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Model for Analysing the Social
and Economic Impact of Child
Undernutrition in Latin America

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Santiago de Chile, December, 2007

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Summary

At present, Latin America is in a paradox, as the effects of both extremes of poor nutrition, obesity, and undernutrition, are present simultaneously in a region where the food supply is much greater than it has been historically and in most cases exceeds the population's dietary energy requirements.

The prevalence of undernutrition is not a mere accident in the region, but a reflection of huge disparities in income and the lack of priority given to food and nutrition issues on the countries' political agendas.

Aside from the ethical imperative to eradicate undernutrition, and the goals the countries set for themselves after the Millennium Declaration, it is necessary to analyse the economic consequences in order to support decision-making and allocate the resources needed to eradicate this scourge.

Thus, in view of the social and economic impact of child undernutrition and hunger in the region, the World Food Programme (WFP) and the Economic Commission for Latin America and the Caribbean (ECLAC) agreed to conduct a joint study for the purpose of estimating the costs that this problem entails for each country.

This document presents the model of analysis developed, which includes first a theoretical framework describing the main causes of undernutrition, the corresponding specific variables and interrelationships, and the consequences that arise from this scourge. The second part presents the methodology proposed for estimating the effects and associated costs based on data currently available in the countries of the region.

I. Conceptual bases

Hunger is a concept associated with food and nutrition insecurity, which is expressed operationally by the undernourishment indicator, reflecting a daily food intake that is less than the minimum necessary to meet energy needs.¹ Not having the funds to pay for a basic basket of food, defined according to cultural guidelines, corresponds to what is known as extreme poverty or indigence. Moreover, from the health perspective, food must be consumed in accordance with minimum standards of hygiene and nutritional balance in order to produce the positive results expected and to avoid problems of malnutrition due to excess (obesity) or due to deficiency (low birth weight, low weight and/or height for the individual's age, low weight/height ratio, low body mass index (BMI), etc.).

The principal theoretical underpinnings of the analysis of hunger and undernutrition in Latin America are described based on the concepts defined above.

1. Food security and vulnerability

As stated at the World Food Summit (1996), there is food security when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. In other words, food security depends on the availability, accessibility, and biological utilization of food.

Food vulnerability reflects “the probability of an acute decline in food access, or consumption, often in reference to some critical value that defines minimum levels of human well-being” (WPF 2002). In other words, it refers to the potential loss of *food security*. That is, the emphasis is placed not only on those who have food and nutrition problems, but also on those who have a high probability of facing such problems (even though at the time of analysis their access is sufficient), which makes it possible to anticipate negative fluctuations and to take preventive measures to target supply and rationalize the use of resources, maximizing their efficiency and impact.

Vulnerability can be defined as a vector with two confronting components, the first attributable to conditions (variables) in the environment (natural, social, and economic) and the second to the capacity-will (individual and collective) to counteract them. Therefore,

$$\text{Vulnerability} = \text{Risk} - \text{Coping Capacity}$$

2. Demographic, epidemiological, and nutritional transitions

The population's age composition and activities are a key factor in determining its nutritional requirements and energy consumption. The economic, demographic, and epidemiological changes that have taken place in Latin America over the last few decades mean that transitions are central elements in the analysis of the countries' situation and the design of long-term food and nutrition policies.

The demographic transition is an evolutionary process characterized by a major decline in both births and deaths, with one usually lagging behind the other, a key factor in the growth of human populations. The epidemiological transition reflects the long-term changes that have been seen in mortality, disease or disability patterns derived from demographic and socio-economic

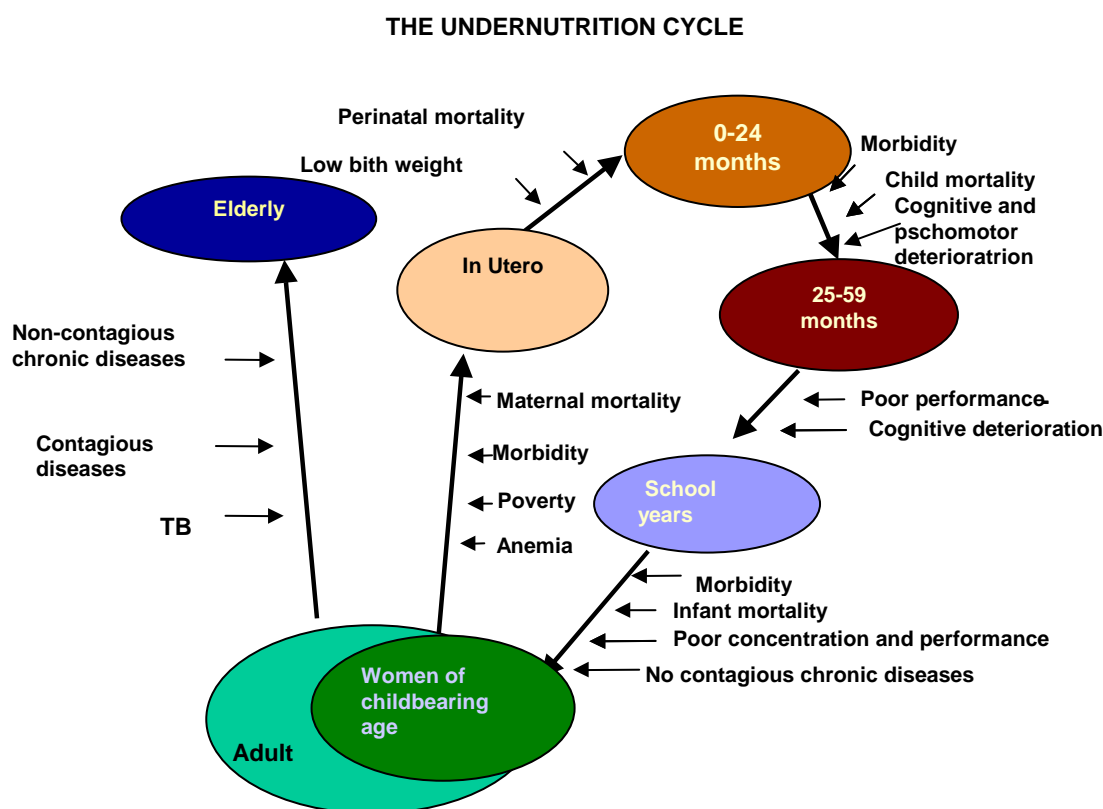
¹ The amount of energy required depends on the age characteristics, anthropometrics, and activity of the population. According to information from FAO, the minimum requirement in countries in this region is approximately 1,800 kcal/day per person. In contrast, the average required for persons with moderate physical activity is 2,100 kcal/day. (FAO, 2004b, ECLAC 2004b p. 88-90).

transformations. The nutritional transition reveals changes in the populations' nutritional profiles as a consequence of dietary changes.

One central element that helps explain the region's epidemiological and nutritional situation is the drastic shift in lifestyles associated with increasing urbanization, especially with respect to diet, physical activity, consumption of tobacco, alcohol, and drugs, stress, and mental health problems.

3. The life cycle

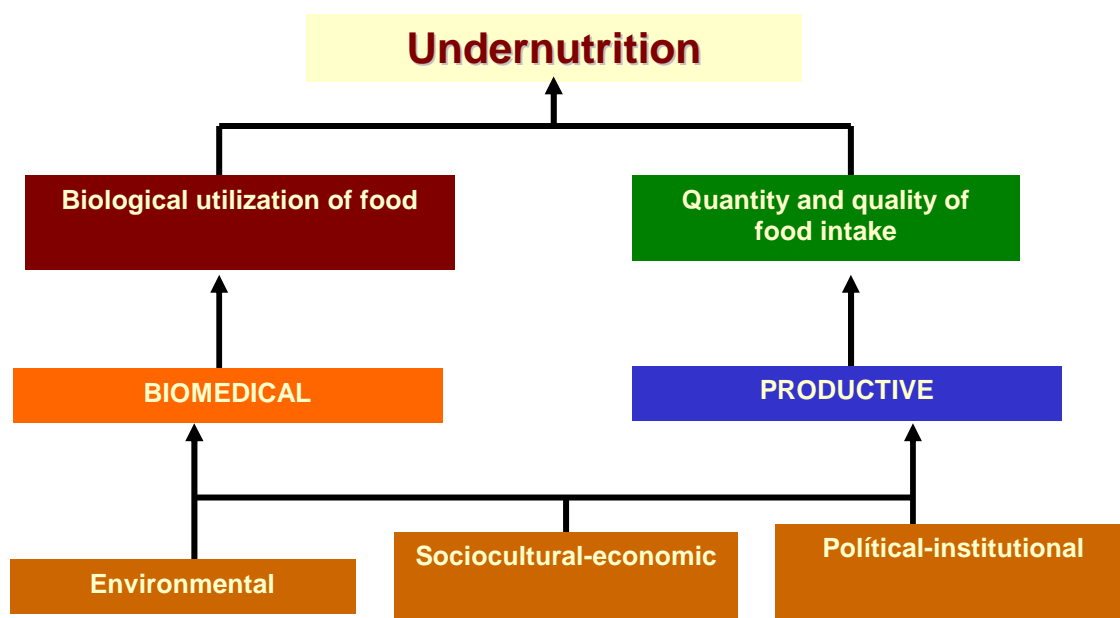
The effects of undernutrition can become evident throughout the life cycle, given that nutritional needs and requirements change over an individual's lifetime. In this process, most noteworthy are the stages associated with: intrauterine and neonatal life, infancy and preschool, school years, and adult life.



Source: Adapted from Branca, F. and Ferrari, M. (2002).

II. Causes of undernutrition

The main factors associated with the emergence of undernutrition as a public health problem can be grouped as follows: environmental (due to natural or entropic causes), socio-cultural-economic (associated with problems of poverty and inequality), and political-institutional factors. All of them work together to increase or decrease biomedical and production vulnerabilities, and through the latter they determine the quantity and quality of food intake and the body's absorption capacity, which in turn determine whether there is undernutrition.

FACTORS ASSOCIATED WITH THE DEVELOPMENT OF UNDERNUTRITION

Source: Authors' compilation

The importance of each of these factors depends on the intensity of the resulting vulnerability and the person's current stage in the life cycle.

Environmental factors define the surroundings in which the subject and his or her family live, including the risks stemming from the natural environment itself and its cycles (from floods, droughts, freezes, earthquakes, and other phenomena), and those produced by humans, that is, entropic risks (such as the combination of water, air, and food, the expansion of agriculture into new territories, etc.).

The socio-cultural-economic determinants include elements associated with poverty and equality, education and cultural norms, employment and wages, access to social security, and coverage of aid programmes.

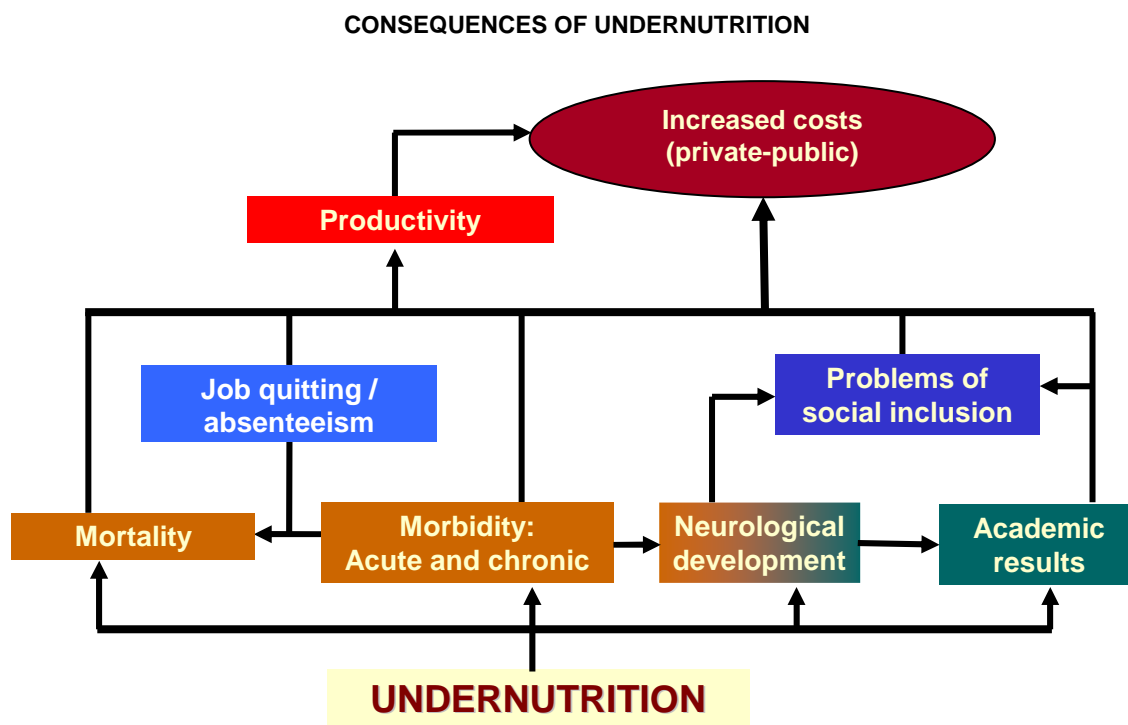
The political-institutional factors encompass government policies and programmes aimed at solving the population's food and nutritional problems.

Production factors include those directly associated with the production of food, as well as the access that the at-risk population has to them. The availability and autonomy of each country's dietary energy supply depend directly on the characteristics of production processes, the degree to which they utilize natural resources, and the extent to which these processes mitigate or aggravate environmental risks.

And finally, biomedical factors take into account the individual's susceptibility to undernutrition, insofar as certain elements limit the capacity to make biological utilization of the food consumed (regardless of quantity and quality).

III. Consequences of undernutrition

Undernutrition has negative effects on various aspects of people's lives, most notably health, education, and the economy (costs and expenditures in the public and private sectors, and productivity). Consequently, these effects exacerbate problems with social integration and increase or intensify the poverty and indigence that plague the population. The vicious cycle is then perpetuated as vulnerability to undernutrition grows.



Source: Authors' compilation.

These effects may appear immediately or throughout a person's lifetime, and they increase the chances of later undernutrition in those who have already suffered it during the early years of the life cycle. Other consequences are more likely to ensue as well. Thus, intrauterine undernutrition can create difficulties from birth to adulthood.

Various health studies have shown that undernutrition makes certain pathologies more likely to appear and/or intensify, and it increases the chances of death in different stages of the life cycle. How these consequences materialize depends on the epidemiological profile of each country.

With respect to education, undernutrition affects student performance because of disease-related deficits and the limited learning capacity associated with deficient cognitive development. This translates into greater probabilities of starting school at a later age, repeating grades, dropping out of school, and ultimately a lower level of education.

Undernutrition and its effects on health and education also translate into heavy costs for the society at large. In this manner, Total Costs resulting from undernutrition (TC^U) are a function of higher healthcare spending (HC^U), inefficiencies in education (EC^U) and lower productivity (PC^U).

$$TC^U = f(HC^U, EC^U, PC^U)$$

In the area of health, the higher probability resulting from the epidemiological profile of individuals suffering from undernutrition proportionally increases costs in the healthcare sector (HSC^U), which at the aggregate level is equal to the sum of the interactions between the probability of undernutrition in each human group, the probability that this group will suffer each of the diseases because of that undernutrition, and the costs of treating the pathology (diagnosis, treatment, and control) in each demographic group. To this are added the costs paid by individuals and their families as a result of lost time and quality of life (IHC^U).

$$HC^U = f(HSC^U, IHC^U)$$

In education, the reduced attention and learning capacity increases costs to the educational system (ESC^U). Repeating one or more grades commensurately increases the demand that the educational system must meet, with the resulting extra costs in infrastructure, equipment, human resources, and educational inputs. To these costs are added the private ones (incurred by students and their families) derived from the larger quantity of inputs, external educational supplementation, and more time devoted to solving or mitigating low performance problems (PEC^U).

$$EC^U = f(ESC^U, PEC^U)$$

The cost of undernutrition in terms of productivity loss is equal to the loss in human capital (HK) suffered by a society, stemming from the lower educational level achieved by individuals suffering from under nutrition (EL^U) and the loss of productive capacity resulting from the higher number of deaths (higher mortality) caused by undernutrition (HM^U).

$$PC^U = f(ELC^U, HMC^U)$$

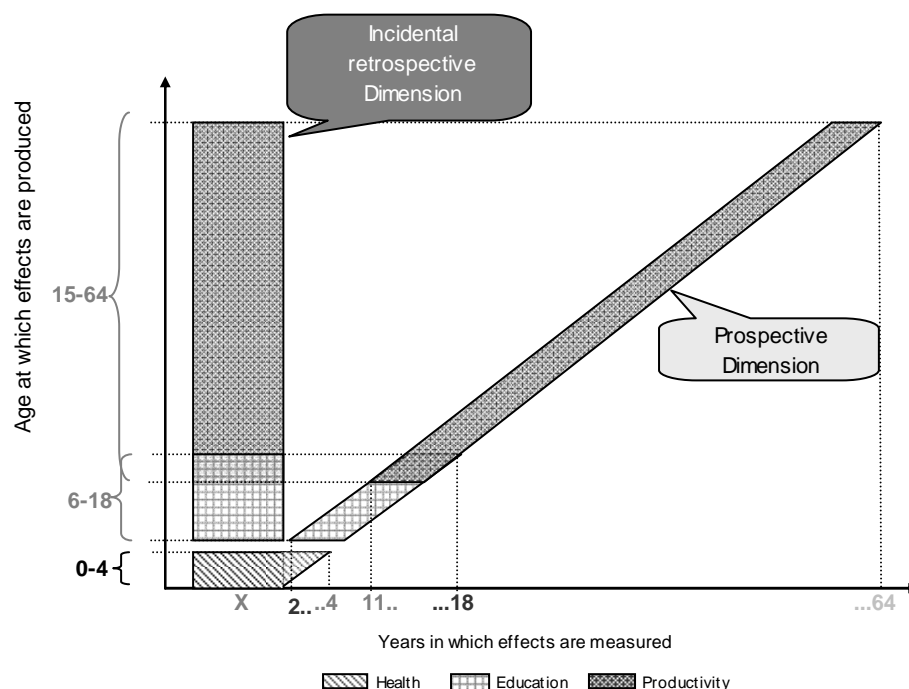
Considering that a country's undernutrition situation and the consequences thereof reflect a specific epidemiological and nutritional transition process, a comprehensive analysis of the matter involves making estimates of the current situation by extrapolating from previous transitional stages, as well as estimates of the future, predicting potential cost and savings scenarios based on the prospects for intervening to control or eradicate the problem.

On this basis, a two-dimensional analysis model has been developed for estimating the costs arising from the consequences of child undernutrition in health, education, and productivity:

1. *Incidental retrospective dimension.* Makes possible an estimate of the cost of undernutrition in a country's population for a given year. Thus, it is possible to estimate the health costs of preschool children who suffer from undernutrition during the year of analysis, the education costs stemming from the undernutrition children now in school suffered during the first five years of life, and the economic costs due to lost productivity by working-age individuals who were exposed to undernutrition before the age of five.
2. *Prospective, or potential savings dimension.* This dimension makes it possible to project the present and future losses incurred as a result of medical treatment, repetition of grades in school, and lower productivity caused by undernutrition among children under the age of five in each country, in a specific year. Based on that, potential savings derived from actions taken to achieve nutritional objectives can be estimated (for example, to attain MDG1, reducing undernutrition by half by 2015).

As the following figure shows, the incidental retrospective dimension includes the social and economic consequences of undernutrition in a specific year (X) for different cohorts that have been affected (0 to 4 years of age for health, 6 to 18 years for education, and 15 to 64 years for productivity). The prospective dimension, on the other hand, projects future effects and costs of the undernutrition that exists in a specific year (X) in a cohort of children less than 5 years old (between years X and X+4 for health, X+2 to X+18 for education, and X+11 to X+64 for productivity).

DIMENSIONS OF ANALYSIS BY POPULATION AGE AND YEAR WHEN EFFECTS OCCUR



Source: Authors' compilation.

The model, with its two dimensions of analysis, focuses on underweight and its effects. It does not, however, take into account the effects of deficiencies in micronutrients (iron, zinc, iodine, vitamin A, etc.), because not enough research has been done to differentiate the incremental costs and effects of each type of deficiency independently or to identify the interactions between deficiencies in some micronutrients and between them and the anthropometric indicators.

The universe of children suffering from undernutrition has been divided into sub-cohorts (0 to 28 days, 1 to 11 months, 12 to 23 months, and 24 to 59 months) to highlight the specificity of certain effects associated with particular stages in the life cycle.

Which undernutrition indicator is used depends on the sub-cohort being analysed. For intrauterine undernutrition, what is estimated is low birth weight (LBW) due to intrauterine growth restriction (IUGR, defined as a weight below the tenth percentile for gestational age). For the preschool stage, moderate and severe underweight (weight-for-age score below -2 standard deviations) are used, taking the National Center of Health Statistics (NCHS) distribution as a comparison pattern.

The estimates of impact of undernutrition on health education, and productivity are based on the concept of relative (or differential) risk incurred by individuals who have suffered from

undernutrition during the early stages of life. This is valid both for the incidental-retrospective analysis and for the prospective savings analysis. However, its operationalization has specific characteristics in each case, so they are detailed separately in the document.

To estimate costs, in the incidental-retrospective dimension the values occurring in the year of analysis are added up and estimates are made of the process undergone by the different cohorts of the population. In the prospective dimension, in contrast, the present value of a flow of future costs is estimated, and it is converted into an equivalent annual cost so that it can be compared with social spending and GDP.

It should be noted that the methodology described in this document not only permits an analysis of a country's situation based on information available in a specific year, but also makes it possible to simulate scenarios in order to estimate both the extra costs a country has incurred because it did not adopt certain mitigation measures previously and the future impacts and savings that may be achieved if these measures are implemented. Thus, the method provides for an evaluation of different hunger and undernutrition mitigation programmes from a cost-effectivity and cost-benefit perspective.

IV. Reflections on the pilot experience

Each of the steps described in the methodology for estimating the costs and effects of child undernutrition was developed in a pilot study in Peru. Some counterpoints were provided based on information about Chile in order to test the proposals, identify weaknesses in the feasibility and reliability of the data, develop alternatives for resolving difficulties, and make the application processes more efficient.

In light of this experience on the ground, it can be concluded that the methodology based on secondary data, both from the countries and from international organizations, plus in-depth interviews with subject-matter experts in each country, efficiently meets the established objectives and duly takes into account the theoretical foundation on which it is based. Nonetheless, this proposal admits of alternative procedures and indicators dictated by the actual situation of the country where it is implemented.

Some of the principal obstacles and challenges presented in the application of the model are described below.

1. Limitations on the quality of information available. Reliable data on health, education, and operating costs is not always available, which means that proxy indicators from the country in question or another country must be substituted.
2. Relative health and education risks are not readily available or representative. In general, Latin America and the Caribbean have little experience in this area, so it becomes necessary to consider related parameters that are not necessarily representative of the region's specific situation.
3. Difficulty incorporating micronutrients into the analysis. Although it is clearly advisable to pursue estimates that include micronutrient deficiency, it has not been done in this case due to the lack of studies with reliable data that would make it possible to differentiate the incremental effects and costs derived from each one independently and to identify the interactions between deficiencies in some micronutrients and between them and the anthropometric indicators.
4. Estimate of productivity scenarios. The lack of reliable information limits the ability to analyse scenarios that reflect the changes in potential income derived from the

hypothetical cases in which there is no undernutrition, due to effects on the labour market. This does not mean that in the future such analyses cannot be incorporated into the estimation models presented here.

5. Definition of an adequate discount rate. For comparison purposes, when prospective analyses are made in different countries, it is advisable to use a single discount rate for all of them. This rate is not easy to define, especially considering that when very long-term estimates are made, it has a direct impact on the present values and on the annual rates estimated. For the pilot study, and as a rate to be tested in other countries, an annual rate of 8% was selected. This was the lowest one found for social evaluation in the region. Using alternative rates will modify the total amounts, but will have no effect on the country-to-country comparisons.

The challenge to improve the quality of the data and new methodological developments is on the table. Meeting it will provide more reliable indicators for decision-making by the officials responsible for implementing programmes and projects aimed at combating hunger and undernutrition in the region. That will have positive consequences not only for research and programme design in this area, but also for the development and improvement of data collection systems and the decision-making process for devising and implementing policy in a variety of sectors.

Introduction

The current nutrition situation in Latin America could well be described as paradoxical. At the regional level, and in many cases the national level as well, it is possible to detect the simultaneous presence of effects from both extremes of poor nutrition: obesity and undernutrition. In vast segments of the urban populace, increased consumption of high-calorie foods and reduced physical activity have generated a constant rise in obesity, which is not necessarily associated with higher income. On the other hand, in large segments of the socio-economically marginalized population, micronutrient malnutrition remains very prevalent and has even increased, threatening to become endemic in the region. Hence the major health challenges in the region –premature death due to maternal-infant problems and infectious diseases, as well as non-contagious chronic diseases (NCCD) in adults– which, ironically, are associated with an increase in life expectancy and with unhealthy lifestyles.

As part of this paradox, it is important to point out that undernutrition is holding steady (or coming back) in a region where the food supply is much larger than it was historically, and in most cases exceeds the population's dietary energy requirements. Thus, it is clear that there is an element of inequality in access to food, which undoubtedly figures large in the region's food and nutrition picture.

The prevalence of undernutrition, then, is not a mere accident in the region, but a reflection of huge disparities in income and the lack of priority given to food and nutrition issues on the countries' political agendas.

One factor that could explain the lack of attention given to undernutrition is that the ethical imperative of eradicating hunger in the region has not been fully embraced. Another reason is that the countries are unaware of, or do not want to know, the economic cost of maintaining the status quo.

At present, beyond the ethical imperative and the goals that the countries set for themselves in the Millennium Declaration, the economic factor must be scrutinized more carefully in order to mobilize decision-making and allocate the resources necessary to eradicate this scourge.

In view of the social and economic impact of hunger and undernutrition in the region, WFP and ECLAC agreed to conduct a joint study for the purpose of estimating the economic and social costs of undernutrition in the region.

The objective of the project was to design a model of analysis that would make it possible to study the dynamics of food consumption, undernutrition, and their economic impact on Latin America and the Caribbean.

This model is now being applied in 14 countries, and there are plans to incorporate at least three other countries in order to cover the majority of the region's population. This will allow new advances in methodology in the medium term that can contribute to a gradual increase in the reliability of estimates and minimize the risk involved in decision-making.

This document contains a proposal for a theoretical framework encompassing the principal factors causing undernutrition, their corresponding specific variables and interrelationships, and the consequences arising out of this scourge, as well as a methodology for analysing them and estimating the associated costs, based primarily on data currently available in the countries of the region

A. Theoretical Framework

I. Conceptual Bases

To reach an agreement on the elements to be considered when using the terms *hunger* and *undernutrition*, some basic concepts need to be revisited.

