IMPROVING NUTRITION FOR BANGLADESH

RESEARCH PAPER

PREGNANCY SUPPLEMENTS:
COSTS AND BENEFITS OF PROVIDING THREE NUTRITIONAL SUPPLEMENTS FOR PREGNANT WOMEN IN BANGLADESH

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Pregnancy Supplements: Costs and Benefits of Providing Three Nutritional Supplements for Pregnant Women in Bangladesh

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Introduction

Nutrition direct interventions have the potential for preventing deaths and improving the quality of life for millions of Bangladeshis. The focus of this paper is on three key nutrition-direct interventions during pregnancy; these include calcium supplementation, balanced energy protein supplementation, and iron-folate supplementation. This paper will show that, according to a benefit-cost ratio analysis, each of these nutrition direct interventions offer substantial economic benefits relative to the costs, in addition to an opportunity to contribute towards SDG goals on nutrition and health. The paper is outlined as follows: after a description of the international and national contexts for nutrition, the paper presents estimates of the costs and benefits of the three interventions, followed by a concluding discussion.

International Context

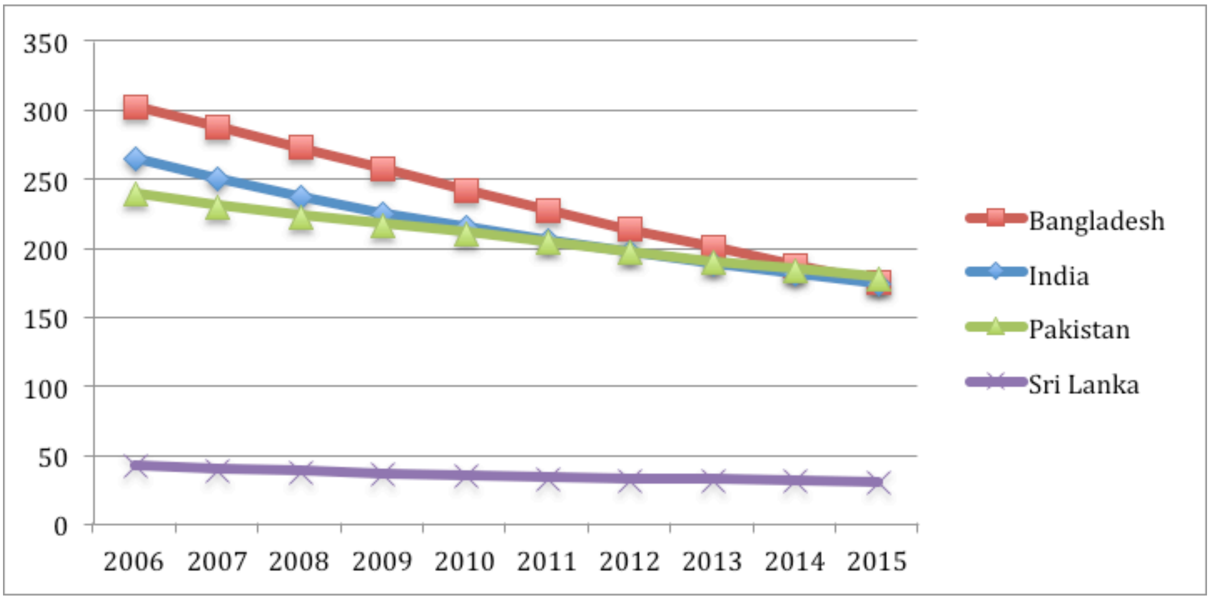
Improving maternal and child health has received widespread attention in international agreements, though the attention on nutritional outcomes has been mixed. Millennium Development Goal (MDG) 4 sought to reduce child mortality, and target 4.A stated, "Reduce by two thirds, between 1990 and 2015, the under-five mortality rate". Goal 5 of the Millennium Development Goals was to improve maternal health, with Target 5.A being "Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio". Stunting was relatively disregarded under the United Nations Millennium Development Goal (MDG). The most relevant goal for nutrition was the MDG 1.8, which calls for halving the rate of underweight children. Although the MDG authors established these targets for the prevalence of underweight children, many nutrition advocates and experts have argued for an increased focus on nutrition overall, and stunting in particular (UNICEF, 2013).

The new Sustainable Development Goals (SDGs) continue to emphasize maternal health and child mortality, and have begun to further emphasize nutrition in particular. The SDG target 2.2 is, "By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons." Goal 3 continues to focus on health, with target 3.1 stating, "By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births" and target 3.2, "By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births." The interventions described in this paper relate to each of these targets.

