Analysis of Economic Losses Due to Iron & Folic Acid Deficiencies in Pakistan - Food Fortification, a Cost-Effective Strategy to Reduce Losses

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Executive Summary

The National Nutrition Survey 2011 of Pakistan (the Survey) reveals stunting, wasting and micronutrient malnutrition are endemic in Pakistan. Micronutrient malnutrition erodes the foundation of economic growth - people's strength and energy, creative and analytical capacity, initiative and entrepreneurial drive. GAIN through its experts have performed an economic impact analysis of Malnutrition in Pakistan. For this purpose "coefficients of loss," developed by international experts, evidence-based estimates of health risks and functional deficits associated with iron and folic acid deficiency have been used. Applying this best evidence from the scientific and economic literature to national health, demographic, labor and economic environment enables us to project that if no intervention is initiated to tackle malnutrition in Pakistan that will lead to ***accumulated economic loss equal to $ 12.251 billion over 10 year period***. The baseline loss by impact of malnutrition is as follows:

	$ billion
Neural Tube Defects (NTD)	0.592
Neonatal Deaths	2.365
Maternal Mortality	0.254
Kids Productivity Loss due to IDA	4.661
Adult Productivity Loss due to IDA	4.379
Total accumulated economic loss over 10 year period	**12.251**

As part of economic impact analysis large scale wheat flour fortification has been considered as the intervention for Pakistan. The cost attributable for the said intervention has been calculated along with related economic benefits over 1o year period.

On the assumption that if all wheat flour produced by flour mills in Pakistan is fortified with Iron and Folic Acid, it will reduce the above noted economic loss by $ 2.359 billion over 10 year period at an accumulated cost of $ 0.442 billion. Accordingly, a large scale wheat flour fortification intervention could generate 5.34 times more benefit than its cost.

The cost of $ 0.394 billion includes following cost elements:

	$ billion
Premix	0.404
Industry	0.030
Government Program Management	0.007
Total Cost	**0.442**

The above cost includes $ 0.172 billion related to taxes and duties imposed by the federal government in Pakistan. If premix is exempted from taxes and duties in Pakistan the overall cost will reduce to $ 0.270 billion leading to 8.75 times more benefit than its cost. This intervention will be able to reduce the negative economic impact of malnutrition to the extent of 19.3%. The current Punjab Wheat Flour Fortification Program Funded by GAIN is expected to reduce the economic loss by $ 1.230 billion at a cost of $ 0.243 billion (including taxes and duties) over a period of 10 year.

The above analysis only represents the potential economic impact of only one intervention. If an integrated approach of intervention through multiple vehicles is used the economic impact as compared to related cost will be phenomenal.

1. GAIN – Tackling Nutrition

The Global Alliance for Improved Nutrition (GAIN) is driven by the vision of a world without malnutrition. GAIN is a Swiss based international organization that mobilizes public-private partnerships and provides financial and technical support to deliver nutritious foods to those people most at risk of malnutrition. The organization is delivering improved nutrition to an estimated 700 million people in more than 30 countries, half of whom are women and children. Since its launch within the UN system in 2002, GAIN's mission has been to tackle the underlying causes of malnutrition around the world. GAIN's longest running and largest project is the large scale fortification of staples such as wheat flour and vegetable oil with key micronutrients such as vitamin A, iron and folic acid, depending on the delivery vehicle. GAIN's large scale food fortification projects directly reach 434 million individuals in 40 countries and are expected to reach 1 billion by 2015 and 1.3 billion by 2017 . GAIN is engaged in supporting public and private sector with the Universal Salt Iodization and the Wheat Flour Fortification Programs in Pakistan and scoping the opportunities to support the oil/ghee industry for the fortification.

2. Pakistan – Malnutrition Status

The National Nutrition Survey 2011 of Pakistan (the Survey) reveals stunting, wasting and micronutrient malnutrition are endemic in Pakistan. These are caused by a combination of dietary deficiencies; poor maternal and child health and nutrition; a high burden of morbidity; and low micronutrient content in the soil, especially iodine and zinc. Most of these micronutrients have profound effects on immunity, growth, and mental development. They may underlie the high burden of morbidity and mortality among women and children in Pakistan. Increasing rates of chronic and acute malnutrition in Pakistan are primarily due to poverty, high illiteracy rates among mothers, food insecurity and improper eating habits.

