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ACTION AGAINST HUNGER
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GRADE
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The economic impact of anaemia in Peru

Lorena Alcázar[1]

1 With the valuable participation of Diego Ocampo and Juan Pablo De la Torre. We are grateful for the comments provided by Susan Horton and the ACF team in Peru, as well as the support provided by MINSA and San Bartolome Hospital in providing the necessary information.

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Index

Prologue

Iron-deficiency anaemia is one of Peru's biggest public health problems. With prevalence rates in children from 6-35 months standing at over 40% nationally and over 60% in several regions (that is, around three quarters of a million child sufferers), fighting anaemia should be a priority for the country, bearing in mind the evidence we have of anaemia's negative impact on human development. The state, however, has yet to show purposeful plans for dealing with anaemia, underlined by the condition's absence from the First 100 Days Report published by the Peruvian Ministry of Development and Social Inclusion (MIDIS)[2].

How can we ensure this issue permeates through the public institutions in charge of preventing and controlling this nutritional deficiency, thus generating political will leading to greater investment in line with the extent and implication of the problem?

Acción contra el Hambre (Action Against Hunger – Spain)[3] considers that there are a range of mechanisms available for ensuring greater action by the state, such as identifying and disseminating the extent of the problem at local, regional and national levels and contributing to understanding and analysing the causes of anaemia and the serious human consequences it brings in its wake. We must also identify the sociocultural aspects that allow us to answer the following questions – "In addition to the biological aspects, what are the other determining factors of anaemia? How does the population understand

2 MIDIS 100 días: Rendición de Cuentas y Lineamientos Básicos de la Política de Desarrollo e Inclusión Social (*MIDIS 100 Days: Accountability Report and Basic Policy Lines for Development and Social Inclusion*). 2012. Ministerio de Desarrollo e Inclusión Social, Lima-Peru.

3 Action Against Hunger - Spain is a non-political, non-religious, non-profit foundation that has been working in Peru since 2010 on an intervention focusing on positioning the fight against anaemia both nationally and regionally and gathering evidence on innovative and cost-effective alternatives for reducing the prevalence of anaemia.

the problem? How does it perceive and live with the condition?” Action Against Hunger – Spain has carried out a range of studies in this respect and they are available on request.

Substantiating the situation is also important. How much money do the effects of such high levels of anaemia cost Peru? How much does the country lose financially? In what ways is this loss demonstrated? In which of the country’s regions is this loss most significant? To what is it equivalent in terms of public investment if we compare it with current spending?

Answering these questions is the goal of this study, which Action Against Hunger – Spain proposed to GRADE in May 2012, after consulting with the World Bank in Lima. We also contacted Dr Susan Horton of the University of Waterloo, Toronto, as the co-author of one of the few similar studies on the issue – “Economic Consequences of Iron Deficiency” (The Micronutrient Initiative, Horton-Ross, 1998) – and she kindly reviewed this study. Finally, this research could not have been carried out without the close collaboration of the Ministry of Health, which provided the necessary data for undertaking the study.

Action Against Hunger – Spain would like to sincerely thank all these agents, with special thanks going to the study’s author, Dr Lorena Alcazar of GRADE.

We hope the results of this study will help situate the importance of fighting anaemia at the level required by a problem that affects the present and future of Peru, that is, its children.

Iñigo Lasa
Country Director - Acción contra el Hambre Perú
(Action Against Hunger Peru)

Prologue

This interesting study undertaken at GRADE estimates the cost of anaemia for Peru as a whole, as well as disaggregated by region. Anaemia remains a serious issue in many countries, and in Peru it is exacerbated by the fact that some of the population live at higher altitudes and hence have higher iron needs. The Peruvian government has recognized the importance of the issue and this study will help them to take steps to improve iron status.

Because iron is needed for various processes in the body, iron deficiency has various deleterious outcomes. In this study the two key outcomes modeled are the effects on adult productivity, and the far-reaching effects of deficiency in childhood on cognitive outcomes, which in turn lead to lower educational attainment, and in the future on adult productivity. Given that interventions to improve iron intake can be relatively inexpensive and are effective and safe, this suggests that these interventions should be a high priority for policy.

I hope that these interesting estimates can help to strengthen the case for policies to help improve the nutritional status of Peruvian households.

Susan Horton
CIGI Chair in Global Health Economics, Waterloo University, Canada

Prologue

Iron deficiency anaemia is one of the most common nutrition problems in developing countries. Our country also faces this problem, and for this reason the State has proposed to prioritize interventions to reduce iron deficiency anaemia in order to improve the nutrition of our children and expand their potential for development in the future. Increased financial resources have been assigned for this issue through the Coordinated Nutritional Program (PAN) within the Budget for Results, and anaemia prevention and treatment has been incorporated in the Essential Plan for Health Insurance. In this manner, promotion and prevention activities are being financed directly through the Health Services, as well as the activities necessary for diagnosis and treatment, financed through Integral Health Insurance.

In this framework, it is worthwhile to point out the contribution to policy formulation as well as to the field of investigation offered by the study "The economic cost of anaemia in Peru" undertaken by the institution GRADE with patronage from the organization Action Against Hunger. The study, whose results go beyond the area of sanitation, helps to shed light on the social and economic implications of this illness.

From a **political perspective** the study is important in terms of the evidence offered regarding the high economic cost of neglecting to intervene adequately to reduce the high prevalence of cases of iron deficiency anaemia in Peru, as this illness negatively affects cognitive abilities in children and productivity in adults. In this sense, it is a call to action for policy makers to accelerate efforts to prevent this illness in the country, by re-evaluating strategies, improving intersectoral coordination and/or increasing resources.

From an **instrumental perspective**, the study offers the scientific community a comprehensive analytical framework and an innovative methodology for measurement, adapted from International literature, which facilitate the construction of more elaborate models to calculate cost – effectiveness, in order to select and evaluate anaemia prevention and treatment interventions more suitable for the Peruvian context.

For these reasons we salute Action Against Hunger and GRADE for their commitment to the development and circulation of evidence regarding the magnitude and consequences of this public health problem and for their contribution to the design of cost-effective and sustainable strategies to solve it, facilitating our fight against the severe nutrition problems that affect children and gestating mothers in the country.

Midori de Habich
Minister of Health

Introduction

Anaemia is one of the world's biggest health problems. According to the World Health Organization (WHO), in 2005, anaemia affected 1.62 billion people worldwide (24.8% of the global population). Preschool children were the social group that showed the highest prevalence of anaemia, with an impact rate of 47.4%, followed by pregnant women at 41.8%. The global prevalence of anaemia among other population groups stands at 25.4% for school-age children and 23.9% for the elderly, 30.2% for non-pregnant women and just 12.7% for adult males[4].

The main cause of anaemia is iron deficiency, although it generally exists alongside other causes such as malaria, parasitic infections or malnutrition[5]. Anaemia is a threat to individual health in that it exposes sufferers to after-effects that will last for the rest of their lives. According to Stoltzfus, Mullany & Black (2004), for example, anaemia is both a direct and indirect contributing factor to death and disability and the authors believe that anaemia is a risk factor associated with infant mortality, maternal mortality, perinatal mortality and low birth weight. It is also the direct cause of reduced productivity and cognitive impairment, which in turn affect the quality of life of sufferers for the rest of their existence.

According to the WHO, anaemia in Peru is a severe public health problem that affects more than 50% of preschool children, 42% of pregnant women and 40% of non-pregnant women of reproductive age[6]. These prevalence levels make

4 World Health Organization (2008), "*Worldwide Prevalence of Anaemia 1993 – 2005. WHO Global Database on Anaemia*".

5 Anaemia is mainly caused by a lack of iron in the blood; however, other causes include a lack of micronutrients, such as vitamin A, vitamin B12, Folate or Riboflavin and the presence of infections such as Malaria or Tuberculosis.

6 World Health Organization (2008), "*Worldwide Prevalence of Anaemia 1993 – 2005. WHO Global Database on Anaemia*".

Peru the South American country that suffers anaemia the most (matching only Guyana) and puts it in a similar situation to most African countries.

In spite of the important role of anaemia in Peruvian society, the magnitude of the problem has not been acknowledged. The same can also be said for its consequences and costs for the country[7]. Furthermore, in spite of being a persistent problem over time, the Peruvian state has not developed a systematic policy for fighting iron-deficiency anaemia. Given that anaemia is a considerable burden on individual development from an early age, it can be said that the condition not only affects the lives of those who suffer it, but that it also affects society as a whole, both socially and economically. In this respect, it is important to bear in mind that anaemia, while leading to economic costs for the State in terms of healthcare spending, also generates a long-term burden for society. These costs must therefore be considered when evaluating interventions that fight the condition and mitigate its effects both individually and for society as a whole.

The aim of this study is to identify, estimate and explain the economic costs for the Peruvian state and economy caused by the current prevalence of iron-deficiency anaemia. Specifically, our aim is to find the economic costs that arise from the prevalence of anaemia among adults, by analysing and explaining its current impact on Peru's economy, by estimating the future economic costs for the Peruvian economy of the current prevalence of anaemia among children and by estimating the costs incurred by the state from the anaemia-related care provided, as well as that related to consequent health problems. Furthermore, the study also undertakes an estimation of the costs that the Peruvian state would incurred in order to prevent anaemia among children and pregnant women. The aim of this is to show the importance and implications of the problem and the possible savings and benefits of a stronger, more systematic and more effective policy for fighting anaemia.

7 For example, the new Ministry of Development and Social Inclusion (MIDIS) makes no reference to the anaemia problem in its report on its first 100 days in operation.

1. Anaemia in Peru

Anaemia is a problem that affects almost all countries. In Latin America, anaemia is a moderate or severe public health problem in almost all countries, except for Argentina and Uruguay, where it is a mild problem. Peru is at the opposite extreme, where anaemia is a severe public health problem regardless of population group, as shown in the following table.

