Introduction

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"For population to be consistently healthy, it is vital that people are active participants in the health development and diseases prevention. With the future in mind, naturally the first group that strikes are children"

- WHO,2005

Malnutrition remains most serious health problem and the single biggest contributor to child mortality. Malnutrition is basically cellular imbalance between the supply of nutrients and energy and the body's demand to ensure growth, maintenance and specific body functions. Malnutrition is thus a health outcome as well as a risk factor for diseases and it can increase risk both of morbidity and mortality. Undernutrition occurs when one or more vital nutrients are not present in the quantity that is needed for the body to develop and function normally. This may be due to insufficient intake, increased loss, increased demand or a condition or diseases that decrease the body's ability to digest and absorb nutrients from available food. Nutrient deficiencies vary in their manifestations, some leading to specific clinical signs, many affecting growth at an early stage (Mason et al, 2003). Malnutrition or undernutrition to be specific includes underweight, stunting and wasting.

Under nutrition both protein energy malnutrition and micronutrient deficiencies, directly affects many aspects of children's development. Undernutrition diminishes the ability of all systems of the body to perform properly, with particularly grave consequences in young children. The relationship between underweight status and ill health, however, is complex because ill health often results in undernutrition and undernutrition increases susceptibility to disease, particularly severe disease. The consequences of malnutrition given by Sue in 2000 can be summarized as:

- Retards mental development
- Hampers physical growth
- Decreases scholastic performance
- Reduce the work capacity
- Increase the risk of Infections

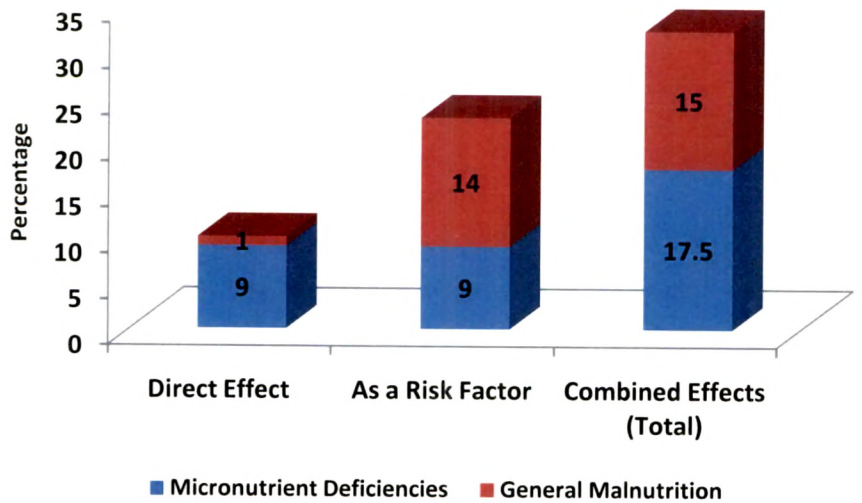
PREVALENCE OF MALNUTRITION

Malnutrition affects millions of people around the world. A third of all deaths in children in developing countries are linked to undernutrition. More than one-half of the 9.7 million child deaths worldwide are linked to under nutrition. Malnutrition alone not only kills, but also exacerbates the burden of infectious diseases (USAID 2009). World Health Organisation (2002) estimated that more than 3.7 million deaths could be attributed to underweight. Since deaths from under nutrition occur among young children, the loss of healthy life years is even more substantial. About 138 million DALYs, 9.5% of the global total, were attributed to underweight. Deficiencies in three key micronutrients – iron, vitamin A and zinc – each caused an additional 750,000 to 850,000 deaths. Malnutrition has its direct effect on the diseases burden at the same time it in itself is a risk factor for various infectious diseases and thus contribute to diseases burden **(Figure 1.1).**

Malnutrition is a "not so silent" emergency in India also. The global community has designated halving the prevalence of underweight children by 2015 as a key indicator of progress towards the Millennium Development Goal (MDG). Economic growth alone, though impressive will not reduce malnutrition sufficiently to meet nutrition target.

Approximately 60 million children are underweight in India. India ranks second only after Bangladesh with regards to the prevalence of underweight children in the world. India has 49 % of underweight children which contributes to 39 % of the world's underweight children. The prevalence of malnutrition in children is much higher in India than all other countries within south Asia and is higher than the averages for other regions of the world (**Table 1.1**). Child malnutrition is responsible for 22 percent of India's burden of disease. Given its health impact, education and productivity, persistent undernutrition is major obstacle to human development and economic growth in the country, especially among poor and the vulnerable, rural areas where the prevalence of malnutrition is highest (Michele 2005).

