Economic Analysis of Flour Fortification in Indonesia: Applying Global Evidence To the National Environment

Jack Bagriansky
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1. Background

Rationale

Micronutrient malnutrition as a result of inadequate intake and absorption of vitamins and minerals is a serious public health in Indonesia. "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.

National and regional surveys in 2001, 2004 and 2007 indicate anemia is a serious public health threat in Indonesia.[2] To address these and other vitamin and mineral nutrition deficits in the national diet, the Government of Indonesia has adopted a range of policies to provide additional dietary iron and other micronutrients. In 1999, the Government of Indonesia initiated a national mandatory flour fortification program in order to reduce the prevalence of anemia, folic acid and other micronutrient deficiencies. This paper aims to provide a general estimate of the magnitude of costs and benefits involved in implementing this national flour fortification program in Indonesia.

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 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 Indonesia based on a two-step algorithm shown below.

Overview of the Economic 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		#

[1] Vitamin and Mineral Deficiency Global Progress Report, UNICEF, 2004
[2] SKRT 2001, SKRT 2004, RISKEDAS 2007

2. *Defining Baseline Economic Losses from Iron and Folic Acid Deficiency*

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

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

Calculation for Projection of Economic Losses										
Risk Group	X	Prevalence of Condition	X	Economically Active	X	Average Wage	/	Coefficient of Loss	=	**Lost Productive Activity**
# in Age		% Deficient		% of 15-65 yrs		$/yr		% or RR		$/yr

Monetizing the lost 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. The flowing national data and estimates will used in this analysis.

Estimates Used in Benefit Cost Analysis		
Demographics		**Source**
Total Population	232,517,000	Word Bank, 2010
Males 15-64	78,236,000	World Bank, 2010
Females 15-64	78,117,000	World Bank, 2010
Children < 15 yrs	62,030,000	World Bank, 2010
Birth Rate 2010-2015	19.7	World Bank 2010
Birth Rate 2015-2020	17.1	World Bank 2010
Births	4,580,585	Calculated from WB 2010
Population Growth Rate 2010-2015	1.25%	World Bank 2010
Population Growth Rate 2015-2020	1.01%	World Bank 2010
Labor Statistics		
Economically Active Adults	67.8%	BPS Labor Survey 2010
Economically Active Males	87.0%	BPS Labor Survey 2010
Economically Active Females	52.0%	BPS Labor Survey 2010
Minimum Wage	Rs 602,702	BPS Key Indicators 2007
Average Manufacturing Wage	Rs 759,999	BPS Key Indicators 2007
Annual Wage Increases	3.57%	Manufacturing Wage Increases BPS 2009
Annual Wage Used in Analysis	Rs 9,082,196	Calculated
Annual Wage Used in USD	$1,005.89	Conversion to USD @ Rupiah 9,029
Length of Working Life	46	UNDP HDR 2009 Health Life Expectancy less 15 years

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

- Average Annual Wage of USD. This provides the earnings potential against which losses will be measured. With many workers employed in an informal and non-wage economy this is a difficult parameter to estimate. For the purposes of this analysis we take an average of the minimum wage and average manufacturing wage reported by BPS in 2007 and correct for three years of average annual wage increase to calculate average annual earnings of Rupiah 9 million or about $1 thousand annually. As a point of reference, this represents about 60% of BPS estimated $1663 per capita GDP for 2006, about 53% of per capita $1870 GNP reported by the World Bank for 2008 and 25% of ~$4000 per capita GDP estimate by US State Department for 2010.[4]

- Average Years in the Work Force: No information was identified on average age of entry and exit into the workforce. The UNDP Human Development Report projection of "Healthy Life Expectancy" for Indonesia of 61 years. Presuming health life and working life to be relatively parallel, we subtract 15 health life years as childhood, schooling and "pre-employment" to speculate an average work life of 46 years.

- Labor Force Participation Rate: Losses are only applied to the 67.8% of population 15-65 years of age reported as economically active by BPS in 2010. Participation by gender used in the analysis for adults is 87% for men and 52% for women.[5] These indicators have changed little over the past 5 years.

- Calculating Future Productivity: Childhood productivity deficits are not felt until children enter work force, as much as 15 years in the future, and stretch 46 years further into the future (total of 61 years assumed in this analysis). The relative value of future to present earnings is calculated via a Net Present Value (NPV) - calculated at a 3% discount rate recommended by the World Bank for social investments.[6] This "social discount rate" does not related to specifically to inflation but merely reflects the subjective time preference for current consumption or savings over future consumption or savings.[7]

- 10 Year Projections: Costs and benefits will be projected over 10 years, period when Indonesia's birth rate and over-all population growth is expected to decline somewhat. Population of adult workers will be projected to expand at general population rates estimated by the World Bank - 1.25% through 2015 and 1% thereafter. Birth rate is expected to continue at 19.7/1000 until 2015 and decline to 17.1/1000 for the second 5 years of the calculations.[8]

- Inflation: 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. Therefore, since these two factors may simply balance each other out, there is no adjustment for inflation over 10 years.

- Activity not measured: 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

[4] BPS Key Indicators for Indonesia 2006; Indonesia at a Glance, World Bank 2009; CIA Fact Book, accessed November 2010
[5] Labor Force Situation in Indonesia, BPS No. 33/05/Th. XIII, May 10th, 2010
[6] World Bank, Development Report 1993: Investing in Health. Oxford University Press World Bank. (1993)
[7] Ross et all, Calculating the Consequences of Micronutrient Malnutrition on Economic Productivity, Health and Survival, AED 2003
[8] World Bank, 2010

overstated. In Indonesia 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.

- 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.

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

2.1. Economic Impact of Deficiency Anemia in Children:

When a large sector of a nation's young people cannot develop their full cognitive potential and take only limited advantage of their educational and related opportunities, the aggregate affect is substantial national economic loss. As Indonesia's economy modernizes 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

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 concludes that a "0.25 SD increase in IQ… would lead to a 5%-10% increase in wages."[9] Further a range of evidence links anemia in children to future productivity deficits as adults. The literature finds both a direct link of anemia-related cognitive 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.[10] A parallel body of literature documents the positive impact of iron intervention on cognitive scores, generally ranging from 0.5 to 1 SD.[11] The *Journal of Nutrition* found, "available evidence satisfies all of the conditions needed to conclude that iron deficiency causes cognitive deficits and developmental delays.[12]"

- 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.[13]

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[9] 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

[10] Pollitt, Ernesto Relationship Between Undernutrition and Behavioral Development in Children, Journal of Nutrition, August, 1995 Volume 125 Number 8s

[11] Annex 7 provides descriptions and sources for a number of individual studies

[12] 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

[13] Bobonis et al, Anemia and School Participation, Journal of Human Resources, Feb 2006

Based on a comprehensive range of literature from child psychology, nutrition and economic science, Ross and Horton concluded that IDA related development deficits in children less than 5 years old children are associated a 4% drop in earnings.[14] 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.[15] Therefore, the original 4% deficit is corrected by a factor of 0.62 to project a 2.5% decrease in future wages for children less than 15 years of age.[16] This 2.5% coefficient of loss is used in this analysis.

Prevalence of Anemia and Iron Deficiency Anemia in Children:
There are a number of sources for anemia in children under 15 years of age. Three BPS surveys from 2001-2007 found anemia rates 28-48% of children less than 5 years. Anemia is older children is generally less than children under 5 years of age. SKRT 2004 found 24% rate among children 5-11 years and RISKEDAS 2007 found a surprisingly low 9.8%[17] among children 5-15 years. For the purposes of this analysis, as a "compromise figure" which might apply to the entire < 15 year cohort, we will apply the 24% prevalence of anemia in 5-11 year olds found by SKRT 2004.