Table 1
Prevalence of anaemia in Latin American countries
1993 – 2005

Group	Children under 5 years old		Pregnant women		Non-pregnant women of reproductive age	
Country	Prevalence	Level of the problem	Prevalence	Level of the problem	Prevalence	Level of the problem
Argentina	18%	Mild	25%	Moderate	18%	Mild
Bolivia	52%	Severe	37%	Moderate	33%	Moderate
Brazil	55%	Severe	29%	Moderate	23%	Moderate
Chile	24%	Moderate	28%	Moderate	5%	Not a problem
Colombia	28%	Moderate	31%	Moderate	24%	Moderate
Ecuador	38%	Moderate	38%	Moderate	29%	Moderate
Guyana	48%	Severe	52%	Severe	54%	Severe
Paraguay	30%	Moderate	39%	Moderate	26%	Moderate
Peru	**50%**	**Severe**	**43%**	**Severe**	**40%**	**Severe**
Suriname	26%	Moderate	32%	Moderate	20%	Moderate
Uruguay	19%	Mild	27%	Moderate	17%	Mild
Venezuela	33%	Moderate	40%	Moderate	28%	Moderate

Source: World Health Organization (2008), "Worldwide Prevalence of Anaemia 1993 – 2005". Compiled by author

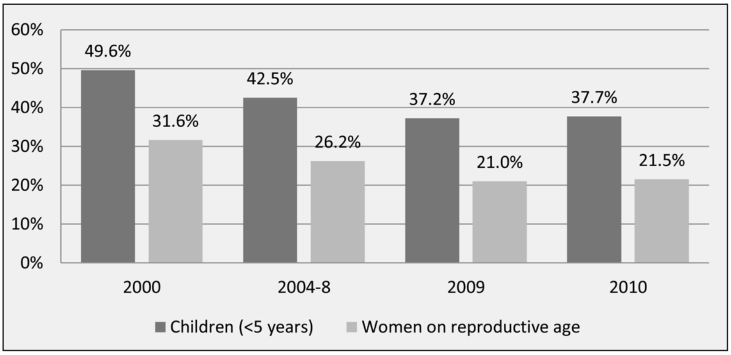
Within this context and through the *Plan Nacional de Acción por la Infancia y Adolescencia 2002-2019* (National Action Plan for Children and Adolescents

2002-2019) and the *Plan Nacional Concertado de Salud 2007-2020* (Official National Healthcare Plan 2007-2020), the Peruvian government has set out a national commitment to reducing iron-deficiency anaemia in children under 5. It specifically proposes a strategy of supplementing diets with multi-micronutrients, which is aimed at girls and boys of between 6 and 35 months and which was initially implemented through a pilot scheme in the regions of Apurímac, Ayacucho and Huancavelica. This approach provided assistance to 110,000 children and was subsequently extended from 2011 to 13 new regions (Cusco, Puno, Pasco, Ucayali, Junín, Arequipa, Moquegua, Huánuco, Amazonas, Áncash, Loreto, Cajamarca and Lima region) and two districts of Lima (Villa María del Triunfo) and Callao (Ventanilla). The scheme has been a joint effort by the Peruvian state, the World Food Programme (WFP) and United Nations Children's Fund UNICEF since 2010, with the aim of improving the consumption of micronutrients among children and fighting anaemia. Furthermore, the Peruvian state considers the prevalence of anaemia in children under 36 months to be a key goal within the *Programa Articulado Nutricional* (Nutritional Programme), which is one of the Ministry of Economy and Finance's strategic programmes, involving actions from several different ministries and government agencies. Another policy implemented by the government involves free distribution of ferrous sulphate to expectant mothers (who are affiliated to the Peruvian public healthcare insurance programme *Seguro Integral de Salud*) during their antenatal check-ups. The measure aims to fight anaemia in pregnant women while also safeguarding the health of newborns.

In order to better understand the important role that anaemia plays in Peruvian society, the information on the prevalence of anaemia in recent years must be made subject to detailed review. According to the National Monitoring Programme for Nutritional Indicators (MONIN), in 2008-2009, anaemia affected 43.4% of children from 6 to 35 months in Peru. ENDES (a survey on demographics and family health), meanwhile, provides similar results to those provided by MONIN. As of 2010, the national rate for the prevalence of anaemia in children under 5 stood at 37.7%, while the rate for women of reproductive age was 21.5%. Meanwhile, SIEN (Nutritional Status Information System) highlights that, in 2010, 25% of pregnant women suffered from anaemia, with the highest prevalence rates among women from the southern and central mountain range.

The evolution over time of the prevalence of anaemia among children under 5 and women of reproductive age in Peru may be observed in Graph 1[8].

Graph 1
Prevalence of anaemia according to population group



Source: ENDES

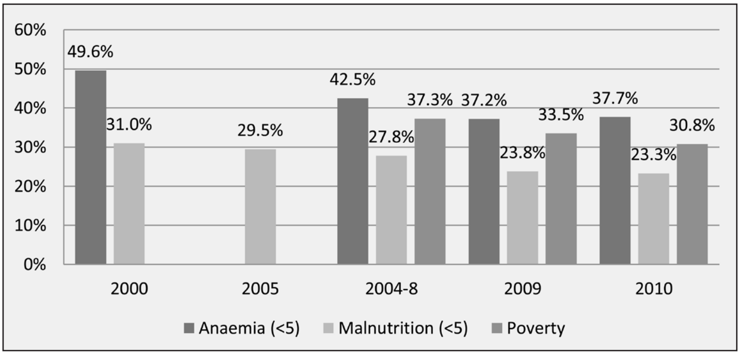
The progress over time of the prevalence of anaemia in children under 5 is compared with that of chronic malnutrition and poverty in Graph 2. Firstly, it is worth noting that, over time, the prevalence of anaemia is higher than that of malnutrition. Another factor that may be observed, as in the case of malnutrition, is that the prevalence of anaemia has remained constant over the past two years. In contrast, the poverty rate has continued to decrease slightly in recent years[9].

8 According to MONIN 1997 – 2001, with a non-comparable sample, the prevalence of anaemia in infants stood at 44% in 1997, 33% in 1998, 40% in 1999 and 42.1% in 2000. Meanwhile, in women of reproductive age, the prevalence of anaemia was registered according to the following percentages from 1997 to 2000 respectively: 37.1%, 31.9%, 32.2% y 40.9%.

9 INEI, Technical Report. The Evolution of Poverty 2004 – 2010. Methodological update.

Graph 2

Prevalence of anaemia, malnutrition and poverty



*For malnutrition, the period goes from 2007-2008

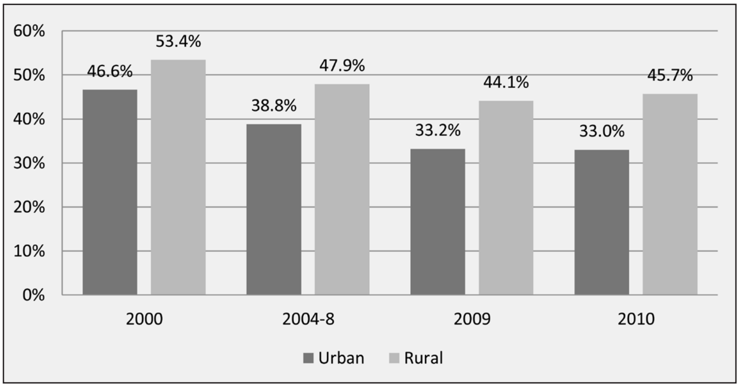
Malnutrition is measured according to the WHO standard (Z score under -2 S. D.)

The graph considers the poverty line as outlined by INEI

Furthermore, it must be highlighted that anaemia affects different population groups in different ways. That is, more children under 5 are affected in rural areas than in urban areas. Graph 3 shows that while the prevalence of anaemia has fallen in both areas, the urban-rural gap has increased over the past decade. According to ENDES 2010, gender differences among children, unlike adults, are not significant. The prevalence of anaemia among boys under 5 stood at 38.9% while for girls the rate was 36.5%.

Graph 3

Prevalence of anaemia in children under 5



Source: ENDES

The high prevalence of anaemia among women of reproductive age and especially among pregnant women is a risk to the health of both the child and its mother, given that anaemia is directly related to preterm birth. The main outcome of this is low birth weight, which is linked to serious health problems for children[10]. Furthermore, one of the main causes of maternal morbidity is miscarriage, which is also related to preterm birth (which is, in turn, related to the anaemia suffered by the mother).

There is evidence to show that anaemia poses a severe health problem in Peru with both immediate and long-term consequences – the former because it generates problems among the current population and the latter because these problems have long-term effects. Consequently, anaemia-related care should be a priority for public policy.

10 Babies with a low birth weight may suffer from respiratory distress syndrome, they suffer an imbalance in salt or water quantities, or insufficient sugar in the blood (hipoglaecemia), which can cause brain damage. A premature baby can be anaemic (insufficient red blood cells), given that it has not had enough time to store iron. Babies with a low birth weight may not have enough fat to maintain normal body temperature, which in turn can cause biochemical changes in the blood and lead to slower growth.

2. Conceptual Framework

The main function of iron, due to its chemical properties, is transporting and storing oxygen. According to Haas & Brownlie (2001), the importance of iron for the body comes from its role in energy production. Meanwhile, Beard (2001) provides evidence of the importance of iron in relation to the proper functioning of the immune system, the nervous system, energy production and metabolism. Consequently, iron deficiency – the main cause of anaemia – and anaemia are both risk factors for individual health and long-term development in several different ways.

A range of authors (Stoltzfus, Mullany & Black, 2004; Ross & Horton, 1998; Walter, 2003; Lozoff *et al.*, 2006) show that anaemia causes deficiencies in children's cognitive development, especially in terms of psychomotor, cognitive and socialisation skills. Lozoff *et al.* (1998) found among a sample of children in Costa Rica that children with iron deficiencies have reduced attention spans, they are more shy and hesitant, are less persevering, less happy and lacking in their motor skills development. Similarly, Nokes, van den Bosh & Bundy (1998) found evidence that children with anaemia, as well as the aforementioned problems, suffer from lower attention levels[11], reduced ability to respond when stimulated and negative effects on their moods.

Palti *et al.* (1985), in a study relating to Israel, found evidence of the long-term effects of iron-deficiency anaemia, by comparing the results from intelligence tests carried out on 10-year-old children who suffered from anaemia during the first months of their lives compared with children who did not. The study found that

11 Attention is the ability to capture stimulants and select those that reach us. Attention plays a fundamental role in the learning process. Without attention, one cannot learn; it is the energy that sets off and maintains learning processes, it is the body's activation mechanism for showing an interest in, selecting and processing stimulants. Source: Red educa: A portal of resources for psychology, education and similar disciplines (http://www.reeduca.com/atencion-aprendizaje-tutoria.aspx).

the children who suffered from anaemia during the first nine months, at 10-13 years of age, registered 2.2 points less in the tests than those who did not suffer from the condition[12]. Furthermore, studies such as Walter *et al.* (1989, 1990) have found that even though anaemia was cured after the first year, the negative effect on a child's cognitive development is not reversed, given that the children who suffered anaemia continue to register lower scores in cognitive development tests compared with those who did not. These authors found that, at five years of age, children who suffered from anaemia during the first 12 months of their lives registered average IQ levels 5 points lower than those who did not suffer from the condition. Similarly, Cantwell (1974) found in a sample of children from the United States, that those who suffered from anaemia between the first 6 and 18 months of their lives had an average IQ level 6 points lower when compared with children who did not. In a longitudinal study, Lozoff *et al.* (1991) discovered that the children who had suffered from anaemia between 12 and 23 months scored 4.1 points less in cognitive skills tests at 5 years.

For preschool children (2-5 years), Nokes, van den Bosh & Bundy (1998) report that iron-deficiency anaemia mainly affects attention spans, the ability to retain concepts and mood. Pollit *et al.* (1978) and Pollit *et al.* (1983) found evidence that (iron-deficiency) anaemia has a negative effect on memory, attention and acquiring new concepts. Nevertheless, after receiving treatment, children reverse the negative effect of iron deficiency on attention and memory, but not on the acquisition of new concepts.