Figure 1.1: Estimated contribution of Malnutrition to the disease burden of developing countries



Source: Disease control priorities in Developing countries; second edition, 2006.

Table 1.1: Ranking by global share of Underweight Children & contribution of India to disease burden

Country	Prevalence of underweight children in country (%)	Share of total underweight children in the world (%)	Cumulative total (%)
India	47	39.0	39.0
Bangladesh	48	5.7	44.7
Pakistan	38	5.5	50.2
China	8	4.8	54.9
Nigeria	29	4.4	59.3
Ethiopia	47	4.2	63.5
Indonesia	28	4.2	67.7
Philippines	28	1.9	71.9
Vietnam	28	1.5	73.4

Source: UNICEF 2009

The progress in reducing the proportion of undernourished children in India over past decade has been modest and slower than what has been achieved in other countries. While aggregate levels of undernutrition are shockingly high the picture is further exacerbated by the significant inequalities across states and economic groups – girls, rural area, the poorest and schedule tribes and castes are the worst affected- and these inequalities appear to be increasing.

There is also large inter state variation in the patterns and trends in underweight. In six states, at least one in two children are underweight namely Maharashtra, Orrisa, Bihar, Madhya Pradesh, Uttar Pradesh and Rajasthan. Gujarat (50 %) has a rural underweight prevalence that is higher than 49 % of all India rural average. Moreover, the prevalence in underweight is falling more slowly in high prevalence states. Undernutrition is concentrated in a relatively small number of districts and villages with a mere 10 % of village and district accounting for 27-28 % of all underweight children, suggesting that future efforts for combating malnutrition could be targeted to a relatively small villages and rural areas (NFHS III 2005).

Further the NFHS III data reports that Undernutrition is substantially higher in rural areas than in urban areas. Even in urban areas, however, 40 % of the children are stunted and 33 % are underweight. In rural area the prevalence of underweight is more than 60 % in India. Children belonging to schedule caste and schedule tribes or other backward classes have relatively high levels of Undernutrition. Children from schedule tribes have the poorest nutritional status.

MALNUTRITION AND ECONOMY

It has long been known that malnutrition undermines economic growth and perpetuates poverty. Yet the international community and most governments in developing countries have failed to tackle malnutrition over the past decades, even though well-tested approaches for doing so exist. The consequences of this failure to act are now evident in the world's inadequate

progress toward the Millennium Development Goals (MDGs) and toward poverty reduction more generally. Persistent malnutrition is contributing not only to widespread failure to meet the first MDG—to halve poverty and hunger—but to meet other goals in maternal and child health, HIV/AIDS, education, and gender equity. The unequivocal choice now is between continuing to fail, as the global community did for more than a decade, or to finally make nutrition central to development so that a wide range of economic and social improvements that depend on nutrition can be realized (World Bank 2006).

The returns to investing in nutrition are very high. The Copenhagen Consensus 2010 concluded that nutrition interventions generate returns among the highest of 17 potential development investments. Investments in micronutrients were rated above those in trade liberalization, malaria, and water and sanitation. Community-based programs targeted to children are also cost-effective in preventing undernutrition.

Malnutrition slows economic growth and perpetuates poverty through three routes—direct losses in productivity from poor physical status; indirect losses from poor cognitive function and deficits in schooling; and losses owing to increased health care costs. Malnutrition's economic costs are substantial: productivity losses to individuals are estimated at more than 10 percent of lifetime earnings, and gross domestic product (GDP) lost to malnutrition runs as high as 2 to 3 percent. Improving nutrition is therefore as much—or more—of an issue of economics as one of welfare, social protection, and human rights.

Reducing undernutrition and micronutrient malnutrition directly reduces poverty, in the broad definition that includes human development and human capital formation. But undernutrition is also strongly linked to income poverty. The prevalence of malnutrition is often two or three times— sometimes many times—higher among the poorest income quintile than among the highest quintile. This means that improving nutrition is a proper strategy,

disproportionately increasing the income-earning potential of the poor (The world bank 2006).

