.2	28,945.8
	9.28%	34.4%	35.5%	79;.1%	20.9%	100.0%

III. Projected Benefits of National Flour Fortification
Defining Impact of Flour Fortification on Mitigating Baseline Economic Losses

Benefits of flour fortification are projected as a reduction of baseline losses from current rates of anemia and folic acid deficiency. This reduction is a function of the coverage along with the effectiveness of flour fortification. Each of the two key parameters will be reviewed individually below.

Market Coverage:
WFP Project and Ministry of Solidarity documents project full scale fortification of baladi bread will be sufficient to at least cover 70% of the population consuming subsidized baladi bread. Based on recent milling information provided to WFP, full implementation of the baladi program is estimated to involve fortifying about 8.1 million metric tons of flour.[50] This suggests an average per capita consumption of 146 kilogram per year or about 400 grams per day of fortified flour per baladi consumer. Since market coverage of baladi bread is predominantly among the lower income where rates of anemia are higher, one might speculate that the coverage of the anemic population by baladi bread is greater than 70%.

Effectiveness in Reducing Anemia:
The current state-of- the- art for projecting the impact of iron interventions remains limited. For a number of reasons, there are no credible established algorithms to quantify the improvements from adding specific levels of iron to the daily diets. However, a parameter for effectiveness (the rate at which the added dietary iron provides protection to regular consumers) is a necessary component to the benefit cost analysis. Therefore, while the impact of added iron nutrition is unpredictable, the sections below explore several relevant factors and venture to project the proportion of consumers protected.

Iron Protection	
Level of Iron in PPM (mg/kg)	30.00
Added mg/dy Iron per consumer	12.0
WHO Estimated Average Requirement/Day	13.2
% WHO EAR WRA	**91%**
WHO RNI WRA	29.40

[50] WFP Internal Documents, May 2009

% WHO RNI WRA	**41%**

The attached table suggests that consumption of 400 g/dy of fortified flour will deliver a significant dose of iron, 91% of the WHO Estimated Average Requirement (EAR) as well as 41% of the more familiar Recommended Nutrition Intake (RNI). [51] Project documents specify a program objective for decreasing anemia from 40% to 28% - or a 30% reduction. Based on daily average delivery of 91% of the WHO EAR, the program objective of 30% anemia reduction seems reasonable – if not conservative – and the effectiveness parameter for this simulation will be set 30% anemia reduction among adults and children. However, given the extremely high needs of pregnant women, particularly in the second and third trimesters, rising to more than 50 mg/day, the reduction in anemia among pregnant women may well be more modest. For the purposes of this analysis the reduction in anemia among pregnant women will be 10%.

The World Health Organization recently published *WHO Interim Recommendations on Flour Fortification*. [52] The WHO author panel comprehensively reviewed published evidence and trials with fortified flour using a range of iron compounds and concluded that fortification with ferrous sulfate delivering a dose of 7.1 mg/dy was "moderately efficacious" while a higher dose of11 mg/dy was considered to be "highly efficacious." The Egyptian program falls into this "highly efficacious category. The panel predicts that a highly efficacious program could "decrease the prevalence of iron deficiency in the target at-risk populations to levels reported in industrialized countries (<10% ID and <5% IDA)."[53] The authors singled out nine countries, including Egypt, "that can expect a positive impact from wheat flour fortifications using ferrous sulfate."[54] Therefore, while this paper will set effectiveness at 30%, in fact, in the long term improvements may be much more significant.

Flour consumption among children under 2 years of age deserves special attention. Based on the DHS 2005, 79% of breastfeeding children 6-23 months consume flour products on a daily basis. Among non-breastfeeding children daily consumption is 92-93%.[55] While frequency is adequate, the level of consumption of flour products is not known. However, since data is not available, for the purposes of this analysis, it is assumed that this presumed lower consumption level parallels lower over-all requirements of young children. Consumption of only100 grams per day, about ¼ the adult average consumption level, will provide an additional 3 milligrams per day of addition bioavailable iron – more than half of the RNI for this age group. Nevertheless, complementary food products may well be needed to address the high needs of the youngest children.