Hunger is associated with ingesting a smaller amount of food than what is necessary to meet a person's energy requirements. To avoid this, the following conditions must be present:

1. Availability of a sufficient quantity and quality of food to cover at least the minimum requirements.² When this condition is not met, there is *undernourishment*, a concept associated with *food and nutrition insecurity* that has been used primarily in programmes for food production and marketing.
2. Facilities to provide the population with ongoing access to food so that it can consume a balanced diet, meaning channels of distribution as well as buying power on the part of the public. When the population does not have the funds to pay for a basic basket of food, defined according to cultural guidelines, it suffers what is known as *extreme poverty or indigence*, a concept linked to the analysis of the population's socio-economic problems and utilized in anti-poverty programmes.

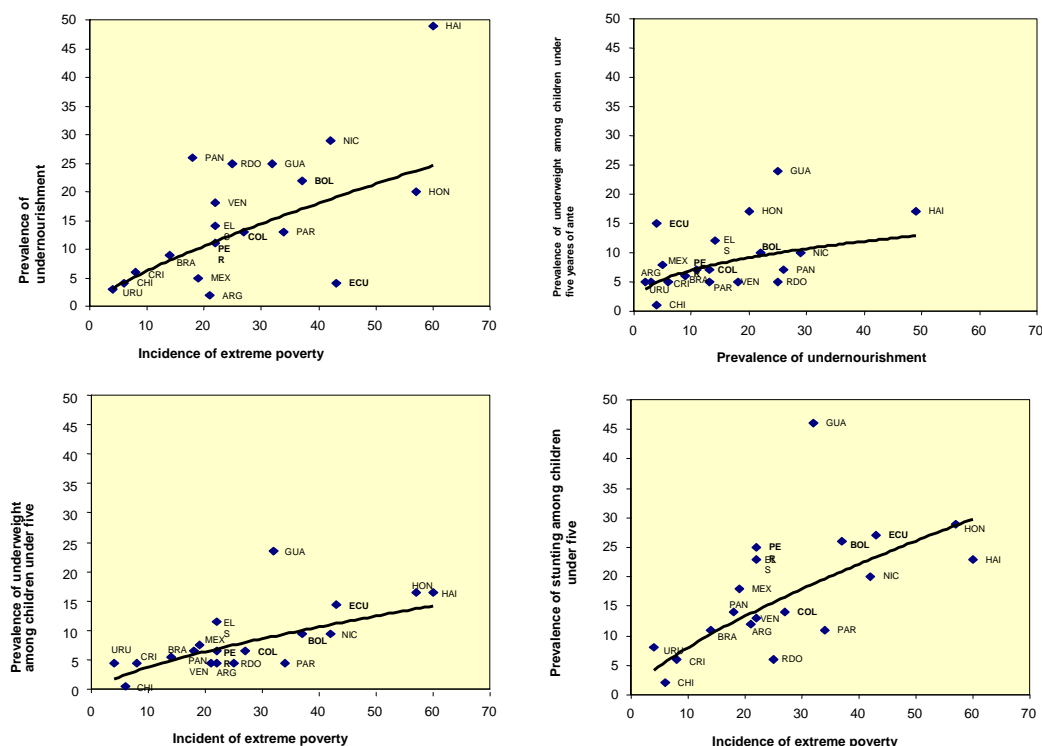
² The amount of energy required depends on the age characteristics, anthropometrics, and activity of the population. According to information from FAO, the minimum requirement in countries in this region is approximately 1,800 kcal/day per person. In contrast, the average required for persons with moderate physical activity is 2,100 kcal/day, (FAO, 2004b, ECLAC 2004b p. 88-90).

3. The food must actually be consumed and be in accordance with minimum standards of hygiene and nutritional balance in order to produce the positive results expected and to avoid problems of *malnutrition due to excess or deficiency* (low birth weight, low weight and/or height for the individual's age, low weight/height ratio, low BMI, etc.). These concepts are mainly associated with the public health and epidemiological perspectives, and are used primarily by health and food aid programmes.

Depending on the intensity, malnutrition due to excess may translate into excess weight or obesity. Undernutrition is divided into different types: acute, serious, and severe. In turn, there can be combinations of both, for example, with excess weight and low height. Populations with a tendency towards low height are very likely to suffer from excess weight.

As can be seen in the figures below, undernourishment, extreme poverty, and undernutrition are concepts that are closely related but independent. In addition, when the causes are examined, it can be seen that the former two increase the probability of undernutrition but do not produce it.

FIGURE 1
LATIN AMERICA (18 COUNTRIES): RELATIONSHIP BETWEEN EXTREME POVERTY, UNDERNOURISHMENT AND UNDERNUTRITION



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of special tabulations derived from household surveys and Demographic and Health Surveys (DHS) in the respective countries, and from the United Nations Food and Agriculture Organization (FAO), Food Balance Sheets.

Based on the concepts defined here, some fundamental theoretical underpinnings should be described, given that they form the framework for the analysis of hunger and undernutrition in Latin America, and without them it is impossible to analyse in a coordinated manner the costs of the consequences or the effectiveness of interventions to prevent this adversity. These underpinnings are related to:

1. Food security and vulnerability

The origin of the concept *food security* dates back to the 1948 “Universal Declaration of Human Rights”, which recognized the right to food as a key element of human well-being.

Different organizations use this concept to guide their development and food aid policies and programmes. The various definitions of the term can be summed up by referring to the one cited at the 1996 World Food Summit, which states that “Food Security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996).

This food security depends on a complex coordination of agricultural, environmental, economic, social, cultural, and biological factors. However, it can be described on the basis of three complementary dimensions: the availability of, access to, and biological utilization of foods.

- *Availability* reflects the quantity and type of foodstuffs that a population (country, community, household, family) or individual has at its disposal. It is the sum of all domestic production, imports, and external donations, less exports.
- *Access* refers to the feasibility that all members of a population (country, community, household, family) will be able to obtain the food that is available, either through their own production, by buying it on the market, or by receiving transfers from other sources. Limitations on access may be physical (lack of distribution channels, roads, etc.), economic (price vs. income), or sociocultural (dietary customs, educational level).
- Biological utilization refers to all of the customs and cultural practices that define the extent to which foodstuffs are actually consumed. This depends on the adjustment of the diet to the needs of each member (selection and combination, amount of cooking and preparation method according to age, sex, energy consumption and health) and hygienic conditions (in preserving, transporting, and handling).

The three dimensions are necessary and interdependent conditions for the population to be able to eat properly. All things considered, Food and Nutrition Security (FNS) has become a central policy objective and is an ideal to be achieved by the countries and institutions involved in this issue, especially when it comes to upholding a right of the individual.

This perspective on the matter is based on representations of a reality at specific points in time, the result of previous processes and a reflection of surrounding circumstances. It says nothing about future risks, so some define it as a “*static perspective*”. Consequently, examining what is going on in the population by looking only at the level of food security may limit the ability to anticipate eventual fluctuations that will exacerbate insecurity (by spreading and/or intensifying it), thus undermining the effectiveness and efficiency of these policies.

Food vulnerability reflects “the probability of an acute decline in food access, or consumption, often in reference to some critical value that defines minimum levels of human well-being” (WPF 2002). In other words, it refers to the potential loss of *food security*.

The focus on vulnerability is intended to be “*dynamic*”, identifying the population groups that are likely to succumb to insecurity. In this way, the emphasis is placed not only on those who have food and nutrition problems, but also on those who have a high probability of facing such problems, even though at the time of analysis their access is sufficient. This makes it possible to anticipate negative fluctuations and to take preventive measures to target supply and rationalize the use of resources, maximizing their efficiency and impact.

This approach considers states of food insecurity as a starting point, but it concentrates on estimating potential variations in flows (both present and future), with a view to facilitating the

management of the food and nutrition problem in a proactive way and forecasting future problems rather than attending only to populations that already have a deficit.

At the household level, there is a high correlation between insecurity and vulnerability. These two elements reinforce each other: those who do not enjoy food security have less protection against fluctuations in access, so they are more susceptible to suffering a gradual worsening of their deficit.

Vulnerability is a function of risk (having one's access to food limited in some way) and of the ability to cope with developments of this nature. Thus, the most vulnerable population is the one that faces high risk and has a low response capability.

$$\text{Vulnerability} = \text{Risk} - \text{Coping Capacity}$$

From this perspective, vulnerability could be defined as a vector with two confronting components, the first attributable to conditions (variables) in the environment (natural, social, and economic) and the second to the capacity-will (individual and collective) to counteract them.

According to this approach, risk has three dimensions:

- environmental (intensity and frequency of: floods, droughts, freezes, and others);
- sanitation-nutrition (undernutrition *per se* and epidemics – in humans, crops, and livestock);
- the food market (variations in the supply and price of foodstuffs).

Response capability, in turn, can be subdivided analytically into two levels: family-community and social-institutional.

At the *family-community* level, all aspects that help or hinder an individual, his or her family, and those around them to face the risks of insecurity. This is the aspect that WFP focuses on in its Vulnerability Access and Mapping (VAM) analyses.³

The most important variables at this level are:

- the availability of physical (food, land, and others), human (health and education-knowledge), social (community and institutional support networks, either internal or external), and infrastructure assets (storage capacity, road access, sanitation systems, irrigation, and damage control systems).
- the levels and degrees to which production, income, and consumption are diversified.

Thus, not having enough income to cover the household's food needs would not be a risk in itself, but a limitation on autonomous problem-solving capacity.

The interventions made by society to compensate for deficient autonomous capacity are grouped at the *social-institutional* level. In this manner, populations that are at high risk for losing access to food and have a limited autonomous problem-solving capacity can reduce their vulnerability if there is a response capacity coordinated at the group level (be it a local, regional, national, or international group). This level includes:

- the coverage and response capacity of food aid programmes,
- monetary and food reserves, as well as the ability to mobilize them to collect and distribute foodstuffs,

³ For more information, see: <http://vam.wfp.org>

- risk mitigation programmes involving physical investments (irrigation channels, reservoirs, storage facilities, and others), sanitation, equipment (machinery), technology transfer, and financing,
- the coverage of the health, education, and social services network.

One key element in determining the social-institutional response capacity is the priority given to the population's food and nutrition situation on the public agenda. The countries that have long-term government policies, clearly defined goals and budgets, and an approach that rises above the day-to-day politics of whatever administration is in office at the moment are the ones with the greatest response capacity. They are therefore able to afford their population a higher probability of achieving FNS.

In addition to differences in vulnerability from one population to the next within the same country, in a single community (family or person) there may be different levels of vulnerability at different times of year. This comes about because of weather cycles and their relationship to the periods when food crops are planted and harvested (both domestically and abroad), which affect availability and access and cause seasonal fluctuations in the food market.

Thus, insecurity not only affects different people differently, but also varies throughout the year. Consequently, it is not "the vulnerability" of each population but "their vulnerabilities" that should be considered when formulating FNS policies and programmes.

This is especially important in rural areas dependent on subsistence crops that cover dietary needs only part of the year. After that supply is exhausted, the population depends on income earned as labourers, which fluctuates according to external marketing and production variables. Even more serious is the plight of those who do not own land and live only on their income as labourers in areas with extremely volatile food prices and no social protection services.

Another example is the impact of droughts or heat spells, on the one hand, and floods and hurricanes on the other hand, which hit countries at different times of year.

2. Transitions: demographic, epidemiological and nutritional

The population's age composition and activities are a key factor in determining its nutritional requirements and energy consumption. Therefore, understanding the nature of the process becomes a fundamental element in analysing the situation of a country or region and designing appropriate food and nutrition policies for the long term.

The above is particularly relevant to Latin America, which in recent decades has undergone a number of economic, demographic, and epidemiological changes that have altered its nutrition and food profile.

a) Demographic transition

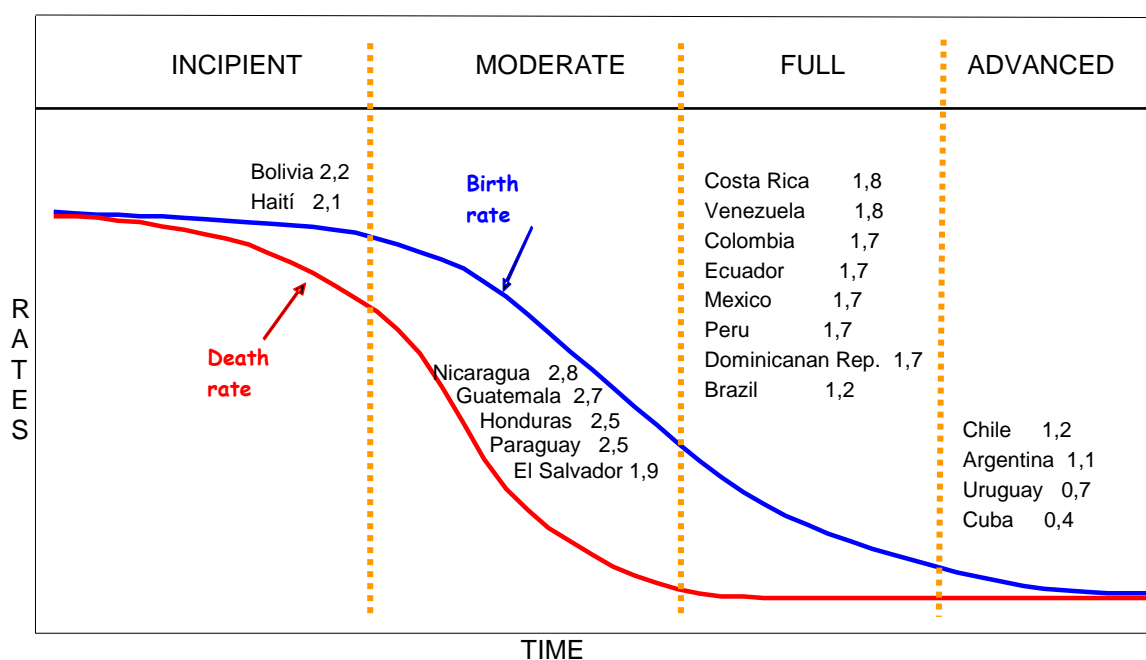
The demographic transition is an evolutionary process characterized by a major decline in both births and deaths, with one usually lagging behind the other. This process is a determinant in the growth of human populations, and takes place in stages.

- The first, *incipient* stage, is characterized by high birth and death rates, with a low population growth rate (examples are Haiti and Bolivia).
- The second, *moderate* stage, is characterized by a more rapid decline in deaths than in births, which leads to a significant increase in the size of the population (examples include Guatemala, Honduras, and Paraguay).

- In the third stage, *full transition*, the birth rate begins to approach the death rate, and population growth slows down (as seen in Brazil and Mexico).
- And finally, the fourth, *advanced* stage corresponds to countries with low rates of demographic growth, such as Cuba and Uruguay.

The ageing of the population is one of the most important manifestations of demographic transition, as the proportion of children and young people diminishes and the relative weight of older adults climbs.

FIGURE 2
DEMOGRAPHIC GROWTH RATE IN LATIN AMERICAN COUNTRIES BY
STAGE OF DEMOGRAPHIC TRANSITION, 2000-2005
(Percentage)



Source: Albala C., Olivares S, Salinas J. and Vio F. (2004).

b) Epidemiological transition

The epidemiological transition corresponds to the long-term changes seen in mortality, disease, or disability patterns derived from demographic and socio-economic transformations.

There are three main stages that make up this process, and their principal characteristics are shown in the table below.

TABLE 1
STAGES OF THE EPIDEMIOLOGICAL TRANSITION

| Characteristic | STAGES | | |
|---|---|--|---|
| | Pre-transition | Transition | Post-transition |
| Population age | Young population | Progressive ageing | Ageing population |
| Location of population | High percentage of rural dwellers | Growing urbanization | Predominantly urban population |
| Characteristics of the most prevalent pathologies | Environmental problems | Increased risk factors for non-contagious chronic diseases | Predominance of non-contagious chronic diseases |
| | Maternal-infant and infectious diseases | Coexistence of contagious diseases with chronic diseases and accidents | High prevalence of congenital and metabolic diseases in children, plus mental illnesses and accidents |

Source: Albala C., Olivares S, Salinas J. and Vio F. (2004).

The epidemiological transition is a dynamic process in which setbacks may occur at one stage or another, for example, as cholera, dengue fever, malaria, and tuberculosis reappear in some countries after they were thought to be eradicated. This phenomenon is known as a “counter-transition”, and it is what has happened with undernutrition that has reappeared and is becoming endemic in many countries.

c) Nutritional transition

The nutritional transition refers to changes in populations’ nutritional profiles as a consequence of dietary changes. This process is caused by the interaction between economic, demographic, environmental, cultural, and physical activity changes that take place in society. In Latin America, it has affected different countries, just as the demographic and epidemiological transitions have.

The process can be subdivided into three stages, the principal characteristics of which are presented in the following table.

TABLE 2
STAGES OF THE NUTRITIONAL TRANSITION

| Characteristic | STAGES | | |
|--------------------|---|---|---|
| | Pre-transition | Transition | Post-transition |
| Diet (prevailing) | Grains Tubers Vegetables Fruits | Increased consumption of sugar, fats, and processed foods | High fat and sugar content Low fibre content |
| Nutritional status | Nutritional deficiencies and undernutrition predominate | Nutritional deficiencies and obesity coexist | Predominance of obesity and hyperlipidemias |

Source: Albala C., Olivares S, Salinas J. and Vio F. (2004).

One central element that helps explain the region’s epidemiological and nutritional situation is the drastic shift in lifestyles associated with increasing urbanization, especially with respect to diet, physical activity, consumption of tobacco, alcohol and drugs, stress, and mental health problems. This phenomenon has become individualized as an increase in risk factors for Non-Contagious Chronic Diseases (NCCD), which is more likely to occur in the poorest sectors. Since the 1950s, the proportion of poor people living in urban areas has risen significantly in all

countries. It is estimated that in 2025 the most common place of residence in the poorest countries will be in urban areas.

In Latin America, this trend has become evident in the last few decades, and as a result the urban infrastructure is not capable of withstanding the impact of this migration. Accordingly, health problems arise in conjunction with the collapse of health systems, precarious living conditions, and problems with environmental pollution and labour and social integration. This scenario is conducive to the development of infectious and maternal-infant diseases, as well as those associated with undernutrition, corresponding to the “pre-transition epidemiological stage”.

As social and labour integration improve, lifestyle changes occur, such as the mechanization of labour and the adoption of a calorie-rich diet that leads to obesity, without the disappearance of undernutrition. The stages of the epidemiological and nutritional transition are characterized by the predominance of infectious and maternal-infant diseases and undernutrition, coinciding with the emergence of NCCDs and increased obesity.

The improvement of the population’s economic circumstances and its progressive ageing lead to the disappearance of infectious and maternal-infant diseases and undernutrition, and NCCDs and obesity clearly predominate. This final stage is called the “post-transition”.

As shown in the table below, five Latin American countries are in the epidemiological and nutritional pre-transition, eight in transition, and five in post-transition. Argentina is an interesting case, having suffered a severe “counter-transition” in the last few years as infectious diseases and undernutrition have returned.

TABLE 3
LATIN AMERICA (18 COUNTRIES): CLASSIFICATION OF COUNTRIES BY STAGE OF
EPIDEMIOLOGICAL AND NUTRITIONAL TRANSITION

| Pre-transition | Transition | Post-transition |
|----------------|-------------|-----------------|
| Bolivia | Paraguay | Costa Rica |
| Haiti | El Salvador | Chile |
| Guatemala | Panama | Cuba |
| Honduras | Mexico | Uruguay |
| Nicaragua | Brazil | Argentina |
| | Colombia | |
| | Ecuador | |
| | Peru | |

Source: Albala C., Olivares S, Salinas J. and Vio F. (2004).

3. The life cycle

The effects of undernutrition can become evident throughout the life cycle, given that nutritional needs and requirements change over an individual’s lifetime. For this reason, some stages of the cycle are associated with undernutrition and its effects, as shown in the following section.

a) Intrauterine and neonatal life

The mother’s nutritional status often determines the newborn’s birth weight, health, and prognosis for life. Consequently, the cycle begins in the maternal womb and is even affected by the mother’s condition before pregnancy.

One of the main determinants in retarded intrauterine growth is the mother’s stature, which in turn is a reflection of her nutritional status during her own childhood and prior to conception, and whether or not she gained weight during the pregnancy. For this reason, the nutritional care of

women of childbearing age is a key factor in the life of the newborn, whose risk of mortality is significantly higher than that of older infants.

Of the nearly 11 million deaths of boys and girls under the age of five occurring throughout the world, 3.9 million occur in the first 28 days of life, that is, during the neonatal period.

The most common consequence of retarded intrauterine growth is low birth weight (LBW = weight < 2.5 Kg), which in turn is one of the most important predictors of infant mortality. This is 14 times greater in children with a history of LBW compared to full-term newborns with adequate weight. Thus, according to World Health Organization data, mortality among children under the age of five is attributable to the following causes:

| | |
|--|-----|
| • Neonatal causes (including LBW and perinatal asphyxia) | 42% |
| • Pneumonia | 19% |
| • Diarrhoea | 13% |
| • Malaria | 9% |
| • Measles | 5% |
| • AIDS | 3% |
| • Other causes | 9% |

In the poorest countries, which have a high infant mortality rate, only 20% of these deaths occur in the perinatal period. In contrast, in countries where the infant mortality rate is less than 35 per 1,000 live births, more than half of infant deaths occur in newborns.

It should be noted that LBW as an indicator of the extent of intrauterine growth restriction (IUGR)⁴ poses serious reliability problems in the region, with both overestimates and underestimates due to the difficulty in pinpointing gestational age in areas with low childbirth follow-up coverage and low levels of education.

Some country-by-country data show that:

1. In underdeveloped countries, IUGR explains most LBW and is heavily influenced by short maternal stature, a low body mass index (BMI) prior to pregnancy, and a low weight gain during pregnancy. As countries advance in their levels of development, the share of intrauterine growth problems decreases and cases of LBW due to premature birth rise.
2. The prevalence of LBW is approximately 8.7% in Mexico and South America, and 10.3% in Central America and the Caribbean (CLAP/WHO 2001). Of the seven South American countries analysed in the region, Chile has the lowest incidence of LBW (5.1%), whereas Bolivia and Venezuela have the highest rates (10%).
3. For the region as a whole, only Haiti has the highest level of severe LBW, 15%.
4. Not only does LBW have an impact on infant mortality, but often children who survive have multiple problems (between 13% and 24% have neurological disorders, for example). It also accounts for 2%, 3%, and 12% of all Disability Adjusted Life Years (DALY) lost due to undernutrition in countries classified as having very low, low, and high infant/adult mortality rates, respectively (WHO, 2002). The same report indicates that the number of DALY losses attributed to low weight in countries of the Americas with a very low mortality rate is 12 for men and 11 for women.

⁴ WHO defines these children as those whose weight is below the tenth percentile for their gestational age, as defined by Williams et al (1982).

The intrauterine nutritional environment appears to be of special importance for imprinting metabolic characteristics on the foetus that will influence its risk of developing obesity or NCCD as an adult. When there is insufficient nutrition *in utero*, the new individual's genes must adapt to live under these conditions. After birth, this programming is maintained, promoting the development of Metabolic Syndrome (Barker, 2004). The children of diabetic, hypertensive, or obese mothers will have a greater risk of replicating those pathologies during their lifetimes, not only because of genetic factors but also because of this foetal programming mechanism, mediated by hormonal and/or nutritional factors.

Until now, nutritional interventions have been oriented towards reducing the prevalence of low maternal weight (BMI <18.5 Kg/m²) and improving weight gain during pregnancy, without taking into account the early identification of women at high risk before conception or a reduction in the number of women who are at low height when they reach reproductive age. In many Latin American countries, in contrast, excess weight and obesity have increased significantly, which requires a constant reevaluation of nutritional intervention strategies with an emphasis on the potential effects this new nutritional condition due to excess may have on maternal and child prognoses for the short and long terms.

b) Infancy and preschool

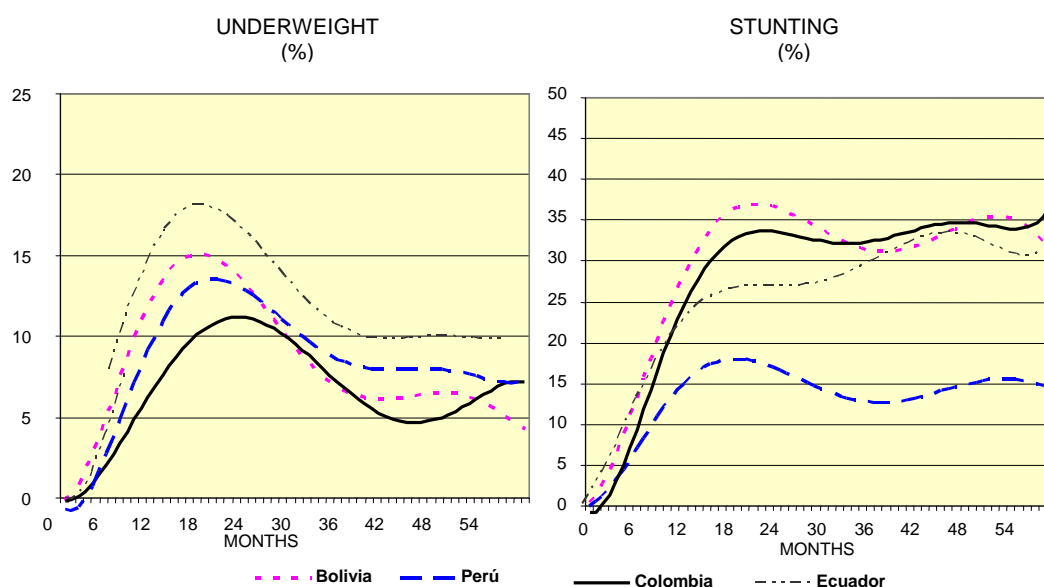
Low birth weight predisposes a child to stunting during infancy. Early in the decade, it was estimated that the number of children who were stunted was 162 million, that is, one in three children.

During the first few months of life, the child depends primarily on the mother's care and on the chances for good nutrition and immunity offered by breastfeeding. There is a great deal of evidence pointing to the benefits of receiving breast milk exclusively because it protects against obesity and other NCCDs, especially if it lasts for the first six months of the child's life.

After six months of age, children should have additional solid food, which exposes them to improper handling in an environment where sanitation conditions are conducive to the development of infectious diseases. As children grow during the preschool years, in addition to focusing on sanitation, it is necessary to try to provide the nutritional tools and the stimuli they need to develop properly once they begin school, as well as the conditions that will ensure the academic achievements required for their development.

Scientific evidence indicates that most of the growth retardation seen in children in underdeveloped countries originates in the first two or three years of life. Later interventions made to compensate for stunting are only partially successful, since the final outcome is a consequence of the cumulative effects on the life cycle, especially if the child continues to live in deprivation.