Globally, WHO estimates about 60% of anemia is from iron deficiency.[18] However, while Iron deficiency is recognized as the most common, the causation of anemia is multi-factorial and includes malaria, hookworm and HIV and other micronutrient deficiencies (such as folic acid and vitamin A). Only iron deficiency anemia (IDA) will be responsive to added dietary iron via fortification. RISKESDES finds 70.1% of anemic children found to suffer from microcytic hypochromic anemia, a condition most commonly associated with dietary iron deficiency. Therefore, we apply this 70.1% to the over-all 24% anemia prevalence to estimate 16.8% of children with IDA. This indicates that of more than 62 million Indonesian children < 15 years of age, about 10.5 million suffer IDA.

Sources for Prevalence of Anemia in Children

Age	Anemia	Source
Children < 5 Yrs	27.7%	RISKEDAS 2007
	48.1%	SKRT 2001
	39.0%	SKRT 2004
Children 5-11 yrs	24.0%	SKRT 2004
Children > 5 and < 15 yrs	9.4%	RISKEDAS 2007

Calculating For Earnings Lost Due to Cognitive Deficits of Children
Among this cohort, 2.5% per year productivity deficits represents a modest loss of ~$25 per year based on potential earning of $1006. However, across a population of more than 10 million children with IDA, these modest deficits will accumulate with significant national economic impact – depressed economic activity of more than half a billion USD annually. Since these losses will occur as much as 61 years into the future, the analysis calculates a Net Present Value (NPV) discounted at 3% to project annual national productivity deficit of $184 million annually – about 1/3rd of the non-discounted or gross losses. The NPV calculation

[14] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[15] Pollitt et al. 1995 and Jensen, 1980 in Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[16] Horton & Ross The Economics of Iron Deficiency Food Policy 28 (2003) 51–75
[17] RISKEDAS Table 3.94
[18] Global Burden of Disease Update, WHO, 2004

assumes an average 7.5 year time lag with no earnings to account for the 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 with IDA	X	Average Annual Wage	X	Labor Force Participation Rate	X	Coefficient of Loss	X	Work Life	X	Discounting for Future Benefits	=	**Net Present Value of Losses**
10,435,927		**$1,006**		**67.8%**		**2.5%**		**46 yrs**		**3%**		**USD 184 million/yr**

Based on a 1.25% annual population increase for the first 5 years and a 1% annual increase in the remaining years, a summary 10 year losses are projected at an NPV of nearly $2 billion.

Summary NPV of 10 Year Losses from Current Childhood IDA (USD 000,000)				
Year		NPV Annual Loss	Year	NPV Annual Loss
	2010	$184.110	2015	$195.444
	2011	$186.412	2016	$197.418
	2012	$188.742	2017	$199.412
	2013	$191.101	2018	$201.426
	2014	$193.490	2019	$203.461
10 Year Total		**NPV $1,941**		

2.2 Economic Impact of Iron Deficiency 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 Indonesia's agriculture, extraction, and manufacturing and electricity sectors. This represents a current loss and therefore no NPV or discounting will be applied. Although there are potentially negative effects on concentration and energy effecting all labor, coefficient of loss for productivity deficit will be applied only to workers in estimated to be engaged in manual or heavy manual labor - where coefficients of deficit has been established by the evidence.

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%.[19] Studies in the real workplace support these laboratory findings. Much of this evidence comes from Indonesia. The output of iron supplemented rubber tree tappers involved in heavy manual labor was 17% higher than non-supplemented co-workers.[20] There is also evidence anemia impairs less physically demanding work in "blue collar labor" or manual manufacturing jobs.[21] Three studies measuring productivity of supplemented female cotton mill workers in China as well as jute mill workers and cigarette rollers s in Indonesia found 5% improvement in work output.[22] [23]

Prevalence of IDA in Adults:

There are significant differences in data for anemia rates among women in Indonesia - with SKRT 2001 finding about 28% and RISKEDAS 2007 19.7%. While the methodology and comprehensiveness of RISKEDAS remains under discussion, there are many reasons to

[19] Celsing F et al Effects of iron deficiency on endurance and muscle enzyme activity Med. Sci. Sports Exerc. 1986;18:156-161
[20] Basta S et al Iron deficiency anemia and the productivity of adult males in Indonesia. Am. J. Clin. Nutr. 1979;32:916-925
[21] Li R et al Functional consequences of iron supplementation in iron-deficient female cotton workers in Beijing, China. Am. J. Clin. Nutr. 1994;59:908-913
[22] Ibid
[23] Scholz B. D et al Anaemia is associated with reduced productivity of women workers in even less-physically-strenuous tasks. Br. J. Nutr. 1997;77:47-57

believe that anemia prevalence among women may have decreased over the past decade. Therefore, the analysis will average these data points to apply a theoretical rate of 23.8%. Based on findings of 59.9% of anemia as microcytic hypochromic, we estimate prevalence of IDA at 14.3% - or more than 13 million women 15-65 years of age. Based on RISKEDAS findings of 13.1% of adult men with anemia with only about 1/3rd from iron deficiency we estimate about 3.5 million adult men with IDA.

Estimates for IDA Among Adults Men and Women

	% Anemia	Source	Estimated Proportion IDA[24]	Prevalence of IDA	Implied Workforce with IDA
Women	27.90%	SKRT 2001			
	19.70%	RISKEDAS			
	23.80%	Average	59.90%	14.3%	13,054,991
Men	13.10%	RISKEDAS	33.40%	4.4%	3,423,138

Segmenting the Workforce to Include only Manual Labor

Productivity deficits are applied only to anemic adults 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 proportion of number of workers in manual labor is estimated from BPS Labor Force Survey 2007. Since there is no hard data for proportion of each sector engaged in manual labor these estimates are considered conceptual.

Employment by Economic Sector with Conceptual Estimated of % in Manual Labor by Economic Sector

Sector	Number of Workers	Estimated % Manual Labor	Number of Workers	Estimated % Heavy Manual	Number of Workers
	BPS	Author Estimate	BPS	Author Estimate	
Agriculture, Forestry & Fishery	42,689,635	90%	38,420,672	25%	9,605,168
Mining & Extraction	1,062,309	90%	956,078	25%	239,020
Manufacturing Industry	12,440,141	75%	9,330,106	10%	933,011
Electricity, Gas, and Water	207,909	50%	103,955	0%	-
Construction	4,733,679	90%	4,260,311	25%	1,065,078
Wholesale Trade, Retail	20,684,041	5%	1,034,202	0%	
Transport & Communication	6,013,947	10%	601,395	0%	
Financing & Business Service	1,440,042	0%	-	0%	
Community & Social Service	12,778,154	0%	-		
Total Number	**102,049,857**		**54,706,718**		**11,842,276**
% Manual and Heavy Manual Labor		**54%**			**22%**

Based on the segmentation and conceptual estimates in the table above, the analysis will apply 5% IDA-related productivity deficits to 54% of the workforce considered to be engages in manual labor requiring some level of physical exertion and endurance. For the 22% estimated as heavy manual labor, mainly in agriculture, mining and construction, an additional 12% deficit will be applied (for a total of 17%).

[24] Microcytic Hypochromic from RISKEDAS 2007

Calculation of National Productivity Loss

Of 156 million working adults about 16.5 million are estimated to from IDA. However, productivity deficit of 5% will be applied only to the 8.8 million estimated to be engaged in manual labor for a total projected loss of $444 million in annual productivity. An additional 12% deficit is applied to the estimated 1.9 million adults with IDA engaged in heavy manual labor for an additional $231 million loss. The total estimated depressed economic activity is projected at $675 million per year – about 80% of this loss from the female workforce. While labor participation is much higher for men, the total anemia rate as well as proportion of anemia from iron deficiency is much higher for women. This calculation does not use any discounting to calculate an NPV because losses are current.