SCHOOL GOING CHILDREN

Childhood is a period of rapid physical and mental growth and development. Children are building up new tissues constantly and replacing the old ones. Their nutritional requirements are higher per unit of body weight than those of adults. If children do not receive the nourishment they need, undernutrition and malnutrition of one type or other will inevitably result, the type and extent depending on the type and quality of nutrients lacking in diets (Cravioto et al 1976). At present 21.8 % of the country's population consist of school going children. According to NFHS III, 90.1 % of the 6-10 years and 74.2 % of 11-14 years old children attended primary school in 2005-06. According to NNMB report, undernutrition ranges from 63 % to 73 % in 6-13 years of school children.

School provides the most effective and efficient way to reach large portion of the population, including young people, school personnel, families and community members. Students can be reached at influential stages in their lives, during childhood and adolescences, when lifelong behavioural pattern are formed. Schools have been given the mandate and responsibilities to enhance all aspects of development and malnutrition of children. School teachers are professionals in disseminating information in and out of the school community. Schools can serve as gateway to the community by providing entry points by liaisioning with children, parents and community at large (WHO report 2007).

ASSESSMENT OF MALNUTRITION THROUGH GROWTH MONITORING

Malnutrition in children can be assessed using anthropometry, biochemical indicators and clinical signs of malnutrition. The advantage of anthropometry is that body measurements are sensitive over the full spectrum of malnutrition, whereas biochemical and clinical indicators are useful only when a child is at

least moderately malnourished. The best global indicator of children's well being is growth. The assessment of growth not only serves as a means of evaluating the health and nutritional status of children but also provide an excellent measure to decide future action (Mercedes de onis et al 2000). Growth monitoring is a screening tool to diagnose nutritional chronic systemic and endocrine diseases at an early stage. It has been suggested that growth monitoring has the potential for significant impact on mortality even in absence of nutrition supplementation or education. Growth assessment is the single measurement that best defines the health and nutritional status of a child, because disturbances in health and nutrition regardless of their etiology, invariably affects child growth (Habicht et al 1974).

Experiences in India indicate that individual growth monitoring of children is both feasible and extremely useful. Monitoring the growth of a child requires taking the same measurements at regular intervals, approximately at the same time of the day, and seeing how they change. A single measurement only indicates the child's size at that moment but repeated measurements on same child gives growth trends (Lalitha et al 1998).

Undernutrition is generally characterized by comparing the weights or lengths of children at a given age to distribution of weights or lengths of generally healthy children, and calculating this relationship in terms of standard deviation scores or z-scores. Z-scores can then be categorized in terms nutritional terms as mild (-1.01 to -2.00 SD), moderate (-2.01 to -3.0 SD) or severe (<-3.0 SD) undernutrition (Laura et al 2005).

Growth is the fundamental physiological process that characterizes childhood. Secular trends in growth show the level of health of the population group. References of growth are one of the most valuable and commonly used instruments in the evaluation of the well being of individuals, groups of children and the community they live in (Juan 2008). Growth is a complex process that varies across individuals and may be influenced by multiple interacting factors. Although genetic factors such as parental height and

weight form a blue print, child factors such as gender, age, early growth and overall health are also important (Maureen & Ambika 1999).

The school age period has been called the latent period of growth. The rate of growth slows down and the body changes occur very gradually. Resources however are being laid down for the growth needs to come in the adolescent period and it is some time a lull before the storm. The body type is established. Growth rates vary widely within this period. Girls usually outdistance boys by the latter part of the period.

ANEMIA

Malnutrition in children leads to other micronutrient deficiencies also. Iron deficiency anemia is one of them. One third of the world's population suffers from anemia. India continues to be one of the countries with high prevalence of iron deficiency anemia (IDA). According to NFHS III the prevalence of anemia is 70- 80 % in children. Anemia affects the oxygen carrying capacity of the cells and thereby reduces the work capacity of the children. There are various ways of tackling micronutrient deficiencies which are as follows:

- Dietary diversification
- Food fortification
- Supplementation through tablets
- Global public health & diseases control

When talking about micronutrient deficiencies, anemia is the most common and highest prevalent micronutrient deficiency diseases caused by low iron stores in the body. Anemia in the developing world is most commonly caused by iron deficiency which affects upto 50 % of country's population. Iron deficiency not only impairs the production of red cells on the body but affects general cell growth too.