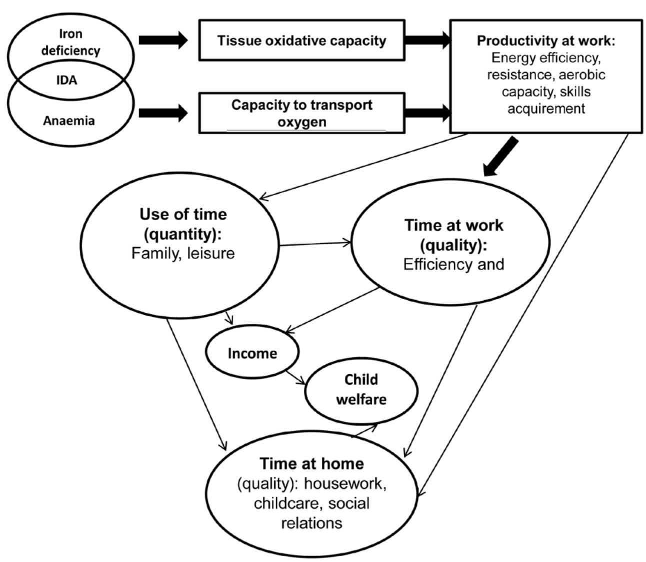
Soemantri *et al.* (1985) found among a sample of children between 10 and 11 years in Indonesia that the anaemic children did not show lower levels of cognitive development than the healthy children. Nevertheless, they did perform worse within the education system – something that cannot be fully corrected by treating the condition. Furthermore and along similar lines, Gaviria & Hoyos (2011) found in Colombia that anaemic children's chance of being over-age in their school year is 5% higher than for healthy children.

In terms of adults, it has been found that anaemia is associated with a reduction in the ability to carry out tasks that require manual work or intense

12 When rating children according to the Shaefer Classroom Behavior Inventory (CBI), which also included measurements of learning progress.

physical activity, consequently leading to reduced productivity. This is because a lack of iron leads to less oxygen in the blood and reduced capacity in terms of using the oxygen as fuel for muscle-related work. Along the same line, Haas & Brownlie (2001) undertook a review of the effects of iron-deficiency anaemia and found that it has a negative effect on the productivity of physical effort. The authors provide the following conceptual model in order to understand the way anaemia and iron deficiency affect the lives of adult sufferers.

Graph 4
The relationship between anaemia and individual productivity



Source: Haas & Brownlie (2001). IDA: Iron-Deficiency Anaemia

Graph 4 shows how anaemia and/or iron deficiency mainly affect sufferers' abilities and, consequently, have a negative effect on the lives of individuals and their families. Basta *et al.* (1979), in a study in Indonesia with a sample of males working at a rubber plantation, found that those who received iron supplements registered productivity rates 17% higher than anaemic workers[13]. Meanwhile,

13 This is the estimate used by Ross & Horton (1998) in a study discussed below.

Li *et al*. (1994) also observed an increase in productivity of 17% among women working in cotton thread factories in China after receiving treatment with a food supplement that included iron.

Anaemia and/or iron deficiency among pregnant women also influence the success of labour and the health of the newborn. It is worth noting that the literature has only succeeded in measuring the causal relationship between anaemia and preterm birth, but not with low birth weight, maternal morality or perinatal mortality. According to Scholl *et al*. (1992), women with anaemia are 2.7 times more likely to go into preterm labour than women who do not suffer from the condition. Allen (2000), meanwhile, after having carried out an extensive review of related literature, also confirms the existence of a relationship between anaemia in pregnant women and preterm birth. Murphy *et al*. (1986) found in a sample of women from Wales that those diagnosed with anaemia between weeks 13 and 24 of pregnancy have a relative risk of preterm birth 1.18-1.75 times higher than those who did not suffer from the condition.

3. Methodological Framework

3.1 The Basic Model

The methodology used in this study, which is mainly based on the one developed by Ross & Horton in 1998 (as part of the Micronutrient Initiative), establishes a model that estimates the economic impact of iron-deficiency anaemia based on three main points: the loss of future work productivity among children who currently suffer from anaemia, the loss of work productivity among adults who currently suffer from anaemia and the cost associated with caring for women who gave birth prematurely due to anaemia. We must also mention that the literature identifies other anaemia-related costs, but they are not considered in this study due to a lack of academic consensus or insufficient information. One example would be the opinion of Stoltzfus, Mullany & Black (2004), who suggest that anaemia has a major effect on infant mortality, maternal mortality and perinatal mortality. Furthermore, the methodology does not consider the cost of anaemia in terms of Disability-Adjusted Life Years (DALY), given that there is insufficient information for implementing this methodology and neither are there studies providing information for Peru.

This model uses macro-level data and the exposure to the risk of anaemia among the different population groups, in order to extrapolate the cost of anaemia to the national context. In other words, by combining the economic information and weighting it with the presence of anaemia and its effects on individuals, it may be estimated how much the illness costs the Peruvian economy.

Our study uses the basic empirical model developed by Ross & Horton (1998) for estimating the cost of anaemia (based on the current prevalence of anaemia), which is derived from the loss of human capital and productivity among children and adults. In order to be able to better adjust the estimates to

Peru's economy and the country's conditions, some national parameters have also been incorporated. Furthermore, we also include some cost elements that are not included in Ross & Horton (1998)'s methodology, such as the late start in formal education due to anaemia and the economic cost of this for the Peruvian state. Finally, by slightly modifying the original methodology, new estimates are made both nationally and according to regions. This modification leads to a consistent estimate that allows regions to be compared. This was not possible with the initial methodology, as it did not have access to the information relating to wage share at a regional level.

The estimates of the impact of anaemia are based on three main elements. The first is cost in terms of loss of current work productivity caused by reduced cognitive development among adults who suffered from anaemia during childhood, in line with the following equation:

*Cost due to cognitive impairment = Effect on wage * WS * GDPcap * Prob(child)… (1)*

Where *Cost due to cognitive impairment* is the reduction in GDP through reduced cognitive development among children due to having suffered anaemia[14], *Effect on wage* is the effect of iron-deficiency on wage (iron-deficiency leads to reduced development of cognitive skills, which later leads to reduced work productivity and, consequently, lower wages). Meanwhile, *WS* stands for wage share within the context of national production, that is, the total value of all the economy's wages as a percentage of total production. *GDPcap* is Gross Domestic Product per capita and *Prob(child)* is the probability of a child suffering from anaemia (measured as the prevalence of anaemia).

The information regarding the effect of cognitive impairment on wages is especially important in the previous equation. In terms of the estimates, the assumption accepted by Ross & Horton (1998) is used, which accepts that the negative effect of anaemia on wage stands at 4%. This estimate is taken from Pollit (1993), in which an anaemic boy or girl registers a lower score with average

14 It is assumed that the prevalence of anaemia in infants who are now adults was similar to current rates among chidren.

standard deviation than a healthy boy or girl in cognitive development tests[15]. Then, by using the estimate established by Psacharopoulos & Velez (1988) that standard deviation in IQ represents between 7% and 9% more in wages, they calculate that the effect of anaemia in terms of wage stands at 4% (anaemia reduces IQ in average standard deviation and standard deviation in IQ affects wages at an average rate of 8%; i.e. anaemia reduces wage performance by 4%).

As well as the estimate using the prior equation, this study makes an estimate of the additional cost, based on the methodology established by Martínez and Fernández (2006) for estimating the cost of malnutrition. The authors suggest that malnutrition affects development and educational achievement in two ways. First, through reduced development of cognitive skills among children due to malnutrition, which reduces the children's abilities for the rest of their lives. Second, through the impact on their progress within the education system, which is reduced, because malnourished children who go to school have less energy and a reduced attention span. Both channels may be applied to the case of anaemia, as shown in the previous section[16].

As mentioned previously, as well as measuring the effect of anaemia on wages through the loss of IQ, the methodology also includes the effect of anaemia on the lost years of education combined with the effect of repeating a school year on the job market. In short:

*Loss due to schooling = Years of schooling lost * Return on education * WS * GDPcap * Prob(child) … (2)*

Where *Loss due to schooling* represents the cost or loss for GDP due to the negative effect of anaemia on children's schooling, *Years of schooling lost* are

15 In the different cognitive development tests, the skills that individuals should have developed up to a certain age are measured. The Intelligence Quotient (IQ) is a standardised measurement of the possession of these skills bearing in mind the person's age.

16 It can be said that both mechanisms overlap, but there are two reasons for counting them separately. The former assumes that going to school develops skills that may only be acquired through the education system and that, furthermore, going to school in itself is valuable in the context of the job market. The second reason is that the estimated effect of cognitive development on wages, as suggested by Psacharopoulos & Vélez (1998) does not include the effect of the years of schooling, given that when regression is applied, it is also controlled by this variable.

the number of years of schooling lost by children due to anaemia (given the combination of the effect of anaemia on cognitive development and the effect of this on schooling or the number of years of education registered). *Return on education* is the return on wages of one more year of education. This element is included because, given that anaemia has a negative effect on the educational performance of children who suffer from the condition, it is assumed that in a situation of poverty, the probability of students leaving school early increases (in comparison with healthy children).

With this modification, which comes about by adapting the model proposed by Martínez & Fernández (2006), we have the option of combining the effect of anaemia with education and education with the job market. While the original model includes the effect of anaemia on IQ and its importance in terms of wages, it ignores the intrinsic importance of education in the job market. Given that the effect of IQ on salary is net of schooling and work experience (Psacharopoulos & Vélez, 1988), this variant – cost due to fewer years of schooling – should be added to measuring the cost caused by cognitive impairment.

In addition, the effect of anaemia on the level of schooling includes the option of estimating and adding the direct cost assumed by the Peruvian state arising from a possibly higher rate of school-year repetition among children due to anaemia. This is carried out by using the prevalence of anaemia according to age group and the increase in the probability of suffering from over-age in the school year due to anaemia (as an approximation of the probability of repeating a school year). In line with Martínez & Fernández (2006), this information is combined with the information from the Ministry of Education concerning expenditure per student and the amount of students in state schools throughout the country. That way, an estimate is obtained of the economic burden of anaemia for the Peruvian State in terms of increased educational costs.

These social and educational costs (*SocEDC*) are calculated in the following way:

$$CsocEd = \sum_{c=1}^{Z} YearsRep_c * CO\,p_c \;\ldots\; (6)$$

Where:

- YearsRepc= Amount of "c"-level years repeated due to anaemia.
- C Opc= The operational costs of an academic year per pupil at "c" level.
- C = 1 (Primary) or 2 (Secondary).

Meanwhile, the amount of repeated years are calculated in the following way:

$$YearsRep = \sum_{z=1}^{Z} \Delta p * A_n N_z \ldots \quad (7)$$

Where

- Δp = The difference in the probability of repeating an academic year if a child has suffered anaemia before he/she was 5[17].
- An_Z = The prevalence of anaemia at 0-4 years among the age group currently studying each grade (z).
- N_Z = The size of the student population that must study in each school grade (z), according to age.

The second element of the methodology used is also based on the model proposed by Ross & Horton (1998). This element aims to measure the economic burden of a loss in work productivity among adults who suffer from anaemia at the time of estimation. Given that the symptoms of anaemia (especially iron-deficiency anaemia) include fatigue and lethargy, it is to be expected that these problems affect adults' performance at work. This is because one of the main roles of haemoglobin is as an iron-based protein that transports oxygen from the lungs to the muscles, brain and all other tissue. Consequently, the bodies of anaemia sufferers have problems in transporting the necessary amount of oxygen to their muscles and brain in order to support demanding activities over prolonged periods of time (physical work carried out throughout the working day). This would especially affect those whose tasks involve sustained physical effort (agricultural workers, labourers, etc), thus leading to a drop in productivity over the course

17 The difference in the probability of repeating an academic year due to anaemia in Colombia has been estimated as 4.6% (Gaviria & Hoyos, 2011). This calculation will be used when considered valid for Peru.

of the working day. Given that this kind of work is usually paid by the piece, income is directly linked to the amount produced and, consequently, fatigue caused by anaemia has a negative effect on the amount an individual produces and, consequently, earns.