FIGURE 3
BOLIVIA, COLOMBIA, ECUADOR AND PERU:
UNDERNUTRITION PATTERNS, 0-59 MONTHS
(Approximately 1999)



Source: ECLAC based on special data processing of the latest Demographic and Health Survey (DHS) Bolivia 1998, Colombia 2000, and Peru 2000; Ecuador, Integrated Social Indicators System of Ecuador (SIISE) - Survey to Measure Childhood and Household Indicators (EMEDINHO) 2000.

Analysis of the DHS data for Bolivia in 1998, Colombia in 2000, and Peru in 2000, as well as existing data for Ecuador (ECLAC-WFP 2005) leads to the conclusion that the first two years of life are key to controlling the process of undernutrition. At birth, a deterioration begins that reaches maximum levels between 18 and 24 months of age, regardless of each country's average incidence. At that time, the problem of underweight starts to become less severe and the trend stabilizes at approximately the halfway point, at 38 to 44 months.

Stunting, on the other hand, worsens significantly (as much as twice as fast as underweight) during the first two years and then stabilizes at a slightly lower level. In other words, a high percentage of boys and girls between the ages of two and five eventually attain an adequate weight, but this does not translate into significant increases in height. Consequently, a boost in the volume of food ingested would not make up for the loss in stature suffered during the first 24 months of life.

c) School years

At school age (6 to 18 years), the growth process continues the pattern established during the preschool years, and is typically slow but constant. From the anthropometric standpoint, in this phase the longitudinal growth of the lower extremities exceeds that of the torso. This is a key stage in emotional, social, and cognitive development.

As far as diet is concerned, children at this age generally eat the same things as adults, and in households at medium or high socio-economic levels this does not represent a threat to their development; but in the poorest sectors, the diet usually needs to be reinforced, particularly with respect to the quantity and composition of food required for their academic activity. A deficit in the consumption of macro- and micronutrients has a direct repercussion on students' attention and learning capacities.

During this stage adolescence begins, posing a major challenge for human development. Secondary sex characteristics appear and the growth rate accelerates for five to seven years after pubescence. In girls, the most accelerated growth is seen at about 11 years of age, while boys are about two years behind that. During this period, 15% of height and 50% of body weight are attained, as well as 37% to 45% of adult bone mass. In association with these growth patterns, nutritional recommendations for this age group are higher than those for the population in general. Also during this period, as part of the process of sexual dimorphism, males develop twice as much lean tissue as females because they experience a greater increase in this tissue over a longer period of time.

Consequently, female hormonal changes and sexual development mark the beginning of a phase when iron deficiency anaemia is more likely, because of menstruation and childbirth. This means that special care must be taken to ingest sufficient micronutrients. In turn, there is a high risk for intergenerational transmission of undernutrition during this period in societies where reproduction begins at a very early age, as is the case with some indigenous groups in Latin America.

Another feature of this period is that significant changes take place in the psychosocial and aesthetic realms, and in some cases this affects eating behaviour. This phenomenon occurs most frequently in urban areas among girls in the medium to high socio-economic levels (the most serious pathological expression being anorexia and bulimia), but it is becoming increasingly common among men as well.

At the policy level, during the school years the focus tends to be primarily on meeting health and academic standards. When the State takes responsibility for providing nutritional support to students, it is fulfilling a dual function, both nutritional and educational. This is because in many cases, food is an incentive for attending school, where children get the best meal of the day, if not the only one.

d) Adulthood

In adult life, the physiological characteristics that were prefigured in earlier stages of development become manifest. Thus, the adulthood of the child that suffered from undernutrition will unfold with more or less difficulty, depending on how the food deficit of childhood has been corrected or whether such deficits have been maintained throughout the cycle.

Moreover, adults' eating patterns set an example for their children, who learn from their daily diet. These patterns can therefore become factors that either protect against or promote dietary risks, either interrupt or perpetuate the vicious circle of malnutrition.

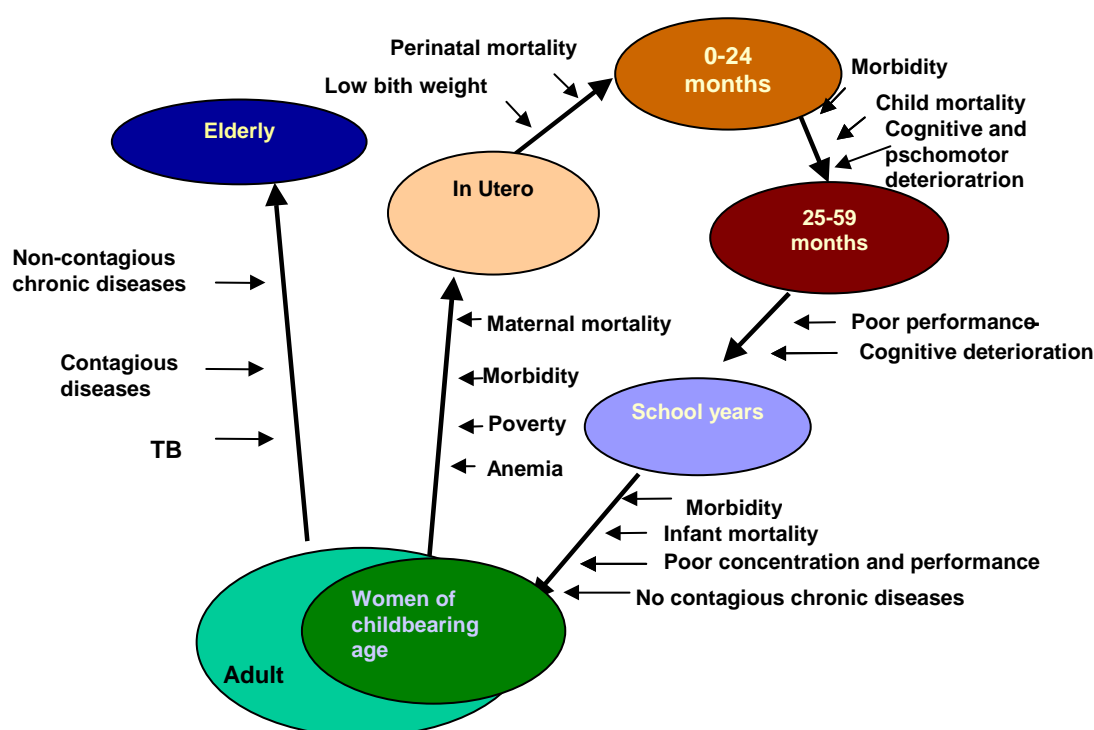
As stated in the preceding paragraphs, adult epidemiology is heavily influenced by NCCDs, and nutritional interventions have been quite successful in counteracting them. In this regard, a diet low in salt and fat calories and rich in fibre and fruits and vegetables promotes health as adults expend less and less energy.

During this period, the nutritional risks characteristic of fertile women because of their specific requirements for micronutrients such as iron either remain the same or rise. Gestating women, in turn, are another important group. Studies conducted in Guatemala demonstrated that children of mothers who had received a nutritional supplement rich in calories and proteins during girlhood were significantly taller at three years of age than those of mothers who had received a supplement rich in calories alone (Martorell, 1995. Ruel et al, 1995). The researchers concluded that the effects of adequate nutrition can appear even in the next generation, thus interrupting a vicious circle of poverty-malnutrition-low weight.

This case and others found in the literature highlight the importance of breaking the undernutrition-poverty cycle in order to protect the next generation. Under these circumstances, providing food to households through food-for-work or food-for-training programmes is aimed at achieving precisely this objective.

Older adults are another subgroup meriting special attention. Normally, their nutritional deficiencies are derived from an essentially sedentary lifestyle that causes a steady loss of lean tissue (musculature) and its replacement with fatty tissue. Their condition is associated with the NCCDs characteristic of their age, with a feedback loop among different pathologies that makes treatment more difficult and costly. This translates into specific requirements for vitamins and other micronutrients to counteract the natural physical and mental deterioration.

FIGURE 4
THE MALNUTRITION CYCLE



Source: Adapted from Branca, F. and Ferrari, M.⁵

II. Causes of undernutrition

The problem of undernutrition is caused by a number of variables from different sources that combine to increase food vulnerability, either by increasing risk or limiting response capability. These variables can be grouped into a few factors that interact to produce a complex chain of events that has been summed up here.

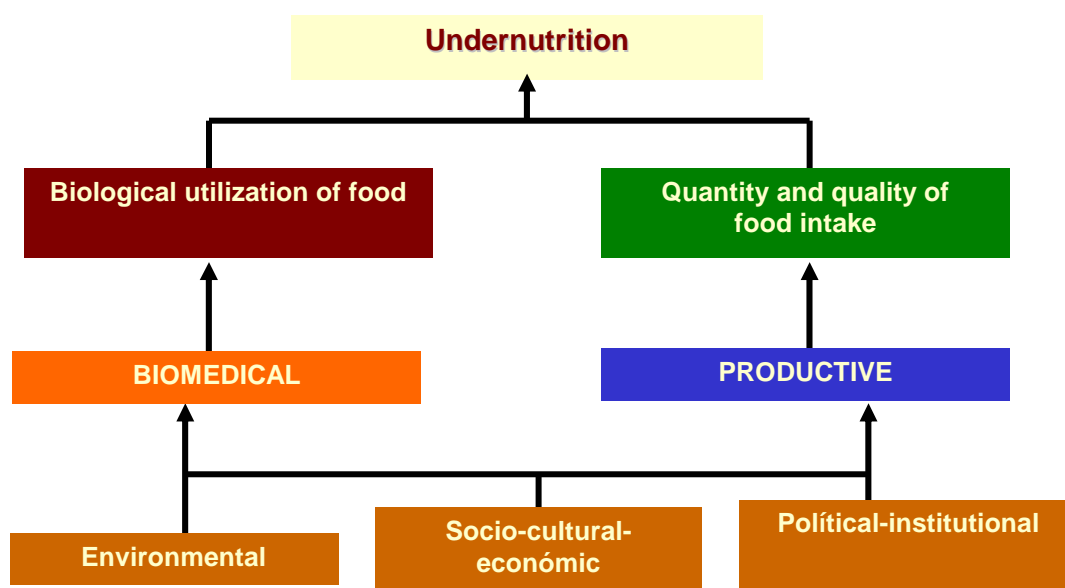
The main factors associated with the emergence of undernutrition as a public health problem are environmental (from natural or entropic causes), sociocultural-economic (associated with the

⁵ Impact of micronutrient deficiencies on growth: the stunting syndrome. Annual of Nutrition and Metabolism. 2002, vol 46, pages 8-4 (suppl. 1).

problems of poverty and inequality), and political-institutional. Together, they increase or decrease biomedical and production vulnerabilities, through which they determine the quantity and quality of dietary intake and the absorption capacity that are elements of undernutrition.

This grouping is basically analytical, since the factors involved are highly interrelated, and in many cases it is difficult to distinguish precisely the relative weight of each one when evaluating a specific nutritional situation. It depends on the intensity of the resulting vulnerability and the stage of the life cycle that the individuals have reached.

FIGURE 5
FACTORS ASSOCIATED WITH THE DEVELOPMENT OF UNDERNUTRITION⁶



Source: Authors' compilation.

1. Environmental factors

These factors correspond to the dimensions that define the surroundings in which a subject and his or her family live, covering a wide range of elements. Among them, most prominent are the risks inherent in the natural environment and its cycles (such as floods, droughts, freezes, and earthquakes) and risks of human or entropic origin (such as water and air pollution, food contamination, and expansion of farming into new territories).

Data compiled by the Hunger Task Force support the argument that 50% of world hunger occurs in rural households in areas that are heavily exposed to environmental risks (UNDP 2004). The highest figures for undernutrition and infant mortality are found in countries of sub-Saharan Africa and South Asia, where agriculture is frequently affected by this type of natural disaster; however, vast sectors of Central America, the Caribbean, and South America also suffer from recurrent hurricanes, droughts, earthquakes, and freezes, which pose direct risks (due to the lack of access to foodstuffs) and indirect ones (caused by economic and social problems derived from these events). The environment in which families with children suffering from undernutrition live often lacks sanitation facilities (drinking water and sewerage) that can prevent infectious diseases (low response capability). Thus, a vicious circle is created in which the environmental element is

⁶ Section V presents a more detailed discussion of the causes and consequences.

an active agent in the development of undernutrition (enteric diseases associated with poor sanitation in the environment are an example of this).

Elements such as those cited above also determine the extent to which a community can take advantage of its natural resources, which in many cases go to waste because of these same environmental risks (natural and entropic alike) and also due to the lack of funding and policy definitions.

Another related aspect is the probability that epidemics will be unleashed by these environmental risks, also contributing to undernutrition.

2. Socio-cultural-economic factors

At the world and regional level, undernutrition and infant mortality are associated directly with poverty. As shown above, in Latin America 50% of undernutrition cases can be attributed to indigence.

In many cases the economic model currently in place does not encourage the implementation of policies aimed at specifically benefiting the poor, such as incentives for school attendance, improved employment and wage levels, greater social security, and coverage by aid programmes.

Among the principal links between poverty and undernutrition are:

- Low per capita income, resulting from lower family income and a larger number of dependents. This determines the household's buying power for certain goods and limits access to nutrients.
- Lack of assets. Having no access to land, either because they are unable to save or because there are problems formalizing property ownership, means that the poorest sectors have little or no access to financing to enable them to exploit resources, and therefore lack income and food in sufficient quantities and/or quality.
- Cultural norms, primarily related to food, in many cases promote diets that are poor in nutrients or encourage the use of less energy-efficient natural resources. On the other hand, there is also sufficient evidence of traditional diets containing low-cost, highly nutritional foods being replaced by those associated with "modernity" that are rich in saturated fats and more expensive. Thus, the great potential offered by indigenous cultures, those that have evolved in local populations, or those derived from Africa is wasted.
- Low educational levels also affect the ability to utilize foodstuffs and diets that have a better quality of nutrients, in combination with access problems and cultural norms that are sometimes inappropriate or economically and nutritionally unviable.
- The lack of education on sexual matters, diet (breastfeeding), and child development also has an impact, especially on the early stages of the life cycle, the fertility rate, and the health care received by women of childbearing age. Insufficient or inadequate knowledge of these subjects results in gestating women who are malnourished (whether suffering from undernutrition or overweight), families with many children, low-quality (or non-existent) breastfeeding, lack of stimuli, limited control of nutrition and health in childhood, etc. All of these factors produce health problems and poor biological utilization of food.
- Finally, the social capital and support networks available to the population to mitigate risks or increase collective response capability to natural or economic disasters that limit access to foodstuffs are a critical component. In many cases, migration and increased

urbanization translate into capital depletion, which also affects the social assets of the poorest sectors. In other cases, however, they can become a margin of safety protecting against a drastic decline in the food supply. Historically, they have multiplied when solidarity flourishes in poor and indigenous urban communities.

3. Political and institutional factors

For some countries in the region, government policies specifically oriented towards confronting the population's food and nutrition problems are a very practical option for approaching a solution to this complex problem. In the history of the region, there have been some very successful cases in which official policies protecting maternal-child health by providing care and nutrition for pregnant women and minor children have made it possible to achieve levels of undernutrition and infant mortality much lower than the countries' socioeconomic development would indicate.

Achieving these objectives depends not only on the willingness to place food and nutrition on the public agenda and invest a portion of the national budget in food, but also on the existence of a public health infrastructure that allows for the implementation of well-designed policies and programmes that deliver food and also provide health screenings, immunization campaigns, and educational programmes promoting a participative and multidisciplinary approach to the problem. It is also important for such initiatives to contain provisions for follow-up evaluations.

By the same token, an institutional programme designed to combat undernutrition cannot be separated from efficient sanitation measures such as access to safe water, which reduce the morbidity toll (particularly from infectious diseases). Very often periods of severe undernutrition follow in the wake of such diseases, as is the case with diarrhoea.

An education system with broad coverage can also lend great support to the achievement of nutritional objectives through breakfast and lunch programmes that assure children of the necessary caloric intake so that they have enough energy for growth and activity. School is also a very good place to disseminate proper nutritional practices and healthy lifestyles. Food policies are a fundamental element, and therefore their absence contributes to undernutrition. Consequently, these policies should not be isolated in certain times or sectors, but should be developed in conjunction with anti-poverty, production, transportation, and marketing policies. They should have a long-range view rather than emphasizing the short term, and should be viewed as State policies, not administration policies, in which all actors (public and private) have a role to play.

Thus, the degree to which different countries' national food and nutrition policies can increase or mitigate risk factors can be analysed on the basis of the following elements:

- The priority given to the food problem on the public agenda.
- The presence or absence of long-term State policies with laws agreed upon at a national level, and the continuity of such policies.
- The extent to which these policies are part of inclusive intersectoral policies combating poverty and its consequences.
- The funds allocated in the national budget and the level of investment in the sector.
- The infrastructure and human resources available to sectors associated with food security and undernutrition, in the operation, monitoring, and evaluation of production processes, marketing channels, and food handling.
- The breadth of coverage of programmes carried out by different sectors (health, education, agriculture and livestock), such as food programmes for pregnant women, infants, and preschoolers at health centres (take-home programmes); food programmes at

kindergartens and schools (on-site programmes); food fortification programmes oriented towards reducing the prevalence of iron, iodine, vitamin A, and zinc deficiencies; financial support and technical assistance for production; sanitation and drinking water, etc.

- The effectiveness of policies and programmes in promoting, overseeing, and stimulating SAN.

4. Production factors

Production factors include those directly associated with the production of food, as well as the access that the at-risk population has to them. The availability and autonomy of each country's dietary energy supply depend directly on the characteristics of production processes, the degree to which they utilize natural resources, and the extent to which these processes mitigate or aggravate environmental risks.

Food production in poor countries is often hindered by unreliable access to technology that could help boost crop yields through genetic improvements in seeds, better (and less) utilization of fertilizers and farm chemicals, pest controls, the reduction of post-harvest losses, and enhanced tolerance to environmental assaults (droughts, floods, and freezes). This also includes investments in water projects and the training of small farmers to make maximum use of their resources and improve the energy potential of their traditional crops, as well as improving harvesting, storage, distribution, and food handling before delivery to the consumer. Microbiological control and mitigation procedures are key components of these efforts. The ability to overcome production problems is a function of environmental factors and depends on the individual and collective response capabilities of persons and communities. In other words, the three factors described above.

The above does not in any way guarantee that food will easily reach the table of the non-producing consumer. Access to foodstuffs has depended to a very great extent on that consumer's buying power, which in turn is very directly related to wages and food prices. This association has been well documented in the experience of some Asian countries, where technological advances proportionally increased crop yields and the food supply. The resultant drop in food prices had a greater impact on the population than any other element.

5. Biomedical factors

This category encompasses factors involving the individual's susceptibility to undernutrition, insofar as certain elements limit the capacity to make biological utilization of the food consumed (regardless of quantity and quality).

The principal biomedical factors leading to child undernutrition are:

- A deficient nutritional status on the part of the mother as a consequence of poor nutrition in previous years, which causes intrauterine undernutrition and low birth weight.
- The short duration of breastfeeding, which exposes the child early in life to the consumption of weaning food that does not meet the specific requirements for his or her development stage, and in many cases is contaminated. In the poorest communities, the promotion of breastfeeding has been shown to be the only intervention that can benefit the vast majority of children at risk for undernutrition. Breastfeeding past six months of age without adequate dietary supplementation can also lead to undernutrition, however.
- In the majority of countries where undernutrition is prevalent, families at risk do not have food to substitute for or supplement breast milk (weaning food) that can provide the necessary macro- and micronutrients for normal development.

The ethnic origin of the population has been analysed on different occasions as a variable associated with undernutrition. In Andean countries, for example, this is expressed in an incidence of undernutrition up to 140% higher among children from households where indigenous languages are spoken than among those of white or mestizo backgrounds (ECLAC, 2004).

The question that arises is whether that is due to a genetic condition or to problems derived from the extreme poverty and discrimination suffered by these groups. Evidence worldwide suggests that the nutritional element (determined by the poverty factor) is the principal determinant of stature in populations of very diverse ethnic origin. Thus, when these differences do not disappear (as ECLAC showed in Andean countries), the answer to this question would have to be found in socioeconomic, cultural, and inequality factors rather than in underlying genetic conditions.

Research carried out in Mexico, home to nearly 7 million indigenous people, shows that the inequality between indigenous and non-indigenous populations is enormous, and is manifested in various indicators such as infant mortality, literacy levels, and the quality of services. Studies of nutritional status showed a greater prevalence of low weight and height in the indigenous population, which was widespread and explained primarily by socioeconomic factors. Therefore, when the height of indigenous and non-indigenous children is analysed according to income decile, the difference shrinks as the socio-economic level rises.

Studies carried out in South Africa when *apartheid* was at its peak revealed that although there was substantial evidence of white children growing faster than black children, much of this difference was attributable to the institutionalized social inequality of that time. These data were contrasted with those of Brazil – a country that, like South Africa, is essentially multiracial and has major socio-economic disparities – and it was concluded that racial categories and racial inequality affecting child health are a social product. Therefore, differences in height in both countries can be explained largely by the socio-economic gaps dividing the different ethnic groups.

Finally, studies conducted in Chile examining delayed growth in Mapuche children between six and nine years of age in the low socio-economic stratum also revealed that the main cause of this retardation was poverty rather than ethnicity.

The foregoing does not mean that genetic factors do not affect the development of nutritional pathologies. It has been written, for example, that there are populations on islands in the Pacific, North American Indians, and Mexicans who are more susceptible to the development of type 2 diabetes than African, Japanese, and Chinese populations, as reflected in an earlier onset of the disease.

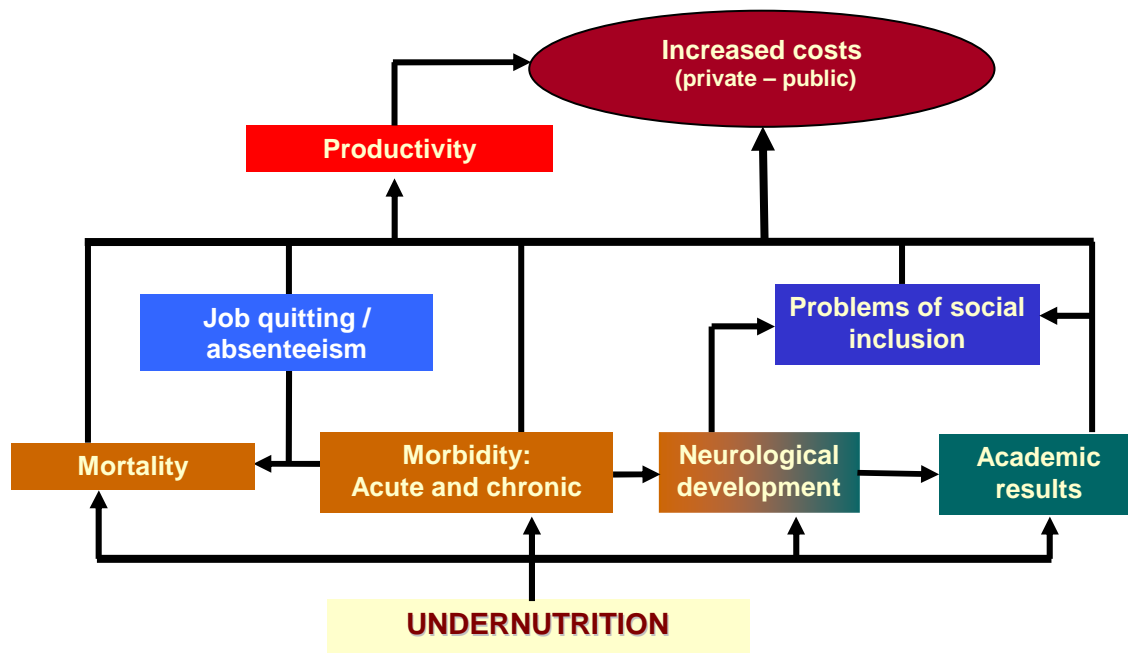
III. Consequences of undernutrition

Undernutrition has negative effects in various dimensions of people's lives, especially in health, education, and the economy (public and private costs and spending, and productivity), leading to problems with social integration and an increase or intensification of the source of poverty and indigence in the population. The vicious circle is then perpetuated as vulnerability to undernutrition rises commensurately.

These effects may appear immediately or throughout a person's lifetime, and they increase the chances of later undernutrition in those who have already suffered it during the early years of the life cycle. Other consequences are more likely to ensue as well. Thus, intrauterine undernutrition can create difficulties from birth to adulthood.

Some of the negative effects of undernutrition have a different impact depending on the age at which they occur. The intensity of undernutrition also determines the appearance and intensity of some of its consequences.

FIGURE 6
CONSEQUENCES OF UNDERNUTRITION



SOURCE: AUTHORS' COMPILATION.

The main effects associated with each of these dimensions are discussed below.

1. Effects on health

The most direct effects of undernutrition are felt in individuals' health, as their vulnerability to both death and illness increases. The incidence of several different pathologies is fueled by nutritional problems at different stages of the life cycle. In this manner, various studies have shown:

Mortality. The greatest impact is seen *in utero* and during the first years of life. A direct consequence of foetal undernutrition is low birth weight, which leads to a greater probability of perinatal mortality. The risk of neonatal death in babies with birth weights between 2,000 and 2,499 grams is four times higher than that of babies weighing 2,500 to 2,999 grams, and 10 to 14 times greater than that of babies weighing 3,000 to 3,499 grams.

In many cases the pregnant mother is young enough that she is manifesting the consequences of her own undernutrition, so the risk of passing this trait on to the next generation is very significant. That, in combination with a higher energy consumption during pregnancy and childbirth, contributes in some cases to her own death. Thus, among pregnant women, deaths associated with anaemia (from iron deficiency) accounted for 20% of the total (Ross and Thomas 1996, Brabin, Hakimi and Pelletier 2001).

The first effect of undernutrition is seen in low birth weight (LBW) children. Longitudinal studies carried out by Guilkey and Riphahn (1998) show that in the first few months of life, children who do not gain weight in the first year have a 50% probability of dying.

According to WHO data, undernutrition accounts for 60% of deaths of preschool children (3.4 million). UNICEF (1998) estimates that 55% of the 12 million deaths of children under the age of five are due to undernutrition problems. Pelletier et al (1995) figure that 56% of preschool deaths can be attributed to the effects of malnutrition, of which 83% were moderate to serious cases and 17% severe cases. Meta-analyses of ten longitudinal studies conducted among children under the age of five indicate, moreover, that 35% of their deaths are attributable (directly or indirectly) to underweight (WHO, 2004). Stunting, in turn, increases the lethality of many infectious diseases that are endemic to the underdeveloped world.

Micronutrient deficiency, on the other hand, also has significant effects. Longitudinal studies indicate that the risk of dying from diarrhoea, malaria, or measles in children with a vitamin A deficit increases by 20% to 24%. A zinc deficit increases the mortality risk of those same diseases by 13% to 21%.