The Survey indicated little change over the last decade in terms of core maternal and childhood nutrition indicators. With regard to micronutrient deficiencies, while iodine status had improved nationally, vitamin A status had deteriorated and there had been little or no improvement in other areas linked to micronutrient deficiencies. The ratio of males to females was approximately 50.4% to 49.6% across Pakistan. A total of 45.7% of household heads were illiterate and 53.6 were workers or laborers. 15.5% of the population was unemployed – with higher rates in the urban population (18.9% urban unemployment, 14.0% rural unemployment) further, 58.1% of households were food insecure nationally.

Widespread micronutrient deficiencies in women. For example, the survey discovered in the following micronutrient deficiency levels in pregnant women:

	In Pregnant Women		In Non-Pregnant Women
i.	Anaemia 51.0%;	i.	Anaemia 50.4%;
ii.	Iron deficiency anaemia 25.9%;	ii.	Iron deficiency anaemia 19.9%;
iii.	Vitamin A deficiency 48.8%;	iii.	Vitamin A deficiency 43.1%;
iv.	Zinc deficiency 48.3%; and	iv.	Zinc deficiency 41.6%; and
v.	Vitamin D deficiency 86.1%.	v.	Vitamin D deficiency 85.1%

3. Economic Impact of Malnutrition – The Economic Consequences

3.1 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. Applying this best evidence from the scientific and economic literature to national health, demographic, labor and economic environment enables rough projections quantifying the health and economic consequences of iron and folic acid deficiencies in Pakistan. Economic consequences are measured via four distinct pathways:

i. Mortality and disability in children and consequent forgone income from future employment;
ii. Deficits in child cognition, inferior school performance and depressed future productivity;
iii. Depressed productivity in working but anemic adults; and
iv. Excess health care costs.

3.2 Monetizing health risks and deficits 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. The general algorithm for projecting the magnitude of economic losses is provided below.

General Algorithm for Projection of Economic Losses										
Risk Group Population		**Prevalence of Condition**		**Population with Deficit**		**Economically Population[1]**		**Average Annual Wage[2]**		**Coefficient Of Deficit or Loss**		**Lost Productive Activity**
# National Statistics	X	% from NNS 2011	=	By Indicator and Risk Group	X	32.8% 49.3% Male 15.6% Female	X	$ 2,348 Per Year	X	% or RR From Global Literature	=	$/year

3.3 Since deficits are applied only to individuals projected to be economically active, with Pakistan's low labor participation rate impacts of iron and folic acid deficiencies are not be applied to about half of working age men and about three-quarters of females.

3.4 Childhood productivity deficits are not felt until children enter the work force, as much as 15 years in the future – and earnings stretch out for another 40-50 years into the future. Therefore a Net Present Value (NPV) is calculated based on a 4% discount rate. The discount rate for social investments is not related to inflation, but reflects the subjective preference for current over future consumption or savings.[3] Although the World Bank recommends a discount rate of 3% for social investments, in an effort to be conservative we use higher rate of 4%.[4]

3.5 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 simply human potential determine work performance. Work place incentives, technology and opportunity all affect how increased potential translates into actual improved productivity and earnings. Additionally, deficits from iron and folic acid nutrition extend beyond the workplace to a range of "voluntary" activities, including parenting, household activities, education, 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.

[1] Labour Force Survey 2010-2011, Pakistan Bureau of Statistics, http://www.pbs.gov.pk/content/labour-force-survey-2010-11
[2] IBID
[3] Ross et all, Calculating the Consequences of Micronutrient Malnutrition on Economic Productivity, Health and Survival, AED 2003
[4] World Bank, Development Report 1993: Investing in Health. Oxford University Press World Bank. (1993)

3.6 Economic Impact of Iron Deficiency Anemia in Children:

The recent National Nutrition Survey (NNS 2011) found 33.4% of children less than 5 years of age suffer iron deficiency anemia.[5] A range of evidence links iron status in children to cognitive development and future productivity deficits as adults.

i. *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."[6]

ii. 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 with a 4% drop in earnings.[7] Intervention studies show iron supplementation in children led to cognitive improvements which were sustained into adolescence with a correlation coefficient 0.62.[8] Therefore, we correct the 4% deficit by a factor of 0.62 to arrive at a 2.5% decrease in wages for children less than 5 years of age.[9]

At this current IDA prevalence, more than 9.8 million children under 5 years of age will not live up to their cognitive potential, perform less well in school and suffer associated earnings deficits as adults. Modest 2.5% productivity deficits estimated at $2348 per child per year, accumulate with a significant impact on the national GDP. The NPV of nation's lost earnings over an estimated 39 year work-life totals $445.5 million per year after applying 4% discount rate and an average 10 year lag until workforce entry.