Bangladesh Context

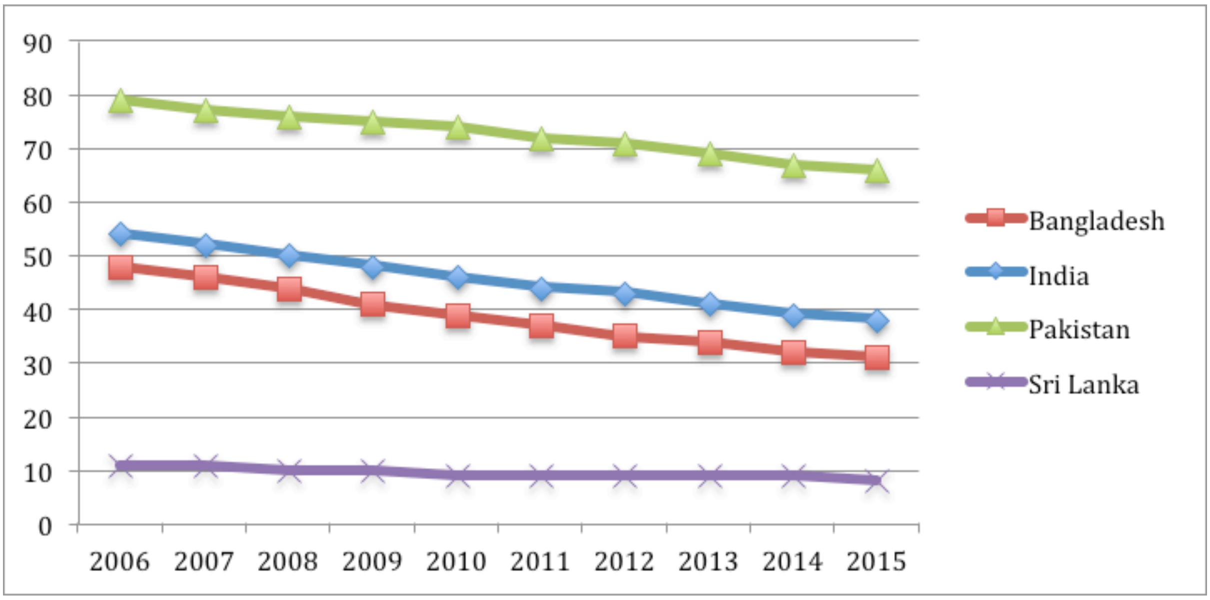
Bangladesh has experienced improved health indicators over time. Two notable areas of improvement are maternal mortality and infant mortality rates. In both of these, Bangladesh has seen considerable progress.

Figure 1. Maternal Mortality Ratio per 100,000 Live Births



The rate of improvement was most dramatic in maternal mortality. As seen in Figure 1, for this, Bangladesh experienced a decline from 303 to 176 per 100,000 live births, a decline of 41.9 percent from 2006 to 2015. The rate was faster than other countries in the region, including India, Pakistan and Sri Lanka. In 2015, the rate in Bangladesh was effectively equivalent to both India at 174 and Pakistan at 178, though much higher than Sri Lanka at just 30.

Figure 2. Mortality rate, infant (per 1,000 live births)



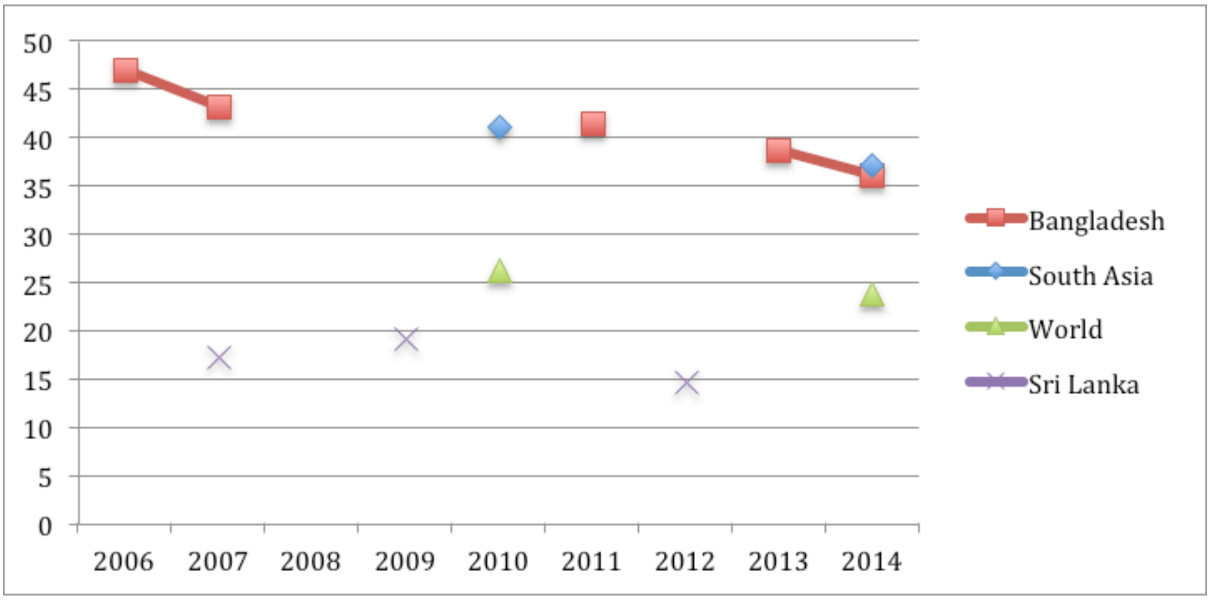
Source: World Bank Data, 2016.