In this second element, the estimate of the economic cost of anaemia is carried out according to the following equation:

*Cost due to loss of productiv = [Loss of productiv I * WS * % Manual Labour * GDP/cap * Prob(adult)* + [Loss of productiv. II * WS * % Intense Manual Labour * GDPcap * Prob(adult)] … (3)*

Cost due to loss of productiv represents the cost for GDP of the loss of work productivity in adults who suffer from anaemia and it is made up of two parts. The first part corresponds to the lost of productivity among individuals who carry out manual labour and, thus, the percentage of the Labour Force that carries out this kind of work (*% Manual Labour*), without it being highly demanding (*Loss of productiv. I,*) – that is, technical staff, machine operators, salespeople – is used as a weighting factor. The second part measures the loss of product (*Loss of productiv. II*) due to low levels of productivity in the individuals who carry out highly demanding physical work, weighted against the percentage of the Labour Force that carries out this kind of work (*% Intense Manual Labour*). They include labourers or agricultural workers. Finally, both elements are weighted against the probability of an adult suffering from anaemia – *Prob(adult)*.

Ross & Horton (1998) had originally suggested that the loss of work productivity in adults stands at 5% when undertaking manual but not mainly physical work (blue collar) and an additional 12% is added when undertaking work that requires major physical effort. Nevertheless, and in line with Ross & Horton (1998), given that for the first element the cost of cognitive impairment in childhood due to anaemia is estimated in relation to adult wages and leads to a loss of 4% in the job market, for the first part of this second element (*loss of productiv I* of an amount of 5%) it is assumed that this effect is already included (based on the assumption that the after-effects of anaemia are permanent) and consequently, the final estimate is only considered to be a factor of 1% (so as not to take the same 4% loss in wages due to cognitive impairment into account twice). Meanwhile, and in line with the original methodology, in the case of gruelling manual labour, where it is assumed that cognitive skills are less important, this adjustment in the influence factor is not taken into account.

Finally, the third element measures the cost associated with attending to women who gave birth prematurely due to anaemia. Scholl *et al.* (1992) estimate that the risk of preterm birth is 2.7 times higher in women suffering from anaemia than in those who do not suffer the condition[18]. One of the main problems related to preterm birth is low birth weight, which leads to higher rates of infant mortality and morbidity. Furthermore, preterm birth often includes birth by caesarean (which has different costs in comparison with a natural birth) and can mean the mother fails to accumulate the natural blood reserve developed by women to protect themselves against severe haemorrhaging during labour. As such, preterm birth has greater costs than a natural birth. In line with Ross & Horton (1998), the following equation is used to estimate this cost:

*Cost of preterm birth = Extra cost of preterm birth * PAR * Live births * % Preterm births … (4)*

Where *Cost of preterm birth* represents the cost of attending to anaemia-associated preterm births, *Extra cost of preterm birth* is the additional cost (in percentage terms) connected to providing assistance during preterm birth in comparison with a normal birth. *PAR* is the proportion of female population who have had a preterm birth due to anemia, *Live births* is the number of babies born alive during the year in question and % *Preterm births* is the percentage of preterm births (defined as those taking place before 37 weeks). PAR is defined in the following way:

$$PAR = \frac{Pr * (RR - 1)}{1 + [Pr * (RR - 1)]} \quad \dots (5)$$

Where Pr is the prevalence of anaemia among women of reproductive age and *RR* is the relative risk of going into preterm labour experienced by women

18 In a study based on low-income females in New Jersey, USA.

suffering from anaemia (the probability of going into preterm birth if suffering from anaemia is greater; Ross & Horton, 1998, use Scholl *et al.* 1992's estimate of 2.7).

3.2 Methodology for Disaggregated Estimates (Areas and Regions)

This section describes an adjustment to Ross & Horton (1998)'s original model, which has the aim of estimating the cost of anaemia due to cognitive impairment, lost years of schooling and the loss of physical productivity, both regionally and according to rural or urban areas. We have modified the original methodology slightly, by using the economic identities of the concepts of wage share and GDP per capita. This is down to the fact that information restrictions only allow for the original methodology to be applied nationally, as no estimate exists of wage share according to area or region or GDP per capita according to area. This would imply the need to combine the data concerning the prevalence of anaemia, which exist for both area and region, with the combined information gathered nationally. On the other hand, with the adjustment described below, the cost of anaemia at a regional level may be estimated using ENAHO.

Equations *(1)*, *(2)* and *(3)* all feature wage share and GDP per capita. Both factors have the function of scaling the effect of anaemia according to its importance in terms of income through employment for individuals and the national economy. The first factor is defined as the total of the sum of the economy's wages divided by GDP, while GDP per capita is defined as GDP divided by the total population. Given that these two factors are multiplied within the aforementioned equations, GDP may be simplified (given that the denominator is found in one while the numerator is found in the other). The remaining central component is wage per capita. Now, the cost due to cognitive impairment depends on the effect of anaemia on wages, wage per capita and the probability that a child should suffer from anaemia. With this adjustment to the methodology developed by Ross & Horton (1998), the cost of anaemia may be internally estimated in greater detail. From now on, the equations for which this methodology is used will be called (*1b*), (*2b*) and (*3b*).

3.3 Information Sources

The most important information sources for implementing the model presented here come from the 2009 and 2010 Demographic and Family Health Survey (ENDES), which provides information concerning the prevalence of anaemia in children under 5, women of reproductive age and pregnant women. Furthermore, we also have access to MONIN, (implemented by the National Food and Nutrition Centre (CENAN) over several different periods (1997-2001, 2002-2004, 2008, 2008-2011)), within which detailed information exists concerning the prevalence of anaemia among adults and children.

Furthermore, the 2009 National Household Survey (ENAHO) and *Niños del Milenio* project database are used for estimating the first cost element (that is, the loss of future production caused by reduced cognitive development among children currently suffering from anaemia). Meanwhile, the study uses the information provided by the Peruvian Ministry of Health (MINSA) in order to estimate the costs associated with preterm birth.

Table 2

Key variables and parameters used during the estimates

Variable	Source	Origin
Prevalence of anaemia in children under 5	INEI-ENDES	Peru
Prevalence of anaemia in women from 15 to 49 years	INEI-ENDES	Peru
Prevalence of anaemia in adult males	INEI-CENAN	Peru
Wage share	INEI – National accounts	Peru
GDP per capita	Cepalstat	Peru
Wage per capita	INEI –ENAHO	Peru
Effect of anaemia on cognitive development	Pollit 1993	Indonesia
Effect of cognitive development on income	Psacharopolous & Velez, 1988	Colombia
Effect of anaemia on manual work	Basta *et al.* 1979	Indonesia
Effect of anaemia on wage	Yamada & Castro 2010	Peru

3.4 The Methodology's Limitations and Assumptions

The methodology presents a certain amount of limitations that are worth mentioning. These limitations may be divided into two categories: those related to the methodology in general, experienced by similar studies, and some others that refer to problems concerning the availability of information, which are specific to this study.

The methodology's first limitation is the use of parameters relating to the effect of anaemia that have been estimated in other countries with populations that have different characteristics to Peru, due to the lack of estimated information available domestically. These factors, used in several different international studies, are mainly estimated through experiments that focus on small samples.

Second, it is assumed that the different effects of anaemia (iron deficiency) are the same for all the population, in that no difference is made between males and females or urban and rural areas, or between the different levels of severity, etc. In short, even though establishing the prevalence of anaemia according to gender or area is possible, this distinction may not be made in relation to the effects of anaemia within each element. For example, it is assumed that the effect of anaemia on IQ is the same among all children suffering from the condition.

Some limitations also arise when using the effect of anaemia on schooling in order to estimate its effect on wage performance. In this case, the effect may not be directly estimated; rather, we use the parameter of the effect of anaemia on cognitive development and, consequently, the effect of cognitive development on years of schooling.

In addition, the aforementioned aspects are joined by some additional conceptual assumptions from the basic model in relation to the first two elements. That is, using wage share implies that the importance of employment remains a constant in the economy (GDP). Furthermore, by using current GDP per capita to calculate losses in future productivity (among children suffering from anaemia), it is assumed that this element is constant. In other words, it is assumed that production and population increase at the same rate.

In terms of the estimate of the cost of preterm birth, the main assumption is that the relative risk of preterm birth for women with anaemia (RR) is the same as the one proposed by Scholl *et al.* (1992).

On the other hand, no information is available concerning the history of anaemia among school children. Neither ENDES nor the data obtained through CENEN provide this kind of information. Similarly, using the *Niños del Milenio* database leads to certain limitations due to its structure. With this survey, we will estimate the relationship between children's cognitive development and the wage they receive, alongside the relationship between this and their progress at school. The limitations arising from using this database, firstly, include the fact that it omits the richest districts (top 5%). Second, those included are just 16 years of age and, therefore, their full educational background is not available, as they are still studying.

Finally, it must be highlighted that the study is based on a conservative scenario when calculating all the cost elements underlined. In other words, the aim is to adjust the parameters as much as possible in order to avoid overestimating the cost of anaemia. For example, using PAR (instead of the prevalence of anaemia in itself when calculating the cost of preterm birth) leads to a conservative scenario, in that this indicator is lower than the prevalence of anaemia in itself. In other words, the other causes of preterm birth are considered by applying this factor. Furthermore, in the case of cost due to loss of work productivity, it is assumed that the first element (*Loss of productiv I*) already includes the effect of cognitive impairment, which may not necessarily be true if it is assumed that the return on employment of cognitive skills and fatigue at work due to any cause are totally separate. In addition to this basic scenario, a simulation process that considers other possible scenarios will be carried out, according to the different values contained within the key parameters. As such, not only will the costs relating to these alternative scenarios be estimated, but the sensitivity of the results in the face of changes in the essential parameters may also be calculated.

4. Results

This section presents the estimates made using the previously presented methodology. It begins by calculating the national cost of anaemia due to reduced cognitive development, educational progress and productivity when undertaking physical work. These elements are then calculated by using the modified methodology in the national context, which in turn, allows for measuring the cost both regionally and according to urban or rural areas. In the following section, we will calculate the direct costs of anaemia for the Peruvian state in terms of greater expenditure on health and education, alongside the cost of treating anaemia among the groups most affected by the condition: children and pregnant women. We also estimate the cost generated for the state of implementing an anaemia prevention programme, which would involve providing iron supplements to risk groups. Finally, we will carry out a sensitivity analysis of the 'cost of anaemia' estimates when changes are made to the main parameters in order to validate the results. It should be remembered that this analysis, which aims to show conservative results, does not consider the effect of conditions whose connection with anaemia remains under discussion in the specialist literature, such as low birth weight.

4.1. Initial Methodology: National Results

First, the study describes the findings relating to the cost of anaemia in Peru using the aforementioned basic methodology (Ross & Horton, 1998). The first element – the production cost caused by lower levels of cognitive development among children currently suffering from anaemia – is estimated according to equation (*1*). It is found that for Peru, as of 2009, the cost per capita of anaemia-associated cognitive impairment stands at S/. 44.38, equivalent to 0.33% of GDP per capita. This considers that the wage share (*WS*) stood at 22% of GDP according to the INEI and the prevalence of anaemia among children under 5 (*Prob(child)*) stood at 37.2%. GDP per capita (*GDPcap*) at current prices for 2009 stood at S/. 13,558[19].