Morbidity: The aforementioned longitudinal studies show that the proportion of disease attributable to low weight is 61% for diarrhoea, 57% for malaria, 53% for pneumonia, and 45% for measles. Iron deficiency has a direct effect on anemia in mothers, infants, and school-aged children, whereas vitamin A deficiency causes problems of blindness, and a lack of iodine leads to goiter or cretinism.

These associations are not unidirectional. Just as undernutrition is an important factor in the emergence and lethality of these pathologies, they in turn contribute to undernutrition, generating a vicious circle of feedback.

With respect to neurological and psychomotor development, undernutrition has direct effects on the first years of life, particularly due to the deficiency of micronutrients such as iron and zinc, or on the neonatal period, when folic acid is critical.

Moreover, undernutrition during critical periods of development significantly increases the risk that contagious chronic diseases, such as tuberculosis, and non-contagious ones (NCCDs) such as coronary heart disease, hypertension, and noninsulin-dependent diabetes will develop during adulthood.

Thanks to the work of D. Barker (2004), it has been established that coronary heart disease, type 2 diabetes, cerebrovascular accidents, and hypertension are a response to foetal and infant undernutrition. This phenomenon appears to be the result of foetal flexibility in responding to maternal “dietary restriction”, and is a “mark” that appears many years later. Thus, data from the research conducted in Hertfordshire indicate that children with a birth weight of 2,350 grams or less had a greater risk of suffering from coronary heart disease than those of normal birth weight, by a factor of 1.5. In this same group, 40% of men aged 64 years had an altered glucose tolerance curve, indicative of diabetes. The study conducted in Helsinki, involving 13,517 men and women born between 1924 and 1944, showed that children at the age of 11 who had weighed less than 3 kg at birth were at greater risk for diabetes (odds ratio = 1.5) and arterial hypertension (odds ratio = 2.0).

Iron-deficiency anaemia is one of the most prevalent nutritional deficiencies in the world. Poor iron nutrition is not something that occurs only in childhood, although it is very common during this period because of the increase in blood volume. It is estimated that 50% of women of childbearing age and 60% of pregnant women are anaemic. This deficiency can last throughout the fertile years, and it can be reversed with a diet that has the necessary iron content.

A woman who is anaemic during pregnancy will provide little iron to the foetus, who will be born with low iron deposits. In the absence of any external source of iron and in the presence of infections, the child will very quickly deplete its iron deposits, which means that if the child is also suffering from undernutrition, it is most likely anaemic as well. The nutritional component of NCCDs and contagious diseases in fertile women is similar to that observed in all adults.

In this group of pathologies, the most prevalent are AIDS, malaria, and tuberculosis (TB). In the case of AIDS, it is most likely that the terminal wasting suffered by some patients is secondary to the infections they have. In TB and malaria, however, it seems that the level of immunodeficiency in populations suffering from prolonged malnutrition plays a role in the risk of contracting the disease.

Osteoporosis, defined as the loss of mineral content in the bone, appears primarily in post-menopausal women. It is a progressive condition that is exacerbated over time. The main nutrients involved in the mineral metabolism of the bone are calcium and vitamin D. In the Western diet, after the age of 10, calcium consumption diminishes to only about half the recommended amounts.

The risk of osteoporosis declines significantly when the diet contains adequate levels of calcium during the longitudinal growth phase of the skeleton, that is, between 9 and 25 years of age. This makes osteoporosis a disease that can be prevented long before it appears if there is an adequate diet at the time when calcium deposits are being consolidated in the body.

In each country or region, the extent and intensity of the effects of undernutrition on the various pathologies related to it will depend on the prevalence of undernutrition and the epidemiological profile of the area. Thus, different diseases will be more or less significant in each country.

Life years lost: Although it comprises aggregate data that do not allow for specific contexts and elements to be differentiated (which hinders its application in a model such as the one presented here), one alternative way of analysing the effects is to quantify the Disability Adjusted Life Years (DALYs) lost due to undernutrition. In the studies conducted by Murray and López (1997) based on 310 nationally representative surveys in 112 countries taken from the WHO database, it was found that as of 1990 a total of 220 million DALYs had been lost due to undernutrition. This figure reportedly fell to 140 million by 2000 (Ezzati et al, 2002).

2. Effects on education

With respect to education, undernutrition affects student performance because of disease-related deficits and the limited learning capacity associated with deficient cognitive development. This translates into greater probabilities of starting school at a later age, repeating grades, dropping out of school, and ultimately a lower level of education.

As with health, the relationship between undernutrition and poor school results depends on the intensity of the undernutrition, and two processes can be identified:

- The first stems from development problems, in such a way that first there is one process in the area of health which then has an effect on school performance. This process begins in the first two stages of the life cycle (*in utero* and up to 24 months of age).
- The second process is directly derived from dietary deficit, which affects the ability to concentrate in the classroom and limits learning. This process therefore coincides with the preschool and school years, and although the impact of the first years of life is very important, it does not necessarily require previous nutritional damage. Rather, it may be merely a reflection of low intake during this very phase.

Deficiencies in micronutrients, particularly iron, zinc, iodine and vitamin A, are related to a cognitive deterioration that interferes with learning. As an example of the foregoing, using data from the Institute for Nutrition of Central America and Panama (INCAP) on Guatemalan rural residents, Behrman and Knowles demonstrated that having received nutritional supplements between 6 and 24 months of age had a significant positive effect on school performance (Alderman, Behrman and Hodinott, 2003, p. 10).

3. Economic effects

Undernutrition and its effects on health and education also translate into heavy costs for society at large (*Total costs derived from undernutrition* = TC^U). That is: higher healthcare spending (HC^U), inefficiencies in education (EC^U) and lower productivity (PC^U).

$$TC^U = f(HC^U, EC^U, PC^U)$$

Studies carried out in Zimbabwe indicate that the loss of 0.7 grades of schooling (less than a year) and a delay of 7 months in entering school yields a 12% loss in wealth throughout a lifetime. In Ghana, moreover, studies showed that for every year of delayed school entry, there was a 3% loss of wealth throughout the lifetime (Alerman, Behrman and Hodinott, 2003, p. 10).

Although the effects are not exactly the same, this occurs both in the population suffering from undernutrition and in those who, though not suffering from undernutrition, are malnourished. According to FAO estimates, increasing per capita energy consumption by 2,770 kcal per day in countries with a low daily energy supply (DES) may have accounted for an average annual growth of 1.6% in GDP between 1960 and 1990. At the same time, the cost of hunger in countries of sub-Saharan Africa is reportedly equivalent to a loss of GDP growth of 0.16% to 4.0% (Arcand 2001).

Health costs: The economic consequences arising out of the effects of undernutrition translate into higher spending (real or potential) on diagnoses, treatments, medications, check-ups, infrastructure usage, human resources management, people's time, etc.

With regard to acute pathologies, which can affect the entire population and are of short duration (such as acute respiratory infection, ARI, or acute diarrhoeal disease, ADD), the effects of undernutrition are related to a greater or lesser number of disease events. As for chronic diseases, which have lifetime effects (such as psychomotor deterioration, TB, osteoporosis, etc.), undernutrition's effects translate into a greater probability that the disease will strike, compared to the "normal" population.

The higher probability resulting from the epidemiological profile of individuals suffering from undernutrition proportionally increases costs in the healthcare sector (HSC^U), which at the aggregate level is equal to the sum of the interactions between the probability of undernutrition in each human group, the probability that this group will suffer each of the diseases because of that undernutrition, and the costs of treating the pathology (diagnosis, treatment, and control) in each demographic group.

To this are added the costs paid by individuals and their families as a result of lost time and quality of life resulting from these diseases (IHC^U). Thus,

$$HC^U = f(HSC^U, IHC^U)$$

According to FAO, worldwide these direct costs could amount to as much as US\$ 30 billion a year (2004).

In the case of the United States, it has been estimated that costs rose by the equivalent of US\$ 263 million in 1995 solely as a result of low birth weight caused by the mother's tobacco use, if tobacco consumption accounts for between 17% and 26% of LBW babies (Lightwood et al, 1999). This incremental cost would rise to US\$ 1 billion for all LBW children.

In 1982, the cost of saving the life of each U.S. child weighing between 600 and 699 grams at birth was US\$ 363, and US \$40.60 for every child weighing 600 to 999 grams (Walker et al, 1984).

In underdeveloped countries, one might think that the costs are lower because fewer cases are treated, in view of the shortfall in healthcare coverage. Actually, it is likely that the costs are even higher in view of the private and public costs arising out of the lost years of life (shorter life expectancy of the population due to maternal, perinatal, and infant mortality, lower productivity),

which are not reflected in the budget allocations for the healthcare sector but should be taken into account in an economic analysis.

It should be noted that the costs identified here do not include the effectiveness of treatments. The treatment's results in combating disease varies according to the intensity of the problem and the technology and resources involved, so it could be that lower spending on treatment also entails higher costs stemming from limited effectiveness. For a more precise evaluation, the cost-effectiveness ratios of the different alternatives would have to be analysed.

Education costs: The effects of undernutrition on school performance include the loss of resources due to restricted attention capacity, repeated grades, delayed schooling, and dropping out of school.

Reduced attention and learning capacity increases costs to the educational system (ESC^U). Repeating one or more grades commensurately increases the demand that the educational system must meet, with the resulting extra costs in infrastructure, equipment, human resources and educational inputs.

On the other hand, delayed schooling (due to late entry or repeated grades) increases those costs to the extent that it increases the age heterogeneity of each grade level, thus introducing more obstacles in the process such as the need to design special offerings or to account for the different interests and abilities of disparate age groups.

To these costs are added the private ones (incurred by students and their families) derived from the larger quantity of inputs, external educational supplementation and more time devoted to solving or mitigating low performance problems (PEC^U). Thus,

$$EC^U = f(ESC^U, PEC^U)$$

Low productivity. The consequences of undernutrition at the production level are directly associated with the low levels of education and learning difficulties described above.

The toll that undernutrition exacts from productivity is equivalent to the loss of the human capital (HK) that production generates for a society.

On the one hand, undernutrition reduces productivity because of lower levels of education attained by persons suffering from undernutrition (ELC^U). On the other hand, there is a loss of production capacity in the population as a result of the larger number of deaths caused by undernutrition (MMC^U). Thus,

$$PC^U = f(ELC^U, MMC^U)$$

Drawing on Human Capital Theory, a central assumption of this model is that wages are a good indicator for estimating labour productivity, and that education level plays a significant role in defining productivity. Thus, there is a transitivity effect between undernutrition, education, and productivity.

Based on the above, a boy or girl suffering from undernutrition is more likely to die, and to achieve a lower education level, than a child without undernutrition. If the child dies, his or her production capacity for an entire working life is lost, which is equivalent to the average income estimated for that period in accordance with the average education level of adults who have not suffered from undernutrition. If the child survives, his or her expected income is equivalent to that of adults with the average level of education for their cohort and who have suffered from undernutrition.

Even though they are not part of the universe of analysis considered in this model, some important findings on adult undernutrition and the loss of physical productivity are worthy of

mention. According to different studies compiled by FAO (2003), there is sufficient evidence linking an individual's physical capacity to work with his or her level of oxygen absorption, which positively correlates to a high body mass index (BMI) and tall stature. In this process, iron consumption is presumably a key factor in anaemia and the concentration of hemoglobin in the blood.

According to Horton and Ross (2003), iron therapy given to anaemic adults is associated (“in a conservative estimate”) with a 5% boost in productivity in physical work (“blue collar”). For heavy manual labour, the corresponding increase is 17%.

FIGURE 7
IMPACT OF VARIOUS FORMS ON MALNUTRITION ON PRODUCTIVITY AND LIFETIME EARNINGS



Source: FAO.-SOFI 2004, The State of Food Insecurity in the World, Rome

The following table sums up some of the findings of empirical research on this subject:

TABLE 4
RELATIONSHIP BETWEEN NUTRITIONAL LEVEL AND PRODUCTIVITY: SUMMARY OF RESULTS

| Authors | Country | Universe of analysis | Principal results |
|--------------------------------|------------------------------|----------------------------------|--|
| Croppenstedt and Muller (2000) | Ethiopia | Rural households, mostly farmers | BMI associated positively with production (1:2.3) and income (1:2.7) plus weight/height. Height has a positive impact on adult income. |
| Bhargava* (1997) | Rwanda | Rural households, mostly farmers | BMI and energy intake have a positive impact on the time devoted to heavy activities among men, but not women. |
| Strauss (1986) | Sierra Leone | Rural households, mostly farmers | Caloric intake has a positive impact on productivity. |
| Satyanarayana et al (1977) | India | Industrial workers | Weight/age is a significant factor in productivity. |
| Deolalikar (1988) | India | Agricultural workers | Significant effect of weight/age on agricultural productivity and income. |
| Alderman et al (1996) | Pakistan | Rural households, mostly farmers | Adult stature is a significant factor in rural income. |
| Haddad and Bouis (1991) | Philippines | Sugar cane harvesters | Adult stature is a significant factor in rural income. |
| Strauss and Thomas (1998) | Brazil and the United States | Adult men | Adult stature and BMI are significant factors in rural income in Brazil. Stature alone has a positive effect on income in the U.S. |
| Thomas and Strauss (1997) | Brazil | Urban population | Adult BMI and stature have a positive impact on market income (1:2.2). |
| Spurr (1990) | Colombia | Sugar cane harvesters | Weight and stature are significant factors in productivity. |
| Immink et al (1984) | Guatemala | Sugar cane and coffee harvesters | Adult stature has a positive impact on productivity. |

Source: FAO, "Nutrition intake and economic growth. Studies on the cost of hunger", Rome, 2003.

It is also feasible to take losses in productivity and from there analyse the loss of economic growth, looking at each country separately and at the region as a whole. The scope could be limited to potential GDP or to annual GDP growth rate. Many of FAO's attempts at analysis focus on this part of the problem, with greater emphasis on the rural sector.

Some specialists in the field have called into question the notion of considering human capital loss as a result of increased mortality due to undernutrition, as a person who dies at an early age does lose potential income, but also does not generate costs for health, education, etc. Consequently, those elements would have to be taken into account as well in a cost-benefit evaluation. However, the objective of this model is not to analyse the cost/benefit ratio of undernutrition but to estimate the costs derived from it. Otherwise, it would be necessary to accept the idea of a potential net benefit of undernutrition and of the resultant deaths, taking into account a lower alternative cost in low-income countries and the need for heavy investments in nutritional care.

Another idea that should be analysed is the replacement effect, so to speak, of the death of a boy or girl during the first years of life. The family would have a tendency to bear another child so as to have a “desired” number of living children. This eventuality is plausible in cases where birth control is widely used and parents have a preconceived idea of family size. It is not clear, however, that in the poorest populations of the region, where the risk of undernutrition is highest, such a response is recurrent or deliberate.

With that in mind, it would be relevant to conduct further research on the loss of human capital due to deaths caused by undernutrition, in order to identify the pathologies associated with the greatest lethality and loss of potential income.

4. Effects and the life cycle

As the table below shows, the effects of undernutrition can be ordered according to the stage in the life cycle when they occur. This is especially important for analysing potential interventions to prevent and mitigate damage in different population groups.⁷

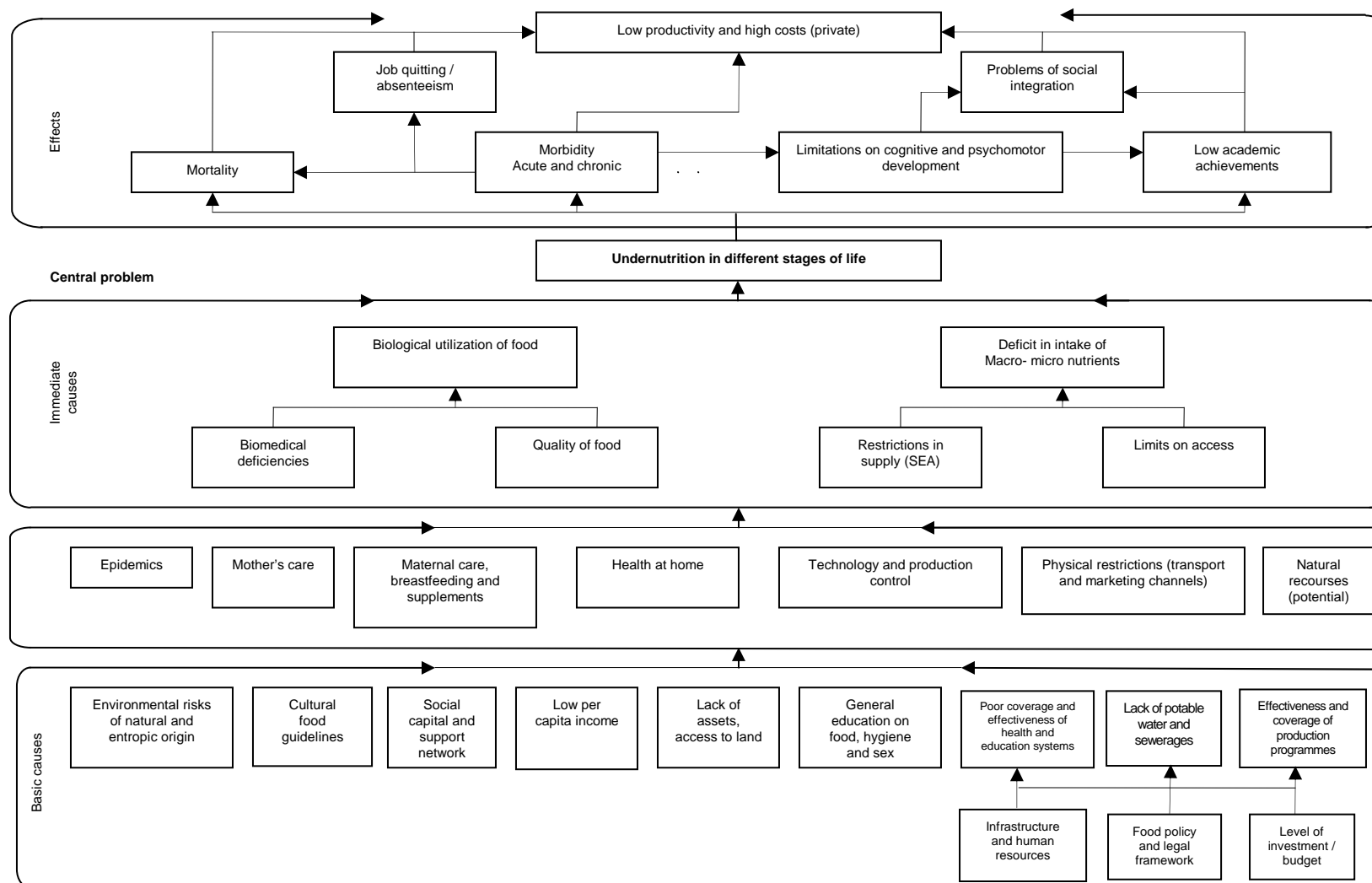
TABLE 5
EFFECTS OF UNDERNUTRITION DURING THE LIFE CYCLE

| Stage | EFFECTS | | |
|---------------------------|---|---|---|
| | Immediate | Medium-term | Indirect |
| <i>In utero</i> | Low birth weight Perinatal mortality | Childhood undernutrition Morbidity (infections, diarrhoea, bronchopneumonia) | Lower productivity Higher public and private costs |
| 0-24 months | Morbidity Cognitive and psychomotor deterioration Infant mortality | Low height Cognitive deterioration | Lower productivity Higher public and private costs |
| 25-59 months | Poor preschool performance Preschool Mortality | Diminished school performance Anemia Obesity | Lower productivity Higher public and private costs |
| School years | Morbidity Mortality during childhood Poor concentration and performance Anemia | Low level of education Dropping out of school | Lower productivity Higher public and private costs |
| Adulthood | NCCD Morbidity: Contagious chronic diseases (TB) | Low birth weight Poverty | Lower productivity Higher public and private costs |
| Women of childbearing age | Anemia Obesity Maternal mortality. NCCD Morbidity: | Low birth weight | Lower productivity Higher public and private costs |
| Senior years | NCCD Morbidity: | Mortality. Poverty | Higher public and private costs |

Source: Authors' compilation

⁷ The information presented in the table on undernutrition can be read in two different ways, differentiated by the stage in which the undernutrition occurs and whether it is perpetuated or not. These two views are diachronic and stage-based. The diachronic view looks at a level of malnutrition accumulated throughout the life cycle. The stage-based view looks at malnutrition acquired during a specific stage of life, without necessarily having any previous malnutrition or any repercussion in the following stage.

IV. Undernutrition cause-and-effect tree



Source: Authors' compilation

V. Dimensions of analysis

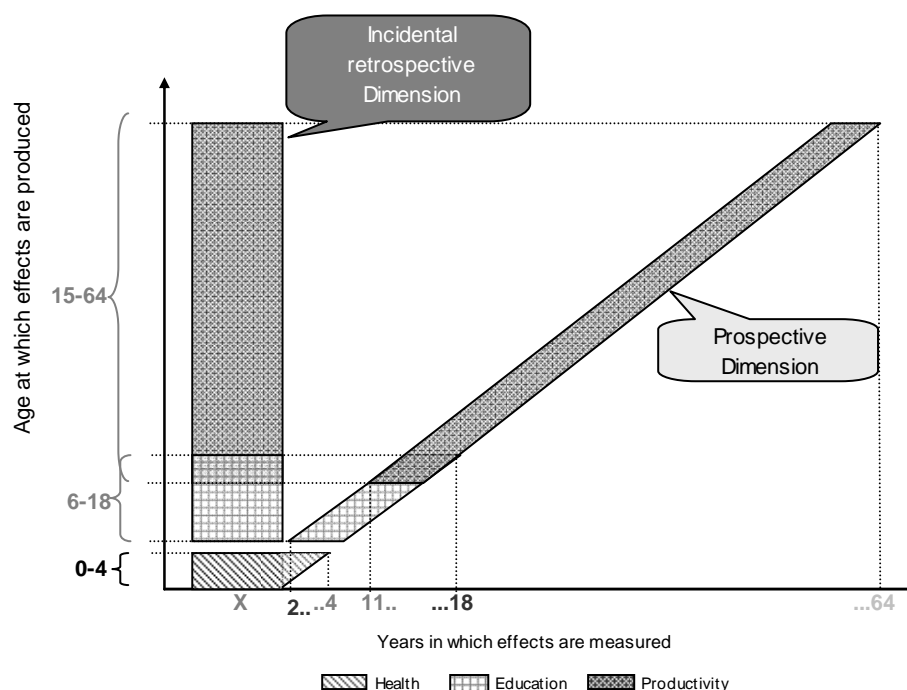
A country's child undernutrition situation and the consequences thereof reflect a specific epidemiological and nutritional transition process in which two time dimensions, each with its own characteristics, can be differentiated. First there is the study of the past to the present, and secondly, the projection of what may occur in the future, based on existing knowledge.

On this basis, a two-dimensional analysis model has been developed for estimating the costs arising from the consequences of child undernutrition in health, education and productivity:

1. *Incidental retrospective dimension.* Makes possible an estimate of the cost of undernutrition in a country's population for a given year. Thus, it is possible to estimate the health costs of preschool children who suffer from undernutrition during the year of analysis, the education costs stemming from the undernutrition children now in school suffered during the first five years of life, and the economic costs due to lost productivity by working-age individuals who were victims of undernutrition before the age of five.
2. *Prospective, or potential savings dimension.* This dimension makes it possible to project the present and future losses incurred as a result of medical treatment, repetition of grades in school, and lower productivity caused by undernutrition among children under the age of five in each country, in a specific year. Based on that, potential savings derived from actions taken to achieve nutritional objectives can be estimated (for example, to attain target 2 of the first Millennium Development Goal: halve, between 1990 and 2015, the proportion of people who suffer from hunger).

As the following figure shows, the incidental retrospective dimension includes the social and economic consequences of undernutrition in a specific year (X) for different cohorts that have been affected (0 to 4 years of age for health, 6 to 18 years for education, and 15 to 64 years for productivity). The prospective dimension, on the other hand, projects future effects and costs of the undernutrition that exists in a specific year (X) in a cohort of children less than 5 years old (between years X and X+4 for health, X+2 to X+18 for education, and X+11 to X+64 for productivity).

FIGURE 8
DIMENSIONS OF ANALYSIS BY POPULATION AGE AND YEAR WHEN EFFECTS OCCUR



Source: Authors' compilation.

The model, with its two dimensions of analysis, focuses on underweight and its effects. It does not take into account the effects of micronutrient deficiencies (iron, zinc, iodine, vitamin A, etc.), because not enough research has been done to differentiate the incremental costs and effects of each type of deficiency independently or to identify the interactions between deficiencies in some micronutrients and between them and the anthropometric indicators.

B. Methodological framework

This chapter contains a description of the principal methodological elements that must be considered for calculating the consequences of undernutrition. Considering the specificity of each dimension of study, universes of analysis, indicators, and procedures are defined specifically for each case.

I. Universes of analysis

As stated in the theoretical framework section, undernutrition affects all stages of the life cycle. In some, the presence of undernutrition itself is the most prominent feature, whereas in others it is the consequences of undernutrition.

For this reason, and given the limitations of the data, the cost analysis focuses on the initial stages of the cycle and its consequences throughout life. That is, the costs derived from the problem of undernutrition from intrauterine life to the beginning of school, with its immediate health consequences and its medium-term effects (during school years and adulthood) on education and productivity, respectively. This limits the analysis of undernutrition and health to the foetus, the infant, and the preschooler (those aged 0 to 59 months).⁸ The effects on education and productivity are analysed for the other population groups.

The universe of children suffering from undernutrition has been divided into sub-cohorts to highlight the specificity of certain effects

⁸ In the original design, the possibility of analysing direct information on the pregnant woman's nutrition and health situation was considered, but the lack of reliable information on the incidence of undernutrition and gestation times led to the decision to exclude them from the analysis.

associated with particular stages in the life cycle. These sub-cohorts are:

- 0 to 28 days
- 1 to 11 months
- 12 to 23 months
- 24 to 59 months

Finally, the universes of analysis of population data and costs change depending on the dimension:

- The incidental-retrospective analysis includes the entire population that suffered undernutrition between 0 and 59 months of age and was aged 0 to 64 years as of the year of the study, differentiating them into sub-universes according to the effects and type of costs.
- The prospective analysis considers only the population suffering from undernutrition in the cohort aged 0 to 59 months of age as of the year of study.

The estimates made for each universe of analysis correspond, in general, to direct data on each segment of the universe. Given that data are not always available for all subgroups, in some cases proxies derived from interpolations or extrapolations from other population segments are used.