The rate of improvement was also notable in the infant mortality rate. As seen in Figure 2, for this, Bangladesh experienced a decline from 48 to 31 per 100,000 live births, a decline of 35.4 percent. The rate of improvement was similarly faster than other countries in the region, including India, Pakistan and Sri Lanka. In 2015, the infant mortality rate in Bangladesh was better than both India at 38 and Pakistan at 66, though much higher than Sri Lanka at just eight.

Stunting, which is more directly related with nutrition, remains quite high in Bangladesh, though there has been improvement over time. Comparable data is scant in the region. The current statistics, compared with Sri Lanka, South Asia, and the World, are presented in

Figure 3. According to this data, 36 percent of children under 5 are considered to be stunted, a decline from 47 percent of children under five in 2006. This rate is marginally less than that of South Asia in 2014, at 37.2 percent, though considerably more than Sri Lanka at 14.7 percent in 2012 and the global average at 23.8 percent in 2014. Meanwhile, 12 percent of children under 5 are severely stunted (below -3 SD) in Bangladesh.

Figure 3. Rates of Stunting Under 5 Years, Various Countries



Source: World Bank Data, 2016.

A reliable measure of the rate of low birth weight (LBW) in Bangladesh, a primary focus of these interventions, is not readily available. From 2003 to 2004, UNICEF (2004) conducted a comprehensive survey on the topic, finding that 35.5 percent of all births are LBW. The only available World Bank statistics on this are from 2004 and 2005, at 35.5 percent and 22 percent respectively. However, Klemm et al. (2015) conducted a survey from 2004 to 2007 among rural newborns, finding that 55.3 percent were LBW; they therefore argue that these rates are vastly underestimated. Relatively more recently, only perception data is available. The 2011 Bangladesh Demographic and Health Survey (MoHFW, 2012) estimated that 17.7 percent of women believed their newborn was very small or smaller than average, though this is not a reliable estimate. This analysis assumes that the LBW rate of Bangladesh is 15 percent, which is perhaps a conservative estimate given the rate of stunting.

The Interventions

Nutrition direct interventions cover a variety of interventions, ranging from nutritional supplements, fortification, and deworming pills to behavioral change. A literature in nutrition has attempted to model the effect of a package of nutrition direct interventions on a variety of health outcomes, particularly infant and child mortality, as well as birth weight and stunting (Bhutta et al., 2013; Bhutta et al., 2008; Horton et al., 2010).

The focus of this paper is on three particular nutrition direct interventions, all three being administered to pregnant women: calcium supplementation, iron-folate supplementation, and balanced energy-protein supplementation. Each of these interventions has a variety of health benefits, some of which overlap. Iron-folate supplementation reduces the rate of anemia of mothers, one major cause of maternal mortality. Folic acid is also known to diminish the change of birth defects among babies. Balanced energy-protein decreases the incidence of a stillbirth, and decreases the risk of small for gestational age infants, though the latter effect is not included in the analysis of this paper. Calcium supplementation reduces the chance of pre-eclampsia during birth, another cause of maternal mortality, and of pre-term birth, though again the latter effect is not included in the analysis of this paper. Bhutta et al. (2013) perform a literature review that provides estimates of the average reduction in risks of these outcomes, building on a variety of statistical studies.

Each of these interventions also influences low birth weight, which has a variety of important effects (Bhutta et al., 2013). A summary of the research on these effects is presented in Behrman, Alderman and Hoddinott – heretofore referred to as BAH - (2004) and Alderman and Behrman (2004), who both describe seven mechanisms by which LBW leads to beneficial outcomes.

Under the first mechanism, a LBW newborn faces a notably higher probability of infant mortality, both neonatal and post neonatal. Combining a series of studies, BAH (2004) estimate that the probability of such infant mortality declines by 7.8 percent when a child moves from being LBW to not LBW. The second mechanism, reduced costs of neonatal health care, refers to the fact that a LBW newborn requires more medical attention after birth. BAH (2004) estimate an average cost of $41.80 per LBW child, which is a balance of the costs of receiving medical attention during a homebirth and hospital bills, which are covered by both public and private funds. The third mechanism consists of costs related to infant illnesses related to LBW. Such infants are subject to increased dehydration and pneumonia, among other sicknesses. BAH (2004) estimates approximately $40 of increased medical costs, experienced at age 1 and after; this must therefore be discounted.

The fourth and fifth mechanisms have a substantial effect on projected income. Under the fourth, BAH (2004) describe that individuals born as LBW will experience a reduced income due to stunting, which in turn affects income, possibly directly (due to physical impairments) or via years in schooling, as stunted children are known to remain in school fewer years. BAH (2004) estimate that the average income of a LBW individual declines by 2.2 percent from this effect. Under the fifth mechanism, individuals born with LBW experience impaired cognitive development, which then influences income. Studies relate these impairments, as measured by IQ, to later reductions in income. The decline in average income from this effect is more substantial, estimated by BAH (2004) at 5.3 percent for LBW individuals. While BAH (2004) present these mechanisms as distinct, literature has related early childhood stunting to limited cognitive development as well, meaning that these two income effects are quite related (Dewey and Begum, 2011).