Then, equation (*2*) is estimated as part of the first element (cost associated with cognitive impairment in children). It is estimated that the *Years of schooling lost* due to anaemia come to 0.22 years, that is, anaemia sufferers register a fifth of a year less at school on average than children who have not suffered from the condition[20]. With this result, we can estimate the effect of anaemia on wages due to less time in formal education. According to Yamada & Castro (2010), the return on wages per additional year of education stands at 5%, which means that the cost would be S/. 12.2 less earned by those who suffered from anaemia during childhood (0.09% of GDP per capita).

As for the second element, the cost associated with loss of product due to lower levels of work productivity among adult anaemia sufferers is estimated according to equation (*3*). According to ENAHO[21], the percentage of individuals who carry out manual labour tasks within the labour force (*% Manual Labour*) stands at 69% and within this group, the percentage that carries out highly demanding physical work (*% Intense Manual Labour*, such as construction workers or farm labourers) is approximately 50%, that is, the equivalent of 35% of the total labour force. The factors for loss of productivity for the former (*Loss of productiv I*) stand at 5%, while for the latter (*Loss of productiv II*) it is 12%, which together come to the 17% estimated by Basta *et al.* (1979) and used by Ross & Horton (1998). Nevertheless, as explained in the methodology, while 4% was established for the loss of cognitive development element (first element), in the case of manual labour (not intense with regards to physical

19 Cepalstat.

20 According to Pollit (1993) anaemia reduces standard deviations in cognitive development by 0.5 in the Raven test, while the *Niños del Milenio* database estimates that standard deviation in the Raven test is the equivalent of 0.44 more years of education. By combining these two results, it is estimated that anaemia reduces schooling by 0.22 years.

21 Compiled by author. This statistic was estimated as the percentage of people with technical or operational jobs and salespeople within the 14-65 age group.

work) a loss of just 1% is applied. The assumed prevalence of anaemia among adults stands at 12%[22].

By using this information and including it in equation (3), it is found that anaemia generated a cost of S/. 17.49 of GDP per capita, of which S/. 2.46 is allocated to those who carry out tasks that involve non-demanding physical work and S/. 15.03 to anaemia sufferers who carry out demanding or highly demanding physical tasks. In percentage terms, this represents 0.02% and 0.11% of GDP per capita respectively, which, when added together, come to 0.13%.

By adding up these three effects, a total estimated loss is achieved of S/. 74.8 per capita, as can be seen in the following table. As an aggregate (multiplied by the population of 28,954,000 inhabitants[23]) this leads to an absolute loss of S/. 2.165 billion, equivalent to 0.55% of GDP.

Table 3
Cost of anaemia at a national level

Elements	Loss per capita	Loss as % of GDP per capita
Cost due to cognitive impairment	44.38	0.33%
Cost due to negative impact on schooling	12.2	0.09%
Cost due to loss of productivity	17.49	0.13%
Total	**74.8**	**0.55%**

4.2. Adjusted Methodology: Results at National, Area and Regional Levels

By using the adjustment made to Ross & Horton (1998)'s original methodology, presented in the methodology section and required in order to estimate the disaggregated costs according to regions, Table 3 shows the results of the cost elements of anaemia. These results are gathered through equations (*1b*), (*2b*) and (*3b*), respectively.

22 In order to obtain this estimate, we used the prevalence of anaemia among females (21%) and males (3%) and this was then weighted according to each gender's weight within the population.

23 Cepalstat.

First, it is observed that with this methodology (which is basically distinguished from the previous one in that it uses information from household-based surveys rather than national financial statistics), the economic burden of anaemia increases significantly. The cost caused by cognitive impairment goes from S/. 44.4 to almost S/. 70 (from 0.33% to 0.51%). In the case of cost caused by loss of schooling, this increases by S/. 7 (from 12.2 to 19.1), which means going from 0.09% to 0.14%, and in the case of cost caused by loss of productivity the increase also goes from approximately S/. 10 to S/. 27 (from 0.13% to 0.20% of GDP). By adding all these costs together, the Peruvian economy loses around 0.86% of its GDP per capita. This means that after carrying out a similar exercise to the previous one (multiplying by the population amount[22]), we obtain an absolute loss for the Peruvian economy of S/. 3.363 billion.

Table 4
Cost of anaemia at a national level (adjusted methodology)

Elements	Loss per capita	Loss as % of GDP per capita
Cost due to cognitive impairment	69.58	0.51%
Cost due to negative impact on schooling	19.3	0.14%
Cost due to loss of productivity	27.44	0.20%
Total	**116.14**	**0.86%**

There is a difference of 0.31% between this estimate and the previous one, based on Ross & Horton's methodology, which leads to a significant increase in the cost of anaemia by almost 60%. This difference is due to the fact that the adjusted methodology for carrying out disaggregated estimates uses wage data from ENAHO, while the initial methodology uses the wage share registered in state accounts. The individual salary data from ENAHO are both suitable and in general use, but, when using the adjusted methodology, the wage share may

24 Cepalstat.

be overestimated in relation to the population (due to the characteristics of the population included in ENAHO), which, in turn, generates overestimated costs when calculated on a national scale[25]. At any rate, per capita estimates and comparisons between areas and regions provide valuable and trustworthy information for analysis.

Considering the varied nature of the country and the different ways anaemia affects one area or another, it is important to bear these differences in mind when calculating the cost of anaemia. For this reason, estimates were made according to area and region, about which some clarifications must also be made. First, these estimates were made using the Ross & Horton (1998) methodology, adjusted according to the information presented in section 3.4. Second, given that the estimates for this case depend on average wage estimates per capita, calculations in absolute values may be overestimated. Consequently, the analysis in this section focuses more closely on the estimates of costs in relative terms.

The results for urban and rural areas (Table 4) are shown below[26]. Regarding this estimate, the wage per capita of each area was used in order to have an idea of the relative importance of the cost of anaemia, given that no estimated GDP per capita rates exist for these contexts. It is found that the cost of anaemia in percentage terms is higher in rural areas for all elements. In other words, greater prevalence of anaemia, combined with the more important role of manual labour in rural areas mean that, in total, anaemia leads to a 3.24% wage loss, while in cities the same rate stands at 2.40%.

25 ENAHO may overestimate wage share due to the fact that, one the one hand, it does not capture the richest end of the population, for whom a significant portion of their earnings come from unearned income. In the same way, on the other hand, the wage share as mentioned in national financial statistics includes the total production and income of the economy, which are not usually included in ENAHO. For this reason, according to this source, wage share would represent a smaller percentage.

26 INEI definition. Rural was defined as places with less than 401 households, the combined rural census area and the simple rural census areas. Urban was defined as places with more than 401 households.

Table 5
Cost of anaemia according to area

	Rural		Urban	
Elements	**Loss per capita**	**Loss as % of Salary**	**Loss per capita**	**Loss as % of Salary per capita**
Cost due to cognitive impairment	36.58	1.76%	75.09	1.33%
Cost due to negative impact on schooling	13.62	0.66%	33.41	0.59%
Cost due to loss of productivity	16.97	0.81%	43.89	0.48%
Total	**67.17**	**3.24%**	**152.39**	**2.40%**

The following table shows the differences at regional level. As can be seen in Table 5, there is a positive relationship between the prevalence of anaemia in young children and the significance of the cost of anaemia in terms of GDP per capita. The prevalence rate in the region with the greatest cost as a percentage of GDP per capita (Apurímac, where anaemia costs almost 2%) is quite high at 48%. The same happens in other regions such as Ucayali, Cusco, Huánuco and Puno. It can also be observed that the costs of anaemia are higher in the poorest regions.

The cost of cognitive impairment is the most important element in all regions. Meanwhile, the importance of the cost due to the negative effect on schooling and the loss of work productivity varies according to region. For example, in Cajamarca, Ica, La Libertad, Lambayeque and Piura, the importance of the cost arising from the loss of work productivity is greater than the cost caused by reduced periods of schooling; in the remaining regions, the cost relating to schooling is greater. This trend can also be related to anaemia prevalence levels, as expected, given that in the former group of regions, the average prevalence of anaemia in children under 5 stands at 30%, while in the latter it represents 43%.

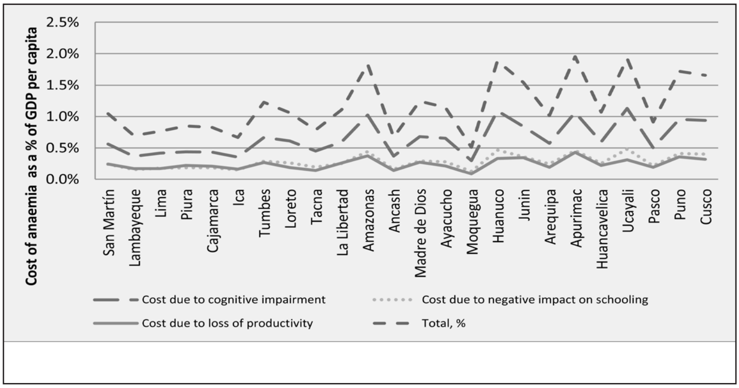
Table 6
Cost of anaemia for regional economies

Region	Cost due to cognitive impairment	Cost due to negative impact on schooling	Cost due to loss in productivity	Total, %	Prevalence in children
Amazonas	**1.02%**	**0.44%**	**0.37%**	**1.83%**	**39%**
Áncash	0.37%	0.16%	0.14%	0.67%	39%
Apurímac	**1.07%**	**0.46%**	**0.43%**	**1.95%**	**48%**
Arequipa	0.57%	0.25%	0.19%	1.01%	47%
Ayacucho	**0.65%**	**0.28%**	**0.21%**	**1.14%**	**40%**
Cajamarca	0.43%	0.19%	0.21%	0.83%	30%
Cusco	**0.94%**	**0.40%**	**0.32%**	**1.66%**	**62%**
Huancavelica	0.59%	0.25%	0.22%	1.07%	50%
Huánuco	**1.09%**	**0.47%**	**0.33%**	**1.89%**	**43%**
Ica	0.35%	0.15%	0.16%	0.67%	31%
Junín	**0.84%**	**0.36%**	**0.35%**	**1.54%**	**46%**
La Libertad	0.59%	0.25%	0.26%	1.11%	37%
Lambayeque	0.37%	0.16%	0.17%	0.70%	23%
Lima	0.42%	0.18%	0.17%	0.77%	30%
Loreto	0.61%	0.26%	0.19%	1.06%	35%
Madre de Dios	**0.68%**	**0.29%**	**0.27%**	**1.24%**	**39%**
Moquegua	0.30%	0.13%	0.09%	0.51%	43%
Pasco	0.50%	0.22%	0.19%	0.91%	53%
Piura	0.44%	0.19%	0.22%	0.85%	30%
Puno	**0.96%**	**0.41%**	**0.36%**	**1.72%**	**54%**
San Martín	0.56%	0.24%	0.24%	1.05%	22%
Tacna	0.45%	0.19%	0.14%	0.78%	36%
Tumbes	0.67%	0.29%	0.27%	1.22%	34%
Ucayali	**1.13%**	**0.48%**	**0.31%**	**1.92%**	**52%**

The following graph shows the relationship between the prevalence of anaemia in each region and its cost as a percentage of GDP per capita. It can be seen that the relationship between cost and the prevalence of anaemia is positive but unclear. Moreover, the difference in the total cost of anaemia between the regions depends almost completely on loss due to cognitive impairment, given that, as well as representing the most important element of the total cost, it is also the one that varies most between regions.