According to the United Nations Administrative committee on coordination, sub committee on Nutrition (ACC/SCN, 2000) about 3.5 billion people

worldwide are affected by iron deficiency. The fact remains that the anemia situation is much more severe in developing countries: 56 % in women and 53 % in school age children. The highest prevalence of iron deficiency anemia – 75 % - occurs in south central Asia.

Iron deficiency affects young children, adolescent and women of reproductive age- three periods of rapid growth during which the body's iron needs are higher than normal (Behrman et al 2000). IDA is linked with depressed mental and motor development during childhood which may be irreversible. IDA during childhood also results in decreased physical activity and decreased interaction with the environment, with negative consequences on learning and school achievements. These translate into decreased adult productivity and ultimately decreased economics (Zlotkinsh et al 2004).

The most commonly used screening methods for the presence of IDA anemia in a population is the measurement of hemoglobin concentration for the presence of anemia. These measurements are relatively cheap, can be carried out under field conditions. Although other iron related tests are required for the confirmation of iron deficiency, it is reasonable to assume that a population with high anemia prevalence is likely to have a high prevalence of iron deficiency (Freire 1989).

Although anemia has been recognized as a public health problem for many years, little progress has been reported and the global prevalence of anemia remains unacceptably high. WHO and UNICEF therefore reemphasize the urgent need to combat anemia and stress the importance of recognizing its multifactorial etiology for developing effective control program. Only by recognizing the complexity of anemia, can effective strategies be established and progress be made consequently. An integrated multifactorial and multisectorial approach is required to combat these public health problem.

Strategies should be built into the primary health care system and existing programs. Furthermore, strategies should be evidence based, tailored to local condition and take into account the specific etiology. Finally to be effective

and sustainable, strategies must be laid with firm political commitment. Also needed is an operational surveillance system with reliable, affordable and easy to use methods for assessing and monitoring anemia prevalence and effectiveness of interventions (WHO-UNICEF 2009).

IDENTIFYING INTERVENTIONS

In countries such as India where there are limited resources and competing demands, some point of prioritization of intervention becomes inevitable. The criteria for intervention should be:

- Those that are technically effective in substantially ameliorating a major health problem and
- Those that are financially inexpensive or cost effective relative to the outcome gains achieved.
- The first ensures that the intervention markedly reduces the burden of diseases and does not simply result in token improvement in health status. The second ensures that the intervention is good value for money (NCMH, 2005).

Looking at the above points for effective interventions, possible intervention can be giving iron folic acid tablet and deworming tablets in school setup and looking at its effect on growth, prevalence of anemia and physical work capacity of school going children. These interventions had been emphasized in Copenhagen consensus 2008 also. Intervention at school level will be more cost effective and large number of children can be covered.

IRON SUPPLEMENTATION

Keeping in mind the dire consequences of IDA, many strategies have been recommended to combat it. Each strategy has its own pros and cons. While fortification is a preventive and long-term strategy, supplementation is more of a short-term strategy. However, for iron deficiency control, supplementation with iron and Folic Acid is considered a feasible and a cost effective approach.

Also, supplementation is a strategy of choice not only because it shows results in lesser time, but also the result is more pronounced.

The evidence is indisputable that iron supplements can substantially reduce IDA. A varied array of intervention exists that are designed to prevent and correct IDA. These include dietary improvements, fortification of foods with iron, iron supplementation and other public health measures, such as helminth control. All these approaches improve iron status in some context. The appropriate use of iron supplements will be an important part of anemia control program in all contexts, but supplements should be viewed as one of the several tools in the battle against IDA.

In many populations the amount of iron absorbed from the diet is not sufficient to meet many individual requirements. These also happens when physiological iron requirement are the highest. In such case iron supplementation will become a necessary component (Rebecca et al 1998).

Iron Folic Acid (IFA) supplementation is a preventive strategy for treating existing anemia. It is effective strategy until the diet of entire population changes significantly or till the time food fortification becomes very common. IFA improves behavioural & cognitive development of the children. It improves overall fitness and work capacity of the children. It also improves child survival where severe anemia is common (INACG 2004).