The disease burden from LBW extends later in life, and forms the sixth mechanism. BAH (2004) estimate that an individual with LBW has an 8.7 percent higher chance to fall victim to a chronic disease, which then leads to lost productivity as well as health care costs. BAH (2004) estimate that this is roughly equivalent to 10 years of income, and is experienced at age 60; they use an average income of $500. However, this analysis simply uses the last ten years of income, reduced by 7.5 percent due to the effect described above.

BAH (2004) also describe a seventh mechanism by which LBW reduces income, particularly the intergenerational effects, though the empirical evidence for this mechanism is mixed. For example, the financial burden of chronic illness described in mechanism six often falls on the children. Also, children of a woman who is LBW are more likely to be LBW themselves, though BAH (2004) acknowledge that this may be due to genetic influences. For this reason, the analysis presented in this paper does not use this mechanism.

The National Nutrition Service (NNS) strategic plan already includes two of three of these nutrition direct interventions, including iron and folic acid supplementation and calcium supplementation. The intervention that does not appear in the NNS plan is balanced energy protein supplementation, which is also the most expensive and logistically challenging intervention.

Cost and Benefit Sources of Data and Method

The costs of the three nutrition direct interventions used in the analysis of this paper were based on a leading article on nutrition direct interventions (Bhutta et al., 2013). The prices appear in 2010 USD[1], and so they were converted to BDT using the 2010 exchange rate, then increased by the inflation of Bangladesh from 2011 to 2015. Use of this cost data is based on the assumption that prices in Bangladesh are equivalent to the international price.[2] The prices also do not include costs related to creating and enhancing the capacity of institutions to deliver the supplements.[3]

This paper focuses on particular effects of three interventions during pregnancy, whose benefits are estimated in Bhutta et al. (2013). As described above, these benefits differ in some areas and overlap in others, particularly in reducing low birth weight. Because these benefits include saving lives, the estimates below are forced to putting an economic value on lives, an exercise of questionable morality.

For calcium supplementation, the estimated reduction in the rate of pre-eclampsia is 52 percent (Bhutta et al., 2013). There is no recent data on pre-eclampsia as a portion of all maternal deaths, so the analysis relies on Khan et al. (2006), which estimates that hypertensive disorders causes 9.1 percent of all maternal mortality in Asia, which this analysis assumes to be currently true for Bangladesh. The analysis further assumes that the effect of calcium supplements on the rate of pre-eclampsia is the same for the rate of all hypertensive disorders; these two figures are multiplied, then multiplied by the maternal mortality rate of 0.188 percent to find the effect on the mortality rate overall (World Bank, 2016). Iron-folate supplementation reduces the risk of anemia in mothers by 69 percent (Bhutta et al., 2013). While there is no recent data on the portion of maternal mortality due to anemia in Bangladesh, Khan et al. (2006) estimate the rate for Asia at 12.8 percent, which the analysis again assumes is currently true for Bangladesh; these two figures are multiplied, then multiplied the maternal mortality rate of 0.188 percent to find the effect of supplementation on maternal mortality overall (World Bank, 2016). Balanced protein energy supplementation causes the rate of stillbirths to decline by 38 percent (Bhutta et al., 2013). Stillbirths make up 3.6 percent of

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[1] The cost estimate for Hoddinott et al. (2013) was actually for a package of 13 interventions that included the ten presented in this calculation.

[2] We assume that this cost is the same for the whole population, though earlier work (Horton et al., 2010) assumes that this price applies only to the first 80 percent of the population, and increases substantially thereafter.

[3] Furthermore, the standard price does not recognize the increased cost involved in reaching relatively more difficult to reach population; the current reductions in stunting can reasonably be assumed to result from programs that target easy to reach populations with less costly interventions.

all births in Bangladesh (WHO, 2013). These figures are multiplied to find the effect of balanced protein supplementation to reduce the rate of stillbirths in Bangladesh. All three of these benefit calculations are reduced by 10 percent, assuming some efficiency loss.

Each of these interventions also influences low birth weight, which has a variety of mechanisms to achieve economically measurable benefits. The mechanisms are presented in Behrman, Alderman and Hoddinott (2004) and Alderman and Behrman (2004). This analysis uses six of the seven mechanisms presented by BAH (2004) by which a reduction of low birth weight (LBW) among newborns leads to monetary estimates of benefits.