Furthermore, it should also be highlighted that the relationship of the other elements bears no connection with the prevalence of anaemia in young children, given that, as can be seen in the graph, there is a trend that is almost completely unrelated to the level of anaemia (their importance is almost constant among regions). This may mean that the cost of loss of work productivity and negative impact on schooling may not have a direct relationship with the prevalence of anaemia among children, but may rather respond to other factors, such as wages and local productivity.

Graph 5
Cost of anaemia according to each element (regions ordered according to the prevalence of anaemia among children, lowest to highest)



4.3. Anaemia-related Costs for the Peruvian State

4.3.1. Costs generated by the effects of anaemia

In this section, we will estimate the costs of anaemia that must be assumed by the Peruvian state as an outcome of the condition. As mentioned in the methodology section, there are two types of economic burden. The first, in line with Ross & Horton (1998), is the cost of attending to preterm births that may be associated with the mother's anaemia. The second is the cost incurred by the state when funding extra years of education for children who must repeat school years in state education due to having suffered from anaemia.

In the first case, the cost for the state is estimated in terms of the healthcare provided; that is, the cost of attending to anaemia-associated preterm births is measured by using equations (*4*) and (*5*). In order to construct the risk factor to which women are exposed in terms of preterm birth caused by anaemia (*PAR*, equation (*5*)), the estimate developed by Scholl *et al.* (1992) was used, which stands at 2.7. Meanwhile, the rate used for the prevalence of anaemia among pregnant women – 26.6% – comes from ENDES. With this information, it was estimated that the percentage of preterm delivery attributable to anemia was equal to 31.1%[27].

Estimating the cost of premature labour for the Peruvian state using equation (*4*) entailed using SIAF's information on the budget of the Peruvian public healthcare insurance programme (SIS) corresponding to labour care. With this information, it was estimated that the costs for SIS are S/. 118 per normal birth and S/. 191 per birth with complications, which, in this case, was accepted as an approximation of the cost of preterm birth. Given that SIS does not cover staff costs and in line with Moncada, Llanos-Zavalaga & Mayca (2009), it is assumed that the cost of preterm births for the state is equivalent to double the cost paid for by SIS. When adding to equation (5) the number of live births in 2009 according to INEI (660,716) and the percentage of live births with low birth weight (11.9%[28]), we come to the following conclusion:

$$\textit{Cost of preterm birth} = 62*0.31*660{,}716*0.12*235 = S/.\ 359904068$$

In other words, the extra cost for the state of attending to preterm births caused by anaemia comes to approximately S/. 360 million per year. That amount represents 0.08% of Peru's GDP in 2010, in contrast with the 0.35% found by Drake & Bernztein (2009) for Argentina. This difference can be explained through the fact that in Argentina, the cost of attending to a birth is considerably higher than in Peru. Furthermore, the incremental cost of attending to a preterm birth is 100%, while in Peru the same assistance stands at 62%.

As previously mentioned, anaemia has a negative influence on progress at school, but not only does this have a long-term negative effect on individuals, but it also generates an extra cost for the state, which must provide assistance

27 This estimate is very similar to that of Drake & Bernztein (2009), who estimate a PAR of 35.9%.

28 Roughly defined as those children with a birth weight of less than 2500 gr.

to the students who repeat school years due to anaemia. By using equations (6) and (7), the amount of students in each school year and by considering that the operational costs of an academic year per student comes to S/. 1,580 for primary education and S/. 1,862 for secondary education (ESCALE, 2010), the aforementioned social cost may be calculated, as showed in the table below.

Table 7
Cost of anaemia due to repeating school years

	Total repeated school years	Operational costs per student, S/.	Total cost
Primary	7 7283	1580	122 107 140
Secondary	6 8520	1862	127 584 240
Total, S/.			**249 691 380**

The above table (Table 7) shows the number of years repeated by children who suffered from anaemia and the annual cost per child paid for by the Peruvian state. With this information, it is estimated that at primary level, the cost for the state comes to almost S/. 250 million, an amount that represents 3% of total state spending on basic education and 0.06% of GDP.

On the other hand, on top of the aforementioned costs, the Peruvian state also incurs costs associated with treating anaemia in women and children. As previously mentioned, anaemia causes serious problems in children's development, while also placing expectant mothers' health and that of their children at risk. Consequently, the state incurs costs for treating anaemia sufferers and for this reason, we will now estimate how much treating anaemia among children aged 0-35 months costs the Peruvian government, given that this is the most vulnerable population group.

The supplementary scheme suggested by Drake & Bernztein (2009) provides 3mg of iron per kilo of weight for each child as ferrous sulphate in liquid form (ferrous sulphate, equivalent to 15mg of elemental iron/5mlx180ml), with a treatment period of one year (360 days). By applying this scheme, it was estimated that the cost incurred when treating the children who suffer anaemia comes to a little more than S/. 15 million, while the cost per child comes to S/. 22. If the programme management costs (15%)[29] are added, we reach a total of just over S/. 17,250,000.

Table 8
Annual cost of therapeutic treatment of anaemia in children from 0-35 months

Age (months)	Population numbers	Daily dose	Number of bottles	Cost per child - S/.	Total cost - S/.
Therapeutic treatment for children with anaemia		mg			
0-35	679 231	34	23	22	15 004 280
Management costs (15%)					2 250 642
Total					**17 254 922**

Source: ENDES 2010, INEI: http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0843/index.htm, Health Directive N° - MINSA/DGSP-V.01.
Compiled by author

The cost of treating anaemia in pregnant women was also estimated by using the therapy suggested by Drake & Bernztein (2009). In this case, the mother receives a box of 30 tablets (folic acid + ferrous sulphate 400 UG + 60 mg of elemental iron) every month from registration in a health centre[30] to birth and for the following six months. Consequently, the cost of dealing with anaemia among pregnant women who suffer from the condition comes to approximately S/. 4.1 million. Furthermore, if we accept that management costs come to 15%, the total cost of this intervention comes to approximately S/. 4.7 million.

29 Calculated by the Anemia NO support group.

30 It was assumed that anaemia is detected during the first antenatal check-up. It was also estimated through ENDES 2010 that the first antenatal check-up for mothers takes place, on average, during the third month of pregnancy, which means that the pre-birth treatment for these women would last six months.

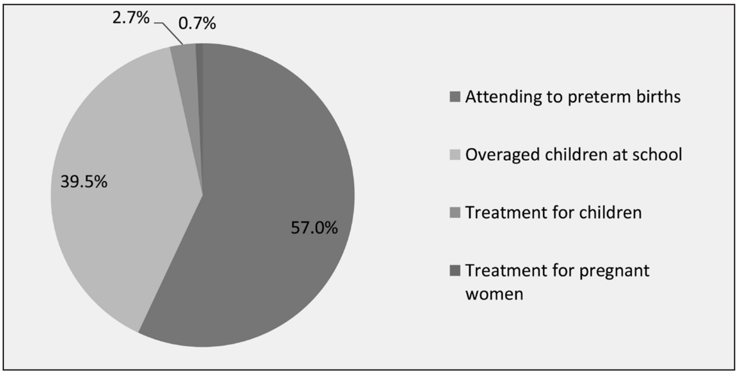
Table 9
Annual cost of therapeutic treatment of anaemia in pregnant women with anaemia

	Population group	Number of capsules	Cost per capsule	Cost per female	Total cost
Therapeutic treatment of women of reproductive age with anaemia					
Pregnant women of reproductive age with anaemia	103 625	360	0.11	40	4 103 550
Management costs (15%)					615 533
Total					**4 719 083**

Source: ENDES 2010; INEI: http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0843/index.htm; MINSA: Operational definitions and scheduling criteria 2012.

These two estimated costs represent direct state intervention in fighting anaemia, unlike the previous ones, which represent costs resulting from the after-effects of anaemia. In spite of this distinction, they are all added together in order to get an idea of the total cost for the state. The total cost for the state that may be attributed to anaemia comes to almost S./ 632 million, of which 57% corresponds to the cost of attending to preterm births that may be attributed to anaemia. The next-ranked cost is the one associated with state expenditure arising from educational deficiencies, representing 40% of total costs. Finally, the cost of treating anaemia among children aged 0-35 months and pregnant women represents 2.7% and 0.7% of the total.

Graph 6
Distribution of direct costs for the State according to their origin



4.3.2. Cost of Preventative Treatment for Fighting Anaemia among the Affected Population

This section shows an estimate of the cost that would be incurred by the state in preventing anaemia among children and pregnant women, in order to obtain a number with which to compare anaemia's direct costs. The hypothetical cost incurred by the Peruvian state in preventing anaemia among children and pregnant women is presented. The target population assumed for this calculation consists of all children aged from 0-35 months (both those who suffer from anaemia and those who do not) and pregnant women. In order to estimate the cost of preventing iron deficiency in children, the main component used was "Health Directive N° -MINSA/DGSP-V.01. Preventative supplementing of iron in girls and boys under 3 years", which stipulates that children born with normal birth weight receive daily treatment of 3ml over a 6-month period from aged 6-11 months and 5ml from aged 12-35 months. In the case of children born with a low birth weight, the preventative treatment for anaemia begins from the first month and lasts 11 months. The child receives 3mg of liquid iron[31] for every kilo of weight[32].

The supplement selected for treatment is liquid ferrous sulphate (ferrous sulphate, equivalent to 15mg of elemental iron/5mlx180ml)[33]. The cost of preventative treatment for children born with normal birth weight comes to approximately S./ 5 700 000, while the prevention of anaemia in children with low birth weight comes to just over S./ 2 700 000. The cost per child is much higher when preventing iron-deficiency anaemia among children with a low birth weight than among children with a normal birth weight. This is down to the fact that a much larger dose of iron must be given to the former group in order to prevent anaemia.

31 The directive stipulates a dose of 2-4mg per kilo of weight.

32 According to Osorio (2002), children with a low birth weight have, on average, the same amount of iron per kilo in their bodies as children born with normal birth weight. Nevertheless, their iron reserve is lower in absolute terms. This, joined with the fact they experience greater growth rates during the first months, means their iron reserves are consumed more quickly, exposing them to a greater risk of suffering from iron-deficiency anaemia. For this reason they receive a bigger dose of iron. For example, given an average weight of 10.55 kilos for children 12 to 35 months old (estimated from ENDES 2010) they should get a daily dose of 30mg, which is approximately equal to 10 ml of liquid solution.

33 The cost of each bottle of this liquid solution is S/. 0.97, in accordance with the costing established by the PAN Nutritional Programme as of July 2011 and based on its operations.

These costs only correspond with purchasing the supplement given to the children and do not include expenses relating to operating the delivery system. According to the Anemia NO support group, management costs would come to 15% of the total investment required to obtain the necessary supplement and deliver it to the children. If we accept this percentage and add the management costs to the supplement purchasing expenses, the total cost comes to S./ 9,766,134.