Annual Net Present Value of Future Earnings Loss from IDA in Children										
Children w/ IDA	x	Average Annual Wage	x	Labor Force Participation Rate	x	Coefficient of Loss	x	NPV for 39 years earnings after 12.5 year delay[10]	=	NPV Economic Loss (12.5 years to workforce entry)
9.8 million		$2348		32.8%		2.5%		4%		NPV $445.5m

Using an annual child birth growth rate of 1% the accumulated project economic loss related to IDA in Kids is in the range of $4.661 billion.

[5] National Nutrition Survey Aga Khan University, Pakistan Medical Research Council Nutrition Wing, Cabinet Division, UNICEF, 2011
[6] Haas, J. and Brownlie T., Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research *Journal of Nutrition.* 2001;131
[7] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[8] Pollitt et al. 1995 and Jensen, 1980 in Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[9] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[10] Average number of years before entering workforce

3.7 Anemia in Adult Workers

Weakness, fatigue and lethargy brought on by anemia in adults, result in measurable productivity deficits across the manual labor sector, including agriculture, manufacturing, construction, mining and defense sectors. NNS 2011 finds IDA prevalence among adult of 20%.[11] While the NNS provides no data for men, a 2010 study among university students in Peshawar indicated male anemia rate at 6% that of women. Applied to NNS this suggests prevalence of about 1-2% in men.[12]

A substantial literature shows the negative impact of anemia on indicators of work performance. Ability to sustain moderate-to-heavy physical labor involving strength, endurance and aerobic capacity, is compromised 10-75%.[13] Studies in the real workplace support these laboratory findings. In Indonesia, the output of iron supplemented rubber tree tappers in heavy manual labor was 12% higher than non-supplemented co-workers.[14] There is also evidence that anemia impairs less physically demanding work in "blue collar labor" or manufacturing jobs. 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.[15] [16] [17] Deficits of 5% for manual labor and 12% for heavy manual labor will be used in the analysis.

The table below summarizes projection for annual productivity deficit of almost $47 million annually. Calculations for male and female workers are done separately to account for significant variance in anemia prevalence, wage levels and labor participation. Productivity deficits are applied only to those engaged in manual labor – where aerobic capacity, endurance and strength play a role in work performance. While doubtless IDA has consequences in non-manual "white collar jobs", the 5% work deficit is not applied to education and social sectors where women represent a significant share of the workforce.

Annual Economic Losses in Adult Manual Labor as Consequence of Iron Deficiency Anemia										
Prevalence IDA: Adult 15-65 y		**Manual labor wage**		**5% Manual Labor Deficit**		**12% Loss Heavy Labor[18]**		**Annual Loss**
Women: 19.9%x7.5m	X	$1902/yr	X	$142.5	+		=	$271.34m/yr
Men: 5%x24.5m		$2113/yr		$128.8				
Women: 19.9%x1.1m		$1902/yr				51.3		$128.59m/yr
Men: 5%x6.1m		$2113/yr				77.2		

[11] NNS 2011
[12] Muhammad Tahir Khan, Tasleem Akhtar, Mussarat Niazi, Prevalence of Anemia among University Students in Peshwar, JPMI 22001100 Vol 2244 No. 0044
[13] 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
[14] Basta S. S., Soekirman D. S.,Iron deficiency anemia and the productivity of adult males in Indonesia. Am. J. Clin. Nutr. 1979;32:916-925
[15] Li R.,et al Functional consequences of iron supplementation in iron-deficient female cotton workers China. Am. J. Clin. Nutr. 1994;59:908-913
[16] 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
[17] 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
[18] Estimated at 12%(From Horton et al 2003)