Effectiveness in Reducing NTDs

The evidence clearly demonstrates that providing additional folic acid can avert most cases.[56] The results of flour fortification with folic acid in the United States, Canada, Costa Rica and Chile provide the background data for both conclusive and emerging evidence on the economic burden of folic acid deficiencies. In all cases, folic acid fortification was followed by an immediate increase in population serum folate concentrations and significantly reduced

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[51] EAR recommended by WHO for the planning and evaluation of fortification programs.

[52] Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement, WHO 2009

[53] Hurrell et al Revised recommendations for the iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs, upcoming in Food & Nutrition Bulletin

[54] Hurrell et al, Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs, Food & Nutrition Bulletin, vol. 31, no. 1 c The United Nations University, 2010

[55] DHS 2005

[56] Medical Research Council Vitamin Study Research Group. Prevention of neural tube defects: results of the Medical Research Council Vitamin Study. *Lancet.* 1991;338:131–137.

rates of NTDs.[57] 3 studies reported reduction in spina bifida and anencephaly in the United States ranging from 20% up to 50%.[58] Two Canadian studies found NTDs reduced from more than 2 per 1000 births to a little over 1 per 1000.[59] Initial data evaluating folic acid fortification in Chile suggests more than 40% decline in NTDs.[60]

The calculation in the attached table suggests that fortification will supply enough folic acid to meet or exceed established WHO requirements – an average of more than 400 uGu/dy of additional folic acid. This level is significantly higher than evaluated fortification programs in the US and Canada where flour consumption is generally thought to be less than half the level found in Egypt. But will benefit be commensurately higher? In order to project conservatively, the effectiveness parameter for this analysis will assume that NTD reduction will roughly equal the 15.8/10,000 to 8.6/10,000 reduction (46%) reduction found in Chile.

Folic Acid Protection	
Level of Folic Acid in PPM (mg/kg)	1.50
Added uGu/dy Folic Acid per consumer	80[61]
WHO Estimated Average Requirement/Day	320
% WHO EAR	**150%**
WHO RNI	400.00
% WHO RNI	**120%**

Projection of Reduced Baseline Losses

The analysis and assumptions described in the previous sections enable a provisional projection for the percentage reductions in baseline losses that might be achievable via flour fortification with iron and folic acid. The general calculation is shown in the table below. The effectiveness parameter for various risk groups and conditions is multiplied by the 70% estimate for market coverage of flour to define the reductions in baseline losses for each risk group.

Benefits Algorithm

Effectiveness		*Market Coverage*		% Reduction in Baseline Loss per condition
Anemia (IDA) *10% Pregnancy, 30% Adults, 30% Children*	**X**		=	
NTD: *46% Births*		*70%*		

Using this algorithm, the summary table below shows current losses from iron deficiency anemia along with losses prevented or "saved" via flour fortification with iron. The model assumes that one-year of fortification is needed before any improvements can be claimed. Therefore, there are no prevented losses in the first year. This suggests nearly LE 4 billion in annual savings from reductions in the prevalence of iron deficiency anemia through baladi

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[57] Lawrence JM, Petitti DB, Watkins M, Umekubo MA. Trends in serum folate after food fortification. Lancet 1999; 354:915-6. Jacques PF, Selhub J, Bostom AG, Wilson PW, Rosenberg IH. The effect of folic acid fortification on plasma folate and Total homocysteine concentrations. New England Journal of Medicine 1999; 340:1449-54.Ray JG, Vermeulen MJ, Boss SC, Cole DE. Increased red cell folate concentrations in women of reproductive age after Canadian folic acid food fortification. Epidemiology 2002; 13:238-40

[58] Honein MA, Paulozzi LJ, Mathews TJ, Erickson JD, Wong LY. Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. JAMA 2001; 285:2981-6; Persad VL, Van den Hof MC, Dube JM, Zimmer P; Incidence of open neural tube defects in Nova Scotia after folic acid fortification. CMAJ: Canadian Medical Association Journal. 2002; 167:241-5; 14. Williams LJ, Mai CT, Edmonds LD. Prevalence of spina bifida and anencephaly during the transition to mandatory folic acid fortification in the United States. Teratology 2002; 68:33-39.