Calculation for IDA-Related Current Productivity Losses in Adults Working in Manual Labor

	Women	Men	Totals
Health Data Background			
Prevalence of Anemia	27.9%	13.1%	
Proportion Anemia from Iron Deficiency	59.9%	33.4%	
Demographic and Labor Data			
Population 15-64	78,117,000	78,236,000	**156,353,000**
Labor Participation Rate	52%	87%	
Proportion Manual Labor	54%	54%	
Proportion Manual Labor Heavy Manual	22%	22%	
Total Workforce with IDA	13,054,991	3,423,138	16,478,129
Manual Work Force with IDA	6,998,498	1,835,070	8,833,568
Heavy Manual Workforce with IDA	1,514,954	397,235	1,912,188
Economic Productivity Loss Projections			
Coefficient of Loss from IDA in All Manual Labor	5%	5%	
Deficit from Workers with IDA	$351,986,531	$92,294,084	$444,280,615
Additional Loss from Heavy Manual Labor	12%	12%	
Deficit from Workers with IDA in Heavy Manual Labor	$182,865,508	$47,949,007	$230,814,515
Grand Total	**$534,852,039**	**$140,243,091**	**$675,095,130**

Based on population growth rates discussed earlier, projecting current rates of IDA and workforce structure across 10 years suggests depressed economic activity of nearly $6.8 billion.

Projected 10 Year Losses from Current Rates of IDA Among Men and Women in Manual Labor (000,000 USD)

2010	$675.10
2011	$675.94
2012	$676.78
2013	$677.63
2014	$678.48
2015	$679.16
2016	$679.85
2017	$680.53
2018	$681.22
2019	$681.91
	$6,786.60

2.3 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, 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.[25] 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. This is equivalent to a relative risk (RR) of 0.84 which used in this analysis. [26] [27]

Prevalence of IDA in Pregnancy and Births at Risk of Perinatal Deaths

About 115 thousand perinatal deaths are estimated based on DHS 2007 reported rate of 25 per 1000 births. Based on 40% pregnant women found anemic in SKRT 2001 and 59%[28] Microcytic Hypochromic anemia in women found by RISKEDES 2007, we estimate a 23.7% IDA rate among pregnant women. The evidence suggests more than 1 million of an estimated annual 4.58 million births are at elevated risk of perinatal mortality.

Births at Risk due to Prevalence of IDA Among Pregnant Women	
Births @ 19.7/1000[29]	4,580,585
Perinatal Mortality @ 25/1000[30]	25
Total Perinatal death	114,515
Prevalence of anemia among pregnant women[31]	40.1%
Proportion of maternal anemia due to iron deficiency[32]	59%
Births At-Risk	1,083,721

Since the evidence for anemia associated perinatal is based on grams per deciliter hemoglobin, our analysis will use mean 11.8 g/dL Hb in pregnant women found by RISKEDAS. Based on algorithm designed Stoltzfus et al, we estimate a theoretical mean Hb of 12.2 g/dL in absence of iron deficiency – resulting in a deficit of .36 g/dL Hb.[33] From these two data points we calculate a Population Attributable Risk (PAR) of 6% suggesting that ~7 thousand annual perinatal deaths can be attributed to the mother's IDA. However, it should be noted that RISKEDAS found only 19.7%[34] of women anemic and therefore this data point may underestimate the anemia related perinatal mortality.

[25] Stoltzfus et al, Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004
[26] Ibid
[27] 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.
[28] RISKEDES Table 3.96
[29] World Bank. 2010
[30] SKRT 2001
[31] RISKEDAS 2007
[32] Ibid
[33] Stoltzfus et al, Iron Deficiency Anaemia, in Global Burden of Disease, WHO 2004
[34] RISKESDES Table 3.94

Calculation of PAR and IDA Related Perinatal Death	
Mean hemoglobin level at current prevalence:	11.8 g/dL
Mean hemoglobin level in absence of iron deficiency:	12.2 g/dL
Difference in mean hemoglobin in absence of iron deficiency:	0.36 g/dL
RR of perinatal mortality associated with a 1 g/dL increase in hemoglobin:	0.84
Proportion of perinatal mortality due to iron deficiency anemia: Population Attributable Risk(PAR)	6.1%
Total Perinatal Deaths Attributed to Anemia	7,000

Calculating Value of Lost Workforce due to Perinatal Deaths

While the loss is immeasurable, in economic terms these 7 thousand annual deaths simply represent a lost future workforce. After discounting earnings and allowing for 15 year time-lag for delay in beginning of the earnings stream, we estimated NPV of losses due to perinatal mortality at $61 million annually. We should note that this NPV values each death at about $8.76 thousand. While the value of life is immeasurable, this cold and hard financial calculation values each death at about $9 thousand. Clearly, this methodology cannot capture the true value of human life.

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

Perinatal Death due to IDA		**Average Annual Wage**		**Labor Force Participation Rate**		**Coefficient of Loss**		**Discounting for NPV**		Net Present Value of Losses
	X		X		X		X		=	
7,000		**$1,006**		**67.8%**		**100%**		46 yrs @ 3% with 15 year lag		$61.3 million/yr

Based on diminishing birth rate projected by World Bank, 10 year projections suggest that as a consequence of current levels of IDA among pregnant women, nearly 70 thousand infants will die within weeks of birth - with economic consequences valued at more than $600 million. As discussed above, both the number of perinatal deaths and the value of these deaths maybe significantly underestimated in this analysis.

10 Year Estimated Number of IDA Related Perinatal Deaths and Future Earnings Loss			
Year	**Births**	**Perinatal Deaths**	**NPV of Earnings Loss**
	000		'000,000 USD
2010	4581 @ 19.7/1000	7,000	$61.32
2011	4638	7,088	$62.09
2012	4696	7,177	$62.87
2013	4755	7,266	$63.65
2014	4814 @ 17.1/1000	7,357	$64.45
2015	4221	6,451	$56.51
2016	4263	6,516	$57.08
2017	4306	6,582	$57.65
2018	4350	6,648	$58.24
2019	4394	6,715	$58.82
		68,799	**$602.67**

2.4. 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. A recent review calculated that more than 200,000 are likely preventable with additional folic acid in the diets of women.[35] There is very little data on the incidence of NTDs in Indonesia as well as the outcome and cost of these cases. Therefore, this analysis is conceptual and speculative. However, relative to economic losses found for IDA, losses from NTDs are relatively low. Therefore, these speculations will not significantly alter any conclusions about the economic benefits of flour fortification with folic acid in Indonesia.

Incidence of NTDs in Indonesia

No nationally representative figures exist for the incidence of spina bifada and anencephaly in Indonesia. The March of Dimes average global is 2.45 NTDs per 1000 live births.[36] This suggests more than 11 thousand NTD births annually. However, the March of Dimes estimate specifically for NTDs in Indonesia is much lower, 3108 annually. The lower figure will be used in this analysis.

Mortality and other Outcomes from NTDs

Limited access to sophisticated medical care for infants with NTDs means high probability of death in infancy. Since only 54% of births in Indonesia are not in a public or private facility, the analysis assumes these infants will die within months of birth as a result of the birth defect.[37] Of the remaining births within health facilities, we assume 2/3rd do not have the necessary pediatric surgery and care needed to prevent early deaths in cases of spina bifada, anencephaly and other NTDs. This suggests 85% of NTDs will result in premature mortality. In addition, not all surgeries are successful so we speculatively add another 5% for a total 90% estimated mortality rate - 2786 annual deaths with an NPV of $24.4 million annually.