3.8 Perinatal & Maternal Mortality Due to Mother's Anemia:

During pregnancy need for iron increases significantly and prevalence of anemia rises in parallel, threatening health and survival of both mother and child. Prevalence of maternal iron deficiency anemia of 25.9% is one cause of the 75 thousand annual perinatal deaths in Pakistan.[19] [20] A recent meta-analysis included with WHO Global Burden of Disease estimates 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 each 1 gram per deciliter increase in hemoglobin - relative risk of 0.84. [21] This suggests more than half a million infants are born annually to women suffering from iron deficiency anemia, with risks to health and survival of both mother and child. Based on IDA prevalence of 25.9% and over-all anemia rate of 51.2%, mean hemoglobin is calculated at 12 gram per deciliter and mean hemoglobin in the absence of iron deficiency, is projected at 12.5 grams per deciliter.[22] The resulting 0.51 gram per deciliter deficit is applied to relative risk of 0.84 to yield an 8.4% Population Attributable (PAR). The PAR is applied to 75 thousand annual perinatal deaths, to attribute about 6,362 annual perinatal deaths to the mother's anemia.

Annual Maternal Deaths Due to Anamia								
Calculated Deficit in Mean Hb	X	Relative Risk Mortality	=	Population Attributable Risk	X	Annual Maternal Deaths(live births x Mat Mortality rate)	=	Annual Maternal Deaths
0.84 g/dL		0.71		25%		13636		3420

While the loss is immeasurable, in economic terms these 6362 annual deaths simply represent the Net Present Value of a lost future workforce, valued at about $19.7 million/yr. At $3102 per child death, this cold hard bankers' methodology clearly does not sufficiently value human life.

Estimate for NPV of Lost Wages Due to Maternal Death										
Attributed Deaths	X	Average Annual Wage(All Sectors)	X	Labor Participation Rate	X	Average Years in Workforce	X	Discount Rate For NPV after 15 years delay	=	Lost Productive Activity
3420		$2113/yr		16%		52		4%		$24.3 million/y

[19] NNS 2011
[20] Projected from 159/10000 rates in DHS 2007 and projected 2012 birth rates
[21] Stoltzfus R, Mullany, L, Black R. Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004
[22] Presuming normal Hb distribution from Stoltzfus above.

A WHO meta-analysis found that correcting anemia of any severity reduces the risk of maternal mortality by about 20% for each 1 g/dL increase in Hb – a Relative Risk of 0.80.[23] Based on DHS 2007 estimating 297 maternal deaths this suggests 1503 annual deaths attributable to IDA as shown below.

Projection of Perinatal Deaths Due to Mother's IDA								
Prevalence of IDA in pregnant women	**X**	**Decreased Relative Risk Mortality**	**=**	**Population Attributable Risk**	**X**	**Annual Deaths of infants<1month**	**=**	**Number of Child Deaths Attributed to IDA in Mother**
26%		1.45		**10.4%**		271732		28324

Presuming 30 years of age is the average age of maternal death,[24] suggesting 22 years of additional work lost, we estimate an NPV of average $4.4 million. The estimate includes lower than national average parameters for annual wage ($817/yr) and labor participation (27%).

Estimate for NPV of Lost Wages Due to Perinatal Death										
Attributed Deaths	**X**	**Average Annual Wage**	**X**	**Labor Participation Rate**	**X**	**Average Years in Workforce**	**X**	**Discount Rate For NPV**	**=**	**NPV Lost Productive Activity(assuming 15 years to workforce entry)**
28324		$2348/yr		26%		50		4%		$226 million/yr

[23] Stoltzfus R, Mullany, L, Black R. Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004
[24] Based on scan of DHS 2007

3.9 Folic Acid Related Neural Birth Defects

Neural Tube Defects (NTD), spina bifada and anencephaly, are a significant cause of death and disability throughout the world. With no available nationally representative figures for the incidence of spina bifada and anencephaly in Pakistan, we use The March of Dimes Global Report which estimates almost 11 thousand cases annually – a rate of 2/1000 births, about the global average.[25] For the sake of analysis we make the following conservative assumptions: that among the 1/3rd of deliveries reported were survivors with Moderate Disability[26]whereas 33% survive among severe disability we presume a fatality rate of 90% (since cases require relatively sophisticated attention including neurosurgery). This suggests approximately >6thousand annual deaths due to NTDs.