[59] De Wals P, Rusen ID, Lee NS, Morin P, Niyonsenga T. Trend in prevalence of neural tube defects in Quebec. Birth Defects Research 2003; 67:919-23; Persad VL, Van den Hof MC, Dube JM, Zimmer P. Incidence of open neural tube defects in Nova Scotia after folic acid fortification. CMAJ: Canadian Medical Association Journal. 2002; 167:241-5.

[60] Grosse SD, Hopkins DP, Mulinare J, Llanos A, Hertrampf E. Folic acid fortification and birth defects prevention: lessons from the Americas. AGROFood industry hi-tech 2006; 17.

[61] Estimated at 80% retention during baking etc. and not adjusted for Dietary Folate Equivalents or DFE.

bread fortification. Most of these economic benefits emerge from improved current productivity of today's working anemic adults and improved cognitive development and improved future work performance of children. Only about LE 166 million represents the annual NPV of reduced perinatal deaths – but this does not begin to describe benefits of saving more than 5000 lives.

Gains from Anemia Reduction from Flour Fortification Covering 70% of Population

	Perinatal Mortality			Adult Anemia			Childhood Anemia			
Year	**Current Losses**	**FF Effectiveness**	**Prevented Losses**	**Current Losses**	**FF Effectiveness**	**Prevented Losses**	**Current Losses**	**FF Effectiveness**	**Prevented Losses**	**Total**
2009	243.7	10%		909.64	30%		1,021.5	30%		0.00
2010	248.6	10%	17.07	927.78	30%	191.02	1,022.9	30%	214.52	422.61
2011	253.6	10%	17.41	946.27	30%	194.83	1,024.2	30%	214.80	427.04
2012	258.6	10%	17.75	965.14	30%	198.72	1,025.6	30%	215.09	431.56
2013	263.8	10%	18.11	984.38	30%	202.68	1,027.0	30%	215.38	436.16
2014	269.0	10%	18.47	1,004.00	30%	206.72	1,028.3	30%	215.66	440.85
2015	274.4	10%	18.84	1,024.02	30%	210.84	1,029.7	30%	215.95	445.63
2016	279.9	10%	19.21	1,044.43	30%	215.04	1,031.1	30%	216.24	450.49
2017	285.5	10%	19.59	1,065.26	30%	219.33	1,032.4	30%	216.52	455.45
2018	291.1	10%	19.98	1,086.49	30%	223.70	1,033.8	30%	216.81	460.50
	2,668.6		**166.42**	**9,957.40**		**1,862.89**	**10,276.54**		**1,940.97**	**3,970.29**

The table below shows 10 year benefits of LE 1.7 billion from decreased rates of birth defects due to improved folic acid nutrition. About 40% of these benefits are current savings to the medical system. The remainder represents the NPV of lost future earnings from death and disability of children born with spina bifada and anencephaly.

Projected Gains IN NTD Reductions Based on 70% Coverage and 46% Effectiveness

	NTD Future Productivity Losses		**NTD Current Medical Costs**		**Total Prevented NTD/FAD Losses**
	Current Losses	**Prevented Losses**	**Current Losses**	**Prevented Losses**	
Year					
2009	306.74		245.33		0.00
2010	312.86	98.77	250.22	79.00	177.77
2011	319.09	100.74	255.21	80.57	181.31
2012	325.45	102.75	260.29	82.18	184.92
2013	331.94	104.80	265.48	83.81	188.61
2014	338.56	106.89	270.78	85.49	192.37
2015	345.31	109.02	276.17	87.19	196.21
2016	352.19	111.19	281.68	88.93	200.12
2017	359.21	113.41	287.30	90.70	204.11
2018	366.38	115.67	293.02	92.51	208.18
	3,357.74	**963.22**	**2,685.48**	**770.37**	**1733.59**