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

Perinatal Death due to IDA	X	Average Annual Wage	X	Labor Force Participation Rate	X	Coefficient of Loss	X	Discounting for NPV	=	Net Present Value of Losses
2786		$1,006		67.8%		100%		46 yrs @ 3% w/15 year lag		$24.4 million/yr

There is an economic cost for surviving infancy with birth defects like NTDs. There is no data available for cost of surgeries, but if we use a speculative $1000 per surgery for the 10% lucky enough to have access to pediatric surgery, this adds about $50 thousand annually to the economic burden. In addition, the 320 survivors will suffer severe or moderate life-long disability – with commensurate costs to the health system, society and the family. Presuming average survival to age 25 years and $1000 annual in costs to the medical system and the family, we calculate an NPV of $5.6 million/yr. In addition to these direct costs, presuming 50% disability among moderate cases and 100% disability in severe cases, we speculate another $2 million annually for the NPV of lost potential productivity. Total folic acid related

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[35] 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.
36 March of Dimes Global Report on Birth Defects, Appendix B, 2008
[37] DHS 2007

losses total $32 million. As discussed earlier, due to lack of data on NTD incidence and outcome, this figure is conceptual and based on a number of assumptions

Summary Annual Economic Costs of Current Rates of NTDs	
Direct Costs	
Cost of Surgery and Care for 10% with access at $1000	$49,511
Cost of Rehab, Care, Medicines for Moderate & Severe Disabled 25 years (NPV)	$5,610,447
Lost Productivity NPV over 46 year work life with average 15 year until entry into workforce	
2786 Deaths	$24,403,076
161 Severely Disabled 100%isability:	$1,411,186
161 Moderately Disabled: 50% Disability:	$705,593
	$32,179,811

Based on declining birth rates during the next decade, 10 year losses are summarized in the table below.

Summary 10 Year Projections for Direct Costs and NPV of Lost Productivity from Current Rates of NTDS (USD $000,000)						
Year	**Deaths**	**Severe Disability**	**Moderate Disability**	**NPV Lost Future Productivity**	**Direct Costs of Surgery & Care**	**Total Annual Losses**
	#	#	#		USD 000,000	
2009	2,786	161	161	$26.52	$5.66	$32.18
2010	2,821	163	163	$26.85	$5.73	$32.58
2011	2,856	165	165	$27.19	$5.80	$32.99
2012	2,892	167	167	$27.53	$5.87	$33.40
2013	2,928	169	169	$27.87	$5.95	$33.82
2014	2,567	148	148	$24.44	$5.22	$29.65
2015	2,593	150	150	$24.68	$5.27	$29.95
2016	2,619	151	151	$24.93	$5.32	$30.25
2017	2,646	153	153	$25.18	$5.38	$30.56
2018	2,672	155	155	$25.44	$5.43	$30.87
Total	**27,378**	**1583**	**1583**	**$260.63**	**$55.63**	**$316.26**

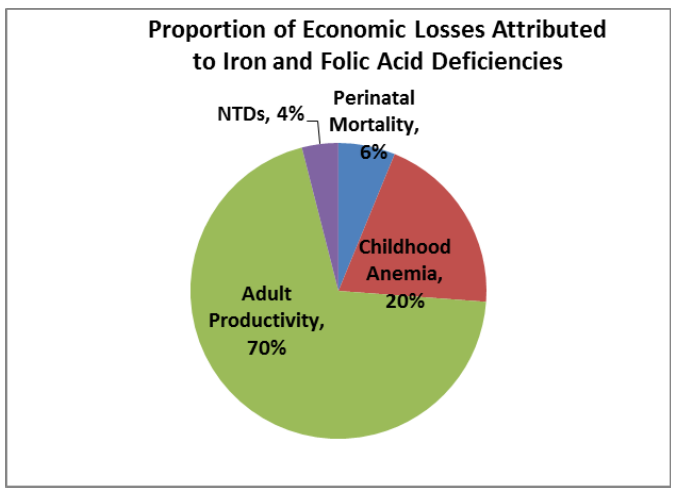
2.5: Economic Consequences of IDA and NTDS: 10 Year Summary

Status quo losses for 2010 are projected forward 10 years along with projected population increase for adult anemia (1.25%) and projected birth rate for other indicators (19.7/1000 through 2015 and 17./1000 thereafter). Based on the best available global evidence applied to national health, labor and demographic data suggests depressed national economic activity of nearly $10 billion over the next decade.

Summary Projected 10 Year Losses from 3 Iron Deficiency Anemia and Folic Acid Associated NTDs

	NPV of Perinatal Mortality	NPV of Child IDA	Adult IDA	Total Anemia	NTD Losses	Total Losses from NTD and IDA
2010	$61.32	$184.11	$675.10	$920.53	$32.18	$952.71
2011	$62.09	$186.41	$675.94	$924.44	$32.58	$957.02
2012	$62.87	$188.74	$676.78	$928.39	$32.99	$961.38
2013	$63.65	$191.10	$677.63	$932.38	$33.40	$965.78
2014	$64.45	$193.49	$678.48	$936.41	$33.82	$970.23
2015	$56.51	$195.44	$679.16	$931.11	$29.65	$960.76
2016	$57.08	$197.42	$679.85	$934.34	$29.95	$964.29
2017	$57.65	$199.41	$680.53	$937.60	$30.25	$967.85
2018	$58.24	$201.43	$681.22	$940.88	$30.56	$971.44
2019	$58.82	$203.46	$681.91	$944.19	$30.87	$975.06
10 yr Total	**$602.67**	**$1,941.02**	**$6,786.60**	**$9,330.29**	**$316.26**	**$9,646.55**

Current and future productivity losses from IDA represent about 96% of these losses. The largest share of IDA-related losses, about 70%, stems from the current productivity losses in manual and heavy labor as a result of workers with IDA. Another 20% is a consequence of childhood IDA leading to retarded cognitive development, inferior school performance and ultimately depressed earnings as adults. Perinatal mortality associated with maternal anemia and NTDs linked to folic acid deficiencies together account for 10% of the losses with an NPV of losses about $1 billion - from a 10 year death toll of nearly 100,000. As noted earlier the immeasurable value of human high life is not well estimated by our financial methodology.



3. *Projected Benefits of National Flour Fortification*

Benefits of flour fortification will depend on several parameters including: dose of added micronutrient, coverage of flour consumption and effectiveness of flour fortification as an intervention. The level of fortificant added at the mill and amount of individual flour consumption define the added "dose" of iron (mg/dy) and folic acid (ug/dy). This added dose, along with evidence from other fortification programs, allows for general estimates about effectiveness - defined as improvement among consumers of fortified flour. National impact will be influences by market coverage of fortified flour. The following algorithm is used to project the magnitude of reduction in current prevalence and the presumed parallel reduction in economic losses.

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

3.1 Consumption Levels and Defining the Required Fortification Level

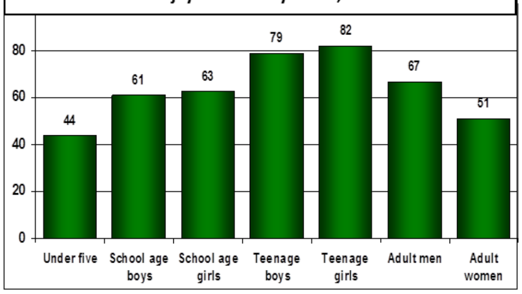
Recently, *WHO published Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement,* which recommends levels of fortification based on average per capita wheat flour consumption. The relevant WHO recommendations are summarized in the attached table. [38] The WHO author panel comprehensively reviewed published evidence and trials using a range of iron compounds and concluded that fortification with ferrous sulfate or ferrous fumarate delivering a dose of 7.1 mg/dy was "efficacious."[39]

WHO Recommendations for Fortification Levels

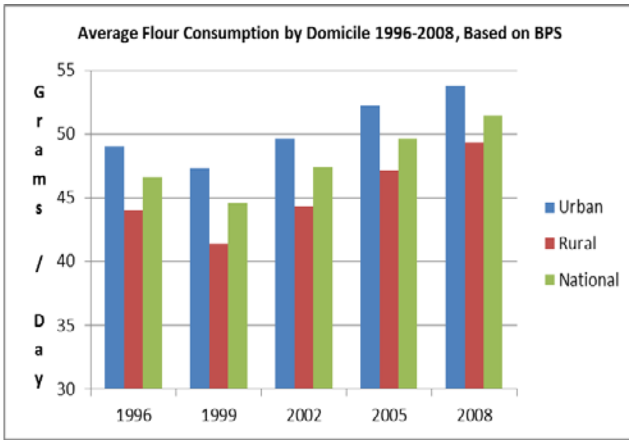
	Average Consumption Level		
	< 75 g/dy	75-149 g/dy	> 149 g/dy
Iron	60 ppm	60 ppm	30 ppm
Folic Acid	5 ppm	2.6 ppm	1.3 ppm