Projected NTD Associated Mortality								
Annual Births	**X**	**Average Annual NTD Rate/1000 Births x Folic Acid Associated/Preventable NTDs**	**=**	**Projected Annual Folic Acid Associated NTDs**	**X**	**Assumed Mortality Rate**	**=**	**Total Projected Folic Acid Associated Deaths from NTDs**
4.9 million		2x72%=1.44		7114		90%		6403

Application of our insufficient methodology, significantly under-valuing human life, projects NPV of lost wages at $51.1 million annually.

Projection of NPV of Economic Losses from NTD Mortality										
Attributed Deaths	**X**	Average Annual Wage	**X**	Labor Participation Rate	**X**	Average Years in Workforce	**X**	Discount Rate For NPV after 15 years delay	=	**NPV of Annual Economic Loss(assuming 15 years to workforce entry)**
6403		$2348/yr		32.8%		50		4%		$51.1 million/yr

[25] March of Dimes Global Report on Birth Defects, Appendix B, 2011
[26] DHS 2007

Projection of NPV of lost productivity due to NTD Cases										
Number of Survivors	X	Average Annual Wage	X	Labor Participation Rate	X	Average Years in Workforce	X	Discount Rate For NPV after 15 years delay	=	**NPV of Annual Lost Productivity (assuming 15 years to workforce entry)**
Severe Disability 235		$2348/yr		32.8%		35		4%		100% Productivity Loss $0.9m/yr
Moderate Disability 477		$2348/yr		32.8%		35		4%		50% Productivity Loss $1.8m/yr

The Projected Annual 7114 Folic Acid Associated NTDs face a lifetime of moderate or severe disability. At birth they require surgery and for the whole lives will require special care. The lost productivity and costs of caring for these cases is estimated very roughly as follows:

i. Presuming appropriate level is available in 1/5 of birth facilities and the cost of surgery is $3 thousand this suggests about $2134 thousand costs to the health system – both public and private.
ii. Presuming a life span of 35 years and the need for $600/yr for rehabilitation and medicines along with $250 estimated Annual Cost per Case of Ongoing Rehabilitation and Care for Moderately Disabled NTD's
iii. Presuming 35 year work life and 100% disability for severely disabled and 50% disability for moderately disabled we calculate an NPV of $0.054 billion.

3.10 Summary of Annual 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 nearly one quarter of billion dollars annually can be attributed to current rates of iron deficiency anemia and folic acid related NTDs.

Summary Economic Consequences for All Indicators						
	Lost Workforce	Lost Future Productivity	Lost Current Productivity	Current Healthcare Costs	Total	
`	$ 'million per year					%
Maternal Mortality	24.31				24.31	2.11%
Neo Natal Mortality	226.04				226.04	19.61%
NTD	51.10	2.81		2.69	56.60	4.91%
Childhood IDA		445.52			445.52	38.66%
IDA in Adults			399.94		399.94	34.70%
Total	**301.45**	**448.34**	**399.94**	**2.69**	**1,152.42**	
	26.16%	38.90%	34.70%	0.23%		

The accumulated economic consequence value spread over 10 year period is in the range of $ 12.251 billion. The details of which are as follows:

	Baseline Loss
2015	1.152
2016	1.168
2017	1.184
2018	1.200
2019	1.216
2020	1.232
2021	1.249
2022	1.266
2023	1.283
2024	1.301
Total	12.252

3.11 Cost of Large Scale Wheat Flour Fortification

The current cost of fortification only covers the costs associated with fortification of wheat flour (Atta) produced by flour mills in Pakistan. For this purpose the base of Atta produced by flour mills have been taken from the recently supply chain study of GAIN in Pakistan. There are three aspects of costs which are covered Premix Cost, Industry Cost and Government Cost. Although, as part of the current Wheat Flour Fortification Program of GAIN in Punjab the cost of fortification will be passed on to the consumer but still for economic analysis this cost has been used for cost benefit analysis. For a national level program other strategies could be used for cost recovery or subsidy but the cost attributable to the fortification will remain the same. Following tables present cost of fortification and detail workings of Premix cost, industry cost and government costs along with related assumptions:

Atta Fortification Cost

	Premix Cost	Industrial Cost	Government Cost	Total	Total $ billion
			$ million		
2015	16,665,047	6,453,277	1,194,000	24,312,324	0.024
2016	35,020,846	2,502,369	644,000	38,167,215	0.038
2017	36,797,366	2,537,899	744,000	40,079,266	0.040
2018	38,664,005	2,575,232	644,000	41,883,237	0.042
2019	40,625,333	2,614,459	744,000	43,983,792	0.044
2020	42,686,155	2,655,675	744,000	46,085,830	0.046
2021	44,851,517	2,698,982	744,000	48,294,499	0.048
2022	47,126,722	2,744,486	644,000	50,515,208	0.051
2023	49,517,343	2,792,299	744,000	53,053,641	0.053
2024	52,029,234	2,842,537	644,000	55,515,770	0.056
	403,983,567	30,417,215	7,490,000	441,890,782	0.442

Premix Cost

	Total Population (1)	Consumption kg/yr (2)	Proportion of Population Consuming Flour (3)	% Flour Fortified (4)	Target/Scale Fortified Production MT/yr (5)	Cost of Premix Using per MT rate of $ 3.03 - $ billions
	A	B	C	D	E	
2015	182,520,000	118	81.0%	56%	4,858,916	0.017
2016	187,083,000	118	81.4%	57%	10,210,793	0.035
2017	191,760,075	118	81.8%	58%	10,728,761	0.037
2018	196,554,077	118	82.2%	59%	11,273,005	0.039
2019	201,467,929	118	82.6%	60%	11,844,856	0.041
2020	206,504,627	118	83.0%	61%	12,445,716	0.043
2021	211,667,243	118	83.5%	63%	13,077,056	0.045
2022	216,958,924	118	83.9%	64%	13,740,422	0.047
2023	222,382,897	118	84.3%	65%	14,437,440	0.050
2024	227,942,469	118	84.7%	66%	15,169,815	0.052
					117,786,780	0.404

1. Population as per latest economic survey of Pakistan. Annual Population growth of 2.5% is assumed.
2. Consumption of Atta as per data provided by Planning Commission of Pakistan.
3. As per FAO data project by a standard increase per year. Annual Atta Consumption as compared to other food items is assumed at 0.5% per annum.
4. 2015 is calculated as quantity of Atta produced by flour mills reported in Wheat & Wheat Flour (Atta) Supply Chain Report. The share of Atta to be fortified is assumed at 2% per year. For the first year only 50% of expected Atta produced flour mills is expected to be fortified.
5. A*B*C*D = E

Industrial Cost

	Equipment - Capex (1)	Equipement Maintenance (2)	Operational Costs (3)	Total	Total $ billion
			$ million		
2015	5,219,000	900,976	294,716	6,414,692	0.006
2016	-	1,801,952	619,333	2,421,285	0.002
2017	-	1,801,952	650,750	2,452,702	0.002
2018	-	1,801,952	683,761	2,485,713	0.002
2019	-	1,801,952	718,447	2,520,399	0.003
2020	-	1,801,952	754,892	2,556,844	0.003
2021	-	1,801,952	793,186	2,595,138	0.003
2022	-	1,801,952	833,422	2,635,374	0.003
2023	-	1,801,952	875,699	2,677,651	0.003
2024	-	1,801,952	920,121	2,722,073	0.003
	5,219,000	17,118,543	7,144,328	29,481,872	0.029

1. Includes costs assocated to microfeeders for 880 flour mills w here microfeeders are not installed, Installation checks at all 1,278 current flour mills and establishment of 15 new labs for quality assurance in Pakistan.

2. Includes costs associated to Process Labor, maintenance of equipment and quality assurance spot testing.

3. Other operational cost at 2% of the premix cost.

Government Cost

	Ongoing Food Control (1)	Additional Monitoring (2)	One time startup cost (3)	Total	Total $ billion
			$ million		
2015	644,000	100,000	450,000	1,194,000	0.001
2016	644,000	-	-	644,000	0.001
2017	644,000	100,000	-	744,000	0.001
2018	644,000	-	-	644,000	0.001
2019	644,000	100,000	-	744,000	0.001
2020	644,000	100,000	-	744,000	0.001
2021	644,000	100,000	-	744,000	0.001
2022	644,000	-	-	644,000	0.001
2023	644,000	100,000	-	744,000	0.001
2024	644,000	-	-	644,000	0.001
	6,440,000	600,000	450,000	7,490,000	0.007

1. This mainly represent the costs associated to in total 2,556 inspections by government officials to flour mills. 2 inspections per year at each flour mill. Further, this also includes cost of laboratory tests per inspection.