IV. Cost of National Flour Fortification in Egypt

Projected 10 year costs for a national program to fortify baladi bread shown below is based on the 3-year budget submitted to the Global Alliance for Improved Nutrition (GAIN), an organization that provided partial start-up financing and technical support. Through discussions with stakeholders in government and at the World Food Program, this budget was extrapolated over 10 years. All inputs beyond year 3 have been added by this analysis and are subject to review. Fortification premix, representing more than 90% of total costs, is based on the most recent procurement at $3/kg or $0.60 per metric ton of flour. Volume of premix is based on the 4 year planned expansion of the program to 100% scale and reflects 1.99% expansion of the target population due to national population growth. The budget attempts to include both hard cash expenditures as well as estimate in-kind effort of the involved mills and government agencies. At full scale the program is expected to require more than LE 30 million annually in financing from the appropriate mix of government institutions.

10 Year Flour Fortification Budget Including Start-Up Expenses and Scale-Up Timetable (USD)

	Target Flour	Program Scale	Industry			Government				Total	
	MT/yr	%	Premix	Start-Up /Capital	Annual Recurring	Regula Tion	Social Marketing	Monito ring	Manage ment	USD	LE
2009	8,101,188	32%	1,535,985	380,000	36,000	90,000	300,000	300,000	230,000	2,871,985	16,216,349
2010	8,262,695	50%	2,478,808	380,000	36,000	80,000	200,000	140,000	230,000	3,544,808	20,015,371
2011	8,427,421	80%	4,045,162	50,000	36,000	60,000	50,000	140,000	230,000	4,611,162	26,036,419
2012	8,595,431	100%	5,157,259		16,000	60,000	25,000		57,500	5,315,759	30,014,848
2013	8,766,791	100%	5,260,075		16,319	60,000		50,000	57,500	5,443,894	30,738,347
2014	8,941,567	100%	5,364,940		16,644	60,000	25,000			5,466,585	30,866,470
2015	9,119,828	100%	5,471,897		16,976	60,000				5,548,873	31,331,101
2016	9,301,642	100%	5,580,985		17,315	60,000	25,000			5,683,300	32,090,128
2017	9,487,081	100%	5,692,249		17,660	60,000				5,769,909	32,579,154
2018	9,676,217	100%	5,805,730		18,012	60,000				5,883,742	33,221,903
	88,679,863		**46,393,091**	**810,000**	**226,926**	**650,000**	**625,000**	**630,000**	**805,000**	**50,140,017**	**283,110,090**

IV. Benefit Cost Analysis

Based on the 10-year projected benefits and costs, a benefit cost ratio of about 17 is calculated over 10 years. This includes a net loss of LE 16 million in the first year and a gradual increase in annual net benefits from about LE 170 million to 635 million as the program reaches scale. Since benefits are presumed to require a full year of fortified flour consumption and scale up is not reached until the 4th year, full benefits are not credited to the program until the 5th year of the program.[62] From that point onwards a ratio of 20 may be expected. Flour fortification with iron and folic acid is clearly an attractive public investment. In addition to the humanitarian and moral imperative to end poverty and hunger, from a purely economic perspective, flour fortification should be expanded, strengthened and sustained – and related fortification and nutrition programs initiated.

Summary 10-Year Benefit Cost Analysis

	Benefits	Costs	Benefit-Cost	Annual Net Benefits	Cumulative Net Benefits
	million/yr				
2009	-	16.22	-	(16.22)	(16.22)
2010	189.72	20.02	9.5	169.70	153.49

[62] The scale-up is estimated to reach 32% , 50% and 80%

2011	304.18	26.04	11.7	278.14	431.63
2012	493.19	30.01	16.4	463.17	894.80
2013	624.77	30.74	20.3	594.03	1,488.83
2014	633.22	30.87	20.5	602.35	2,091.19
2015	641.83	31.33	20.5	610.50	2,701.69
2016	650.61	32.09	20.3	618.52	3,320.21
2017	659.56	32.58	20.2	626.98	3,947.18
2018	668.68	33.22	**20.1**	635.45	4,582.64
	4,865.75	**283.11**	**17.2**	**4,582.6**	

ANNEX 1: Selection of Discount Rate and NPV Analysis at 3%.

