The cost of the double burden of malnutrition: Social and economic impact

Summary of the pilot study in Chile, Ecuador and Mexico

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Prologue

Worldwide, the attention placed on the topic of Food and Nutrition Security (SAN) has steadily increased over the past decade as the scientific evidence has shown that nutrition and present-day diets are drivers of health problems and a relevant factor in social inequality.

The Sustainable Development Goals, adopted in 2015, call for an end to malnutrition in all its forms and for all people by the year 2030. At the regional level, Latin America and the Caribbean has made significant progress in reducing the prevalence of undernutrition in recent years. However, there has also been a simultaneous increase in overweight and obesity in adults and children. Referred to as the *double burden of malnutrition*, both problems—of excess and deficit—coexist in the same communities, families and even individuals.

Health and development policies addressing nutritional problems have mostly been aimed at the reduction of undernutrition. These, coupled with an increase in public expenditure for social protection and health, have eradicated acute malnutrition in most countries of the region and reduced chronic malnutrition by 62% when compared to that in 2000. However, together with the presence of micronutrient deficiencies, the rapid increase in overweight, obesity and chronic diseases is becoming a pressing problem in a changing regional context, characterized by high geographic mobility, urbanization and nutrition transition. National development, health and nutrition policies must therefore be adapted to meet these emerging challenges. To achieve it requires comprehensive and detailed knowledge of the social and economic impact of a complex nutritional landscape.

The Economic Commission for Latin America and the Caribbean (ECLAC) and the World Food Programme (WFP) are committed to developing tools that deliver the evidence to design public policies and implement effective programmes to promote FNS. Since 2005, ECLAC and WFP have jointly developed the *Cost of Hunger* project, which started with the design of a model to understand the social and economic impact of undernutrition. To date, the methodology has been applied in eleven countries in our region and in more than fifteen countries in Africa. In many cases, the application of the tool has generated the information necessary to forge alliances and to advocate in favour budgetary allocations to act.

Based on this methodology, and complemented with new approaches for the analysis of the impact of obesity, *The social and economic cost of the double burden of malnutrition* study adopts a broader view in order to evaluate a new reality: the increase of overweight and obesity in a context where undernutrition still prevails. We hope that decision makers are empowered by having a comprehensive vision of the effects and impacts of malnutrition – both by excess and by deficit – on individuals and families, and on the economies of nations, so that they can comprehensively inform the elabouration of nutrition-specific and nutrition-sensitive policies that can respond to this multifaceted problematic.

In this pilot study three countries were analysed: Chile, Ecuador and Mexico. It is estimated that the combined impact of the double burden of malnutrition represents a net loss of gross domestic product (GDP) of 4.3% and 2.3% yearly in Ecuador and Mexico. In the case of Chile, where undernutrition has already been eradicated, this cost reaches 0.2% of GDP. In Ecuador and Mexico, where undernutrition is still a public health problem, the results from this study confirm that given the high costs of lost productivity, it represents a social and financial burden of 1.5 to 3 times that of overweight and obesity. As it has been extensively documented over the years, chronic malnutrition has irreversible lifelong health consequences—including an increased risk of overweight and

obesity in adulthood—and reducing potential productivity in adulthood. However, the results also suggest that the human and financial burden of overweight and obesity is already significant and on the rise. This is mostly a result of the costs derived from chronic diseases associated with overnutrition, especially type II diabetes and hypertension. These costs impact both, the health care system and affected families. As undernutrition declines, overnutrition will rapidly become the largest social and economic burden in Latin America and the Caribbean.

Many collabourators participated in this study. We acknowledge the commitment of country teams and the invaluable methodological contributions made by the Technical Advisory Group gathering leading international experts.

It is our hope that this work promotes the debate on the importance of changes in the nutritional panorama of the region and serves to position the issue of the double burden of malnutrition in the public agenda and that is used as evidence to design programs and public policies that respond in a timely manner to this challenge.