2. Project costs assocaited with external backstopping engagements.

3. This represents one time capacity builiding and social advocacy costs for related government officials.

3.12 Projecting the Benefits of Fortification

Large scale wheat flour (Atta) fortification could generate material economic value through reduction in economic loss due to malnutrition to the extent of $ 2.359 billion over a period of ten years. For the purpose of economic benefit calculation the coverage has been used as fortification of Atta produced by flour mills in Pakistan and effectiveness of this intervention related to five areas of economic loss from international studies. This benefit analysis is only for wheat flour (Atta) related intervention. The impact of other inventions including Salt Iodization and fortification of Edible Oil will substantially increase the benefits of fortification. The summary calculations of the intervention benefits is as follows:

Wheat Flour (Atta) Fortification Intervention Economic Impact

	Base Economic Loss - $ billions						
	Neo Natal	Maternal Mortality	NTD	IDA Kids	IDA Adults	Total	Coverage (1)
2015	0.226	0.024	0.057	0.446	0.400	1.152	45%
2016	0.228	0.025	0.057	0.450	0.408	1.168	46%
2017	0.231	0.025	0.058	0.454	0.416	1.184	47%
2018	0.233	0.025	0.058	0.459	0.424	1.200	49%
2019	0.235	0.025	0.059	0.464	0.433	1.216	50%
2020	0.238	0.026	0.059	0.468	0.442	1.232	51%
2021	0.240	0.026	0.060	0.473	0.450	1.249	52%
2022	0.242	0.026	0.061	0.478	0.459	1.266	54%
2023	0.245	0.026	0.061	0.482	0.469	1.283	55%
2024	0.247	0.027	0.062	0.487	0.478	1.301	56%
Total	2.365	0.254	0.592	4.661	4.379	12.252	

Effectiveness (2)	15%	15%	70%	40%	50%	
2015	0.008	0.001	0.009	0.040	0.045	0.103
2016	0.016	0.002	0.018	0.083	0.094	0.213
2017	0.016	0.002	0.019	0.086	0.098	0.222
2018	0.017	0.002	0.020	0.089	0.103	0.231
2019	0.018	0.002	0.021	0.092	0.108	0.240
2020	0.018	0.002	0.021	0.095	0.113	0.249
2021	0.019	0.002	0.022	0.099	0.118	0.259
2022	0.019	0.002	0.023	0.102	0.123	0.270
2023	0.020	0.002	0.024	0.106	0.129	0.281
2024	0.021	0.002	0.024	0.110	0.135	0.292
Total	0.172	0.018	0.201	0.903	1.065	2.359

1. As per level of fortification stipulated as part of Atta fortification intervention.
2. As per international studies.

3.13 Cost and Benefit Cost Ratio for Atta Fortification

A cost benefit analysis has been performed for large scale food fortification program which is presented below. As per analysis by spending $ 0.394 billion economic benefit equal to $ 2,359 billion could be generated which is 5.98 times. Annualized cost over 10 years is roughly estimated at $3.868 million as shown in the table below.

	Cost	Benefit	Benefit Cost Ratio
	$ billion		
2015	0.024	0.103	4.22
2016	0.038	0.213	5.59
2017	0.040	0.222	5.53
2018	0.042	0.231	5.51
2019	0.044	0.240	5.45
2020	0.046	0.249	5.41
2021	0.048	0.259	5.37
2022	0.051	0.270	5.34
2023	0.053	0.281	5.29
2024	0.056	0.292	5.26
	0.442	2.359	**5.34**

The cost of fortification includes $0.124 billion related to taxes and duties. If fortification programs in Pakistan are exempted from taxation this will enhance the benefit cost ratio to 8.75.

The current Wheat Flour (Atta) fortification program of GAIN in the province of Punjab if implemented effectively will have following cost and benefit ratios over a period of 10 years.

	Cost	Benefit	Benefit Cost Ratio
	$ billion		
2015	0.015	0.053	3.64
2016	0.021	0.111	5.32
2017	0.022	0.116	5.26
2018	0.023	0.120	5.25
2019	0.024	0.125	5.19
2020	0.025	0.130	5.16
2021	0.026	0.135	5.12
2022	0.028	0.141	5.11
2023	0.029	0.146	5.05
2024	0.030	0.152	5.03
	0.243	1.230	**5.06**