About 44% of the estimated economic burden of iron deficiency anemia and folic acid deficiency is from current deficits in work performance by anemic adults and medical costs due to folic acid related birth defects. However, the remaining 56% represents the Net Present Value of lost earnings due to infant mortality or due to cognitive deficits as children which depress future productivity. Valuing the future earnings for children stretching up to 60 years in the future involves the selection of credible discount rate. This is an assessment to some extent based on the current financial environment – which represents a fluid and changing baseline. Therefore, this is ultimately a subjective judgment.

World Bank landmark *Investing in Health*, selected a discount rate of 3% to value the future benefits of improving the health and nutrition status of children in the developing world.[63] The Asian Development Bank nutrition investment plans for 5 Asian countries used a discount rate of 5%.[64] The Hunger and Nutrition Copenhagen Consensus Challenge Paper applied a 3% discount as well. [65] A more recent nutrition related paper presented to the Copenhagen Consensus used a 5% discount rate to value the impacts of anemia in children.[66] To keep with the conservative perspective used throughout this analysis, the authors of this paper selected a higher interest that might more closely represent the rate charged on a concessional loan. The results of this secondary analysis are presented in the tables below. Costs of flour fortification along with current losses due to adult anemia and medical costs for NTDs remain unchanged. The Benefit Cost Ratio at 3% NPV rises from 17.2 presented in the main paper at 5% to 22.8

Calculation of Net Present Value of Future Earnings Loss from Today's Anemic Children

Children with Iron Deficiency Anemia		Average Annual Wage All Sectors		Labor Force Participation Rate		Coefficient of Loss		Discounting @ 3% for 45 years earnings after 7.5 year delay		Net Present Value of Losses
7,768,901	X	LE 13,104	X	51.7%	X	2.5%/15yrs	X	25.9%	=	**1,569,396,687**

Calculation of Net Present Value of Future Earnings Loss from Perinatal Mortality

Perinatal Death due to Iron Deficiency Anemia		Average Annual Wage		Labor Force Participation Rate		Coefficient of Loss		Discounting @ 3%%: Proportion Gross Lifetime Earnings		Net Present Value of Losses
5,188[67]	X	13,104	X	51.7%	X	100%	X	16.5%	=	LE 420,274,412

Calculation of Net Present Value of Future Earnings : NTD Mortality & Severe Disability

Death & Severe Disability due to NTD		Average Annual Wage		Labor Force Participation Rate		Coefficient of Loss		Discounting @ 3%%: Proportion Gross Lifetime Earnings		Net Present Value of Losses
6199 Deaths 676	X	13,104	X	51.7%	X	100%	X	16.5%	=	**LE 535,737,463**

[63] World Bank, Development Report 1993: Investing in Health. Oxford University Press World Bank. (1993)
[64] Bagriansky et al, Food Fortification in Asia: Improving Health and Building Economies, Asian Development Bank & Keystone Center, 2004
[65] Sue Horton, Harold Alderman and Juan A. Rivera, Hunger and Malnutrition: Copenhagen Consensus 2008 Challenge Paper, Draft, May 11 2008
[66] Sue Horton, Harold Alderman and Juan A. Rivera, Hunger and Malnutrition: Copenhagen Consensus 2008 Challenge Paper, Draft, May 11 2008
[67] Based on PAR of 14.2% applied to 36.57 thousand perinatal deaths.