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Introduction

The epidemiological and nutrition transition of Latin American countries imposes a double challenge for nutrition and food security public policies. On the one hand, to continue the task of eradicating young child undernutrition and, on the other, to face the increasing prevalence of overweight and obesity. The international relevance of this reality has resulted in both dimensions of malnutrition being included in the Global Goals for Sustainable Development. One of the targets of Hunger Zero, the second global goal, is "by 2030, ending all forms of malnutrition, including achieving, no later than 2025, the goals agreed to internationally on delayed growth and emaciation of children younger than five years old, and addressing the nutritional needs of adolescents, pregnant and breastfeeding women, and the elderly".

Despite the relevance of both types of malnutrition for the region, due to their prevalence and effects and consequences, their prioritization in public policies is still lacking. Therefore, building on the experience that has been developed over the last decade to estimate the Cost of Hunger, in 2015 the Economic Commission for Latin America and the Caribbean (CEPAL) and the Regional Office of the World Food Programme (WFP) signed a memorandum of understanding to develop aa model of analysis to estimate the effects and costs of the double burden of malnutrition in countries in the region.

Within this context, this document explains the principal results of the pilot study, with estimates of the social and economic impact of malnutrition in three countries in the region.

The purpose of this project has been to design and apply a methodology to, first, estimate the effects of the double burden of malnutrition (undernutrition and overweight/obesity) on health, education and productivity, and the associated costs, with an initial pilot in three countries in the region: Chile, Ecuador and Mexico. The learning generated with this experience will allow for the methodology to be improved and later replicated it in other countries in the region.

The conceptual and methodological approach of this study is based on the analysis model developed by CEPAL to estimate the "cost of hunger",[1] used between 2006 and 2009 in countries in Latin America and the Caribbean, and later—from 2009 to present—adapted and used in countries in Africa. It also includes key aspects of the conceptual note[2] developed by the National Institute of Public Health of Mexico specifically for this pilot study.

The document is comprised of three chapters. The first outlines the *model of analysis* developed for the study, including the main concepts linked to malnutrition and the double burden, the processes of epidemiological, demographic and nutrition transition that are on-going in the region, and the life cycle within the context of the problem addressed; the effects and economic consequences of malnutrition are also described. This is complemented by a description of the main characteristics of the methodology used.[3]

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1   "Modelo de análisis del impacto social y económico de la desnutrición infantil en América Latina" [Model of analysis of the social and economic impact of young child undernutrition in Latin America] (2006).

2   "The double burden of malnutrition: the combined economic impact of undernutrition and obesity in Latin America and the Caribbean," July 2015, (unpublished document).

3   An explanation of the causes of malnutrition, as well as more in-depth methodological details, can be found in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

In the second chapter, the estimates obtained by applying the model are explained and discussed in three different sections: the first section of the chapter explains the effects and costs associated with undernutrition, in the second section the estimates for overweight and obesity are presented, and the third explains the total costs of the double burden of malnutrition.

Finally, the third chapter is dedicated to a discussion about the feasibility of replicating the model in other countries in the region, the main findings of the study, and their relevance for the formulation of public policies.

1

Model of analysis

Background information

In recent decades, the Latin America and the Caribbean region has undergone a series of demographic, epidemiological and nutritional transformations, three complementary transition processes that in the nutrition field have given rise to what has been called the double burden of malnutrition (FAO, 2006; Freire, et al., 2014; Sarmiento, et al. 2014; Kroker-Lobos, 2014). This phenomenon is characterized by the coexistence of undernutrition, and overweight and obesity,[4] and includes micronutrient deficiencies (iron, zinc, vitamin A or others).

While in the region, emphasis has been placed on undernutrition, it is observed that overnutrition is a growing problem. Data shows a high prevalence of overweight and obesity, both in the adult population as well as among children, as the coupled result of nutrition regimens and increased sedentariness. Moreover, the deficit in micronutrient intake known as "hidden hunger" reflects a state of malnutrition due to insufficiency of one or more essential nutrients.