Table 10
Annual cost of preventative treatment of anaemia in children aged 0-35 months according to birth weight

Age (months)	Population group requiring assistance	Daily dose	Number of bottles	Cost per child - S/.	Total cost - S/.
Preventative treatment, children with normal birth weight		(ml)			
0-5	379 378				5 715 752
6-11	160 067	3	3	3	47 2005
12-35	1 066 959	5	5	5	5 243 747
Subtotal for prevention in children with normal birth weight					5 715 752
Preventative treatment, children with low birth weight		(mg)			
0-5	34 745	16	10	10	331 557
6-11	19 280	23	14	14	261 970
12-35	114 874	32	20	19	2 183 011
Subtotal for prevention in children with low birth weight					2 776 538
Subtotal, preventative treatment					**8 492 29**0
Management costs (15%)					1 273 844
Total	**1 775 303**				**9 766 134**

Source: ENDES 2010, INEI: http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0843/index.htm, Health Directive N° - MINSA/DGSP-V.01.
Compiled by author.

On the other hand, the cost of preventing anaemia among pregnant women is calculated by using the dose of 210 tablets of folic acid + ferrous sulphate (400 UG + 60 mg elemental iron), of which 180 should be given to women before birth and the remaining 30 afterwards[34]. Through this supplement regimen, it was estimated that the cost of supplements for the preventative treatment of anaemia in pregnant women would come to approximately S./ 7,163,000. Meanwhile, the management costs would come to more or less S./ 1 million, which means that the total cost of an intervention of this nature would come to approximately S./ 8,240,000.

Table 11

Cost of preventative treatment of anaemia in pregnant women

	Population group	Number of capsules	Cost per capsules	Cost per female	Total cost
Prevention					
Pregnant women of reproductive age	310 090	210	0.11	23	7 163 078
Management costs (15%)					1 074 462
Total					**8 237 540**

Source:
ENDES 2010, INEI: http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0843/index.htm, Compiled by author.

Bearing these estimates in mind, the cost of preventing anaemia among both children aged 0-35 months and pregnant women would reach S./ 18 million. If these prevention costs are compared with those generated by anaemia for the Peruvian state, which stood at S./ 632 million, the S./ 18 million spent on prevention come to just 2.8% of the former. This would mean that an anaemia prevention programme would be highly cost effective. Furthermore, the state currently implements programmes within which it would be easy to include an anaemia prevention strategy, which would mean that costs would be reduced even further.

Nevertheless, it should be remembered that providing iron supplements is not enough to prevent or fight anaemia among sufferers, especially children. Osorio (2002) suggests that there are other anaemia-related factors such as access to sanitation services, access to proper healthcare, birth weight, etc. Another factor

34 MINSA: Operational definitions and scheduling criteria for 2012.

emphasised by the author is that the children must eat properly, given that, if they fail to accompany the iron supplement with a proper diet that will allow them to absorb the iron, their bodies will not take on the micronutrient. For this reason, it is also necessary to ensure the child eats a balanced diet.

Along similar lines, and complementing Osorio's hypothesis (2002), the Anemia NO support group identifies five different types of intervention for fighting anaemia: i) supplementing iron and micronutrients in boys and girls from 6-36 months, ii) strengthening their diet, iii) timely clamping of the umbilical cord, iv) improving iron intake in their diet through nutritional education, and v) treating parasites, malaria and infant diarrhoea. All these interventions have a cost, which are not included here due to a lack of information. Consequently, the estimated costs of preventing anaemia in this case would only be part of a more complete and complex strategy, which would involve attacking anaemia on several different fronts. Nevertheless, it should be remembered that these interventions are already included in state programmes; as such, they need to be better expressed. Regardless, the expenses that have emerged from this exercise represent the possible cost of direct intervention by the state in order to prevent anaemia, attacking the condition through one of its major causes.

4.3.3. Total Cost of Anaemia for Peru

We will now present the results of the two estimates carried out when calculating the cost of anaemia in Peru. With Ross & Horton (1998)'s original model, the cost of anaemia is lower than when estimated with the adapted methodology. However, it does not register more than 1% of GDP per capita in either case. The importance of both results is that each one of them allows to compare the costs of anaemia with a different look of the economy. On the one hand, the accurate application of the model highlights the significant cost of anaemia for the economy, while, on the other, the second estimate provides us with a more direct approximation of the costs faced by individuals in that it uses wage per capita (however, there may be a certain degree of bias given that it uses information derived from household surveys).

Table 12

The cost of anaemia as a percentage of GDP per capita

Elements	Ross & Horton, 1998	Adapted model
Cost due to cognitive impairment	0.33%	0.51%
Cost due to negative impact on schooling	0.09%	0.11%
Cost due to loss of productivity	0.13%	0.20%
Total	**0.55%**	**0.83%**

The costs presented are based on the most conservative estimate (the one based on the original methodology), given that it does not require the use of the information deriving from household surveys and is instead based on data from national financial statistics and compared with the results found in other studies. According to the calculations, the cost of anaemia in Peru reached approximately S./ 2.777 billion during 2009-2010, representing 0.62% of the country's GDP.

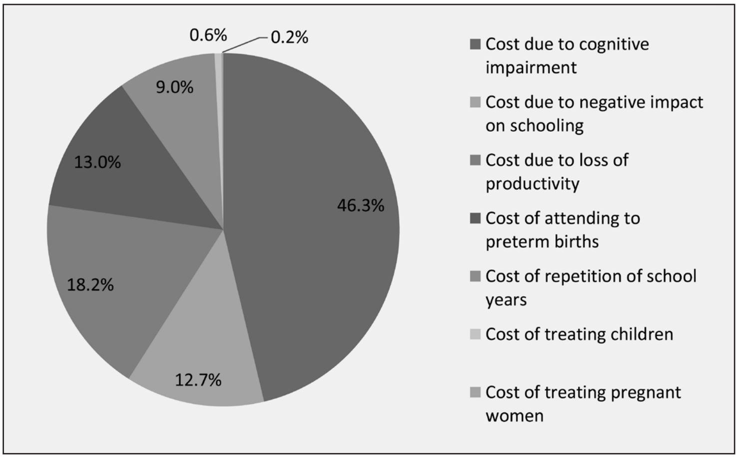
Table 13

Cost of anaemia for Peruvian society

Elements	Cost of anaemia (millions of Soles)
Costs for the economy	
Cost due to cognitive impairment	1285
Cost due to negative impact on schooling	354
Cost due to loss of productivity	506
Costs for the State	
Cost of attending to preterm births	360
Cost of repetition of school years	250
Cost of treating children	17
Cost of treating pregnant women	5
Total	**2777**

The following graph shows the distribution of the costs of anaemia for the country. As can be observed, 46% of costs for Peruvian society may be attributed to cognitive impairment, while the costs arising from a loss of productivity lie in second place. Then, the costs associated with loss of schooling and attending to pregnant women with preterm births due to anaemia are shown to be almost equally important. Meanwhile, the lowest costs are those directly attributed to anaemia treatment by the state (for children and pregnant women), which represents just 0.6% of the total.

Graph 7
Distribution of costs for the country according to origin



If we compare our estimates of the economic burden of anaemia in Peru with that found in Argentina by Drake & Bernztein (2009) using a very similar methodology, it can be seen that the associated costs of anaemia as established by these authors stood at 0.77% of GDP in 2005, a higher percentage than the 0.62% found here. They found that the cost of anaemia due to cognitive impairment comes to 0.38% of GDP per capita, compared with the 0.33% estimated for Peru. These differences in the Argentine case may be explained by the fact that the wage share is greater in Argentina than in Peru; that is, the importance of the cost of anaemia is greater because the wage share within the economy is greater. Ross & Horton (1998) found that, for Bangladesh, the cost of anaemia for this element represents 1.2% of GDP per capita. As can be observed, the estimated costs for Peru are below those found for Bangladesh, where the prevalence of anaemia and the importance of employment in the economy are both greater.

The cost anaemia inflicts on productivity due to the fatigue it produces is estimated by these authors for Argentina as 0.04% of GDP per capita, while in the case of Bangladesh it stands at 0.7% of GDP per capita and the estimate for the Peruvian case stands at 0.13%. In short, the percentage for Peru is higher that Argentina and the same as for Bangladesh. The discrepancy with Argentina is mainly down to the fact that in Peru, tasks that require physical activity are much more important, at 69% and 35% depending on the intensity level of the work, while in Argentina, the same figures stand at 16.4% and 6.1%. Conversely, in Bangladesh the importance of this kind of labor is much bigger than in Peru.

4.3.4. Sensitivity Analysis

This section proposes a sensitivity analysis for the results. The reason for this exercise is that in all estimates (from this one and other international studies), factors from external studies (experiments) are used, which may not all be suitable for the actual situation in Peru. In line with Drake & Bernztein (2009), the values that reflect the real situation in Peru will not be changed, as they come from national sources such as INEI and CENAN (prevalence of anaemia, GDP per capita, wage share). In contrast, the parameters that measure the effects of anaemia come from different countries and are mainly the result of a specific experiment. Based on the original methodology developed by Ross & Horton (1998), which has been applied at a national level, we examine the change in the cost of anaemia as a percentage of GDP in the face of the variation in the factors used to measure the effect of anaemia on cognitive impairment, the years of schooling registered and work productivity.

A 10% fluctuation in the effect of anaemia on cognitive impairment causes a 7.6% change in the cost of anaemia as a percentage of GDP; that is, if the effect of anaemia on cognitive impairment were 10% greater in Peru than that used by Ross & Horton (1998), the cost of anaemia would increase by almost 8%[35]. A similar change (10%) in the effect of anaemia on productivity would generate a percentage change of 2.4% in relation to the cost of anaemia. Finally, given that the effect of anaemia on schooling is made up of three different parameters, we will examine a change in cost for each one. The first is the effect of cognitive development on the years of education registered. If this parameter

34 It should be remembered that this parameter is also included in the element relating to the loss of income due to fewer years of schooling caused by anaemia. For this reason, the variation arises in both elements.

increased by 10%, the cost of anaemia would fall by 1.65%. This would also occur if the effect of anaemia on cognitive development increased by 10% and the effect of education on wages (Yamada & Castro, 2010) grew by the same rate. These three factors constitute the effect of anaemia on wages through years of schooling, which if increased by 10% (the simultaneous increase of the three aforementioned elements), a change of 4.46% would take place in the cost of anaemia as a percentage of GDP.

This exercise shows that the estimates carried out are more sensitive to changes in the effect of anaemia on cognitive development and this, in turn, on the introduction of individuals into the job market. Meanwhile, the factor that causes least variation in the cost is the loss of job productivity due to fatigue.

5. Conclusions

This study has focused on estimating the cost of the prevalence of anaemia for Peru, given that knowledge of the burden generated by the condition for the Peruvian economy will provide a target amount that will act as the basis for any policies. Furthermore, being aware of the cost provides another reason for fighting anaemia. This is important because anaemia is a severe public health problem for the country, affecting almost 40% of children under 5 and more than 20% of women of reproductive age. These figures are similar to those presented in less developed countries, including many African states.