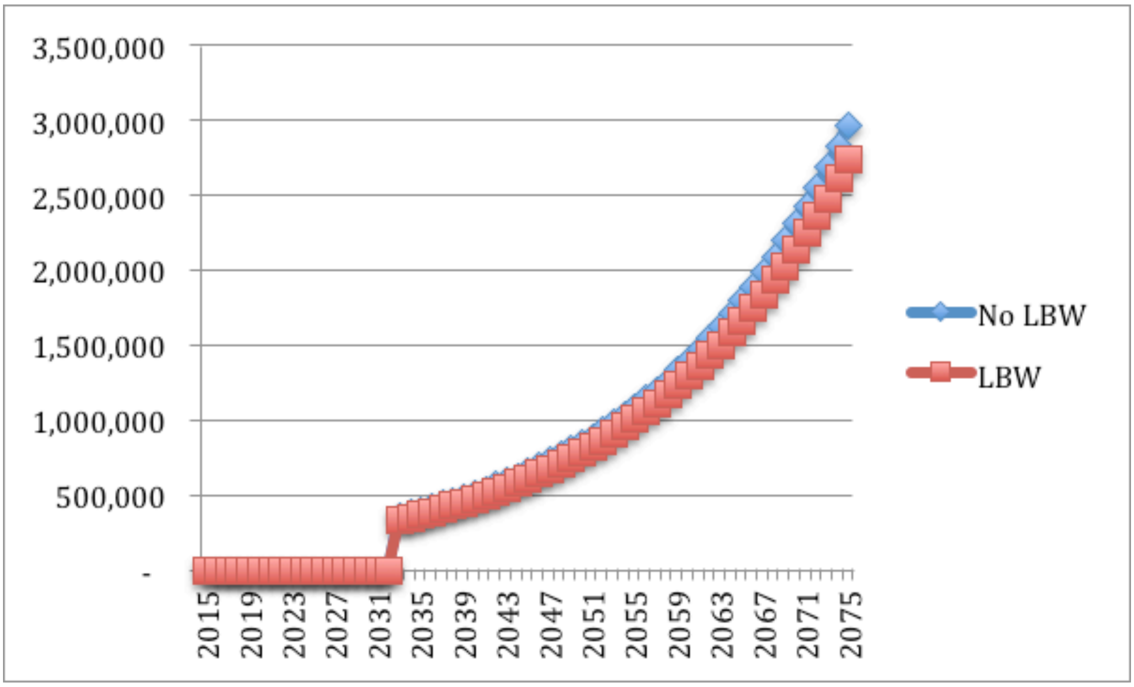
Under the first mechanism, a newborn that has moved from LBW to not LBW faces a lower probability of infant mortality by 7.8 percent (BAH, 2004). For each life saved, an economic value of 2015 GDP per working age individual of 147,630 is given per year of life saved, for 72 years, which is the average life span in Bangladesh. This is multiplied by the current rate of infant mortality in Bangladesh, 0.078 percent, and then discounted.

The second mechanism, reduced costs of neonatal health care, refers to the fact that a LBW newborn requires more medical attention after birth. BAH (2004) estimate a cost of $41.80 per LBW child, which is a balance of the costs of receiving medical attention during a homebirth and hospital bills, which are covered by both public and private funds.

The third mechanism consists of costs related to infant illnesses related to LBW, such as dehydration and pneumonia, among others. BAH (2004) quote approximately $40 of increased medical costs, experienced at age 1 and after; this must therefore be discounted.

The fourth and fifth mechanisms have a more substantial economic effect. Under the fourth mechanism, BAH (2004) approximate that income declines by 2.2 percent for person born with LBW, due to stunting, which affects schooling. Also, under the fifth mechanism, individuals born with LBW have reduced cognitive skills, which then influences income, the reduction estimated at 5.3 percent by BAH (2004). These are combined in the analysis of this paper as a 7.5 percent decline in wages from a not LBW individual to a LBW individual. The wage is assumed to increase by 5.13 percent, which is the average GNI per capita growth rate over the last ten years, with the wage of 2015 starting from an estimated average of BDT 147,630 per annum, which is based on the 2015 GDP per working age individual.

Figure 4. Path of Wages of LBW and not LBW Individuals, in BDT, 5.13% Growth



Source: Author calculations.

The difference in wages between not LBW and LBW individuals is notable under the wage growth rate of 5.13 percent. According to Figure 4, the average annual wage of the 18 year old in 2033 is BDT 363,191 for a not LBW individual, vs. 336,044 for a LBW individual. For the working life of 18 to 60 years old, the average difference in wages earned per year is nearly BDT 68,000. See Appendix 1 for an analysis using a growth rate of 3 percent.

The disease burden from LBW that occurs later in life is the sixth mechanism. BAH (2004) estimate that an individual with LBW has an 8.7 percent higher chance to fall victim to a chronic disease. BAH (2004) estimate that the economic impact is roughly equivalent to 10 years of income, and is experienced at age 60; they use an average income of $500. However, this analysis simply uses the last ten years of income from ages 50 to 60 of an LBW individual, which is reduced by 7.5 percent due to the fourth and fifth mechanisms described above.

In terms of the effectiveness of the three interventions, the influence of each supplement on the rate of LBW newborns in Bangladesh was made using the following approach. First, the analysis required an estimate of the current level of LBW births, which as described above, is not available. The analysis therefore used 15 percent as a conservative estimate of the current rate of LBW among all births. To find the effect of these interventions on the rate of LBW, the analysis took an estimated percentage of births that would fall into LBW given an overall rise in birth weight due to the given intervention.[4] Bhutta et al. (2013) present the following values as the average increase in birth weight if all pregnant women receive the supplement: 73 grams for balanced energy protein supplementation; 85 grams for calcium supplementation; and 57.7 grams for iron-folate supplementation. As a result, for balanced energy protein supplementation, 3.5 percent of births would move from LBW to not LBW; for calcium supplementation, 4.1 percent; and for iron-folate supplementation, 2.9 percent. All of the benefits described above would then be multiplied by this portion of the population that move from LBW to not LBW to find the average benefit from each pregnant mother that receives the given supplement. These must then be discounted to find the NPV.