II. Variables and indicators

Variables are organized into the following subgroups, depending on their relationship to the problem and the characteristics of each:

1. Undernutrition

The undernutrition indicators used in this study depend on the stage in the life cycle. Thus, three major groups are considered:

a Low birth weight (LBW): This is the indicator used to measure intrauterine undernutrition. It corresponds to live births when the baby weighs less than 2,500 grams and has intrauterine growth restriction at birth (IUGR = weight below the tenth percentile for gestational age).⁹

b. Anthropometric ratios: These correspond to the ratios between weight, height, and age in children under the age of five years, using as a pattern of comparison for distribution the standard established by the National Center for Health Statistics (NCHS), recommended by PAHO/WHO.

Types of undernutrition, according to the most commonly used indicators:

- *Underweight:* corresponds to cases in which the weight/age ratio is below average, according to the reference pattern.

⁹ There is literature on the relationships between morbidity and babies born weighing between 2,500 and 2,999 g., but there is not yet enough empirical evidence to consider this case. When the issue of LBW and its causes is examined in more depth, doubts are raised as to the reliability of using it as a factor in analysing nutritional deficit exclusively, since the latter is determined by two different processes: gestational duration and foetal growth rate. As described in the annex, to date it has not been possible to isolate completely the phenomenon of short gestation without associated nutritional causes, but for purposes of the study it was decided to consider only the group with IUGR based on the formula developed by De Onis et al.

- *Stunting*: corresponds to cases in which the height/age ratio is below average.
- *Wasting*: includes those who have a below average weight/height ratio.

As indicated in the preceding chapter, when the nutritional situation of children is analysed, the weight- and height-for-age data are taken into consideration. However, although there is a greater prevalence of short stature in Latin America, for the reasons presented below it has been decided to focus on underweight and its relative risks.

- When analysing the health consequences of undernutrition, recent literature shows that the greatest effects on morbidity and mortality are seen in weight deficits, from LBW on, with sharp increases in health sector costs and a major impact on productivity.
- In the case of education, special data processing carried out on the results of the study conducted in Chile (Ivanovic 2005) reveals that although definitive conclusions cannot be drawn due to the structure and size of the sample, all the children with a moderate to severe weight deficit also have a height deficit, and the negative impacts are greater for those who have weight problems compared to those who have only a height deficit.
- Another factor to bear in mind is that the weight deficit is the most immediate indicator of nutritional problems, even in the absence of a distinction between a deficit originating in low weight for height or low height for age, and there may be significant cyclical variations (WHO 1995). Furthermore, the first impact of nutritional interventions can be verified in the recovery of weight, whereas in the long term these interventions contribute to the normalization of height.
- Finally, with the weight deficit indicator the comparability of results between countries and with the Millennium Development Goals is greater. This indicator is “the one most extensively used in developing countries” (WHO 2004).

Levels of intensity of undernutrition: The comparison to the norm is made in terms of standard deviations, and three levels of undernutrition intensity are established.

- Mild: Between -1 and -1.999σ (standard deviations).
- Moderate: Between -2 and -2.999σ (standard deviations).
- Severe: -3σ or less.

In general, specialized studies include in the group with undernutrition boys or girls with a weight or height below -2σ with respect to the average of the reference pattern (moderate or severe). However, the effects are found in those who have even mild undernutrition ($-1\sigma > x > -2\sigma$), as shown in the health risk studies (WHO 2004). In education, follow-up data from Chile (Ivanovic 2005) demonstrate that the differences in grade failure and level of education are greater when those suffering from mild undernutrition are compared with those who have no undernutrition, than when they are compared with their counterparts suffering from moderate and severe undernutrition.

Despite findings such as these that might suggest the effects are a continual progression rather than discrete points, the cut-off point has been kept at -2σ , because that is the point used in most studies and data sources.

The data sources for these indicators are: international records and estimates for LBW; and health surveys (DHS and others) for anthropometric ratios.

2. Consequences of undernutrition

Estimates of the impacts of undernutrition on health, education, and productivity are based on the concept of the *relative risk* run by individuals who suffer from undernutrition during the early stages of life.

To estimate relative risk, probability estimators of the occurrence of consequences for health (mortality, morbidities) and education (repeated grades and dropping out) are needed for the population groups with and without undernutrition.

Relative risk is not the same thing as the impact achieved by social programmes aimed at mitigating the problem. The former corresponds to the differential probability of having a problem (in health, education, productivity) between different populations (those that do or do not suffer from undernutrition). The latter, in contrast, reflects the effectiveness of an intervention in the affected population (that is, those who have those problems), compared to the population for which no intervention has been made. When reliable data for relative risk estimation are not available, the impact estimator can be used as a proxy, provided that allowance is made for the bias that may be introduced.¹⁰

The relative risk indicators used in this study are:

(a) Probability differences (ΔP): this corresponds to the difference between the probability of occurrence of a consequence (i) among those suffering from undernutrition (P^U) and those not suffering from undernutrition (P^{NU}). That is,

$$\Delta P_i = P_i^U - P_i^{NU}$$

(b) Probability ratio (PR): this corresponds to the ratio between the probability of occurrence of a consequence (i) among those suffering from undernutrition (P^U) and those not (P^{NU}). That is,

$$PR_i = P_i^U / P_i^{NU}$$

(c) Probability odds (PO): when the data in a cross-sectional study are displayed in a tetrachoric table just as in a prospective study or a cases and controls study, in the health field the expression “*prevalence – odds*” has been proposed, corresponding to the ratio between the probability of having a consequence (i) among those not suffering from malnutrition (P^U) and their counterparts. That is,

$$PO_i = P_i^U / (1 - P_i^U)$$

(d) Odds ratio (OR): this corresponds to the relationship between two PO values. That is,

$$OR = (P_i^U / (1 - P_i^U)) / (P_i^{NU} / (1 - P_i^{NU}))$$

The above formula, using the classic denomination of cells in a double-entry table, is also expressed as follows:

$$OR = (a * d) / (b * c)$$

According to the specialized literature, the OR calculation seems to be the most appropriate one, given that the evaluation of “exposure” variables (in this case, exposure to undernutrition) often has a retrospective view in cross-sectional studies. In addition, the vast majority of available studies are indeed cross-sectional and not prospective.

The ΔP indicator is particularly important, since that is the one that makes it possible to estimate the number of cases to consider in the cost calculation. In the literature, however, estimates for total probabilities (P_i) and associations with PR and OR can be found, so to use them

¹⁰ For example, if a group of students suffering from undernutrition reduces the dropout rate from 10 to 8 percentage points thanks to a nutritional supplement, the effectiveness is 2, or 20%. On the other hand, if the dropout rate among students not suffering from undernutrition is 7%, the difference for students with undernutrition would be 3 (10-7), and the differential relative risk of dropping out of school for those with undernutrition would be equivalent to 3/7, or 42.86%.

as ΔP requires derivations that allow for the estimation of P^U and P^{NU} , both for the different morbidities and for mortality.¹¹

Depending on the variable used, the probability P acquires a specific name. Thus:

- for mortality, it is ΔP_{MM} or ΔMM
- for morbidity, it is ΔP_M or ΔM
- for repeated grades, it is ΔP_r or Δr
- for school dropouts, it is ΔP_d or Δd
- for proportions of the population that reach each level of education, it is ΔP_e or Δe
- for average level of education or schooling, it is ΔP_E or ΔE

The concept of relative risk is applied, and plays an equally important role, in both dimensions of analysis. These two differ, however, as indicated above, in terms of both the period of time considered and the cohorts analysed. Thus, to facilitate presentation and understanding of the Method, first the definitions and procedures corresponding to the incidental retrospective dimension are discussed, and then those of the prospective dimension.¹²

2.1 Effects and costs in one period: Incidental retrospective dimension

2.1.a. Effects on health

These are measured as the ΔP corresponding to the incidence of mortality and the prevalence of morbidity¹³ that exist among people without undernutrition and those who have suffered undernutrition at some point before the age of five.¹⁴

The value of these differences, specific to each pathology and each age group, depends on the intensity of the undernutrition, and is generally different also in each locality, region, or country. However, few estimates have been made in the world, so the relationships most recently described in the literature can be used for developing countries, along with the epidemiological follow-up data, official statistics from the countries, and interviews with specialists.

To estimate the *number of deaths* associated with undernutrition in a year (x), the formula is:

$$MM_x^U = \sum_{i=1}^i MM_{ix}^U \quad (1)$$

In which,

$$\begin{aligned} MM_x^U &= \text{Number of annual deaths associated with undernutrition (in a year } x) \\ MM_{ix}^U &= \text{Number of deaths from each pathology (i) associated with undernutrition (in a year } x) \end{aligned}$$

Alternatively, this indicator can be defined as:

¹¹ Annex 3 contains details on the procedures used to derive ΔP from other indicators.

¹² The sequence of processes and activities required to implement the methodology is shown in annex 4.

¹³ Prevalence is understood to mean the proportion (every 100, 1,000, 10,000 or more persons) of cases of death or disease present in a population at the time of measurement, regardless of when the pathology began. In contrast, incidence refers to the proportion of new cases arising in a given period (generally a year). Thus, prevalence is a result of incidence, pathology duration, and remission resulting from (effectiveness of) the treatments used.

¹⁴ In the absence of reliable data on the relative risks derived from epidemiological effects in later stages of the life cycle (school years, adulthood, and senior years), neither these nor their associated costs are analysed in this method.

$$MM_x^U = (M * N * \Delta MM^U)_x \quad (2)$$

In which,

| | |
|---------------|--|
| M | Prevalence of undernutrition among boys and girls aged 0 to 59 months |
| N | Population size of the cohort aged 0 to 4 years (or 59 months) |
| ΔMM^U | Difference in probability of death between those who do and those who do not suffer undernutrition before 60 months of age |

The cumulative number of deaths, or burden of mortality, caused by undernutrition in a period of n years, is:

$$MM_n^U = \sum_{x=n}^x (M * N * \Delta MM^U)_x \quad (3)$$

In which,

| | | |
|----------|---|--|
| MM_n^U | = | Number of annual deaths associated with undernutrition occurring in a period of n years (from $x-n$ to x) |
|----------|---|--|

Undernutrition affects mortality through a number of different pathologies, the most prominent of them being: diarrhoea, pneumonia, malaria, and measles. In order to limit the number of errors resulting from the quality of official records on cause of death, for the estimates in this study the differential relative risks for all causes of death are used, derived from the research of Fishman et al (WHO 2004), who apply the total causes of death to children under five years of age estimated by the Latin American Demography Centre (CELADE) for each country.

To estimate the number of *disease events* occurring for each pathology in a specific year, caused by undernutrition in children under five, the formula is:

$$M_x^U = \sum_{j=1}^j \sum_{i=1}^i (\Delta M_{ij}^U * \mu_{ij}) * M_j * N_j)_x \quad (4)$$

In which,

| | | |
|-------------------|---|---|
| M_x^U | = | Number of annual disease events occurring for each pathology (i) caused by undernutrition in a year x . |
| ΔM_{ij}^U | = | Difference in the probability of occurrence of a pathology (i) caused by undernutrition, in each sub-cohort or stage of the cycle (j) where there is undernutrition in children under the age of five (0-28 days, 1 to 11 months, 12 to 23 months, 24 to 59 months) |
| μ_{ij} | = | Annual average number of times a pathology (i) occurs in those who present with it, during each stage of the cycle (j). |
| M_j | = | Prevalence of undernutrition (differentiated according to the age group or sub-cohort among children 0-4 years old (j)) |
| N_j | = | Number of persons making up each sub-cohort of the cycle of 0-4 years (j). |

2.1.b Effects on education

The effects of undernutrition on an individual's school performance can be summed up as the results shown in five indicators:

- Performance: grade point average below that of students that do not suffered from undernutrition.
- Repeated grades: loss of one or more years as a result of poor performance.
- Dropping out: leaving the educational system permanently or partially (on hold) before completing the process.
- Delay: entering a grade at an older age than is normal for the grade. This can be the result of late entry into school (due to coverage or access problems, immaturity, lack of resources), repeated grades, or putting school on hold for a certain period.
- Level of education: lower number of grades and levels passed.

The aggregate effect is estimated based on the achievement differentials corresponding to each indicator, annually at the population level, between those with and without undernutrition. However, for the purpose of measuring the associated costs, the analysis focuses on two indicators:

- Academic years lost*: this corresponds to the larger number of academic years per student that the system must operate due to repeated grades caused by undernutrition in the early stages of the life cycle (up to five years).

$$Y_{rep_x}^U = \sum_{z=1}^z (\Delta r_z * M_z * N_z)_x \quad (5)$$

In which,

- $Y_{rep_x}^U$ = Extra number of years of operation per child generated in a year (x) because of repeated grades due to undernutrition.
- Δr_z = Difference in the probability of repeating grade (z) due to undernutrition suffered before the age of five.
- U_z = Modal prevalence of undernutrition for the age group currently in each grade (z) at the time when those students were zero to four years old.
- N_z = Size of the student population that should be assigned to each school grade (z) according to age (estimated from the corresponding time of enrolment).

- Schooling differential*: this is equivalent to the differential of average years of schooling caused by undernutrition during the initial stages of the life cycle.

$$\Delta S_x = (S^{NU} - S^U)_x \quad (6)$$

In which,

- ΔS_x = Differential of average number of years of schooling due to undernutrition in a year (x).
- S^{NU} = Average level (years) of schooling attained by children and adolescents in the population that do not suffered from undernutrition.
- S^U = Average level (years) of schooling attained by children and adolescents who suffered undernutrition before the age of five.

To estimate the effects of undernutrition on school results and thence the costs, the official indicators available in the different countries are used, applying differential risks of passing, failing, and dropping out during basic (primary) education and intermediate (secondary) education, for boys and girls who suffered undernutrition before the age of five. Thus, the range of individual and average schooling S varies between 0 years and 11 or 12 years of schooling, depending on the current standard in each country.

The country data are generated by the respective national ministries and are organized to respond to the specific needs of their administrative procedures.

The principal assumptions, instruments, and sources of information related to educational indicators that were considered in the methodology are the following:

- a. *Student population*: To estimate the number of boys and girls attending each grade (z) in the formal education system, the number officially enrolled in each country is considered. Alternatively, the net enrolment rate or coverage of primary and secondary education for each country according to UNESCO can be used, along with the population in the age group corresponding to each grade level, based on population estimates carried out by CELADE. This second alternative facilitates country-by-country comparisons.
- b. *Student population by nutritional history*: To determine the effects of undernutrition associated with the education sector, the highest value of the prevalence (mode) of undernutrition observed in the categories is applied for the cohort of children aged 0 to 59 months,¹⁵ to the enrolment per grade in a given period, or, in its absence, to the aggregate enrolment figure for each level of education.¹⁶

The prevalence of undernutrition for a cohort changes with age. Based on empirical evidence presented in the specialized literature, however, in this model it is assumed that undernutrition in the first years of life causes effects in educational achievement throughout the school years. This is based on the following considerations:

- Equal prevalence of undernutrition between the population enrolling in the school system at the appropriate time and those who do not enrol or do so at a late age. An association between undernutrition and late school entry has been hypothesized, but there are no data that can corroborate it reliably. Even though the net school enrolment rate is less than 100% and those outside the system are part of the same vulnerable population that suffers from undernutrition, existing data are not sufficient to verify the causal relationship. Therefore, this potential effect has not been included in the analysis.
- Early undernutrition has an effect on school results, with an impact on the system's aggregate pass and fail rates.
- Assuming a positive correlation between failing a grade and dropping out of school, if the previous point is proven correct, boys and girls who have had undernutrition early in life have a greater probability of dropping out.^{17 18}

¹⁵ If disaggregated data are not available for the cohort aged 0-59 months, alternatively the average prevalence of undernutrition for the entire group may be used, instead of the modal value.

¹⁶ In the first case, statistics compiled on the basis of a longitudinal study are needed; the second case requires at least a cross-sectional study of the universe of students or of a statistically significant sample of them.

¹⁷ The issue of the higher dropout rate in the population that suffered from undernutrition before the age of five compared to the population with normal nutrition will be addressed in more detail in the estimate of costs associated with undernutrition due to the loss of productivity during the economically active life of the population.

¹⁸ In this indicator, no differentiation is made with respect to the intensity of the undernutrition, due to the difficulty of obtaining data of this nature.

- c. *Years of schooling and mandatory education:* The years of schooling correspond to the number of grades in the educational system passed by an individual, whereas mandatory education refers to the minimum number of years of schooling a country establishes for its citizens in the corresponding regulations. In Latin America and the Caribbean, that requirement varies between 6 and 12 years of schooling. Schooling is considered incomplete when the number of grades successfully completed by an individual is lower than the total number of grades in the primary and secondary levels of education in each country.
- d. *Passage rate per grade:* This corresponds to the number of students who have passed – that is, who have performed satisfactorily in evaluations, according to current legislation – compared to the total number enrolled in a grade or level during an academic year.
- e. *Repetition rate per grade:* A student who has failed a grade is one who has not met the academic requirements necessary to be promoted to the next grade. In this manner, the failure rate is calculated as the ratio between the number of students who have failed a given grade or level, and the total number enrolled in that level or grade, during the same academic period.

Repeated grades refers to a student re-enrolling in a grade after having failed it.

It should be emphasized that not all countries in Latin America and the Caribbean have equivalent requirements for promotion and/or failure. Those with automatic promotion in one or more grades show a bias in this indicator and in the passage rate.

To estimate the composition of the population repeating grades according to their nutritional status in a given year (x), different alternatives can be used depending on the information available in each country. In those where cohort studies have been done on students to determine their nutritional profile, those results can be used directly. In other countries, it is possible to estimate this figure by considering: the incidence of failed and repeated grades for the population for each grade (or level), the populations with and without undernutrition per grade or level, and the differential relative risk of repeating (Δr_{zx}). Thus, for a given year (x), the formula is:

$$\Delta r_{zx} = (r_z^U - r_z^{NU})_x \quad (7)$$

In which,

Δr_{zx} = Differential probability of repetition for each level (z) in a year (x) for those who had undernutrition before the age of five.

r_z^{NU} = Probability of repetition for the population that suffered from undernutrition before the age of five at that educational level (z).

r_z^U = Probability of repetition for the population that suffered from undernutrition before the age of five at that educational level (z).

Since the rate of repetition (r) in the total population in a certain grade (z) is a weighted average of the repetition rate of the population according to its state of undernutrition, with an estimate of the repetition probability ratio (RPr) it is feasible to estimate the incidence for the population suffering from undernutrition and the population not suffering from it, as well as the differential.¹⁹

When direct information on repeated grades is not available, but there is information on failed grades, the latter can be used as a proxy for the former.

¹⁹ See the procedure detailed in annex 3.

- f. *Dropout or attrition rate:* This is equal to the proportion of students who leave the education system during the school year or between years, either during basic (primary) or intermediate (secondary) education (ECLAC 2003).²⁰

To estimate the dropout rate among students suffering from undernutrition (d^U), the same procedure is followed as in the case of failure, using a dropout probability ratio (PRd) estimator that is applied to students who suffered undernutrition before the age of five.

The dropout rate is estimated for each year in the education level, based on the average number of years of schooling reported in household surveys. All those who did not complete the secondary level are identified as dropouts. The distribution of the total number of dropouts according to their undernutrition status is estimated using an optimization function that generates differential average dropout risks for each grade (PRd), thus adjusting it for the total estimated dropout figure for the entire education level.²¹

When a specific PRd is not available for a given country, an external one can be used as a proxy. However, in view of the differences in coverage and education level among these countries, the percentage distribution of years of schooling attained may be biased. These can be estimated by comparing the estimates with the information provided by the household surveys for the age range of 20 to 24 years. To correct this problem, the risk factor that is applied must be made more sensitive to eliminate the differences in this comparison.

When direct information on dropouts is not available, but there is information on withdrawal (meaning that the student has left the education system but has not indicated whether it is a permanent departure), the latter can be used as a proxy for the former.

When a differential risk estimate is available for repeated grades but not for dropouts, the same factor can be used for both.

- g. *Level of education:* This indicator reflects the last grade of school completed. Thus, students who drop out at a given grade (z) achieve a level of education equivalent to the previous grade (z-1).

The indicator for the effect of undernutrition on education corresponds to the differential percentage distribution of years of schooling attained. Thus, there is one distribution for the universe of students that suffered undernutrition before the age of five and another for those who didn't suffered. The differences in each grade (0, 1, 2, ... 11, 12 years of school) and in the general average reflect the effect.

Estimating the education differential requires an indicator of proportion differences or of probabilities, (Δe^U) specific to each grade (1 to z) for each year (x). Due to the effects of undernutrition itself, these differences tend to be negative at the lower levels and positive at the higher ones.

$$\Delta e_{z\ x}^U = (e_z^{NU} - e_z^U)_x \quad (8)$$

In which,

$\Delta e_{z\ x}^U$ = Probability differential of having a level of education (z) due to undernutrition, existing in a year (x).

e_z^{NU} = Proportion of students that do not suffered from undernutrition who

²⁰ Panorama Social, 2001/2002, Santiago, p. 98

²¹ See annex 3

reach each level of education (z).

e_z^U = Proportion of students that suffered from undernutrition who reach each level of education (z).

For this variable, all levels of education can be counted. However, in this study only the basic and intermediate levels are considered. The differential for higher education is not estimated because there is no reliable data on the impact that child undernutrition has on it.

To estimate the additional years caused by repeated grades due to undernutrition, the following steps are taken:

- Take available data on the numbers passing and failing each grade.
- Obtain a relative risk estimator for failed grades.
- Compile population sizes by age group and estimate the potential number of enrolments in a scenario of total coverage.
- Total the number of students failing each grade.
- Apply to the above number the relative risk of failure caused by undernutrition.

To estimate the education differential generated by undernutrition, the following steps are taken:

- Obtain a relative risk estimator for dropping out.
- Estimate the proportional distribution of education levels for the total population in the study. For this process, there are three alternatives:
 1. Official information – longitudinal follow-up: estimate based on follow-up studies of cohorts for school results. Although this is a recommended alternative, it is not customary to find this type of study in the region, making it unlikely that the data necessary for its application will be available.
 2. Cohort Reconstruction Method:²² If longitudinal follow-ups are not available, this method is a good alternative. The problem, in particular, lies in the reliability of estimating the dropout rate based on aggregate data.
 3. Household survey – closest cohort (20-24): estimate based on the level of education declared in the latest household survey available in each country. The advantage of this alternative is that it is estimated on the basis of persons who are already past school age and their level of education is not very likely to change. However, it has the disadvantage that this cohort was affected by a different undernutrition rate than the one corresponding to the year of analysis (x).
- Create a table of relative frequencies with the proportion corresponding to each level of education for each group (e_z^{NU} y e_z^U), based on the number of students dropping out of each grade and those completing each level (basic and intermediate). Ideally, as many distributions should be constructed as there are cohorts in the analysis, but if reliable data are not available, the current distribution for all cohorts should be used.
- Estimate Δe_z^U (probability differential of students that suffered from undernutrition for each grade, compared to non-malnourished students).

²² See detail in: Guadalupe, C. (2002). Indicadores de cobertura, eficiencia y flujo escolar: necesidades de política, problemas metodológicos y una propuesta, p. 6.

- Calculate the weighted average level of education for each group (malnourished and non-malnourished) based on the data on population, coverage, undernutrition rate and relative frequency distribution of the levels of education.²³

2.1.c Economic effects

As indicated in the theoretical framework section, total costs derived from undernutrition (TC^U) are summed up in a function that is a result of: higher public and private spending on healthcare (HC^U), inefficiencies in educational processes (CE^U), and lower productivity (PC^U). Thus:

$$TC^U = (HC^U + EC^U + PC^U) \quad (9)$$

The costs derived from undernutrition are estimated in national currency at the current exchange rate, on the basis of an annual period. To make a country-to-country comparison, these costs are expressed in current dollars and PPP,²⁴ and as percentages of GDP and sectoral and total social spending.

- *Health costs:*

$$HC_x^U = (HSC_x^U + IHC_x^U) \quad (10)$$

In which,

| | | |
|-----------|---|--|
| HC_x^U | = | Health costs due to undernutrition, estimated for a specific year of analysis (x). |
| HSC_x^U | = | Incremental costs in the healthcare system resulting from the epidemiological profile of malnourished individuals in the year of analysis (x). |
| IHC_x^U | = | Private costs incurred by individuals and their families as a result of the time and quality of life lost due to these illnesses and mortality, in the year of analysis (x). |

The *cost to the healthcare system*, at an aggregate level, for the year of analysis (x) equals:

$$HSC_x^U = \sum_{j=1}^j \sum_{i=1}^i (M_{ijx}^U * AHC_{ijx}) \quad (11)$$

In which,

| | | |
|-------------|---|--|
| M_{ijx}^U | = | Number of annual disease events caused by undernutrition occurring for each pathology (i), in a sub-cohort (j), in the year of analysis (x). |
| AHC_{ijx} | = | Average unit cost of treatment in the healthcare system for each pathology event (i), in a sub-cohort (j), in the year of analysis (x). |

The costs associated with treatment protocols are calculated based on the values reported by the respective ministries and public agencies that make up the healthcare sector in each country, equivalent to the treatment of one person for one event, and for the number of events associated

²³ The authors acknowledge that this is an approximation that increases the margin of error of the estimates, but it is the best alternative in the absence of historical data.

²⁴ The unit of measurement known as PPP, or purchasing power parity, is a monetary conversion rate that makes it possible to express a country's currency in a common artificial currency that equates buying power in different countries. In other words, PPP eliminates the price differences that exist in different countries at a given time.

with the pathology. These costs include both fixed costs (infrastructure and equipment) and variable costs (human resources and inputs) during the diagnostic, treatment, and follow-up phases, at the primary and hospital care levels required for each pathology. The latter includes the costs of intensive treatment, applied to the proportion of cases requiring it, in accordance with the corresponding treatment protocol.

Thus,

$$AHC_{ij} = PCC_{ij} + h_{ij} * HC_{ij} \quad (12)$$

In which,

- PCC_{ij} = Average unit cost of primary care for the pathology (i), for each a sub-cohort (j).
 h_{ij} = Proportion of pathology events (i) requiring hospitalization in each sub-cohort (j).
 HC_{ij} = Average unit cost of hospital care for the pathology (i), for each a sub-cohort (j).

To estimate *private health costs*, incurred by malnourished individuals and their families as a result of illnesses derived from undernutrition in a year (x), the formula is

$$IHC_x^U = \sum_{j=1}^j \sum_{i=1}^i (M_{ijx}^U * AIC_{ijx}) \quad (13)$$

In which,

- M_{ijx}^U = Number of annual disease events caused by undernutrition occurring for each pathology (i), in a sub-cohort (j), in the year of analysis (x).
 AIC_{ijx} = Average cost incurred by the individual or his family for each pathology event (i), in a sub-cohort (j), in the year of analysis (x).