The cost of anaemia was estimated by taking into account its burden for the Peruvian economy. The calculation takes into account the influence of anaemia on personal development and productivity in order to measure the importance of the condition in relation to production and the cost that anaemia generates for the Peruvian state. Furthermore, the study estimated the cost of implementing a programme for fighting anaemia among children and pregnant sufferers. The costs in terms of the economy's aggregate production are measured as the cost of anaemia generated by cognitive impairment among children, which affects their future performance in the labour market; the reduced years of schooling registered by children with anaemia, which leads to lower wages; and the reduced work productivity levels among adults suffering from anaemia. The burden for the state was estimated through the cost of cases of preterm birth caused by anaemia and the extra years of schooling required for those who repeat a year due to anaemia.

The methodology used in this study is based on the one developed by Jay Ross & Susan Horton (1998) as part of The Micronutrient Initiative. Similar studies have also been carried out both nationally and internationally. Using this methodology, the study has also incorporated elements from other methodologies in order to undertake a more detailed measurement of the cost of anaemia. They include the ones incorporated from the methodology developed by Martínez & Fernández (2009) to estimate the costs associated with the influence of anaemia on individuals' education. The outcome of this study is a conservative calculation, in that it does not include some of the costs of anaemia, such as those associated with conditions whose connection with anaemia has yet to be established through a consensus in the specialist literature. Furthermore, some costs are not included due to a lack of information, such as the cost of treating pregnant women with anaemia in hospitals, which, if included, would considerably increase the anaemia burden.

It was found that anaemia costs Peruvian society approximately S./ 2.777 billion and represents 0.62% of GDP. The most important element within this total amount is the one associated with the effects in adulthood of the cognitive impairment generated by anaemia in childhood, which stands at approximately S/. 1.285 billion and represents around 0.33% of GDP. The costs faced by the state stand at S/. 632 million, of which the greatest is the cost corresponding to providing assistance for preterm births caused by anaemia, which stands at S/. 360 million (0.08% of GDP). Furthermore, the cost incurred by the state for treating anaemia would come to S/. 22 million. In contrast, the cost of preventing anaemia would be S/. 18 million, which represents just 2.8% of the total cost that anaemia generates for the state.

Given that the estimate of costs is based on the use of assumptions, especially in terms of the use of parameters derived from experiments in other countries, such as the effect of anaemia on cognitive impairment among children, the loss of years of schooling and the anaemia-related loss of work productivity among adults, a sensitivity analysis has been carried out reflecting the effect on the results of changes (10%) in the aforementioned parameters. It was found that an increase in these parameters would see the cost of anaemia for the country (in relation to the three elements) increase from 0.55% to 0.62% of GDP. In a similar way, should the parameters be reduced by 10%, the cost of anaemia for these three elements would fall to 0.48%. It is worth mentioning that the most influential factor in terms of the cost of anaemia is the one related to cognitive loss, given that a 10% fluctuation would lead to the greatest variation in cost, compared with the same fluctuation in any of the other parameters.

The study also explored the diverse nature of the impact of anaemia according to geographic area and region. First, it was found that the cost of anaemia is much greater for the rural economy than the urban economy in relative terms, in relation to the three aforementioned elements. While these three elements reduce rural wages per capita by S/. 67 and in the city by S/. 152.4, in the former this amount represents 3.2% of wage per capita and for the latter, 2.4%. As for the importance of anaemia for Peru's different regions, it was found that Apurímac and Ucayali suffered the greatest losses due to anaemia and the condition represents almost 2% of GDP per capita in these two regions. Furthermore, it was found that there are not many differences, in percentage terms, in the importance of the loss of years of schooling or the loss of productivity at work between the regions, while on the other hand, the differences between regions could be explained by the relative importance of the cost of increased cognitive impairment among children.

In conclusion, it may be said that anaemia represents a major economic burden for the Peruvian economy, given that the condition causes the country to lose 0.62% of GDP (as the most conservative estimate), that is, approximately S/. 2.777 billion. This amount is more than five times the SIS budget for 2009 and constitutes almost 38% of the national health budget for the same year.

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Epilogue

This study, as shown, is based on three main questions. The first one refers to the cost of the prevalence of anaemia for the state and the country's economy, a condition that, as mentioned at the beginning, "is one of the world's biggest health problems." The second question refers to the costs that must be accepted by the state in order to deal with the issue of anaemia. And finally, the study evaluates the cost-benefit ratio of state intervention in this issue.

The conclusion is clear – the prevalence of anaemia leads to a major economic burden for Peru's economy, which is also considerably greater than the cost of attending to the population groups that suffer the condition. It is therefore advisable, for economic reasons, to carry out the actions identified and estimated financially, in order to deal with the issue of anaemia.

As tends to happen with this kind of research, while also attempting to answer questions, the study itself raises new ones, both as part of and separate from the process of analysis. These questions include the role of this kind of study when defining public policies in the context of guaranteeing people's rights.

The aim of this epilogue is not to answer any questions, given than the relationship between these end notes and anaemia, unlike the research document itself,are based on what we could call a testimonial (rather than analytical or academic) perspective.

Themost important moment ofthe story I would like to share takes place in early 2010 and accompanies the results-based follow-up of the budget and the distribution of ENDES 2009's preliminary results. The data reviewled a group of people from a range of organisations linked to children's rights, the fight against poverty and especially, the fight against hunger, to come together and implement a dialogue about anaemia. This dialogue included previous discussions about anaemia in Peru, current experiences both in Peru and in other countries and the necessary review of public policies for dealing with the condition.

The outcome of these initial informal conversations was the decision to set up an interinstitutional working group to deal with what we all thought was a weakness or delay in the development of effective public policy on the issue.

Therefore, in April 2010, a range of institutions connected to the official monitoring group of the PAN (Nutritional Programme) and the IDI (Initiative against Child Malnutrition) agreed to set up a support group for the "ANEMIA NO" campaign. This was an interinstitutional group aiming to place anaemia on the public agenda and on the table of policy decision-makers, alongside a range of proposals about what could be done and the best possible estimate of how much it would cost.

The group, which was set up within the framework of the MCPLP (Roundtable for the Fight Against Poverty), brought together representatives from the public sector (MINSA and the IIN – Institute of Nutritional Research), private development organisations (Action Against Hunger – Spain, ADRA, CARE, Plan International, A.B. PRISMA), United Nations organisations (World Food Programme and UNICEF) and the Peruvian business sector (National Association of Industries), as well as the technical team from the MCLCP.

The options and directions for this joint effort emerged through a dialogue between the members of the group about the nature and extent of the problem. The main point of agreement was the shared recognition of anaemia as a "health problem", as this research reminds us. In fact, the information provided by ENDES 2009 showed that anaemia affected more than 50% of children between 6-36 months and while this showed an improvement on figures from 2000, it was not enough to be a reason for celebration. It should also be highlighted that the issue of anaemia in Peru was not a new one in 2009. A couple of examples illustrate this:

i) the inclusion of anaemia in the PAN – designed in 2007 and implemented during the 2008 budget – as a concurrent factor in defining the nutritional state of children, which, in turn, should be subject to intervention; and,
ii) the inclusion of anaemia as a metric for women of reproductive age and all children under 5 years since the 1996 ENDES, which applied the

anaemia test to a sub-sample of 2,818 cases. This is without mentioning other studies on the condition in Peru or abroad.

A review of the data from ENDES 1996 and 2009, as well as the more recent 2011 and 2012 editions show us that anaemia was and is **an unresolved public health problem**. It also shows us that the segments most exposed to the condition are children under 5 and, within this group, children under 36 months and, furthermore, within this one, the critical segment of 6-18 months.

There were two key issues for the group – the after-effects of anaemia on sufferers' development and the options for dealing with the condition.

In terms of the after-effects: for example, in the case of expectant mothers, the probability of pre-term birth and low birth weight babies was remarkable. Among children who suffered anaemia in their first years, the effect on intellectual development, performance at school, the development of physical capacities, their general health, etc, all stood out. These issues are in line with those seen in the initial pages of this document, the economic costs of which have been estimated in Lorena Alcázar's research.

As for the options for attending to the anaemia issue as a public health problem, the support group identified and appropriated several proposals, which became part of a basic list of interventions, all complementary, to be applied. In fact, most institutions had and continue to have specific experience in this field and in a range of local contexts, both in Peru and abroad.

The options reviewed at the time, which were appropriated and promoted by the "Anemia NO" group, are as follows:

Iron supplements for boys and girls from 6-36 months and pregnant women. In this context and bearing in mind the extent of the problem, the Group considered that supplementing should be a general practice and could therefore use multi-micronutrients as well as other types of supplements in the most severe cases.

The Group considered that, in the short term, supplementing was the most suitable strategy type for making a significant contribution to closing the existing gap, while other interventions are devised and make an impact. These other interventions could, for example, be associated with **improving nutritional practices**, which would involve or require changes in diet to improve iron absorption. These are interventions based on knowledge and consumption of iron-rich foods and good bioavailability and means families must include foods that facilitate iron absorption in their diets (such as fish or foods rich in vitamin C). All this requires a **nutritional education strategy** and other factors and assumptions, such as the availability of supplies and sufficient family income to acquire them.

We also highlighted the option of making complementary use of **fortified mass consumed foodstuffs**, as has already been done for many years with iodine. In addition to fortifying wheat flour, we also have fortified rice, as this product is more widely consumed in Peru. An additional point is the development of technology that increases iron levels in crops, including potatoes, through **biofortification**.

Alongside the aforementioned points, we also considered the need to insist on **promoting exclusive breastfeeding** for the first 6 months. The group also highlighted the need to review and improve practices relating to the birth, in order to promote **timely clamping of the umbilical cord** (once pulsating has stopped), as this increases initial iron reserves in newborns, thus contributing to reducing the prevalence of anaemia between 6 and 12 months.

Finally, we highlighted the need to guarantee **treatment for parasitism and malaria**, which lead to abnormal blood loss.

It is also worth mentioning that, in terms of the Group's approach, all these possible interventions make sense as part of a public policy and results-based management, for which the PAN acts as the main management tool in both the past and present.

In this context, in 2010, the member organisations of Anemia NO, both individually and as a group, and as part of IDI and the Roundtable, promoted the inclusion of express goals for reducing anaemia in the country's different regions, as part of the "regional governability agreements", which were signed during that year's regional and local pre-elections.

The actions in 2011 and 2012 have been aimed at reinforcing the development and progress(in different ways)of the positive interventions that may be carried out by the state at its different levels of government, as well as by civil society, development organisations and the business sector, in order to guarantee people's right to proper nutrition.

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President of the Mesa de Concertación para la Lucha contra la Pobreza
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Peru is the South American country that suffers anaemia the most (matching only Guyana) according to the WHO. It affects more than 50% of preschool children, 42% of pregnant women and 40% of non-pregnant women of reproductive age. These prevalence levels put Peru in a similar situation to most African countries. In spite of the important role of anaemia in Peruvian society, the magnitude of the problem has not been acknowledged in its consequences and costs for the country. Furthermore, the Peruvian state has not developed a systematic policy for fighting anaemia.

The aim of this study is to identify and estimate the economic costs for the Peruvian state and economy caused by the current prevalence of iron-deficiency anaemia among adults; to estimate the future economic costs for the Peruvian economy of the current prevalence of anaemia among children and to estimate the costs incurred by the state from the anaemia-related care provided, as well as that related to consequent health problems. Furthermore, the study also undertakes an estimation of the costs that the Peruvian state would incurred in order to prevent anaemia among children and pregnant women. The aim of this is to show the importance and implications of the problem and the possible savings and benefits of a stronger, more systematic and more effective policy for fighting anaemia.

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