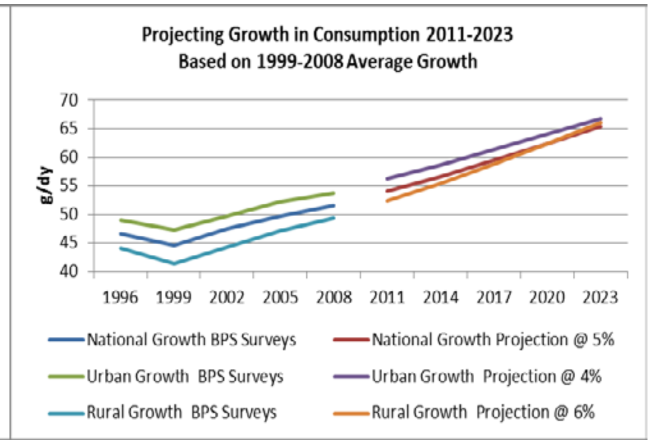
Where does the Indonesian consumer fit in this continuum of average consumption categories defined by WHO? An analysis of 5 BPS surveys from 1996 to 2008 finds that in 2008 average national consumption reached about 52 grams per day. This is consistent with a consumption study undertaken in two low income areas of Jakarta which found 51 gram per day average consumption among woman of reproductive age and generally higher consumption by school aged children. [40] Consumption among under 5 olds was 44 grams per day or 86% the level found in women of reproductive age. These survey results are relatively consistent with 59 grams per day wheat consumption found by FAO Food Balance Sheets for 2007 (though this is for wheat and not corrected for flour extraction).

Flour Consumption for Key Groups
Sandjaya and Study Team, 2008



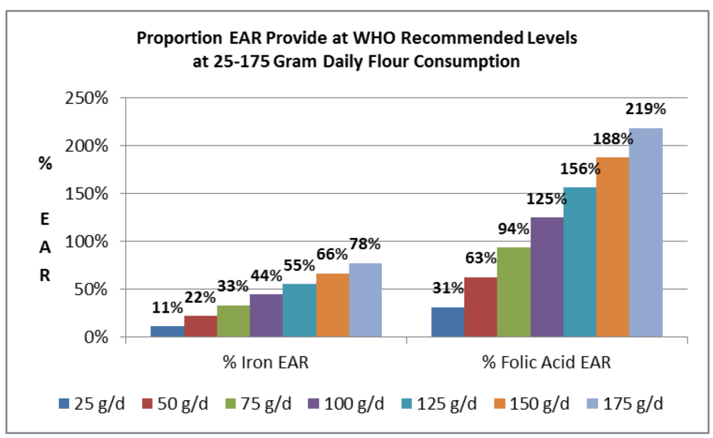
[38] Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement, WHO 2009
[39] Hurrell et al, Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs, *Food and Nutrition Bulletin,* vol. 31, no. 1, 2010
[40] Sanjaya et al, Unpublished, ADB Report for Japan Fund for Poverty Reduction





As indicated in the graph above, 15 years of BPS data show that in rural areas, consumption is consistently about 5 grams per day less (~10%) than urban areas – not a dramatic difference. These surveys taken every 3 years suggest that from 1999-2008 national consumption grew ~ 5% every 3 years – 4% in urban areas and 6% in rural areas. AS illustrated by the graph above, extending these trends 15 years into the future suggests that by 2023 average national per capita flour consumption will reach 65 grams per day with less than 1 gram difference between the average urban and rural consumer.

BPS suggests that iron and folic acid fortification levels fall in the WHO < 75 gram per day category - 60 ppm iron and 5 ppm folic acid. The WHO Recommendations include two statements of particular importance to programs based on average national consumption of < 75 grams per day. First, the less bioavailable elemental and electrolytic iron compounds currently used in the Indonesian fortification program are “not recommended because very high levels of electrolytic iron needed could negatively affect sensory properties of fortified flour.”[41] Second, per capita consumption of <75 g/day does “not allow for addition of sufficient level of fortificant to cover micronutrients needs for women of childbearing age.”[42]

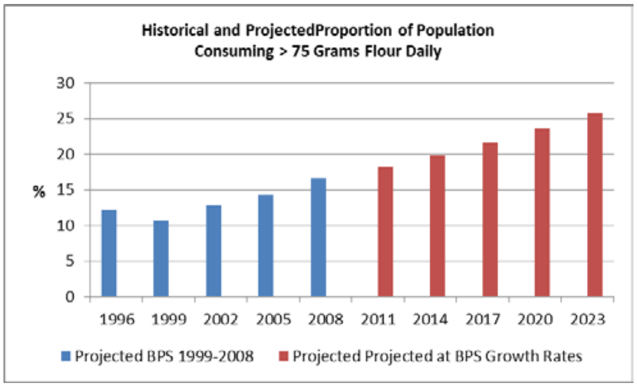


WHO notwithstanding, can any benefit at all be attributed to those consuming less < 75 grams per day? As shown in the attached graph, women of reproductive age consuming 25-75 grams day will benefit from 11%-33% of WHO Estimated Average Requirements (EAR for mid-bioavailability diet) and 31% to 94% of EAR for folic acid (presuming 80% retention)[43]. While the benefit or protection may not be as great as for those

[41] Recommendations on Wheat and Maize Flour Fortification Meeting Report: Interim Consensus Statement, WHO 2009
[42] Ibid
[43] EAR is used, as opposed, for example, to recommended daily intakes, as recommended by WHO & FAO “Guidelines on food fortification with micronutrients”.2006

with higher flour consumption, surely there must be some benefit from an additional 22-33% EAR provided to those consuming 50-75 grams of fortified flour daily. Fortified flour consumption at 50 grams per day delivers 3 mg/dy of additional bioavailable iron while consumption of 75 grams per day delivers 4.5g/dy – 50% more iron. Therefore, for the purposes of this study, we will assume that for those consuming 50-75 grams of flour a day the benefits of fortification will be half that of those consuming more than 75 grams per day. We will assume no benefit the population consuming less that 50 grams flour per day.

3.2 Proposed Assumptions for Coverage



A recent analysis of 5 BPS surveys from 1996 to 2008 suggested that the proportion of Indonesians consuming some wheat ("participating") flour rose from 81% in 1996 to 92% in 2008. However, for many, consumption may not reach the 75 g/day threshold defined by the authors of the WHO document or even the less efficacious 50 gram per day threshold assumed for this analysis. BPS surveys over 12 years found the population consuming more than 75 grams per day growing from 12% to 17% - an annual growth of this consumer segment of about 3%. At this growth rate, by 2010, 19% or more than 40 million Indonesians could benefit from efficacious protective doses of iron from normal consumption of fortified flour. Applying this growth rate to the next 15 years suggests that by 2023, 26% of the population will be consuming an efficacious dose of more than 75 grams per day. By 2023 that protected population may each 70 million.

There is no available segmented data for the 83% of Indonesians consuming < 75 grams per day. For the purposes of this study, we presume a normal distribution, and assume 1/3rd of these consumers fall within the 50-75 gram per day segment - about 65 million consumers. We will further assume that this consumer segment will grow at 3% annually – the same rate as the > 75 gram per day category, from current estimate of 28% to 36%. Note this suggests that the consumer segment with < 50 gram per day intake will continue to shrink.

3.3 Review of Evidence for Effectiveness of Flour Fortification

The current state-of-the-art for projecting the impact of flour fortification is 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.