Severe Disabled										

Summary 10 Year National Economic Burden

Year	Perinatal Mortality Future Productivity	Adult Anemia Current Productivity	Childhood Anemia Future Productivity	Total IDA	Folic Acid NTDs Death & Medical Costs	Total Projected Damage
	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr	LE 000,000/yr
2009	420.27	909.64	1,569.40	**2,899.31**	781.06	**3,680.38**
2010	428.65	927.78	1,571.48	**2,927.91**	796.64	**3,724.55**
2011	437.20	946.27	1,573.57	**2,957.04**	812.52	**3,769.56**
2012	445.91	965.14	1,575.66	**2,986.71**	828.72	**3,815.43**
2013	454.80	984.38	1,577.76	**3,016.94**	845.24	**3,862.18**
2014	463.87	1,004.00	1,579.85	**3,047.73**	862.09	**3,909.82**
2015	473.12	1,024.02	1,581.95	**3,079.09**	879.28	**3,958.37**
2016	482.55	1,044.43	1,584.06	**3,111.04**	896.81	**4,007.85**
2017	492.17	1,065.26	1,586.16	**3,143.59**	914.68	**4,058.27**
2018	501.98	1,086.49	1,588.27	**3,176.75**	932.92	**4,109.67**
	4,600.5	**9,957.4**	**15,788.2**	**30,346.1**	**8,549.9**	**38,896.1**

Gains from Anemia Reduction from Flour Fortification Covering 70% of Population

	Perinatal Mortality			Adult Anemia			Childhood Anemia			Total IDA
Year	Current Losses	FF Effectiveness	Prevented Losses	Current Losses	FF Effectiveness	Prevented Losses	Current Losses	FF Effectiveness	Prevented Losses	
	LE000000	LE000000	LE000000	LE000000	LE000000	LE000000	LE000000	LE000000	LE000000	LE000000
1	420	10%	0	910	30%	0	1,569	30%	0	0
2	429	10%	**29**	928	30%	**191**	1,571	30%	**330**	**550**
3	437	10%	**30**	946	30%	**195**	1,574	30%	**330**	**555**
4	446	10%	**31**	965	30%	**199**	1,576	30%	**330**	**560**
5	455	10%	**31**	984	30%	**203**	1,578	30%	**331**	**565**
6	464	10%	**32**	1,004	30%	**207**	1,580	30%	**331**	**570**
7	473	10%	**32**	1,024	30%	**211**	1,582	30%	**332**	**575**
8	483	10%	**33**	1,044	30%	**215**	1,584	30%	**332**	**580**
9	492	10%	**34**	1,065	30%	**219**	1,586	30%	**333**	**586**
10	502	10%	**34**	1,086	30%	**224**	1,588	30%	**333**	**591**
	4,601		**287**	9,957		**1,863**	15,788		**2,982**	**5,132**

Projected Gains IN NTD Reductions Based on 70% Coverage and 46% Effectiveness

	NTD Future Productivity Losses		NTD Current Medical Costs		Total Prevented NTD/FAD Losses
	Current Losses	Prevented Losses	Current Losses	Prevented Losses	
Year	LE000000	LE000000	LE000000	LE000000	LE000000
1	536		245		0
2	546	173	250	79	252
3	557	176	255	81	257
4	568	179	260	82	262
5	580	183	265	84	267
6	591	187	271	85	272

7	603	190	276	87	278
8	615	194	282	89	283
9	627	198	287	91	289
10	640	202	293	93	295
	5,864	1,682	2,685	770	2453

Summary 10-Year Benefit Cost Analysis

	Benefits	Costs	Benefit-Cost	Annual Net Benefits	Cumulative Net Benefits
	million/yr				
2009	-	16.22	-	(16.22)	(16.22)
2010	253.28	20.02	12.7	233.26	217.05
2011	405.68	26.04	15.6	379.65	596.70
2012	657.12	30.01	21.9	627.11	1,223.80
2013	831.63	30.74	27.1	800.89	2,024.69
2014	842.05	30.87	27.3	811.18	2,835.88
2015	852.67	31.33	27.2	821.34	3,657.22
2016	863.50	32.09	26.9	831.41	4,488.63
2017	874.53	32.58	26.8	841.95	5,330.58
2018	885.78	33.22	**26.7**	852.56	6,183.14
	6,466.25	**283.11**	**22.8**	**6,183.1**	