There are various factors which enhance or inhibit the iron bioavailability in the body. Phosphates, phytates in the diet, worm infestations negatively affects the iron absorption in the body while Vitamin C, citric acid, malic acid, proteins of lower molecular weight increase the absorption of iron in body. The iron absorption increases in body The iron absorption in the body is a complex process. Body iron stores affect the intestinal mucosal absorption when the iron stores deplete and reduce absorption as iron store replete (Moore et al 1990). The iron absorption in the body depends on intestinal mucosal block theory, where high dose of iron given at a time, would block the subsequent dosage of iron from absorption. By reducing the dose frequency to once a

week, matching the mucosal turnover of humans, iron from the tablets is absorbed (Brown, 1963). One of the study done in Nepal to study the effect of mucosal block theory, found a significant rise in hemocratic values of children who were given IFA supplementation on weekly basis as compared to daily dosage. This further supports the mucosal block theory (Shah k 2002).

DEWORMING

The infections caused by round worms, whipworms and hook worms- known as helminth infections- afflict more than 1 billion people world wide and are responsible for 150,000 deaths annually. They exacerbate iron deficiency and can thwart the physical growth and educational advancement. This anemia can further lead to malnutrition. These major interventions can reduce or eliminate helminth infections.

About half the population in South India and 50% of school children in tribal areas of Central India is infected with Ascaris lumbricoides, Trichuris trichiura and/or hookworm. In the western part of Nepal, 86.7% of the pre-school children are infected with a single geohelminth infection and 13.3% with mixed infections. Thus, worm infestation as a public health problem needs immediate attention from policy makers in India and other South Asian countries (Awasthi et al 2008).

School age children are an important high risk group for worm infestation because of rapid physical growth and rapid metabolism resulting in increased nutritional need. In a period of intense learning, helminth infections have been shown to have negative impact on cognitive tasks. Children are continuously exposed to contaminated soil and water.

Anthelmintic treatment of children in developing countries has had varying success in terms of growth improvement in school children (Narthrop et al 2001). Secure evidence for the fact that worm infestation can be a determinant of iron deficiency anemia (Ball 1996).

The benefits of deworming in school are:

- Deworming children through the simple distribution of tablets has the potential to improve children's health and educational achievement, especially for those worst affected and most disadvantaged children.
- Delivering services through schools is efficient and cost-effective. There is widespread support in schools and communities for teachers to play a role in providing services, as long as the procedures are simple, safe, and familiar.
- Providing health services in schools does not require long or complex training, nor does it add significantly to teachers' or administrators' workloads.
- Delivering services through schools should not require any additional infrastructure as long as the existing school system functions well. (Miguel and Kremer 2003).

Deworming is the best and effective way of removing worm infestation. Deworming is simple, safe, and cheap. Deworming tablets are practically not absorbed in the body. Around 99.5 % of the tablets get used up in intestinal lumen where it kills the worms. Deworming through school is simple, efficient and cost effective. No long or complex trainings are required. There is no additional burden on school teacher and no additional infrastructure is required. Albendazole is widely used as a deworming tablet as it is highly effective and easy to administer (Powlawski et al 1991).

Deworming pills are heat-stable and require no cold chain for delivery. With a shelf life of up to four years, they can be purchased in bulk to reduce costs and to ensure uninterrupted supply. In communities where infection is common all children should be offered treatment.

MID DAY MEAL

To tackle the problem of malnutrition and micronutrient deficiencies, Government of India launched the Mid Day Meal (MDM) programme. The MDM scheme which has overcome many of the teething problems that

besieged it since its launch in 1995, has become an almost universal scheme, feeding primary school children all over the country. The Mid Day Meal Scheme is the largest school lunch program in the world covering 114 million children. The Mid-day Meal Scheme has been extended to upper primary classes also. This is expected to benefit an additional 25 million children, taking the total number of children covered to 139 million (Jean et al, 2003).

Each of these objectives in turn has different aspects, some more ambitious than others. To illustrate one basic contribution of mid day meal to educational advancement is to boost school enrollment. Such meal may also enhance learning achievements, in so far as "classroom hunger" undermines the ability of pupils to concentrate and perhaps even affects their learning skills. Finally a well organized school meal can have intrinsic educational value, in addition to what it contributes to the routine learning process. For instance, school meals can be used as an opportunity to impart various good habits to children such as washing hands and to educate them about the importance of clean water, good hygiene, a balanced diet and related matters (Agrawal 1987).