Summary National Program and Large Scale Trial Evaluations

	Program Type	Risk Group	Pre Fortification	Post Fortification	Decrease
Venezuela	National	Children	16%	9%	44%
Oman	National	School girls	56%	38%	32%
		Pregnant	49%	43%	12%
Darjeeling	State	School aged	60%	46%	23%
		Teen Girls	70%	55%	21%

Evaluations of impact on anemia or iron deficiency as a consequence of national flour fortification are scarce. The most comprehensive evaluation is from a national program in Venezuela during the 1990's which found a decrease in anemia among lower income urban children from 16% to 9% - an improvement of 44% - and reduction in iron deficiency from 37% to 15% - an improvement of 59%.[44] Other national and subnational programs found anemia decrease of 21% to 32%. However, questions remain about implementation, choice of iron compound and coverage – suggesting these programs could be more effective.

The evidence demonstrates that providing additional folic acid can avert most cases of neural tube defects.[45] The results of flour fortification with folic acid in the United States, Canada, Costa Rica and Chile provide the background data for projecting effectiveness of flour fortification in reducing rate of NTDs. In each case, folic acid fortification was followed by an immediate increase in population serum folate concentrations and significantly reduced rates of NTDs.[46] 3 studies reported reduction in spina bifida and anencephaly in the United States ranging from 20% up to 50%.[47] Two Canadian studies found NTDs reduced from more than 2 per 1000 births to a little over 1 per 1000.[48] Initial data evaluating folic acid fortification in Chile suggests up to 47% decline in NTDs.[49] Costa Rica found reductions in well covered urban populations of 87%.[50]

For this analysis, there are a number of additional limitations in the evaluations reviewed above. First, this analysis will include coverage as a parameter while these evaluations measure decreases in over-all national status over-all and do not correct for coverage. Coverage is most probably less than 100% and therefore, effectiveness among actual consumers may be greater than the indicated improvement in national prevalence. Second, the key indicator used in these evaluations is anemia (Hb) rather than for IDA. Only IDA will be responsive to added dietary iron through flour fortification. This analysis has corrected for proportion of anemia from IDA based on proportion of microcytic hypochromic in the various target groups ranging from about one-third to nearly 2/3[rds]. Finally, these programs do not have the benefit of the *WHO Recommendations* for level and iron compound and are therefore not as optimally effective.

Based on the review above we will make the following assumptions about effectiveness of fortification.

- **Reduction in IDA among adult consumers.** While the Venezuela evaluation found 59% reduction in IDA, combined consumption of wheat and corn flours is significantly higher that Indonesia, an average of than 200 grams per day.[51] On the other hand, the Venezuelan program does not deliver as high a bioavailable dose of iron as 60 ppm iron from ferrous fumarate. Based on this general guidance, we will

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[44] Layrisse, M et al. Early response to the effect of iron fortification in the Venezuelan population, Am. J. Clin. Nutr. 1996 and Scrimshaw et al, Success of Micronutrient Fortification of Cereal Flours in Venezuela, Micronutrient Initiative, 2002

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

[46] Lawrence JM et al 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

[47] Honein MA et al , Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. JAMA 2001; 285:2981-6; Persad VL, et al 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 et al Prevalence of spina bifida and anencephaly during the transition to mandatory folic acid fortification in the United States. Teratology 2002; 68:33-39.

[48] De Wals P et al Trend in prevalence of neural tube defects in Quebec. Birth Defects Research 2003; 67:919-23; Persad VL et al Incidence of open neural tube defects in Nova Scotia after folic acid fortification. CMAJ: Canadian Medical Association Journal. 2002; 167:241-5.

[49] Grosse SD et al Folic acid fortification and birth defects prevention: lessons from the Americas. AGROFood industry hi-tech 2006; 17.

[50] Chen LT, Rivera MA. The Costa Rican experience: reduction of neural tube defects following food fortification programs. Nutr Rev 2004;62:S40-3.

[51] Based on FAO Food Balance Sheet for 2007

assume that in the segment consuming > 75 grams per day of flour benefiting from > 4.5 grams per day of additional iron, reduction in IDA may be 30%. Further, we will assume that among consumers of 50-75 grams per day, reductions may be half that level achieved in the > 75 gram segment – or 15%.

- **Reduction in IDA among Children Consumers.** The study by Sanajaya et al finds consumption among children < 5 years (with lower iron needs) about 86% that of adult women. In Consumption of older children is generally higher than adults. However, while there is no segmented data, we presume consumption in the critical 6-24 month age group is lower than the average for the category. If consumption and iron dose for children < 2 years old is not sufficient, this suggests protection for only ~87% of the under 15 year time frame. Therefore, we will assume that effectiveness among children is 87% that of adults - or 26% effectiveness among children consuming > 75 grams per day and 13% effectiveness in the 50-75 gram per day consumption segment.

- **Reduction in IDA among Pregnant Women.** With EAR rising to > 40 mg/dy during the second trimester, full iron requirements for pregnant women cannot be delivered via fortification. Presuming there must be some benefit to some women with borderline iron status, we will presume effectiveness of fortification in this segment at 20% of effectiveness among adult women - or 6% in pregnant women consuming > 75 grams per day and 3% in the 50-75 gram per day segment.

- **Reductions in NTDs.** The evidence indicates that in countries with flour fortification national prevalence of NTDs fell 20% to nearly 70%. However, the only evaluation that corrected for coverage was in Costa Rica, finding reductions in 87% among well covered consumers. We will define "well covered" populations as parallel to correcting for coverage as in our study. On the other hand, while Costa Ricans consume more flour than Indonesians, the WHO recommended folic acid fortification level for Indonesia (5 ppm) is about 3 times that used in Costa Rica. Therefore, for the purposes of this study, we assume among women of reproductive age consuming > 75 grams per day of flour (and benefiting from > 94% of EAR for folic acid), improvements can be conservatively projected at 60% - roughly 2/3^{rds} the Costa Rica results. For women consuming 50-75 grams per day we will assume half that effectiveness or 30% reduction in NTDs.

Based on assumed coverage and effectiveness for the two consumption groups considered, the study products a national 11.1% reduction in IDA among adults and 19.8% reduction in NTDs. Improvements among children < 15 yrs are projected at 9.6% and among pregnant women at 2.2%. The table below shows results for each of the flour consumption segments and sums these for an estimate of improvement in baseline national prevalence. We assume no benefit for the population consuming less than 50 grams per day of flour.

	Projected Improvement Among Adults			Children < 15 yrs	Pregnant Women
Consumer Segment	**Coverage (2010)**	**Effectiveness Estimate**	**Projected Improvement**	**Projected Improvement**	**Projected Improvement**
IDA				@ 80% adult	@20%
> 75 g/dy	19%	30%	5.6%		
50-75 g/dy	28%	15%	5.5%		
National			11.1%	9.6%	2.2%
NTD					
> 75 g/dy	19%	60%	11.4%		
50-75 g/dy	28%	30%	8.4%		
National			19.8%		

Based on effectiveness parameters above and increasing coverage of both the > 75 g/dy segment and the 50-75 g/dy segment at a rate of 3% per year (as discussed earlier), percentage improvement from baseline is shown over 10 Year.