The average unit cost for each pathology, incurred by the individual (or his family) in a given year (x), is:

$$AIC_{ijx} = \left((tPC_{ij} * Ct + T_{ij} + ICPC_{ij}) + h_{ij} * (tH_{ij} * Ct + T_{ij} + ICH_{ij}) \right)_x \quad (14)$$

In which,

- tPC_{ij} = Average time an adult (accompanying a child patient) spends on primary care treatment for the pathology (i) in the sub-cohort (j). Includes travel and treatment time.
 Ct = Alternative time cost
 T_{ij} = Cost of transportation (or access) required to continue treatments for each pathology (i) in the sub-cohort (j).
 $ICPC_{ij}$ = Input costs to the family (not covered by the healthcare system) for primary care treatment of the pathology (i) in the sub-cohort (j).
 h_{ij} = Proportion of pathology events (i) requiring hospitalization in each sub-cohort (j).

- tH_{ij} = Average time an adult (accompanying a child patient) spends on hospital treatment for the pathology (i) in the sub-cohort (j).
- ICH_{ij} = Input costs to the family (not covered by the healthcare system) for hospital treatment of the pathology (i) in the sub-cohort (j).

The time cost (Ct) is measured in \$/hour and corresponds to the equivalent of the monthly minimum wage (Wm) for each country, divided by the number of working hours per month according to each country's laws. For comparison purposes, this number has been set at 200 hours. Thus,

$$Ct = Wm/20 \quad (15)$$

The cost of transportation has been estimated as the average equivalent value of two trips on urban public transportation in each country.

When the costs of treating certain pathologies are not detailed in this manner in the model, but rather are presented as aggregate values (per group of pathologies, type of care and/or cohort), the average costs of treatment per patient can be calculated. It should be noted, however, that this can increase the estimation errors.

- *Education costs:*

$$EC_x^U = (ESC_x^U + PEC_x^U) \quad (16)$$

In which,

- EC_x^U = Education costs due to undernutrition, estimated for a year (x) of analysis.
- ESC_x^U = Public costs to the education sector in a year (x) due to the need to cover the incremental demand produced by the higher probability of repeated grades among students who suffered undernutrition before the age of five.
- PEC_x^U = Private costs in a year (x) due to the increase in inputs and transportation requirements produced by the higher probability of repeated grades among students who suffered undernutrition before the age of five.

The aggregate *costs to the educational system* (during a period x) equals:

$$ESC_x^U = \sum_{l=1}^l (Y_{replx}^U * OC_{Elx}) \quad (17)$$

In which,

- Y_{replx}^U = Extra number of years of operation per child generated in the year of analysis (x) at the education level (l) because of repeated grades due to undernutrition.
- OC_{Elx} = Operating cost per academic year per student (infrastructure, equipment, human resources, educational inputs, and meals) at the education level (l) in the year of analysis (x).²⁵

The *private education costs* incurred by malnourished individuals and their families due to the need for more educational inputs and others, in the year of analysis (x), are the result of:

²⁵ If disaggregated data are not available for each level of education (l), a single estimate for all levels can be made using average costs.

$$PEC_x^U = \sum_{l=1}^l (Y_{replx}^U * FC_{Elx}) \quad (18)$$

In which,

- Y_{replx}^U = Extra number of years of operation per child generated in the year of analysis (x) at the education level (l) because of repeated grades due to undernutrition.
- FC_{Elx} = Average family cost of keeping the student in school for one year (transportation and educational material and inputs) at the education level (l) in the year of analysis (x).

Substituting equations 17 and 18 in equation 16, the education cost is:

$$EC_x^U = \sum_{l=1}^l (Y_{replx}^U * (OC_E + FC_E)_{lx}) \quad (19)$$

For purposes of analysis, when some inputs or meals are not covered by the educational system, these costs are passed on to the family.

Due to a lack of access to data, the other incremental costs derived from the need for more heterogeneity of offerings because delays in schooling expand the age range of the student body, and from the loss of the investments made in students who drop out of school, have not been considered in this phase of the study.

To estimate public costs, the budget allocations associated with payments of salaries, administrative personnel, teachers, materials, inputs, and payment of services, and the budgets corresponding to student support programmes (meals, supplies, textbooks) and learning support programmes (to improve the quality of education, introduce technologies, etc.) should be taken into account.

For private costs (of educational inputs and materials) it is recommended that the data be based on the average cost per student participating in public programmes that provide these services. The values corresponding to private education are not used in order to avoid overestimating costs with the gains made in each country.

Transportation costs are estimated based on urban public transport fares, in current prices for the year on which the calculation is based. For purposes of comparison, two daily trips on 200 days of the year are assumed.

- *Lower productivity.*

Undernutrition affects productivity in two alternative scenarios, which are presented as opportunity costs for individuals:

- Those who survive undernutrition: it is estimated that they will have less potential income because of the lower level of education attained by a population that has suffered from undernutrition before the age of five, compared to the population with no undernutrition (ELC^U).
- Those who die of undernutrition: they have a loss of all potential income (during working life)²⁶ because of the higher infant mortality rate caused by undernutrition (MMC^U). This is equal to the income a person would earn after surviving the first years of life without dying of undernutrition.

²⁶ The working life is assumed to be 50 years, between the ages of 15 and 64 years.

Thus, the level for society as a whole is:

$$PC_x^U = (EL_x^U + MMC_x^U) \quad (20)$$

In which,

EL_x^U = Lower potential income in the year of analysis (x) resulting from a lower level of education attained by a person who has suffered from undernutrition before the age of five.

MMC_x^U = Loss of potential income for the year of analysis (x) due to death associated with undernutrition in boys and girls before the age of five.

The *lower potential income* (EL_x^U) corresponds to the sum of average differential wages, estimated for a year of analysis (x), earned by those who suffered from undernutrition before the age of five, compared to those who did not, due to the impact on their level of education.

$$CNE_x^U = \sum_{z=0}^z \sum_{j=1}^j (\Delta y_{jz}^U)_x \quad (21)$$

In which,

Δy_{jz}^U = Potential income differential of people who has suffered from undernutrition before the age of five in an age group (j)²⁷ and at a level of education (z).²⁸

The effect of less schooling on productivity is estimated on the basis of the income differential affecting people who suffered from undernutrition before the age of five. For this purpose, consideration is given to the differences in the distribution of education level due to undernutrition (estimated for effects on education)²⁹ and their relationship to average expected income, based on Human Capital Theory and the proposals of Jacob Mincer (1958 and 1962) and Gary Becker (1964), together with the idea that in a competitive market with balanced factors, labour productivity corresponds to the marginal product reflected in wages.³⁰

Thus,

$$y = f(EDU, EXP)$$

To implement this, the following steps must be taken:

- a. Using the data from the household survey in each country, create a matrix in which the individuals making up a working-age population (WAP), aged 15 to 64, are classified according to their level of education (0 to 11/12)³¹ and age quintiles (as a proxy for experience).³²

²⁷ The age group (j) reflects the year of birth.

²⁸ The value of z has a range of 0 (for no education) to 11 or 12 years, depending on the country.

²⁹ If data are available allowing for an estimate of the differences in this distribution for each population group, they should be taken into consideration. In this case, it is proposed that only the distribution estimated for the population currently in school be used (as a proxy for the rest), due to the lack of reliable data on the different cohorts.

³⁰ There is ample evidence showing that among the determinants of a worker's productivity – given a certain technology – are years of education (including basic, intermediate, and higher education) and the experience the worker has gained. In this manner, considering differences in average monthly income of workers who have had undernutrition and “normal” workers, controlling for experience based on age, would in fact acknowledge the difference in productivity of these workers.

³¹ In general, the primary and secondary, or basic and intermediate, levels of education amount to 11 or 12 years.

³² If the sample size allows, this classification can be made for each year of age.

- b. Estimate the average annual income for each education and experience category, considering the entire WAP of the population, regardless of whether or not it is part of the economically active population (EAP), in order to obtain the expected income for the entire set of individuals in each age-education combination.³³
- c. Estimate the probability of undernutrition to which each age category in the WAP was exposed before the age of five (if the analysis is conducted for the year 2004, the population between 1940 and 1989 would be considered). For this purpose, the historical series must be reconstructed, interpolating data on average undernutrition for each year based on estimates from national surveys.³⁴
- d. Estimate the number of people who, probabilistically, may have had undernutrition in each age group of the WAP, multiplying the population sizes by the prevalence of undernutrition corresponding to each group in the corresponding quintiles (for example: 1940-44, 1945-49, ... 1985-89).
- e. Based on the estimates of the effects on education, estimate the differential probabilities that malnourished individuals have of being placed in each level of education (0 to 11/12), contrasting the frequency distributions of both groups.
- f. Apply the distribution of differential probabilities to the total number of potential malnourished individuals in each age group of the WAP.
- g. Calculate the differential income for each group by multiplying the aforementioned distribution by the average expected income of each level of education.
- h. Add up the results in the matrix.

Thus, if for each level of education the years of experience (EXP) are controlled, the difference in income depends on the difference in the distribution of years of education (EDU) resulting from the effect of undernutrition (e), and therefore:

$$\Delta y_{jz}^U = y_{jz} * \Delta e_z^U * U_j * N_j \quad (22)$$

In which,

- Δy_{jz}^U = Estimated income differential of all malnourished individuals in an age group (j) and at a level of education (z).
- y_{jz} = Estimated annual income of an individual in an age group (j) and at a level of education (z).
- Δe_z^U = Probability differential of having a level of education (z) due to undernutrition.
- U_j = Prevalence of undernutrition at 0 to 59 months for the age group (j).³⁵

³³ Certain data could be specified considering only the sectors of the economy in which the most vulnerable population typically participates. However, that would skew the estimates, excluding potential sectors of production that might incorporate a person with access to developing the capacity. On the other hand, given the high rates of international migration from some poor urban and rural areas in the countries of our region with the highest levels of undernutrition to neighboring and developed countries, it could even be argued that an estimator taking this effect into consideration should be included in the alternative cost analysis.

³⁴ In the absence of reliable data for the period prior to 1960 and lacking a valid estimate of undernutrition trends in preceding decades, the oldest undernutrition rate reported is set as a constant for the previous years.

³⁵ The undernutrition rate to use, U_j , corresponds to that applying to the group aged 0-59 months when each cohort was at that age (in each year $x+5-j$). Since there are normally not extensive enough temporal series, it is recommended that the most representative existing one(s) be used for the different cohorts. It should be emphasized that this could lead to an underestimate of the size of the population suffering from undernutrition, but it is the best available approximation.

N_j = Size of the age group (j).

Applying the above procedure in a year of analysis (x) for all of the cohorts studied yields an estimate of the total cost of undernutrition on the productivity of persons who have survived child undernutrition (CNE_x^U).³⁶

The *loss of productivity due to mortality* corresponds to the potential annual income that individuals would have earned if they had not died of undernutrition before 60 months of age.

This potential income corresponds to the average income in each cohort according to level of education, of persons who did not suffer from undernutrition, estimated in the above procedure.

To analyse the situation in a specific year (x), the number of deaths related to child undernutrition must be estimated for the different age groups that, at the time of the analysis, make up the working-age population (WAP), as well as the average expected income of each according to the level of education they might have achieved. That is,

- Apply the undernutrition mortality rate most representative for each cohort comprising the WAP at their respective population sizes when they were less than five years of age. Thus, for each cohort (j), use the undernutrition mortality rate for the year x+5 (upper limit of cohort (j)+1), from x-15 to x-60.³⁷
- Adjust the number of undernutrition deaths by the probability of survival of those without undernutrition (s_j^{NU}) for each cohort (j). That is, the survival rate for each cohort for the year of analysis (x) (projected by CELADE), discounting deaths due to undernutrition.
- Distribute the number of deaths in each cohort (j), adjusted by its corresponding survival rate, according to the level of education proportion achieved by those who did not have undernutrition (to reflect the level of education they could have attained if they had not been malnourished and had not died from it).
- Multiply the result for each cohort (j) and each level of education (z) by the estimated average income for each combination jz.

Thus,

$$CMM_x^U = \sum_{z=0}^z \sum_{j=1}^j ((MM_j^U * s_j^{NU} * e_z^{NU}) * y_{jz})_x \quad (23)$$

In which,

- MM_j^M = Number of deaths due to undernutrition before the age of 60 months for each age group (j) between 15 and 64.
- s_j^{NU} = Survival rate of those who did not have undernutrition in each age group (j).
- e_z^{NU} = Proportion of non-malnourished individuals who reach each level of education (z).
- y_{jz} = Estimated average income of an individual in an age group (j) and at a level of education (z).

³⁶ During the development of this methodology, initially the procedure used by ECLAC in the Social Panorama 2001-2002 (p. 86) was used, which is based on Mincer's regression equations, adapted to incorporate the non-employed population. However, after a detailed analysis of the methodological foundations of that model and the requirements of this estimate, as well as the low levels of explained variance characterizing that model in these countries ($0.2 < r^2 < 0.4$), it was concluded that for the purposes of this study, it is more reliable to make direct use of the average income of each subgroup j-z (education level-age), as described here.

³⁷ For example, for the group aged 15 to 19 analysed in 2004, the mortality due to undernutrition to be considered is that corresponding to $2004+5-20 = 1989$.

The information on income and employment rate for each level of education and experience comes from the household surveys conducted in each country.

2.2 Future costs and potential savings: prospective dimension

Considering the prospective characteristic of this dimension of analysis, the effects of undernutrition occur at different times for the population analysed. In this manner, a “flow of estimated effects” is created, with the corresponding flow of costs, in which potential consequences in the following areas are analysed:

- Health for five years, from the year of analysis ($x=0$) until those born in that year (0) turn five years old ($x=4$).
- Education, from the time those who are four years old in the year of analysis ($x=0$) are of school age ($x=2$), until the repetitions of the last school year (11 or 12) occur, for those born in year 0 ($x=17$ or 18).
- Productivity, during the years when the population under study is part of the WAP. That is, from $x=11$, the year of entry for the older members of the cohort (4 years old in $x=0$), until $x=64$, the year of exit for the younger members (those born in $x=0$).

As its name suggests, this dimension of analysis makes it possible to project costs and also potential savings. Thus, the costs estimated here are equal to the potential savings that nutritional programmes and policies in a country can generate. The effectiveness of these policies and programmes will correspond to the amount of savings.

2.2.a Effects on health:

Considering that the epidemiological consequences occur at the same time that the cohort aged 0 to 9 months suffers from undernutrition,³⁸ the effects are the same as those estimated in analysing the incidental dimension, but applied to a specific year (x).

To estimate the *total number of deaths* associated with undernutrition in a cohort of children aged 0 to 59 months ($MM^U_{(0-4)}$), equation 3, “burden of mortality,” described for the incidental dimension, is applied to the years corresponding to the occurrence of the effects in the cohort (from $x = 0$ until $x = 4$).

$$MM^M_{(0-4)} = \sum_{x=0}^4 (U * N * \Delta MM^U)_x \quad (24)$$

In which,

| | | |
|----------------|---|---|
| $MM^U_{(0-4)}$ | = | Number of annual deaths associated with undernutrition occurring during the period $x = 0$ to $x = 4$. |
| U | = | Prevalence of undernutrition among children aged 0 to 59 months |
| N | = | Population size of the cohort aged 0 to 59 months. |
| ΔMM^M | = | Differential probability of death of those who suffer undernutrition before 60 months of age. |
| X | = | Year of analysis. |

³⁸ Recall that due to data limitations, the epidemiological effects are not analysed for later stages in life.

To estimate the number of *disease events* ($MM^U_{(0-4)}$) occurring for each pathology, equation 4 is used for the “burden of disease” in the period from $x = 0$ to $x = 4$.³⁹ This burden of disease can be estimated for each cohort (j), which results in the formula:

$$M^U_{(0-4)} = \sum_{i=1}^i \sum_{j=1}^j ((\Delta M^U_{ij} * \mu_{ij}) * U_j * N_j)_x \quad (25)$$

In which,

$M^U_{(0-4)}$ = Number of annual disease events caused by undernutrition occurring for each pathology (i), in a sub-cohort (j), as a result of undernutrition (between years $x = 0$ and $x = 4$).

Thus, an estimator of $M^U_{(0-4)}$ can be obtained for each pathology (i) and for each sub-cohort (j) in each year (x).

The numbers of deaths and cases of pathology are estimates for the cohort 0-4 years, based on the most recent data.

2.2.b Effects on education

The educational effects are analysed in a similar manner to that of the incidental dimension, but with a view to estimating the consequences in boys and girls under five in a given period (x) at the time they reach school age, generating specific effects for a period of 11 to 12 years (depending on the school system in each country) from the time they turn 7 years of age ($x + 2$ for those who are four years old) until the end of their expected schooling ($x + 18$, for those born in year x).

Thus, to estimate the number of *academic years lost* ($Y^U_{rep(x)}$), equation 6, described above, is used for each period in which the children now suffering from undernutrition are expected to be in school (from $x = 2$ to $x = 18$). This yields an estimator of $Y^U_{rep(x)}$ for each year (x).

The total number of years lost is:

$$Y^M_{rep(0-4)} = \sum_{x=2}^{18} \sum_{z=1}^z (\Delta r_z * M * N_z)_x \quad (26)$$

In which,

| | | |
|------------------|---|--|
| $Y^U_{rep(0-4)}$ | = | Extra number of years of operation per child estimated for a cohort aged 0 to 4 years in the year of analysis (x), because of repeated grades due to undernutrition. |
| Δr_z | = | Difference in the probability of repeating grade (z) due to undernutrition suffered before the age of five. |
| M | = | Modal prevalence of undernutrition for the cohort aged 0 to 4 years. |
| N_z | = | Size of the student population that should be assigned to each school grade (z) according to their age. |

To estimate the differential probability of repetition Δr_{zx} , the same repetition probability ratio estimator (PRr) is used, along with the population sizes and matrix estimated for the malnourished and non-malnourished groups, depending on the prevalence rates prevailing in the year of analysis (x).

³⁹ See Section 2.1.a.

The *education differential* ($\Delta E_{(0-4)}$) is estimated with equation 7, and the corresponding procedures described above are applied to the specific cohort that is aged 0 to 4 years today, using as a proxy for expected education attained the average years of schooling obtained for the most recently studied cohort old enough to have completed its education.

The dropout probability ratio (PRd) to be used is the same as in the procedure for the incidental dimension, but considering the population sizes and enrolment numbers corresponding to the group being analysed.

Following the corresponding procedures, adapted to the cohort being analysed, it is possible to obtain the differential probabilities of attaining each level of education ($\Delta e_{z,x}^U$) and the expected distribution for the malnourished and non-malnourished groups.

2.2.c Economic effects

In keeping with what has been stated in earlier chapters, the estimate of the total costs of undernutrition in children under the age of five in a year x ($TC_{(0-4)}^U$) is based on the additional public and private spending on healthcare ($HC_{(0-4)}^U$), inefficiencies in educational processes ($EC_{(0-4)}^U$) and lower productivity ($PC_{(0-4)}^U$). Thus:

$$TC_{(0-4)}^U = (HC_{(0-4)}^U + EC_{(0-4)}^U + PC_{(0-4)}^U) \quad (27)$$

From the savings perspective, the costs estimated here correspond to the potential savings that nutritional programmes and policies in a country can generate. The effectiveness of these policies and programmes will correspond to the amount of savings.

Given that the effects for a specific cohort occur throughout the life cycle, costs are estimated at present values. This is equal to the summation of incidental costs in the future, adjusted by a discount rate.

- *Health costs:*

$$HC_{(0-4)}^U = (HSC_{(0-4)}^U + IHC_{(0-4)}^U) \quad (28)$$

In which,

| | | |
|-----------------|---|---|
| $HSC_{(0-4)}^U$ | = | Incremental costs in the healthcare system resulting from the epidemiological profile of malnourished boys and girls under the age of five in the year of analysis. |
| $IHC_{(0-4)}^U$ | = | Private costs incurred by malnourished children and their families as a result of the time and quality of life lost due to these illnesses and mortality. |

The *cost to the healthcare system*, at an aggregate level, equals:

$$HSC_{(0-4)}^U = \sum_{x=0}^4 \sum_{j=1}^j \sum_{i=1}^i \left(\frac{M_{ij}^U * AHC_{ij}}{(1+i)^x} \right)_x \quad (29)$$

In which,

| | | |
|------------|---|---|
| M_{ij}^U | = | Number of annual disease events estimated for each pathology (i), for every a sub-cohort under the age of five (j). |
| AHC_{ij} | = | Average cost of treatment in the healthcare system for each pathology event (i), for the sub-cohort (j). |

- I = Social discount rate
- X = Period of analysis (year) in which the pathologies occur (from $x = 0$ to $x = 4$).

To estimate the costs associated with the treatment protocols, the procedures described for equations 11 and 12 in the incidental dimension are used.

To estimate *private health costs* that will be incurred altogether by malnourished individuals in a cohort aged 0 to 4 years and their families as a result of illnesses derived from undernutrition in the year of analysis (x), the formula is:

$$IHC_{(0-4)}^U = \sum_{x=0}^4 \sum_{j=1}^j \sum_{i=1}^i \left(\frac{M_{ij}^U * AIC_{ij}}{(1+i)^x} \right)_x \quad (30)$$

In which,

- M_{ij}^U = Number of annual disease events caused by undernutrition occurring for each pathology (i), in a sub-cohort (j), (in a year x).
- AIC_{ij} = Average cost incurred by the individual or his or her family for each pathology event (i), in the sub-cohort (j).
- i = Social discount rate
- X = Period of analysis (year) in which the pathologies occur (from $x = 0$ to $x = 4$).

In this case, the same assumptions and procedures as those described in equations 13, 14, and 15 of the incidental dimension are applied.

- *Education costs:*

$$EC_{(0-4)}^U = (ESC_{(0-4)}^U + PEC_{(0-4)}^U) \quad (31)$$

In which,

- $ESC_{(0-4)}^U$ = Public costs to the education sector due to the need to cover the incremental demand projected on the basis of the higher probability of repeated grades among future students who have undernutrition between the ages of 0 and 4 years.
- $PEC_{(0-4)}^U$ = Private costs due to the increase in inputs and transportation requirements produced by the higher probability of repeated grades among future students who have undernutrition between the ages of 0 and 4 years.

The *cost to the education system*, at the aggregate level ($ESC_{(0-4)}^U$), equals:

$$ESC_{(0-4)}^U = \sum_{x=2}^{18} \sum_{l=1}^l \left(\frac{Y_{replx}^U * OC_{Elx}}{(1+i)^x} \right) \quad (32)$$

In which,

- Y_{replx}^U = Extra number of years of operation per child generated at the education level (l) because of projected repetition of grades due to undernutrition in the period

(x).

OC_{Elx} = Operating cost per academic year per student (infrastructure, equipment, human resources, educational inputs, and food) at the education level (l) in the period (x).⁴⁰

i = Social discount rate

The *private education costs* incurred by malnourished individuals and their families due to the need for more educational inputs and others, are the result of:

$$PEC_{(0-4)}^U = \sum_{x=2}^{18} \sum_{l=1}^l \left(\frac{Y_{repcx}^U * FC_{Ec x}}{(1+i)^x} \right) \quad (33)$$

In which,

Y_{replx}^U = Extra number of years of operation per child generated at the education level (l) because of projected repetition of grades due to undernutrition in the period (x).

FC_{Elx} = Average family cost of keeping the student in school for one year (transportation and educational material and inputs) at the education level (l) during the period (x).

i = Social discount rate

Substituting equations 32 and 33 in 34, the estimated education cost for the malnourished cohort aged 0 to 4 years is:

$$EC_{(0-4)}^U = \sum_{x=2}^{18} \sum_{l=1}^l \left(\frac{Y_{rep}^U * (OC_E + FC_E)}{(1+i)^x} \right)_{lx} \quad (34)$$

In this case, the same assumptions and procedures as those described in the incidental dimension are applied.

- *Lower productivity.*

The effects on future potential productivity ($PC_{(0-4)}^U$) due to differentials in income caused by the lower level of education and the deaths associated with undernutrition in children aged 0 to 59 months in a given year (x) are equal to:

$$PC_{(0-4)}^U = (ELC_{(0-4)}^U + MMC_{(0-4)}^U) \quad (35)$$

In which,

$ELC_{(0-4)}^x$ = Less potential income estimated because of the lower level of education attained by a person who has suffered from undernutrition before the age of five and has survived that condition.

$MMC_{(0-4)}^U$ = Loss of potential income due to deaths associated with undernutrition in boys and girls before the age of five.

⁴⁰ If disaggregated data are not available for every education level (l), a single estimate can be made for all levels using average costs.

The *lower potential income* estimated for malnourished boys and girls ($EL_{(0-4)}^U$) corresponds to the sum of average differential wages, estimated for each work year (x), earned by those who suffered from undernutrition before the age of five and survived that condition, compared to those who did not have undernutrition, due to the impact on their level of education.

$$CNE_{(0-4)}^U = \sum_{x=11}^{64} \sum_{z=0}^z \sum_{j=-4}^0 \left(\frac{\Delta y_{jz}^U}{(1+i)^x} \right)_x \quad (36)$$

In which,

- Δy_{jz}^U = Potential income differential of malnourished individuals in an age sub-cohort (born in year j) and at a level of education (z), in each work year.
- X = Year in which the income would be earned.
- I = Social discount rate

In this case:

- There are five age cohorts (j), corresponding to each age sub-group of those under five: those born four years prior to the year of analysis (x = -4) and those born in the year of analysis (x = 0).
- The maximum number of grades considered at the education level (z) depends on the school system in each country (normally between 11 and 12 years, total, for the primary and secondary levels).
- The range of years (x) for which income is estimated extends from the year when the older members of the cohort (those aged four at the time of analysis) turn 15 years old, (x=11), and the year when those born in the year of analysis complete the work period taken into consideration (x=64).
- Work experience (EXP) is estimated based on the difference between the age of each person and the lower limit of the work period. A person at the age of 15 years is considered “zero” or “no experience”, whereas the maximum possible is “50 years of experience” at the time the person leaves the work period (age of departure from the WAP).

Following the procedure detailed for the incidental dimension, if for each level of education the years of experience (EXP) are controlled, the projected difference in expected income depends on the difference in the distribution of years of education (EDU) resulting from the effect of undernutrition (Δe), and therefore:

$$\Delta y_{jzx}^U = y_{jzx} * \Delta e_z^U * U * N_j \quad (37)$$

In which,

- Δy_{jzx}^U = Projected income differential for the total number of malnourished persons (who survive that condition), for the sub-cohort (j) and the education level (z) in each work year (x).
- y_{jzx} = Estimated income of a person in the sub-cohort (j) and at the education level (z) in each work year (x).
- Δe_z^U = Probability differential of having a level of education (z) due to undernutrition.
- U = Prevalence of undernutrition at 0 to 59 months of age in the year of analysis.
- Nj = Size of the sub-cohort (j).

The *loss of productivity due to mortality* corresponds to the potential annual income that children aged 0 to 59 months ($CMM_{(0-4)}^U$) would have earned if they had survived their undernutrition.

As in the incidental dimension, this potential income corresponds to the average income in each cohort according to level of education, of persons who did not suffer from undernutrition.