Similarly the nutritional objectives of mid day meals have several layers, ranging from elimination of classroom hunger to the healthy growth of school children. In many respects a mid day meal is a nutritionists dream: the children come everyday on their own and they eat what ever is given to them. This makes it possible to raise their intake of calories and proteins but also provide nutritional supplements such as iron and iodine which needs to be ingested in small doses over a period of time.

Mid day meals also provide an excellent opportunity to implement nutrition program that requires mass intervention, such as deworming (Brahmam 2003). Available experiences indicate that these interventions are highly effective. For instance, a combination of mass deworming with vitamins and iron supplementations can significantly enhance children nutrition for as little as Rs. 15 per child per year (Dreze 2001).

The nutritional impact of MDM depends both on the quality and quantity of food provided at school. There are very few studies conducted in India to see the impact of MDM on the nutritional status of school children. Some studies have noted that the amount of food provided by the school does not meet the nutritional requirement as given by Supreme Court (Jain & Shah 2005). Another concern regarding the quantity of food is that the needs of a class one child are very different from those of class five; however this has not been taken into consideration while fixing the food provided. The possibility of shortage arises because food is cooked based on attendance records of the previous day.

The quality of the meal is the main remaining challenge as far as MDM is concerned. The nutritive value of the meal needs to be monitored carefully. The net impact of a MDM on the child's health is ultimately determined by whether the meal is a supplement or a substitute for the home meal. The issue of supplement versus substitute is not easy to disentangle and require information on eating habits of children before and after the MDM. Research is also required in this aspect (Menon et al 2003).

RATIONALE

Thus school going children are an important but neglected group especially in the rural areas. Today's adolescents are tomorrow's future. Most of the programs have focused on children under 5 years. MDM (Mid Day Meal) is currently going on all over India and in Gujarat, but the evaluation has not been done in terms of its impact on nutritional status of children. The data from rural area is especially lacking as the areas are not easy to reach. We need to relook at the prevalence of malnutrition and IDA (Iron Deficiency Anemia) and identify the causative factors.

Till now IFA tablet were given only to girls that to when they come in secondary section. Further IFA supplementation was given to children of urban areas only. Looking at the almost equal prevalence of anemia in boys and girls and that too in younger age group, the study was planned to see the

growth dynamics in rural school children of Vadodara and the effect of IFA supplementation and deworming tablets on growth pattern, anemia prevalence and physical work capacity of children from 4th to 7th Standard. The effort was to map the prevalence of malnutrition and come out with cost effective remedial techniques to tackle it.

Thus the study tries to answer the following research questions:

- What is the magnitude of the problem of malnutrition among the rural school children of Vadodara?
- What is the prevalence and severity of IDA among the rural school children?
- What is the sensitivity and specificity of clinical signs and symptoms of IDA with Hb levels when it is done with the help of pediatrician?
- What is the yearly MDM consumption pattern among the rural school children using secondary data?
- What is the growth dynamics of rural school children over a period of 3 years under standard care conditions?
- What is the efficacy of once weekly IFA supplementation along with Deworming and Deworming alone against the standard care conditions on growth, hemoglobin and physical work capacity?

The broad objective of the study was to assess the nutritional status of underprivileged school children of rural Vadodara and to see the impact of IFA supplementation and deworming on nutritional status of children. The study was divided in to 3 phases as follows

PHASE 1: FORMATIVE RESEARCH

Specific Objectives

- To assess the nutritional status of school children in terms of prevalence & severity of malnutrition
- To assess the prevalence & severity of micronutrient deficiencies in children through clinical examination

- To assess the dietary pattern of the rural school children
- To assess the utilization of mid day meal program by the children
- To map the prevalence and severity of Iron deficiency Anemia by Hb estimations

PHASE 2: LONGITUDINAL STUDY

- To monitor the school children for a period of 3 years with regards to their growth profile (Anthropometric Measurements).

PHASE 3: INTERVENTION STRATEGIES TO COMBAT IDA: RANDOM CONTROL TRIAL

Specific Objectives

- To study and compare the impact of weekly IFA supplementation (60 mg elemental Iron) for 30 weeks along with deworming dose of 400 mg Albendezole every 6 months and deworming alone (twice a year) on:
    A) Growth parameters (Height and Weight)
    B) Anemia Prevalence (Hemoglobin estimations)
    C) Physical activity capacity (Step Test)
- To assess the wash out effect of the supplementation after a period of 6 months