10-Year Projections for Percentage Savings from Reductions in Baseline IDA in Adults, Children and Pregnant Women via Flour Fortification

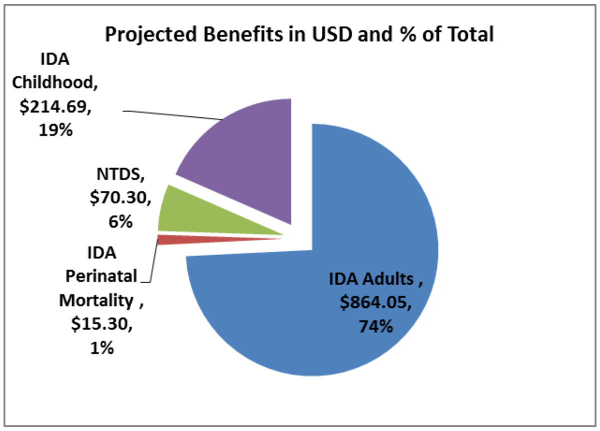
	Segment: >75 gram		Segment: 50-75 gram		National Benefit or Improvement		
	Coverage	Benefit @ 30% Effectiveness	Coverage	Benefit @ 30% Effectiveness	Adult Benefit	Child @ 80%	Pregnant @ 20%
2011	19%	5.6%	28%	5.5%	11.1%	9.6%	2.2%
2012	19%	5.7%	28%	5.7%	11.4%	9.9%	2.3%
2013	20%	5.9%	29%	5.9%	11.8%	10.2%	2.4%
2014	20%	6.1%	30%	6.0%	12.1%	10.5%	2.4%
2015	21%	6.3%	31%	6.2%	12.5%	10.8%	2.5%
2016	22%	6.5%	32%	6.4%	12.9%	11.2%	2.6%
2017	22%	6.7%	33%	6.6%	13.3%	11.5%	2.7%
2018	23%	6.9%	34%	6.8%	13.7%	11.8%	2.7%
2019	24%	7.1%	35%	7.0%	14.1%	12.2%	2.8%
2020	24%	7.3%	36%	7.2%	14.5%	12.6%	2.9%

10-Year Projections for Percentage Savings from Reductions in Baseline NTD Rates and Total Projected Savings from Reductions of both IDA and NTD from Baseline via Flour Fortification

	Segment: >75 gram		Segment: 50-75 gram		National Benefit Or Improvement
	Coverage	Benefit @ 60% Effectiveness	Coverage	Benefit @ 60% Effectiveness	
2011	19%	11%	28%	8.300%	19%
2012	19%	11%	28%	8.549%	20%
2013	20%	12%	29%	8.805%	21%
2014	20%	12%	30%	9.068%	21%
2015	21%	13%	31%	9.340%	22%
2016	22%	13%	32%	9.620%	23%
2017	22%	13%	33%	9.908%	23%
2018	23%	14%	34%	10.205%	24%
2019	24%	14%	35%	10.510%	25%
2020	24%	15%	36%	10.825%	25%

3.4 Calculation for Improvement from Status Quo or Benefits

We project 10 year benefits or savings from the reduction of IDA and NTDs at more than $1.16 billion. Reduction in IDA among adults and children represent more than 90% of this savings. Reductions in IDA among adults are about 3/4s of this savings. This is because there is no discounting for future benefits (for an NPV) as well as the high rates of anemia among adult men and women. Prevention of NTDs represents another potential $70 million in savings. Benefits rise annually over 10 years along with increasing size of the segments consuming > 75 grams and 50-75 grams. Summary 10 Year calculations are shown in the tables that follow.



Summary 10 Year Estimate Projections for National Economic Benefits in IDA Reduction from Reduction in IDA Prevalence (USD'000,000)

	Perinatal Mortality			**IDA in Children < 15 years**			**IDA in Adults**			**Total Benefits**
	Baseline Loss	Improvement	Benefit	Baseline Loss	Improvement	Benefit	Baseline Loss	Improvement	Benefit	
2010	$61.32	2.2%	$1.36	$184.11	9.6%	$17.72	$675.10	11.1%	$ 74.97	$94.0
2011	$62.09	2.3%	$1.42	$186.41	9.9%	$18.48	$675.94	11.4%	$ 77.31	$97.2
2012	$62.87	2.4%	$1.48	$188.74	10.2%	$19.27	$676.78	11.8%	$ 79.73	$100.5
2013	$63.65	2.4%	$1.54	$191.10	10.5%	$20.10	$677.63	12.1%	$ 82.22	$103.9
2014	$64.45	2.5%	$1.61	$193.49	10.8%	$20.96	$678.48	12.5%	$ 84.79	$107.4
2015	$56.51	2.6%	$1.45	$195.44	11.2%	$21.80	$679.16	12.9%	$ 87.42	$110.7
2016	$57.08	2.7%	$1.51	$197.42	11.5%	$22.68	$679.85	13.3%	$ 90.13	$114.3
2017	$57.65	2.7%	$1.57	$199.41	11.8%	$23.60	$680.53	13.7%	$ 92.92	$118.1
2018	$58.24	2.8%	$1.64	$201.43	12.2%	$24.55	$681.22	14.1%	$ 95.80	$121.9
2019	$58.82	2.9%	$1.70	$203.46	12.6%	$25.54	$681.91	14.5%	$ 98.77	$126.0
Total	$602.67	2.54%	$15.30	$1,941.02	11.1%	$214.69	$6,786.60	12.7%	864	$1,094.

	NTD			**Summary IDA and NTD Reduction**		
	Baseline Loss	Improvement	Benefit	Baseline Loss	Improvement	Benefit
2010	$32.18	19.4%	$6.26	$952.71	10.5%	$100.31
2011	$32.58	20.0%	$6.53	$957.02	10.8%	$103.74
2012	$32.99	20.6%	$6.80	$961.38	11.2%	$107.29
2013	$33.40	21.2%	$7.10	$965.78	11.5%	$110.96
2014	$33.82	21.9%	$7.40	$970.23	11.8%	$114.76
2015	$29.65	22.5%	$6.68	$960.76	12.2%	$117.36
2016	$29.95	23.2%	$6.95	$964.29	12.6%	$121.27
2017	$30.25	23.9%	$7.23	$967.85	12.9%	$125.32
2018	$30.56	24.6%	$7.52	$971.44	13.3%	$129.51
2019	$30.87	25.4%	$7.83	$975.06	13.7%	$133.84
Total	**$316.26**		**$70.30**	**$9,646.55**	12.1%	$1,164.35

4. Cost of Flour Fortification

Flour fortification in Indonesia has been implemented for about a decade. The technology and business models are well integrated into milling industry processes. Capacity has been built among regulatory institutions including MOH, MOA and BPOM. Awareness has been raised among key audiences and populations. While cost parameters for the program are relatively clear, these are based on levels of iron and folic acid fortification specified in the SNI. AS discussed earlier, these do not match the appropriate WHO recommendations. Therefore, this analysis will not include current costs because effectiveness estimates will not be valid for the fortificant mix currently used. The analysis will be based on "hypothetical" costs for a proposed reform of the SNI to include WHO guidance for levels and compounds used for iron and folic acid.

	Premix for Current SNI	Premix for Reformed SNI with new Fe and Folic Acid Levels	Theoretical Cost for WHO Recommended Levels of Iron and Folic Acid only
Premix only	**$1.33**	**$2.66**	**$1.73**
With $0.20/MT Mill Cost	**$1.53**	**$2.86**	**$1.93**

The cost difference in adopting the WHO recommendations is not insignificant. Presuming processing, overhead and other costs of milling at about $0.2/MT the table below shows different cost of fortification at current SNI mandated profile and at a projected "reformed SNI" fortification profile which includes 60 ppm iron from ferrous fumarate and 5 ppm folic acid as indicated by WHO Guidelines.[52] Over 10 years, additional costs for a revised premix formula are nearly $7.5 million – an 87% increase. On other hand, without incurring this additional cost, the effectiveness of any investment is brought in to question.

Cost Difference Applying Current versus Reformed SNI

	Projected Annual MT Consumption	Current SNI @ $1.53/MT	Reformed SNI @ $2.86/MT
2011	4,321,063	$6,613,778	$12,362,646
2012	4,445,575	$6,804,356	$12,718,880
2013	4,573,676	$7,000,426	$13,085,379
2014	4,705,468	$7,202,146	$13,462,438
2015	4,841,058	$7,409,678	$13,850,363
2016	4,980,555	$7,623,190	$14,249,466
2017	5,124,071	$7,842,855	$14,660,070
2018	5,271,723	$8,068,850	$15,082,505
2019	5,423,630	$8,301,357	$15,517,112
2020	5,579,913	$8,540,563	$15,964,243

For a number of reasons, our projections take into account only the benefits arising from additional iron and folic acid. However, the budgeted premix also includes zinc, thiamin and riboflavin. We estimate $2.86 for the full SNI with iron and folic acid conforming to WHO guidance as opposed to $1.93 for the iron and folic acid only. Therefore, we will run BCR projections for these two costs in parallel.