To analyse the situation in a cohort under the age of five in a year (x), the number of deaths related to child undernutrition must be estimated for that group, and the average expected income of each according to the estimated level of education and the years of experience projected for those who are not malnourished. For this purpose, it is necessary to:

- Estimate the rate and number of deaths due to undernutrition for children under the age of five in the year of analysis (x=0).
- Estimate the population of those now aged 0 to 4 years for the period when they will enter the WAP (x=11 to x=64), adjusting the projected population by the survival rate of those who are not malnourished (s_{NM}), estimated for the period. That is, the survival rate for the cohort,⁴¹ discounting deaths due to undernutrition.
- Distribute the number of deaths in each sub-cohort (j) according to the proportion of education level estimated for those who are not malnourished, based on the results of the cohort that most recently finished its schooling (20-24 years).
- Multiply the result for each cohort (j) by the estimated average income for each combination of education level (z) and experience per year (x).

Thus,

$$CMM_{(0-4)}^U = \sum_{x=11}^{64} \sum_{z=0}^z \sum_{j=-4}^0 \left(\frac{(MM_j^U * s_j^{NU} * e_z^{NU}) * y_{jz}}{(1+i)^x} \right)_x \quad (38)$$

In which,

- MM_j^U = Number of deaths due to undernutrition before the age of 60 months for each age sub-cohort (j).
- s_j^{NU} = Survival rate of the age sub-cohort (j) for the year of analysis (x = 0).

⁴¹ In order to preserve comparability, CELADE projections are used.

| | | |
|------------|---|--|
| e_z^{NU} | = | Proportion of non-malnourished individuals who reach each level of education (z). |
| y_{jz} | = | Estimated average income of a person in the sub-cohort (j) and at the education level (z) in each work year. |
| I | = | Social discount rate |
| X | = | Year in which the income would be earned. |

The information on income and employment rate for each level of education and experience comes from the household surveys conducted in each country.

To consolidate the projections of health, education, and productivity costs, it is advisable to group the data in a cost flow, with all the values corresponding to each item throughout the life cycle.

To compare future costs, or potential savings, with social spending and GDP in each country, the equivalent annual cost of each item must be calculated by converting the present values into annual amounts, with the same discount rate and a single horizon for all analyses.

Costs are expressed in the currency of each country, United States dollars (USD) for the year of analysis, and United States dollars of purchasing power parity (USD PPP) for the year 2000.

2.3 Analysis of scenarios

With the methodology described in this document, in addition to analysing the situation in a country based on existing information in a specific year, it is possible to simulate different types of scenario.

Using the procedures described for the incidental-retrospective dimension, it is possible to estimate the additional effects and costs that a country has incurred because its undernutrition rates are higher than they would have been if it had developed more effective mitigation programmes earlier. For this purpose, it is necessary to:

1. Estimate the change that undernutrition rates would have undergone over time if other undernutrition mitigation programmes had been implemented.
2. Apply the incidental-retrospective method to those rates to obtain the potential version (with projection);
3. Contrast the cost estimates for the actual situation (without projection) with those estimated for the potential situation (with projection).

To enhance the picture with the cost-benefit ratio of the potential situation (without projection), the incremental costs entailed in its implementation must also be taken into consideration.

Using the procedures of the prospective dimension, on the other hand, it is possible to project and compare the effects and costs of different future scenarios. For this purpose, it is necessary to:

1. Estimate undernutrition and its associated effects on health and education for a scenario in which the current situation continues its trend (without projection) until the year of analysis (for example, the horizon of the Millennium Development Goals, 2015).
2. Define an expected undernutrition rate for the projected year (for example, the goal of cutting worldwide undernutrition in half that was set for the year 2015 in 1990);

3. Project the indicators associated with health and education resulting from that estimate of undernutrition (with projection) for the year of analysis (in this example, 2015);
4. Analyse the situation of both scenarios (with and without projection), applying the costs of the year when the projection is made (for example, 2006);
5. Evaluate the differential of effects and costs between the two scenarios.

The steps described here can be used with more than one alternative scenario, and in this manner the method allows for evaluating whether or not different hunger and undernutrition mitigation programmes should be implemented from a cost-effectiveness and cost-benefit perspective.

C. Analysis and discussion of the model

In light of the experience obtained by applying in the field the procedures for estimating effects and costs, both in the incidental-retrospective dimension and the prospective dimension, it can be concluded that the methodology based on secondary data from the countries and international organizations, plus in-depth interviews with experts on the issues in question in each country, effectively meets the stated objectives and adequately accounts for the theoretical framework on which it is based.

The methodological design described here incorporates technical solutions to many difficulties encountered during its development, particularly throughout the pilot study conducted for Peru, and partially for Chile, as well as other experiences now being gained in the Central American countries.

It should be noted that, although the feasibility of applying the model has been demonstrated, using the different indicators required, this proposal could have alternative procedures and indicators in accordance with the situation in the country where it is being implemented, and it can certainly be improved gradually in future applications.

Below are some of the principal obstacles and challenges that have emerged during its application.

I. Limitations in the quality of data available

It is not possible in every case to obtain reliable base information on the health and education situations and operating costs, and this shortcoming must be offset by using proxies from the same country or another country. In the area of health, the greatest difficulty in this regard is the lack of exhaustive databases on morbidity and mortality records. Moreover, treatment costs are not always segmented by levels of care or by specific pathologies, which limits the accuracy of the estimates.

With respect to data on school results, the countries' record system generally allows for a calculation of the required indicators for a given year, but there are no yearly follow-ups.

The above limitations, together with the fact that there is rarely any segmentation of the indicators between the malnourished and the non-malnourished, make it necessary to reconstruct some processes based on external parameters.

The situation described here is even worse in the case of assessments of circumstances on a smaller scale, below the national level.

II. Limited availability and representativeness of relative risks, both for health and for education

In general, there is little experience in this matter in Latin America and the Caribbean, which means that at some stages of the estimation processes it is necessary to consider relationship parameters that are not necessarily representative of the specific reality of the region. The systematization of programme evaluations and new diagnostic studies offer an opportunity to develop specific estimators that will increase reliability.

III. Difficulty incorporating micronutrients into the analysis

It is clearly advisable to obtain more estimates that include a more exhaustive analysis of the effects and costs associated with micronutrient deficiencies, taking into account that: a) deficiencies in micronutrients, particularly *in utero* and during the early stages of the life cycle, are associated with height and weight deficits; and b) they affect other areas of health, education, and productivity.

This is a challenge that should definitely be considered a complement to the methodology developed. However, it should be viewed as a future challenge, since there are not yet any studies with reliable data that allow for the differentiation of the incremental costs and effects derived from each nutritional deficiency independently, or the identification of interactions between deficiencies in some micronutrients and anthropometric measurements. In cases such as zinc, moreover, there are no reliable indicators in these countries to determine the prevalence of the deficiency.

In view of the foregoing, this model considers only the relationship between underweight and iron-deficiency anemia, because there is available information to estimate the relative risk of this deficit.

IV. Estimation of productivity

Estimating productivity lost due to mortality and lower levels of education associated with underweight nutrition before the age of five involves estimating a potential situation based on a labour market scenario functioning in the real world, which obviously does not account for those who do not participate because they have died; such a scenario only considers the workforce with existing capacity at the time of analysis.

Estimates of wage variation could be attempted, considering the potential scenarios, because with a supply of better quality and/or a larger quantity of human resources, expected income changes. In light of this situation, this methodology does not yet involve any further inquiry into these factors, which limits the possibility of incorporating adjustment variables into these indicators.

V. Defining an appropriate discount rate

For purposes of comparison, when prospective analyses are made in different countries, it is advisable to use a single discount rate for all of them. However, the selection of one rate or another is not an easy decision, especially considering that when making very long-term estimates, this rate has a direct impact on the present and annual values that are estimated.

Since the 1980s, the social discount rate in countries of the region has been set at between 10% and 12% per year. At present there is greater diversity, with some countries using 8% and others 14%. Furthermore, the analytical models of Disability Adjusted Life Years (DALY) use a discount rate of 3%, which has been adopted by some researchers and analysts for projects in the healthcare sector.

For the pilot study, and as a test for use in other countries, the rate of 8% a year was chosen. This is the lowest rate employed in social evaluations of projects in the region. However, using alternative rates will change the total amounts, though it will have no effect on the country-to-country comparisons.

Therefore, the challenge to improve the quality of data and to develop new methodological approaches remains on the agenda. Undertaking this challenge will mean improving the reliability of indicators for decision-making by those responsible for implementing programmes and projects with a view to combating hunger and undernutrition in the region. This will have positive consequences not only for studies and the design of programmes of this type, but also for the development and improvement of information, monitoring, and evaluation systems in different sectors.

D. Annexes

Annex 1: Undernutrition indicators

Nutritional status has been analysed at the individual and population levels by means of clinical evaluations (for example, to measure marasmus, or caloric undernutrition, and kwashiorkor, or protein-deficiency undernutrition), as well as evaluations of food intake and socio-economic level (ability to buy food) and anthropometric indicators of the nutritional status. The use of these evaluations has evolved over time.

To better understand the issue of evaluating nutritional status through anthropometric indicators, a differentiation must be made between standards or reference patterns, undernutrition indicators, and cut-off points.

Until the 1980s, each country used the standard or reference pattern that best suited it, be it national (such as Legarreta Curves in Argentina) or foreign but adapted to the country (such as the SEMPÉ Pattern in Chile, adapted from France). Since the 1980s, it has been agreed to use a common reference pattern that allowed, on the one hand, for comparison with an ideal to be achieved by developing countries, and on the other hand, a country-to-country comparison. For this purpose, it was agreed that the NCHS/CDC/WHO 1977 curves would be used.

Traditionally, what have been used are weight/age, an indicator of underweight; weight/height, an indicator of wasting; and height/age, an indicator of stunting.

The weight/age indicator is very useful for measuring the nutritional status of populations under the age of five, when major distortions are not produced by the failure to consider height. In fact, this indicator has served well in monitoring populations.

The Weight/Height indicator has been used for individual follow-up in children, as it allows for the detection of wasting in a child and for monitoring changes month to month.

The height/age indicator is appropriate for determining whether there is stunting or the effect of previous malnutrition in children, which is manifested in retarded growth. Therefore, it is used in populations, especially those more than five years of age.

However, the ideal is to use the combination of all three indicators, which is complex and difficult to apply to individual monitoring efforts intended to follow the nutritional status of a child; and it is also difficult for analysing populations. Nonetheless, there are population surveys that use the three indicators with the NCHS/CDC/WHO reference, which allows for a comparison between countries. An example of this is the Demographic Health Surveys (DHS) applied by USAID in different Latin American countries.

The cut-off points most frequently used in establishing nutritional levels have been the Standard Deviations (σ): -1σ to -2σ to determine Mild undernutrition; -2σ to -3σ to establish Moderate undernutrition, and -3σ for Severe undernutrition. These cut-off points are established for each indicator according to the Standard or Reference Pattern chosen. The cut-off point is generally established in accordance with each country's intervention capacity.

Given the increasing prevalence of obesity in the world, this nutritional evaluation system is undergoing a major change towards growth curves that consider the Body Mass Index (BMI) indicator, which corresponds to Weight (in kilograms) divided by Height (in meters), squared ($BMI = W/H^2$). This has been established to diagnose excess weight (BMI between 25 and 30) and obesity (BMI above 30) in adults. When the BMI is below 18.5, there is a nutritional deficit.

To adapt this classification to children, there are Standards or Reference Patterns based on curves developed by the International Obesity Task Force (IOTF), and others from the Centers for Disease Control (CDC/NCHS 2000). The cut-off points are based on the 85th to 95th percentiles for establishing excess weight, and above the 95th percentile for obesity, extrapolated from an adult population to children over the age of two. To establish a nutritional deficit or undernutrition, the cut-off point was set for those below the 5th percentile.

Annex 2: Low birth weight and undernutrition

Low birth weight is determined by two processes: length of gestation and foetal growth rate. Children born before the 37th week of gestation are premature, and the majority of them have LBW. On the other hand, intrauterine growth restriction (IUGR) causes children to be small for their gestational age (SGA). That is, they have a nutritional deficit.

Although the processes associated with LBW are known, the relative weight of each of the determining factors has not been clearly defined, which poses some challenges for future research.

One way of determining the weight of the nutritional factor in LBW is the model developed by DeOnis and collaborators (1998),⁴² which estimates the proportion of newborns who are IUGR vs. premature, based on the incidence of LBW. According to this model:

$$LBW_{IUGR} = -3.2452 + 0.8528 LBW$$

⁴² De Onis M, Blössner M, Villar J. (1998) Levels and patterns of intrauterine retardation in developing countries. *European Journal of Clinical Nutrition* 52(suppl.1): S5-S15.

In which,

LBW_{IUGR} = Birth weight below the 10th percentile for gestational age

LBW = Total LBW percentage.

This model, whose $r^2 = 0.92$, makes it possible to distinguish cases of LBW with just IUGR due to nutritional problems from those that are premature, the distribution of which can be seen in the following table.

At first glance, this model appears to allow for the isolation of cases caused by nutritional factors. However, among premature babies there are also situations caused by foetal or maternal undernutrition, along with other causes such as infections of the respiratory or gastrointestinal tract, malaria, insufficient access to and quality of healthcare services, hygiene, and health in the household, as well as the mother's age. Unfortunately, the weight of each factor is still a challenge for research.

Considering the foregoing, and aware that making the adjustment with the above formula may create a bias in some cases (by failing to consider the relationship between short gestation and nutritional problems),⁴³ after technical discussions with the study Advisory Committee it was decided to consider only the LBW_{IUGR} group.

The following table shows the relationship between the LBW rate and the IUGR rate.

| LBW rate (%) | Type of LBW | |
|--------------|-------------|-----------------|
| | IUGR (%) | Prematurity (%) |
| 5 | 1,0 | 4,0 |
| 10 | 5,3 | 4,7 |
| 15 | 9,5 | 5,5 |
| 20 | 13,8 | 6,2 |

Annex 3: Estimation of ΔP based on other relative risk indicators

The differential risk of undernutrition in causing, for example, a given pathology, is rarely expressed in terms of ΔP , as the methodology requires. In that case, it must be derived so that the number of additional cases caused by undernutrition can be estimated. Below are the two most recurrent cases and their derivation.

- Estimation of ΔP based on the prevalence ratio (PR).* When only the PR is available ($PR_i = P_i^U / P_i^{NU}$), the components of ΔP can be derived by considering P_i as a weighted average of P_i^U and P_i^{NU} , which means that:

$$P_i^{NU} = \frac{N * P_i}{PR_i * N^U + N^{NU}}$$

and the corollary is,

$$P_i^U = P_i^{NU} * PR_i$$

⁴³ Depending on the total incidence of LBW in the countries of the region, if nutritional factors had a very low weight among premature babies, non-nutritional cases could represent a maximum of 80% of LBW (in cases of low incidence) or 35% (in cases of the highest incidence).

In which,

| | | |
|------------|---|---|
| P_i | = | Probability that the pathology i will occur in the total population. |
| P_i^{NU} | = | Probability that the pathology i will occur in the non-malnourished population. |
| P_i^U | = | Probability that the pathology i will occur in the malnourished population. |
| PR_i | = | Probability ratio that pathology i will occur. |
| N | = | Size of the total population. |
| N^U | = | Size of the malnourished population. |
| N^{NU} | = | Size of the non-malnourished population. |

For example: To analyse the effects of education, the formula is as follows:

- i. To estimate the differences in the repetition probability in a given year (x), the formula is:

$$\Delta r_{zx} = (r_z^U - r_z^{NU})_x$$

In which,

| | | |
|-----------------|---|--|
| Δr_{zx} | = | Differential probability of repetition for each grade (z) in a year (x) for those who had undernutrition before the age of five. |
| r_z^{NU} | = | Probability of repetition of the grade (z) for the non-malnourished population. |
| r_z^U | = | Probability of repetition of the grade (z) for the malnourished population. |

Continuing with the above:

$$r_z^{NU} = r_z * \frac{e_z}{RPr * e_z^D + e_z^{NU}}$$

In which,

| | | |
|------------|---|--|
| r_z^{NU} | = | Probability of repetition of the grade (z) for the non-malnourished population. |
| RPr | = | Probability ratio of repetition between those who had undernutrition before the age of five and those who did not. |
| r_z | = | Average rate of repetition of the grade (z). |
| e_z | = | Total enrolment in the grade (z). |
| e_z^U | = | Enrolment of the malnourished population in the grade (z). |
| e_z^{NU} | = | Enrolment of the non-malnourished population in the grade (z). |

And,

$$r_z^U = r_z^{NU} * PRr$$

In which,

- r_z^U = Probability of repetition of the grade (z) by the malnourished population.
 r_z^{NU} = Probability of repetition of the grade (z) by the non-malnourished population.
 PRr = Probability ratio of repetition between those who had undernutrition before the age of five and those who did not.

- ii. By analogy, to estimate differences in the dropout rate in each year of the education level, the formula is:

$$d_z^{NU} = d_z * \frac{e_z}{PRd * e_z^M + e_z^{NU}}$$

In which,

- d_z^{NU} = Probability of dropping out of the grade (z) by the non-malnourished population.
 PRd = Probability ratio of dropping out between those who had undernutrition before the age of five and those who did not.
 d_z = Average dropout rate for the grade (z).
 e_z = Total enrolment in the grade (z).
 e_z^U = Enrolment of the malnourished population in the grade (z).
 e_z^{NU} = Enrolment of the non-malnourished population in the grade (z).

AND,

$$d_z^M = d_z^{NU} * PRd$$

In which,

- d_z^U = Probability of dropping out of the grade (z) by the non-malnourished population.
 d_z^{NU} = Probability of dropping out of the grade (z) by the non-malnourished population.
 PRd = Probability ratio of dropping out between those who had undernutrition before the age of five and those who did not.

- b. *Estimation of ΔP based on the Odds Ratio (OR).* When the indicator available is OR ($OR = (P_i^U / (1 - P_i^U)) / (P_i^{NU} / (1 - P_i^{NU}))$, or $OR = (a * d) / (b * c)$), then:

$$\Delta P = ((a / (a + c)) - ((b / (b + d)))$$

In this case, to estimate ΔP the procedure described below is followed:

A tetrachoric table is created in which total N is equal to 1;⁴⁴ the marginal total (a + b) corresponds to the prevalence of the pathology (P_i), and the marginal total (a + c) corresponds to the prevalence of undernutrition (P_U). Then, to complete the table, first the proportion of box “d” is calculated⁴⁵

The foregoing can be represented thus:

| | | Undernutrition | | |
|---------------|-------|------------------------|-------|------------------------|
| | | YES | NO | Total |
| Pathology (i) | YES | a | b | P _i = a + b |
| | NO | c | d | c + d |
| | Total | P _U = a + b | b + d | 1 |

To estimate “d” the following formula is used:

$$d = \frac{-B - \sqrt{(B^2 - 4AC)}}{2A}$$

In which,

$$\begin{aligned} A &= OR - 1 \\ B &= OR (P_U + P_i - 2) - P_i - P_M + 1 \\ C &= OR (1 - P_U - P_i + P_U P_i) \end{aligned}$$

To complete the table and calculate P, the following values are used:

$$\begin{aligned} b &= 1 - P_U - d \\ c &= 1 - P_i - d \\ a &= P_U - c = P_i - b \end{aligned}$$

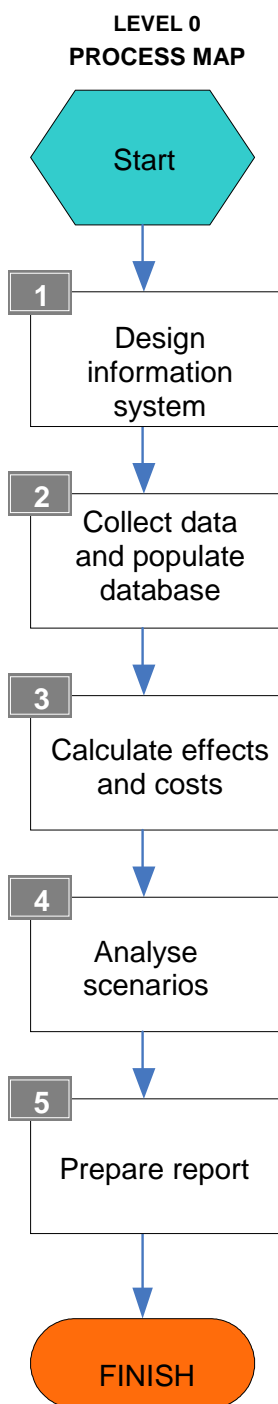
⁴⁴ Since this approach deals with proportions, 1 represents the entire cohort under analysis.

⁴⁵ Note that both OR and DP use all four cells in the table in their calculation.

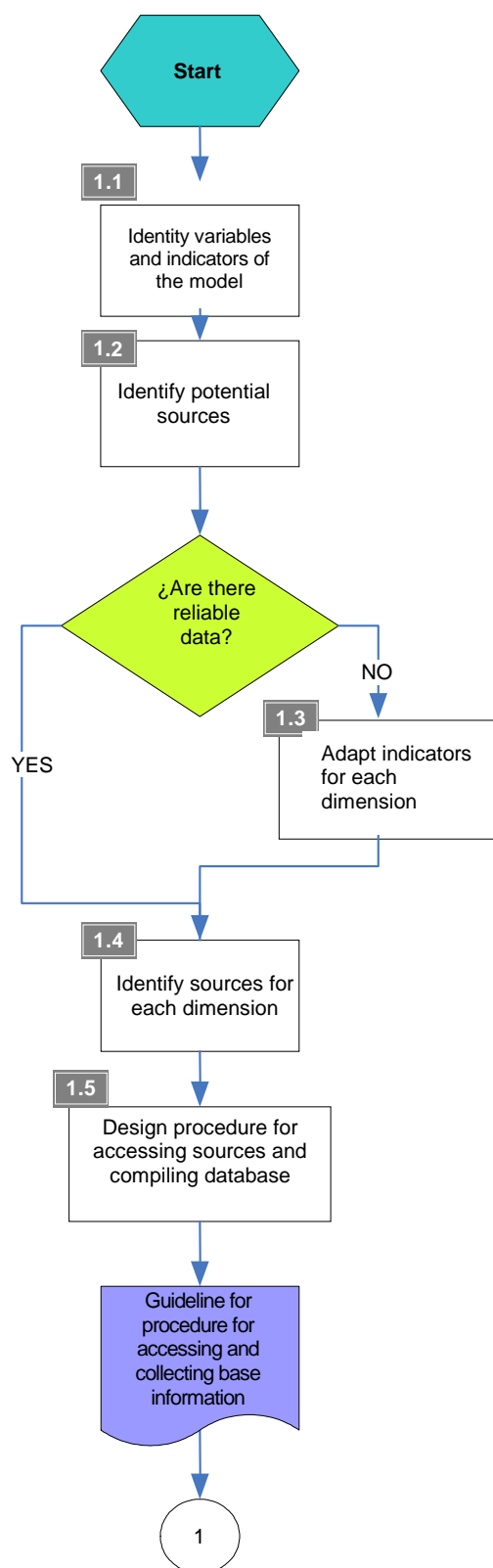
Annex 4: Methodology implementation processes

Below is a series of schemas depicting the processes necessary to implement the methodology developed in the analytical model.

The flows are presented on two levels of specificity, the more general one (0) being shown in the Process Map. In level 1, each process is presented with its sub-processes and principal activities.