There are a number of assumptions built into this approach. First, the analysis takes the assumption of a standard international effect of each of the interventions. However, given the present availability of some supplements in Bangladesh – iron in particular, it is unclear how much the approach is currently implemented, which may reduce the overall effectiveness rate of the intervention. The analysis also assumes that the average wage of a non-LBW is equivalent to the given estimated wage. The analysis further assumes that the interventions would be implemented in 2015, and tracks the results as such.

Benefit to Cost Ratios

The benefit to cost ratios (BCRs) for these interventions yielded generally positive results according to the analysis, though it is highly dependent on the discount rate. The results are presented by for the three interventions, with two tables for each: one describing the net present value of the discounted benefits, and one summarizing the benefit cost ratio for each. A sensitivity analysis with a three percent growth rate in wages is presented in Appendix 1.

[4] This was done by taking following steps. First, I assumed a normal distribution of birth weights in Bangladesh. Then, from UNICEF (2004), I derived the mean and standard deviation for the weight of newborns, and the current z score. I then estimated the current mean and z score, given that 15 percent of the population is LBW. I then increased that mean by the estimated average impact of the given intervention on birth weight, still using the previous standard deviation, which led to the decline in the percentage of newborns who are LBW.

Table 1. NPV Benefit Estimates of Iron-Folate Supplementation in Bangladesh, 5.13% Growth, in BDT

Description		Discount Rate		
		3%	5%	10%
1.	Maternal Mortality from Anemia	354.92	256.14	141.47
2.	LBW Infant Mortality	177.66	117.39	60.44
3.	LBW Neonatal Healthcare Costs	151.26	151.26	151.26
4.	LBW Infant Illness	140.53	137.85	131.59
5.	LBW Productivity Losses	27,676.87	12,421.21	2,251.66
6.	LBW Chronic Illness Costs	9,391.89	3,163.10	230.30

Source: Author calculations.

There are a variety of benefits due to iron-folate supplementation, and the analysis calculates six of them. Table 1 presents the Net Present Value (NPV) from iron-folate supplementation for pregnant women in Bangladesh. These may be interpreted as the average present benefits from each pregnant mother who has received iron-folate supplementation. By far, the largest effects are from items 5 (LBW Productivity Losses) and 6 (LBW Chronic Illness Costs). Because these benefits are experienced in the future, they decline dramatically depending on the discount rate. The NPV from items 1 (maternal mortality due to anemia) and 2 (infant mortality from LBW), are both quite low due to the overall limited rate of maternal mortality and infant mortality in Bangladesh.

Table 2. Benefit to Cost Ratio Estimates of Iron-Folate Supplementation in Bangladesh, 5.13% Growth

	Discount rate		
	3%	5%	10%
NPV (BDT)	37,893.13	16,246.96	2,966.70
Cost (BDT)	591.01	591.01	591.01
BCR	64.12	27.49	5.02

Source: Author calculations.

The BCRs for iron-folate supplementation of pregnant mothers in Bangladesh are quite high, depending on the discount rate. The three percent discount rate yields a BCR of 64.12; in other words, for every taka spent, the social and economic benefit is 64.12 taka. The rate for a five percent discount rate was 27.49, and 5.02 for 10 percent. These BCRs are the highest of the three interventions for the discount rates of 3 percent and 5 percent.

Table 3. NPV Benefit Estimates of Balanced Energy Protein Supplementation in Bangladesh, 5.13% Growth, in BDT

	Description	Discount Rate		
		3%	5%	10%
1.	Stillbirths	34,658.95	22,901.86	11,790.42
2.	LBW Infant Mortality	214.41	141.68	72.94
3.	LBW Neonatal Healthcare Costs	182.55	182.55	182.55
4.	LBW Infant Illness	169.60	166.37	158.81
5.	LBW Productivity Losses	33,403.11	14,991.12	2,717.52
6.	LBW Chronic Illness Costs	11,335.04	3,817.54	277.94

Source: Author calculations.

In Table 3, the various NPV of benefits from balanced energy protein supplementation for pregnant women in Bangladesh are presented. These may be interpreted as the average benefits from each pregnant mother who has received balanced energy protein supplementation. As with iron-folate supplementation, the largest effects are from items 5 (LBW Productivity Losses) and 6 (LBW Chronic Illness Costs). Because these benefits are experienced in the future, they decline dramatically depending on the discount rate. The NPV from items 1 (stillbirths) and 2 (infant mortality from LBW), are both quite low due to the overall limited rate of stillbirths and infant mortality in Bangladesh.

Table 4. Benefit to Cost Ratio Estimates of Balanced Energy Protein in Bangladesh, 5.13% Growth

	Discount rate		
	3%	5%	10%
NPV (BDT)	79,963.68	42,201.12	15,200.19
Cost (BDT)	2,529.99	2,529.99	2,529.99
BCR	31.61	16.68	6.01

Source: Author calculations.

The BCRs for balanced energy protein supplementation of pregnant mothers in Bangladesh are quite high, depending on the discount rate. The three percent discount rate yields a BCR of 31.61; in other words, for every taka spent, the social and economic benefit is 31.61 taka. The rate for a five percent discount rate was 16.68, and 6.01 for 10 percent. Balanced energy protein supplementation is the most expensive of the three interventions, which drives down the BCR.