Finally, while there have been donor investments into government capacity to regulate, monitor and manage Indonesia's flour fortification program there no available data regarding

[52] See Annex for itemized estimate of premix costs

government budgets to operate the relevant systems. We therefore use a general estimate of $150 thousand annually based on the following.

- Quarterly sampling at each of Indonesia's 15 mills for a total of 60 industrial inspections and laboratory analysis. While imports represent only 15% of national consumption, we speculate 50 shipments annually defining a need for another 50 inspections and analysis. We estimate the total cost of inspection, sampling, analysis, communications and management at $150 for each sample. Given the equipment and technical capacity present within BPOM, MOA and other institutions we believe this may be on the high end.
- Adding fortification relevant questionnaires, samples and analysis to BPS surveys every three years @ $120 thousand per survey – or amortized to $40 thousand annually.
- Management and overhead by MOH, BPOM and MOA, possibly including a small office specifically focused on fortification @ $50 thousand annually.
- Communications cost at $25 thousand annually to ensure key stakeholders remain involved.

Given the rough nature of this estimate we add 15% overhead. This brings the total estimated government cost to $151 thousand. Note that much of this may represent the value of effort and established infrastructure rather than actual budgeted "cash" cost.

Summary Annual Government Cost Estimate			
Mill & Port Sampling		110 Samples @ $150	$16,500
BPS Surveys	BPS Survey @ $120k per 3 yrs		$40,000
Management			$50,000
Communications			$25,000
15% Overhead			$19,725
			$151,225

5. Benefit Cost Ratio of Flour Fortification

Based on the 10-year projected benefits and costs, we calculated two parallel benefit cost ratios (BCR). In cases, benefits (or reductions in status quo losses from IDA and NTDs) over 10 years are estimated at $1.164 billion. The first scenario is based on full costs of 5 vitamin and mineral premix current specified by SNI – but including levels for iron and folic acid which correspond to WHO Guidelines. The 10 Year projected cost of $145 million defines a 10 year benefit cost ratio of 8 - meaning that for every $1 of estimated costs there is a return of $8 in program benefits. This first scenario includes costs for thiamin, riboflavin and zinc even though no benefits are attributed to these micronutrients within the BCR. In the second scenario, we match program costs specifically to the measured program benefits from reduction in IDA and NTDs – only fortification with iron and folic acid to WHO recommended levels. For this "hypothetical" scenario benefits are the same but 10 year costs drop to $77 million. Due to these lower attributed costs the BCR rises to 15.

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 Ratio for Flour Fortification in Indonesia: Two Scenarios				
Scenario 1: Full Reformed SNI Premix with Iron and Folic Acid in Accordance with WHO Recommendations				
	Benefits	**Costs**	**Benefit Cost Ratio**	**Annual Net Benefit**
	$000,000	**$000,000**		**$000,000**
2010	100.312	12.514	8.02	87.80
2011	103.739	12.870	8.06	90.87
2012	107.286	13.237	8.11	94.05
2013	110.956	13.614	8.15	97.34
2014	114.756	14.002	8.20	100.75
2015	117.355	14.401	8.15	102.95
2016	121.273	14.811	8.19	106.46
2017	125.323	15.234	8.23	110.09
2018	129.510	15.668	8.27	113.84
Total	133.840	16.115	8.31	117.72
	1,164.3	142.465	8.17	$1,021.9
Scenario 2: Iron and Folic Acid Only in Accordance with WHO Recommendations				
	Benefits	**Costs**	**Benefit Cost Ratio**	**Annual Net Benefit**
	$000,000	**$000,000**		**$000,000**
2009	100.312	6.765	14.83	93.55
2010	103.739	6.956	14.91	96.78
2011	107.286	7.152	15.00	100.13
2012	110.956	7.353	15.09	103.60
2013	114.756	7.561	15.18	107.19
2014	117.355	7.774	15.10	109.58
2015	121.273	7.994	15.17	113.28
2016	125.323	8.220	15.25	117.10
2017	129.510	8.453	15.32	121.06
2018	133.840	8.692	15.40	125.15
	1164.349	76.919	15.14	$1,087.4

ANNEX: Premix Cost Estimates

Cost of 5 Micronutrient Premix Including Ferrous Fumarate @ 60 ppm and Folic Acid @ 5 ppm. Estimated Addition Rate 300 g/MT						
	Fortification Level	Fortificant Compound	Fortificant Compound Activity	Fortificant Compound in MT Flour	Compound Cost/Kg	Cost per Component
	mg/kg		%	mg/kg	$/kg	
Thiamin	**2.5**	Thiamin Mononitrate	81%	3.08	**$24.50**	$0.25
Riboflavin	**4**	Riboflavin	100%	4.00	**$55.00**	$0.73
Folic Acid	**5**	Folic Acid	90%	5.56	**$35.00**	$0.65
Iron	**60**	Ferrous Fumarate	32%	187.50	**$6.00**	$3.75
Zinc	**30**	Zinc Oxide	36%	82.42	**$5.20**	$1.43
Nutrients				282.56		
Excipient				17	$1.00	$0.06
Premix Totals				300	**Nutrient Cost/KG**	**$6.87**
					Up Charge/kg	**$2.00**
					Cost/kg Premix	**$8.87**
					Cost/MT	**$2.66**

Cost of 5 Micronutrient Premix Including as Per Current SNI: Estimated Addition Rate 150 g/MT						
	Fortification Level	Fortificant Compound	Fortificant Compound Activity	Fortificant Compound in MT Flour	Compound Cost/Kg	Cost per Component
	mg/kg		%	mg/kg	$/kg	
Thiamin	**2.5**	Thiamin Mononitrate	81%	3.08	**$24.50**	**$0.50**
Riboflavin	**4**	Riboflavin	100%	4.00	**$55.00**	**$1.47**
Folic Acid	**2.5**	Folic Acid	90%	2.78	**$35.00**	**$0.65**
Iron	**50**	Electrolytic Iron	99%	50.51	**$4.00**	**$1.35**
Zinc	**30**	Zinc Oxide	36%	82.42	**$5.20**	**$2.86**
Nutrients Subtotal				142.78		
Excipient				7	**$1.00**	**$0.05**
Premix Totals				150	**Nutrient Cost/KG**	**$6.87**
					Up Charge/kg	**$2.00**
					Cost/kg Premix	**$8.87**
					Cost/MT	**$1.33**

Cost of Theoretical Premix with Iron and Folic Acid Only: Estimated Addition Rate 200 g/MT						
	Fortification Level	Fortificant Compound	Fortificant Compound Activity	Fortificant Compound in MT Flour	Compound Cost/Kg	Cost per Component
	mg/kg		%	mg/kg	$/kg	
Thiamin		Thiamin Mononitrate	81%	0.00	**$24.50**	**$0.00**
Riboflavin		Riboflavin	100%	0.00	**$55.00**	**$0.00**
Folic Acid	5	Folic Acid	90%	5.56	**$35.00**	**$0.97**
Iron	60	Ferrous Fumarate	32%	187.50	**$6.00**	**$5.63**
Zinc		Zinc Oxide	36%	0.00	**$5.20**	**$0.00**
Nutrients Subtotal				193.06		
Excipient				7	**$1.00**	**$0.03**
Premix Totals				200	**Nutrient Cost/KG**	**$6.63**
					Up Charge/kg	**$2.00**
					Cost/kg Premix	**$8.63**
					Cost/MT	**$1.73**