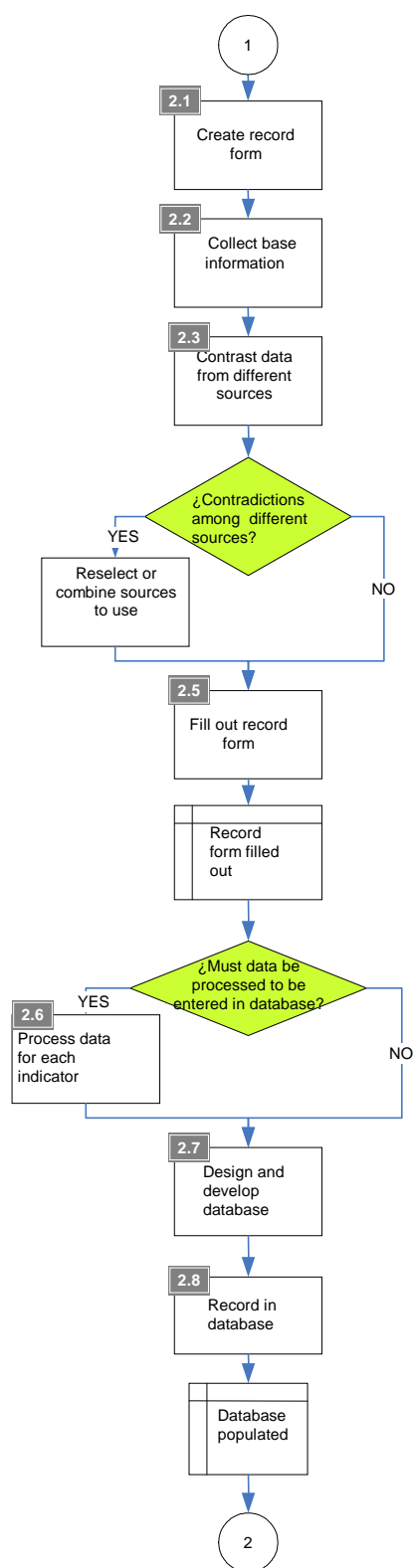


LEVEL1
PROCESS 1: DESIGN INFORMATION SYSTEM

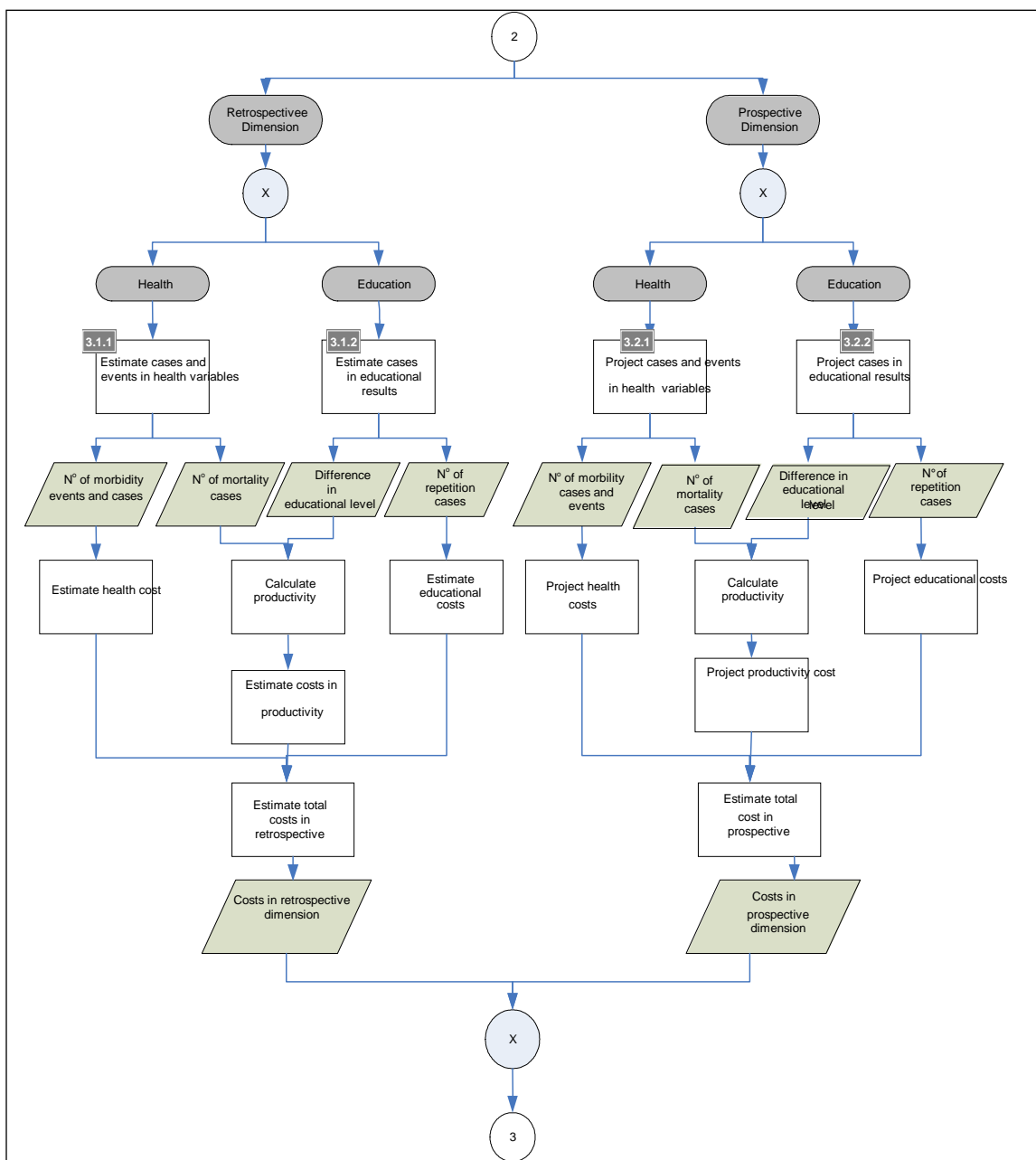


PROCESS 2

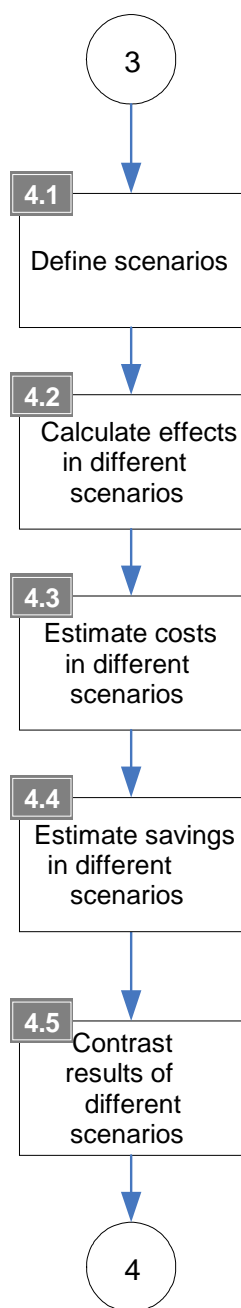
COLLECT INFORMATION AND POPULATE DATABASE



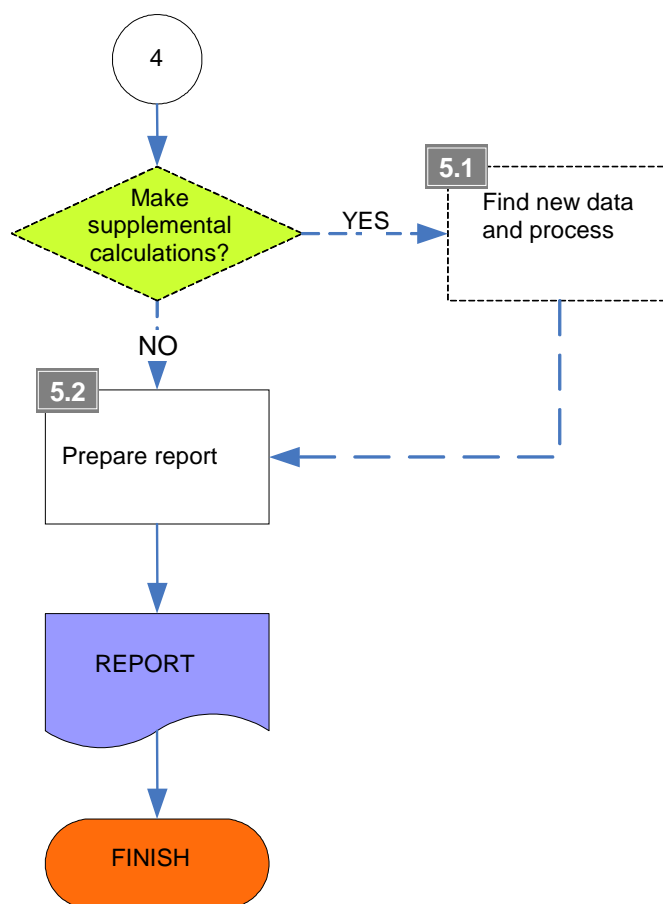
PROCESS 3 CALCULATE EFFECTS AND COSTS



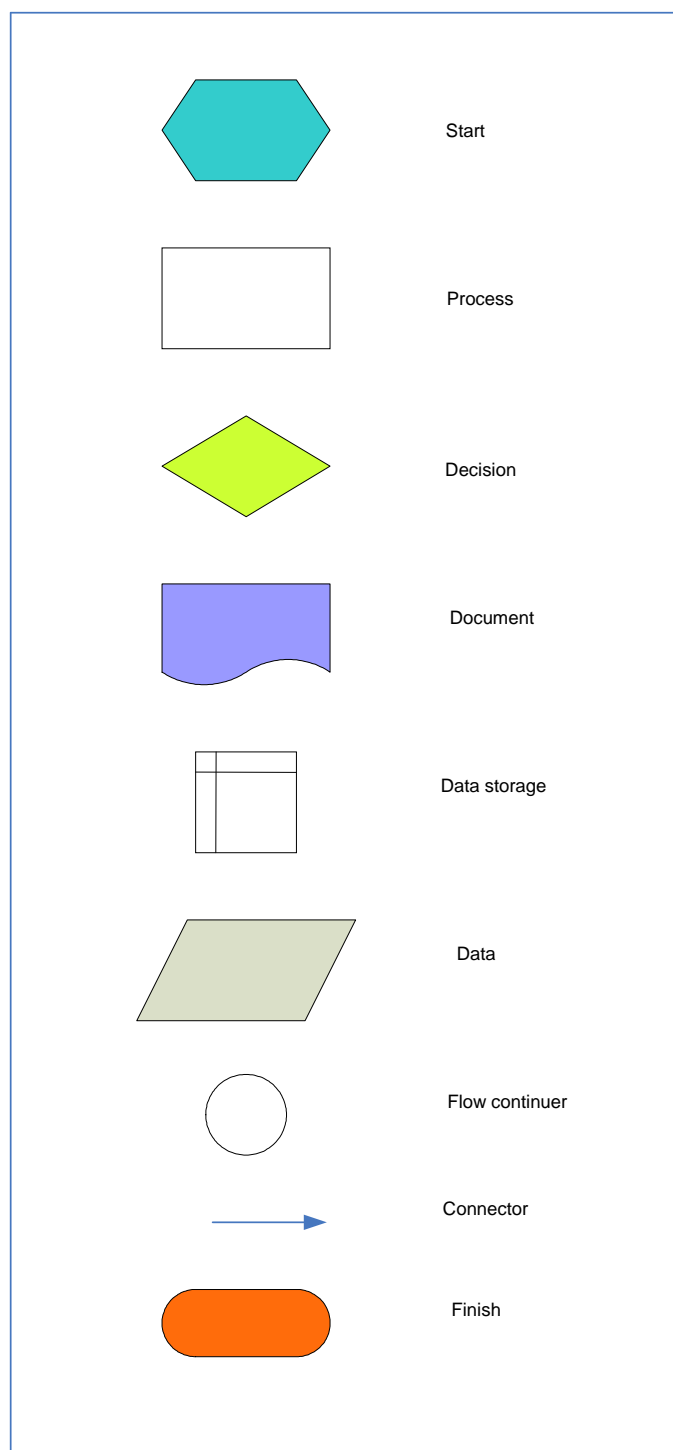
PROCESS 4 ANALYSE SCENARIOS



PROCESS 5
PREPARE REPORT



The symbols used in the preceding process diagrams have the following meanings:



Annex 5: Case report forms for calculating effects and costs

1. ECONOMIC STATISTICS

TABLE 1.1: VARIOUS ECONOMIC STATISTICS (FOR YEAR OF ANALYSIS X)

| Various economic statistics) | Value | Source | Year |
|--|-------|--------|------|
| GDP (in millions of current dollars) | | | |
| Exchange rate | | | |
| Conversion factor to US\$ PPP | | | |
| Total Social Spending (in millions of current dollars | | | |
| Education Social Spending (in millions of current dollars)) | | | |
| Health Social Spending (in millions of current dollars) | | | |
| Value of two urban public transportation fares (in local currency) | | | |
| Minimum wage per hour (in local currency) | | | |

Note: Indicate year when data does not correspond to “year of analysis x”

TABLE 1.2: CONSUMER PRICE INDICES

| Consumer Price Indices | Year | | | | | |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| | x - 1 | x - 2 | x - 3 | x - 4 | x - 5 | x - 6 |
| CPI as of December of each year | | | | | | |
| Source: (indicate source used) | | | | | | |

1. ECONOMIC STATISTICS (continued)

TABLE 1.3: AVERAGE MONTHLY INCOME

| Average monthly income (in local currency) by age and education level | | | | | | | | | | | | | |
|---|--------------------|----------------|---|---|---|---|---|---|---|---|----|----|----|
| Age group | Years of schooling | | | | | | | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 15-19 | | | | | | | | | | | | | |
| 20-24 | | | | | | | | | | | | | |
| 25-29 | | | | | | | | | | | | | |
| 30-34 | | | | | | | | | | | | | |
| 35-39 | | | | | | | | | | | | | |
| 40-44 | | | | | | | | | | | | | |
| 45-49 | | | | | | | | | | | | | |
| 50-54 | | | | | | | | | | | | | |
| 55-59 | | | | | | | | | | | | | |
| 60-64 | | | | | | | | | | | | | |
| Source: Latest available household survey | | Year of survey | | | | | | | | | | | |

TABLA 1.4: HOURS OF WORK

| Average of hours of work each week by age | |
|---|-------|
| Age group | Hours |
| 15-24 | |
| 25-34 | |
| 35-44 | |
| 45-54 | |
| 55-64 | |
| Source: Latest available household survey | |

1. ECONOMIC STATISTICS (continued)

TABLE 1.5: EMPLOYMENT RATE

| Employment rate | | | | | | |
|--|--------------------|--------------------|------------------|----------------------|--------------------|-------|
| Age group | Level of education | | | | | |
| | No education | Primary incomplete | Primary complete | Secondary incomplete | Secondary complete | Total |
| 15 - 24 | | | | | | |
| 25 - 34 | | | | | | |
| 35 - 44 | | | | | | |
| 45 - 54 | | | | | | |
| 55 - 64 | | | | | | |
| TOTAL | | | | | | |
| Source: Latest available household survey. | | | | | | |

Note 1: The employment rate is the ratio between the employed population and the total population in each age group

Note 2: Consider the year at which each level of education finishes according to the standard in each country. For primary education, this may be after 6 or 8 years of school, and for secondary reduction, after 11 or 12 years of school.

1. ECONOMIC STATISTICS (continued)

TABLE 1.6: SIZE OF THE WORKING-AGE POPULATION.

| Size of the Working Age Population (WAP) by age and amount of schooling | | | | | | | | | | | | | |
|---|--------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| Age group | Years of schooling | | | | | | | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 15-19 | | | | | | | | | | | | | |
| 20-24 | | | | | | | | | | | | | |
| 25-29 | | | | | | | | | | | | | |
| 30-34 | | | | | | | | | | | | | |
| 35-39 | | | | | | | | | | | | | |
| 40-44 | | | | | | | | | | | | | |
| 45-49 | | | | | | | | | | | | | |
| 50-54 | | | | | | | | | | | | | |
| 55-64 | | | | | | | | | | | | | |
| TOTAL (15-64) | | | | | | | | | | | | | |
| Source: Latest available household survey | | | | | | | | | | | | | |

Note: If the country does not have secondary up to grade 12, fill in the corresponding cells with n/a (not applicable).

2. DEMOGRAPHIC STATISTICS

TABLE 2.1: SIZE OF THE POPULATION UNDER THE AGE OF FIVE IN YEAR X

| Size of population by age group, In the year of the analysis (x) | |
|--|--|
| 0-11 months | |
| 12-23 months | |
| 24-59 months | |

Source: CELADE

TABLE 2.2: SIZE OF THE POPULATION AGED 0 YEARS

| Size of population aged 0 years | | | | |
|---------------------------------|------|-------|-----|-------|
| Age in year of analysis x | Year | Total | Men | Women |
| 0 | x | | | |
| 1 | x-1 | | | |
| 2 | x-2 | | | |
| 3 | x-3 | | | |
| 4 | x-4 | | | |
| 5 | x-5 | | | |
| ▪ | ▪ | | | |
| ▪ | ▪ | | | |
| ▪ | ▪ | | | |
| ▪ | ▪ | | | |
| ▪ | ▪ | | | |
| ▪ | ▪ | | | |
| 60 | x-60 | | | |
| 61 | x-61 | | | |
| 62 | x-62 | | | |
| 63 | x-63 | | | |
| 64 | x-64 | | | |

Source: CELADE

2. DEMOGRAPHIC STATISTICS (continued)**TABLE 2.3: SIZE OF THE POPULATION AGED 0 TO 4 YEARS**

| Size of the population aged 0 to 4 years | | | |
|--|-------|-----|-------|
| Year | Total | Men | Women |
| x | | | |
| x-1 | | | |
| x-2 | | | |
| x-3 | | | |
| x-4 | | | |
| x-5 | | | |
| ▪ | | | |
| ▪ | | | |
| ▪ | | | |
| ▪ | | | |
| ▪ | | | |
| ▪ | | | |
| x-60 | | | |
| x-61 | | | |
| x-62 | | | |
| x-63 | | | |
| x-64 | | | |

Source: CELADE.

2. DEMOGRAPHIC STATISTICS (continued)**TABLE 2.4: MORTALITY RATES**

| Mortality rate | |
|-----------------------|---|
| Year | Population aged 0 to 4 years |
| x | |
| x-1 | |
| x-2 | |
| x-3 | |
| x-4 | |
| x-5 | |
| ▪ | |
| ▪ | |
| ▪ | |
| ▪ | |
| ▪ | |
| ▪ | |
| x-60 | |
| x-61 | |
| x-62 | |
| x-63 | |
| x-64 | |

Source: CELADE

2. DEMOGRAPHIC STATISTICS (continued)**TABLE 2.5: SURVIVAL RATES OF THE POPULATION AGED 0 YEARS**

| Survival rates of population aged 0 years | | | |
|---|---------------|------|-------------|
| Year | Retrospective | Year | Prospective |
| x | | x | |
| x-1 | | x+1 | |
| x-2 | | x+2 | |
| x-3 | | x+3 | |
| x-4 | | x+4 | |
| x-5 | | x+5 | |
| ▪ | | ▪ | |
| ▪ | | ▪ | |
| ▪ | | ▪ | |
| ▪ | | ▪ | |
| ▪ | | ▪ | |
| ▪ | | ▪ | |
| x-60 | | x+60 | |
| x-61 | | x+61 | |
| x-62 | | x+62 | |
| x-63 | | x+63 | |
| x-64 | | x+64 | |

Source: CELADE.

2. DEMOGRAPHIC STATISTICS (CONTINUED)

TABLE 2.6: SIZE OF THE WORKING-AGE POPULATION

| Size of the Working Age Population (WAP) by age and amount of schooling | | | | | | | | | | | | | |
|---|--------------------|---|---|---|---|---|---|---|--|---|----|----|----|
| Age group | Years of schooling | | | | | | | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 9 | 10 | 11 | 12 |
| 15-19 | | | | | | | | | | | | | |
| 20-24 | | | | | | | | | | | | | |
| 25-29 | | | | | | | | | | | | | |
| 30-34 | | | | | | | | | | | | | |
| 35-39 | | | | | | | | | | | | | |
| 40-44 | | | | | | | | | | | | | |
| 45-49 | | | | | | | | | | | | | |
| 50-54 | | | | | | | | | | | | | |
| 55-64 | | | | | | | | | | | | | |
| TOTAL (15-64) | | | | | | | | | | | | | |
| Source: Latest available household survey. | | | | | | | | | | | | | |

Note: If the country does not have secondary education up to grade 12, fill in the corresponding cells with w/a (not applicable).

2. DEMOGRAPHIC STATISTICS (CONTINUED)

TABLE 2.6: SIZE OF THE WORKING-AGE POPULATION

| Size of the Working Age Population (WAP) by age and amount of schooling | | | | | | | | | | | | | |
|---|--------------------|---|---|---|---|---|---|---|--|---|----|----|----|
| Age group | Years of schooling | | | | | | | | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 9 | 10 | 11 | 12 |
| 15-19 | | | | | | | | | | | | | |
| 20-24 | | | | | | | | | | | | | |
| 25-29 | | | | | | | | | | | | | |
| 30-34 | | | | | | | | | | | | | |
| 35-39 | | | | | | | | | | | | | |
| 40-44 | | | | | | | | | | | | | |
| 45-49 | | | | | | | | | | | | | |
| 50-54 | | | | | | | | | | | | | |
| 55-64 | | | | | | | | | | | | | |
| TOTAL (15-64) | | | | | | | | | | | | | |
| Source: Latest available household survey. | | | | | | | | | | | | | |

Note: If the country does not have secondary education up to grade 12, fill in the corresponding cells with w/a (not applicable).

3. UNDERNUTRITION STATISTICS

TABLE 3.1: UNDERWEIGHT RATE FOR THE YEAR X

| Underweight rate by age group in the year of analysis x or the latest available | |
|---|------------|
| Age group | Percentage |
| 28 days to 11 months | |
| 12 to 23 months | |
| 24 to 59 months | |
| Indicate source and year | |

TABLE 3.2: UNDERWEIGHT RATES OF THE POPULATION AGED 0-4 YEARS (HISTORICAL)

| Underweight rates for 0-4 years (historical measurements available) | | | | | | | | |
|---|--|--|--|--|--|--|--|--|
| Percentage | | | | | | | | |
| Measurement date | | | | | | | | |
| Sources used | | | | | | | | |

Note: Add columns if necessary.

TABLE 3.3: UNDERWEIGHT MODAL RATES (HISTORICAL)

| Modal rates of underweight (historical measurements available) | | | | | | | | |
|--|--|--|--|--|--|--|--|--|
| Percentage | | | | | | | | |
| Measurement date | | | | | | | | |
| Age at date of measurement | | | | | | | | |
| Age in year x | | | | | | | | |
| Sources used | | | | | | | | |

Note: Add columns if necessary.

4. MORBIDITY STATISTICS, PROTOCOLS, AND HEALTH COSTS

TABLES FOR MORBIDITY RECORDS AND CALCULATING DIFFERENCES IN PREVALENCE

Note 1: Record, in the body of each table, the absolute frequencies (expanded if corresponding factor is available).

The body of the table corresponds to the cells where the "Yes" and the "No" intersect (marked by bold lines).

Note 2: When absolute frequencies are not available, record the percentage prevalence of the corresponding pathology in the cell shaded in yellow.

| 0 to 11 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Anemia | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 12 to 23 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Anemia | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 24 to 59 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Anemia | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 0 to 11 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ADD | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 12 to 23 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ADD | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 24 to 59 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ADD | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 0 to 11 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ARI | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 12 to 23 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ARI | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 24 to 59 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| ARI | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 0 to 11 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Other (specify) | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 12 to 23 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Other (specify) | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

| 24 to 59 months | | Underwgt Malnut | | TOTAL |
|-------------------------|-----|--------------------|----|-------|
| | | YES | NO | |
| Other (specify) | YES | | | |
| | NO | | | |
| TOTAL | | | | |
| Indicate source & year: | | | | |

4. MORBIDITY STATISTICS, PROTOCOLS, AND HEALTH COSTS (continued)

TABLE 4.2: PROTOCOLS

| Pathology | Annual average of events | | | Average primary care visits per event | | | Proportion of events requiring hospitalization | | |
|----------------|--------------------------|----------------|----------------|---------------------------------------|----------------|----------------|--|----------------|----------------|
| | Age group | | | Age group | | | Age group | | |
| | 28 days - 11 months | 12 - 23 months | 24 - 59 months | 28 days - 11 months | 12 - 23 months | 24 - 59 months | 28 days - 11 months | 12 - 23 months | 24 - 59 months |
| Anemia | | | | | | | | | |
| ADD | | | | | | | | | |
| ARI | | | | | | | | | |
| Undernutrition | | | | | | | | | |
| Marasmus | | | | | | | | | |
| Kwashiorkor | | | | | | | | | |
| Other 1 | | | | | | | | | |
| Other 2 | | | | | | | | | |
| Source used: | | | | | | | | | |

Note: The lines for "other pathologies" were included for cases in which a country has information for another pathology (in addition to those identified) associated with undernutrition.

4. MORBIDITY STATISTICS, PROTOCOLS, AND HEALTH COSTS (continued)

TABLE 4.2: PROTOCOLS

| Pathology | Average days of Hospitalization per event | | | Proportion of hospital patients requiring ITU/IUC | | | Average days of ITU/IcU per event | | |
|----------------|---|----------------|----------------|---|----------------|----------------|-----------------------------------|----------------|----------------|
| | Age group | | | Age group | | | Age group | | |
| | 28 days - 11 months | 12 - 23 months | 24 - 59 months | 28 days - 11 months | 12 - 23 months | 24 - 59 months | 28 days - 11 months | 12 - 23 months | 24 - 59 months |
| Anemia | | | | | | | | | |
| ADD | | | | | | | | | |
| ARI | | | | | | | | | |
| Undernutrition | | | | | | | | | |
| Marasmus | | | | | | | | | |
| Kwashiorkor | | | | | | | | | |
| Other 1 | | | | | | | | | |
| Other 2 | | | | | | | | | |
| Source used: | | | | | | | | | |

4. MORBIDITY STATISTICS, PROTOCOLS, AND HEALTH COSTS (continued)**TABLE 4.3: HOURS LOST**

| Pathology | Waiting time (hours) for ambulatory care | | | Daily hours lost due to hospitalization | | |
|----------------|--|----------------|----------------|---|----------------|----------------|
| | Age group | | | Age group | | |
| | 28 days - 11 months | 12 - 23 months | 24 - 59 months | 28 days - 11 months | 12 - 23 months | 24 - 59 months |
| Anemia | | | | | | |
| ADD | | | | | | |
| ARI | | | | | | |
| Undernutrition | | | | | | |
| Marasmus | | | | | | |
| Kwashiorkor | | | | | | |
| Other 1 | | | | | | |
| Other 2 | | | | | | |
| Source used: | | | | | | |

TABLE 4.4: LOW BIRTH WEIGHT

| Statistics for Newborns with Low Birth Weight (LBW) | |
|--|--|
| Rate (%) of low birth weight | |
| Proportion of LWB's requiring hospitalization | |
| Average days of hospitalization | |
| Proportion of hospital patients requiring ITU/ICU | |
| Average days of ITU/ICU | |
| Average adult daily hours lost due to hospitalization of child | |
| Source used: | |

TABLE 4.5: COSTS

| Average cost in local currency, by tipe of care, age group, and pathology, for the year of analysis (x) | | | | | | | | |
|---|----------------|---------------------|-------------------------------|------------------|-------------------------------|------------------|-------------------------------|-------------------------|
| Age group | Pathology | Primary Care | | Hospitalization | | ITU/ICU | | Private |
| | | Unit cost per visit | Cost per event medical inputs | Cost per day/bed | Cost per event medical inputs | Cost per day/bed | Cost per event medical inputs | Cost inputs not covered |
| Newborn | LBW | n.a | n.a | | | | | |
| 28 days to 11 months | Anemia | | | | | | | |
| | ADD | | | | | | | |
| | ARI | | | | | | | |
| | Undernutrition | | | | | | | |
| | Marasmus | | | | | | | |
| | Kwashiorkor | | | | | | | |
| | Other 1 | | | | | | | |
| | Other 2 | | | | | | | |
| 12 - 23 months | Anemia | | | | | | | |
| | ADD | | | | | | | |
| | ARI | | | | | | | |
| | Undernutrition | | | | | | | |
| | Marasmus | | | | | | | |
| | Kwashiorkor | | | | | | | |
| | Other 1 | | | | | | | |
| | Other 2 | | | | | | | |
| 24 - 59 months | Anemia | | | | | | | |
| | ADD | | | | | | | |
| | ARI | | | | | | | |
| | Undernutrition | | | | | | | |
| | Marasmus | | | | | | | |
| | Kwashiorkor | | | | | | | |
| | Other 1 | | | | | | | |
| | Other 2 | | | | | | | |
| Source used: | | | | | | | | |

Note 1: n.a.= not aplicable

Note 2: Recall that the private cost corresponds to the cost not covered by the public health system

5. EDUCATION STATISTICS

TABLE 5.1: SCHOOL RESULTS

| School results, by grade, for the year of analysis (x) | | | | | | | |
|--|--------------------------------|---|---|---|---|---|------------------|
| | Primay for Children and Youths | | | | | | Total Primary |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| Initial enrolment | | | | | | | |
| Final enrolment | | | | | | | |
| Passed | | | | | | | |
| Dropped | | | | | | | |
| Repeated | | | | | | | |
| Source used: | | | | | | | |

| School results, by grade, for the year of analysis (x) | | | | | | | | |
|--|-----------------|---|-----------------|----|----|----|--------------------|-------|
| | Lower Secondary | | Upper Secondary | | | | Total Secondary | Total |
| | 7 | 8 | 9 | 10 | 11 | 12 | | |
| Initial enrolment | | | | | | | | |
| Final enrolment | | | | | | | | |
| Passed | | | | | | | | |
| Dropped out | | | | | | | | |
| Repeated | | | | | | | | |
| Source used: | | | | | | | | |

Note: If the country does not have secondary education up to grade 12, fill in the corresponding cells with n/a (not applicable).

5. EDUCATION STATISTICS (continued)**TABLE 5.2: COSTS**

| Annual operating cost per student, by level, for the year of analysis (x) | | |
|---|---------|-----------|
| Type of cost | Primary | Secondary |
| Public cost | | |
| Private cost | | |
| Sources used: | | |

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