Undertaking the study of malnutrition requires a conceptual approach that can visualize the complexity of the problem in all its dimensions, considering the context in which it occurs, the demographic, socioeconomic and cultural changes that have transformed the risks and levels of vulnerability to food and nutrition security (FNS) in the region. Thus, a comprehensive view of FNS integrating the set of dimensions in which malnutrition is expressed is vital. It is equally important to identify the transition processes that the phenomenon inflicts on the population, and its manifestations throughout the life cycle.

Following World Food Summit (1996) definitions, FNS assumes that the entire population has physical, social and economic access at all times to safe and nutritious food that meets their dietary needs and food preferences, for an active and healthy life. This includes access to food and its adequate biological use. Any imbalance, whether by deficit or excess, becomes a situation of insecurity, and a person is vulnerable to this situation to the extent that there is a risk of not accessing those foods and/or insufficient capacity of response to it (WFP, Martínez and Fernández, 2006).

The demographic, epidemiological and nutrition transitions show great transformation processes that are directly related to the phenomenon of malnutrition experienced by the region today. The demographic transition is an evolutionary process characterized by a significant decrease in the birth and mortality rates, an indicator that is usually lagging. The aging of the population is one of the most important expressions of the demographic transition, reducing the proportion of children and young people parallel to an increase in the relative weight of the elderly. The epidemiological transition refers to the long-term changes in mortality, disease and disability patterns, from a high prevalence of vector-borne diseases to a greater presence of non-communicable diseases, mental health and accidents that derive from the demographic, socioeconomic, technological and lifestyle changes of the population.

Lastly, the nutrition transition is expressed in changes in the nutritional profile, which, in turn, catalyses the change from a stage characterized by high prevalence of undernutrition to another with a predominance of overweight and obesity. This change is determined by the interaction of economic, demographic, environmental and cultural factors (see table 2).

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4   This dimension of malnutrition is called "excessive diet" by the WHO. Hereinafter we will use the terms malnutrition due to deficit (undernutrition) and malnutrition due to excess (overweight and obesity).

Table 1: Stages of the nutrition transition

Characteristic	Stages		
	Pre-transition	**Transition**	**Post-transition**
Diet (prevalent)	Grains Tubers Vegetables Fruits	Increased consumption of sugar, fats and processed foods	High content of fat and sugar Low fibre content
Nutrition status	Nutritional deficiencies and undernutrition predominate	Nutritional deficiencies and obesity coexist	Obesity and hyperlipidaemia predominate

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

A central element to explain the regional epidemiological and nutrition situation is the abrupt change in lifestyles, especially in the diet, physical activity, tobacco consumption, alcohol and drugs, stress and mental health problems, in turn, increasing exposure to risk factors for non-communicable diseases (NCDs). With the improvement of the economic situation and aging of the population, infectious, maternal and child and undernutrition diseases tend to disappear, with a clear predominance of NCDs and obesity.

Along with a transformation at the population level, the evolution of malnutrition is directly associated with age and its effects are manifested in various ways throughout life. It can begin at any point in the life cycle, and its effects may manifest immediately or in subsequent stages, even with inter-generational consequences. The various stages of the life cycle from the perspective of malnutrition and its effects are briefly described below.

Intrauterine and neonatal life

The nutritional status of the mother often determines the birth weight, health and the vital prognosis of a newborn. The cycle begins inside the mother's womb, and is also associated with the mother's health prior to becoming pregnant (Black, et al., 2013).

One of the main determining factors in delayed intrauterine growth is the mother's height, which in turn reflects her nutritional status during her childhood, her nutritional condition prior to conception, and whether she has gained weight—or not—during pregnancy. Thus, looking after the nutrition situation of women of child-bearing age is crucial to a newborns' life, whose risk of mortality is significantly higher at that time, relative to the rest of his infancy. Nearly 45% of deaths in children under age five occur in the first 28 days of life.[5]

The most common consequence of intrauterine growth restriction is low birth weight (LBW = weight < 2.5 kg), which in turn is one of the most important predictive indicators of infant mortality. It is 14 times higher in children with a history of LBW with respect to full-term newborn born with an adequate weight.