Table 5. NPV Benefit Estimates of Calcium Supplementation in Bangladesh, 5.13% Growth, in BDT

	Description	Discount Rate		
		3%	5%	10%
1.	Maternal Mortality Hypertensive Disorders	129.99	105.91	68.96
2.	LBW Infant Mortality	249.33	164.75	84.82
3.	LBW Neonatal Healthcare Costs	212.28	212.28	212.28
4.	LBW Infant Illness	197.23	193.47	184.67
5.	LBW Productivity Losses	38,843.05	17,432.53	3,160.08
6.	LBW Chronic Illness Costs	13,181.03	4,439.25	323.21

Source: Author calculations.

Table 5 presents the NPV of benefits from calcium supplementation for pregnant women in Bangladesh. These may be interpreted as the average benefits from each pregnant mother who has received calcium supplementation. As is true for the other interventions, the largest effects are from items 5 (LBW Productivity Losses) and 6 (LBW Chronic Illness Costs). Because these benefits are experienced in the future, they decline dramatically depending on the discount rate. The NPV from items 1 (maternal mortality due to hypertensive disorders) and 2 (infant mortality from LBW), are both quite low due to the overall limited rate of maternal mortality and infant mortality in Bangladesh.

Table 6. Benefit to Cost Ratio Estimates of Calcium in Bangladesh, 5.13% Growth

	Discount rate		
	3%	5%	10%
NPV (BDT)	52,812.91	22,548.20	4,034.03
Cost (BDT)	1,881.30	1,881.30	1,881.30
BCR	28.07	11.99	2.14

Source: Author calculations.

The BCRs for calcium supplementation of pregnant mothers in Bangladesh are quite high, depending on the discount rate, but each still lower than the other two interventions. The three percent discount rate yields a BCR of 28.07; in other words, for every taka spent, the social and economic benefit is 28.07 taka. The rate for a five percent discount rate was 11.99, and 2.14 for 10 percent. The reasons the BCRs are less than other two interventions are due both to the relatively high cost of the intervention balanced by the limited effect on the reduction of LBW rates.

Discussion and Conclusion

According to the benefit cost ratio analyses presented in this paper, investments in each of the three nutrition direct interventions during pregnancy – calcium supplementation, iron-folate supplementation, and balanced energy protein supplementation – are sensible from an economic benefit point of view. This benefit is in addition to their important contribution to reducing peri-natal, infant and maternal mortality.

Table 7. Benefit to Cost Ratio Estimates from the Three Interventions in Bangladesh, 5.13% Growth

	Discount rate		
	3%	5%	10%
Iron-Folate Supplementation	64.12	27.49	5.02
Balanced Energy Protein Supplementation	31.61	16.68	6.01
Calcium Supplementation	28.07	11.99	2.14

Source: Author calculations.

Under both the three percent and five percent discount rates, iron-folate supplementation is the most rewarding in terms of the benefit cost ratio, at 64.12 for a three percent discount rate and 27.49 for a five percent discount rate. Interestingly, under the 10 percent discount rate, balanced energy protein supplementation is the most sensible investment, with a BCR of 6.01. This is due to the effectiveness of energy protein supplementation in preventing stillbirths.

However, there are several observations relevant to the analysis. First, as mentioned, the analysis is sensitive to the discount rate, with the lower discount rate of three percent obviously offering the highest return. This is particularly true for these interventions, as much of the benefit is driven by the income is generated by the not LBW individuals starting only at 18 years after the treatment of interventions. Second, the overall effectiveness of the intervention would increase greatly if it can target individuals most likely to be LBW. For example, if rural rates are much higher, then the interventions would be much more beneficial if targeted there. Third, the cost data does not take into account the costs of building the capacity of local institutions to not only deliver these interventions, but to deliver them consistently to all pregnant women who need them. Such a capacity is especially challenging in difficult to reach areas, particularly the Chittagong Hill Tracts. The capacity of government institutions that deliver nutrition direct interventions, such as the National Nutrition Services and the Community Clinics, are particularly in need of attention (Rose et al., 2014; Saha et al., 2015). Finally, as shown in Appendix 1, the analysis is sensitive to the projected wage growth rate; if growth would decline to just three percent, the benefits would decline dramatically.

Further research is needed on this topic, particularly among existing nutrition programs. Conducting a benefit to cost estimation based on the extensive local program experience would better identify the precise benefits and costs within Bangladesh. The diverse NGO sector of Bangladesh could also better target these interventions to the most needy populations, thus increasing the benefits from the program, and possibly resulting in much higher BCRs for the investments. This research could possibly yield enhanced benefits, and justify a much larger push for nutrition work on Bangladesh.

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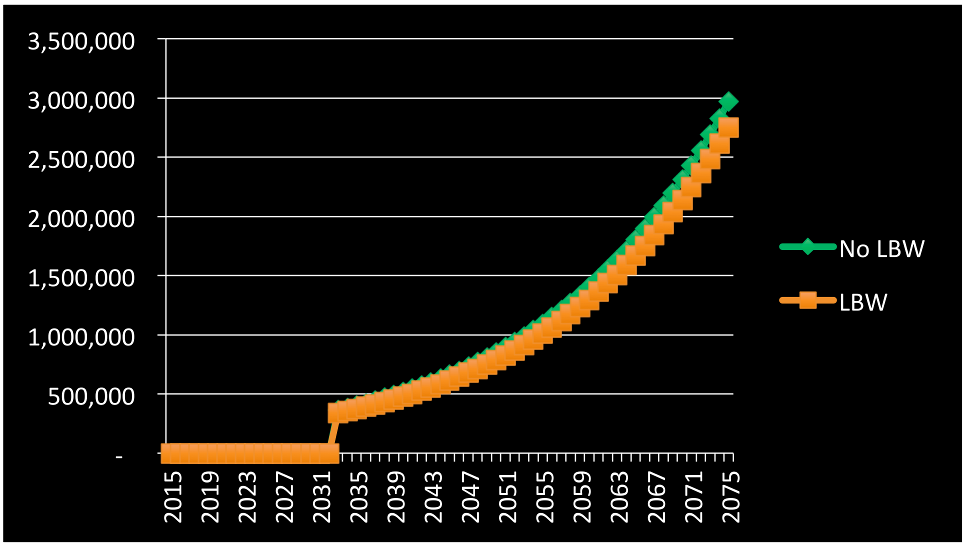
Appendix 1. Sensitivity Analysis: Path of wages for not LBW and LBW individuals assuming 3 percent wage growth

Figure i. Path of Wages of not LBW and LBW Individuals, in BDT, 3% Growth



Source: Author calculations.

The difference in wages between not LBW and LBW individuals is less substantial assuming a wage growth rate of 3 percent. According to Figure, the average annual wage of the not LBW 18 year old in 2033 is BDT 251,330, vs. BDT 243,790 for a LBW person. For the working life of 18 to 60 years old, the total difference in wages earned has an average of BDT 12,584.

The effect of this change in the growth rate of income is a decline in benefits regarding productivity losses from LBW (item 5), and a reduction in benefits regarding the costs of chronic illness (item 6). These changes are presented in Table i. For the iron folate supplementation under a three percent discount rate, the former declines from 27,677 to 4,826, and the latter from 9,392 to 3,157. For balanced energy protein supplementation, the changes are 33,403 to 5,824 and 11,335 to 3,810. For calcium supplementation, the changes are 38,843 to 6,773 and 13,181 to 4,430.

Table i. Comparison of NPV Benefits with Different Wage Growth Rates

Description	Discount Rate 3%	5%	10%
Iron-Folate Supplementation 5.13% Growth Rate			
5. LBW Productivity Losses	27,676.87	12,421.21	2,251.66
6. LBW Chronic Illness Costs	9,391.89	3,163.10	230.30
3% Growth Rate			
5. LBW Productivity Losses	4,825.78	2,300.29	475.72
6. LBW Chronic Illness Costs	3,156.96	1,066.69	78.27
Balanced Energy Protein Supplementation 5.13% Growth Rate			
5. LBW Productivity Losses	33,403.11	14,991.12	2,717.52
6. LBW Chronic Illness Costs	11,335.04	3,817.54	277.94
3% Growth Rate			
5. LBW Productivity Losses	5,824.22	2,776.21	574.14
6. LBW Chronic Illness Costs	3,810.12	1,287.39	94.47
Calcium Supplementation 5.13% Growth Rate			
5. LBW Productivity Losses	38,843.05	17,432.53	3,160.08
6. LBW Chronic Illness Costs	13,181.03	4,439.25	323.21
3% Growth Rate			
5. LBW Productivity Losses	6,772.73	3,228.34	667.65
6. LBW Chronic Illness Costs	4,430.63	1,497.05	109.85

Source: Author calculations.

For each of these BCRs, the reduction in the growth rate greatly reduces the outcome, particularly at the three percent growth rate. For iron-folate supplementation, the BCR is 64.12, which declines to 13.51. For balanced energy protein supplementation, the BCR is 31.61, and then shrinks to 17.73. And finally, for calcium supplementation, the BCR goes from 28.07 to 6.37.

Table ii. Benefit to Cost Ratio Estimates of Iron-Folate Supplementation in Bangladesh, 3% Growth

	Discount rate 3%	5%	10%
NPV (BDT)	7,982.74	3,366.98	553.99
Cost (BDT)	591.01	591.01	591.01
BCR	13.51	5.70	0.94

Source: Author calculations.

Table iii. Benefit to Cost Ratio Estimates of Balanced Energy Protein Supplementation in Bangladesh, 3% Growth

	Discount rate		
	3%	5%	10%
NPV (BDT)	44,859.87	27,456.06	12,873.34
Cost (BDT)	2,529.99	2,529.99	2,529.99
BCR	17.73	10.85	5.09

Source: Author calculations.

Table iv. Benefit to Cost Ratio Estimates of Calcium in Bangladesh, 3% Growth

	Discount rate		
	3%	5%	10%
NPV (BDT)	11,992.19	5,401.80	1,328.24
Cost (BDT)	1,881.30	1,881.30	1,881.30
BCR	6.37	2.87	0.71

Source: Author calculations.

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