It should be noted that LBW as an indicator of the magnitude of intrauterine growth restriction (IUGR) presents reliability problems in the region due to lack of precision in determining the gestational age in geographic and population sectors with low coverage of care for pregnant women and low education level. It is estimated that LBW is approximately 10%, but it is also estimated that in Latin America and the Caribbean nearly 20% of children are not weighed at birth.[6]

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5 http://www.who.int/mediacentre/news/releases/2014/child_mortality_estimates/es/

6 https://www.unicef.org/spanish/specialsession/about/sgreport-pdf/15_LowBirthweight_D7341Insert_Spanish.pdf

The intrauterine nutritional environment could be of special importance in terms of imprinting metabolic characteristics on the foetus that influence the risk of developing obesity or NCD during adult life. When insufficient nutrition is received during intrauterine life, the genes of the new individual must adapt to living in such depressed conditions. After birth, this programming remains, favouring the development of metabolic syndrome (Barker, 2004). Children of diabetic, hypertensive or obese mothers will have a greater risk of replicating those pathologies throughout their life, not only resulting from genetic factors, but also due to the foetal programming mechanism, mediated by hormonal and/or nutritional factors.

Infants and pre-school children

During the first months of life, a child essentially depends on maternal care and on the prospects of good nutrition and immunity that natural breastfeeding confers. There is a great deal of evidence that shows the benefits of exclusively breast-feeding and its protective effect against developing obesity and other NCDs, especially when sustained exclusively up to six months of age, with continued breastfeeding along with complementary foods until the age of two or beyond (Victora, et al., 2016).

The scientific evidence shows that the highest proportion of delayed growth in children in developing countries happens during the first two or three years of life. Starting at birth, a deterioration begins that reaches maximum values between 18 and 24 months of age, regardless of the average incidence in individual countries. At that time, global undernutrition shows a decrease that stabilizes at approximately half of its trajectory, between 38 and 44 months of age. In turn, during the first two years of life, chronic malnutrition shows a significantly higher increase (with values that double those for global undernutrition), and later stabilizes at a slightly lower level. That is, a high proportion of children between ages two and five years reach an adequate weight, but it does not translate into sufficient growth in height, thus an increase in the amount of food consumed would not be enough to recover the loss in height that occurred in the first 24 months of life.

Together with the high prevalence observed during this phase, its relevance revolves around the fact that subsequent interventions to improve the height deficit are only partially successful given that the result is a consequence of the cumulative effects on the life cycle, especially if the child continues to live in a deprived environment (Bhutta, et al., 2008; Bhutta, et al., 2013).

School life

During this phase (6 to 18 years old) the process of growth follows the trend established during pre-school age, and it is key to the emotional, social and cognitive development.

In terms of feeding patterns, children usually share the same type of diet with adults, not posing a major threat for development in houses of medium or high socio-economic status. In poorer sectors, however, emphasis is required to guarantee the adequate quantity and composition food necessary for learning, since a deficit of macro and micronutrient consumption has direct repercussions on attention and comprehension.

Along with adolescence, secondary sexual characteristics appear and growth accelerates. In girls, this growth spur is seen around 11 years of age, and two years later in boys. For this reason, in this stage the nutritional recommendations are higher for adolescents than for the general population. In addition, given the hormonal changes and sexual development distinctive of this stage, there is a higher probability of iron deficiency anaemia resulting from menstruation and childbirth which requires special care in terms of micronutrient intake.

In relation to overweight and obesity, between 22 and 25 million school-age children, and 17 and 21 million adolescents, are overweight or obese. This translates into roughly 20–25 % of the population in that age range (Rivera, et al., 2013).

Adult life

During adult life, the physiological characteristics that began to prefigure in previous development stages are manifested. In this way, the trajectory of an adult who was undernourished as a child will depend on how and if the childhood intake deficit was corrected throughout the life cycle.

On the other hand, adults shape their children's eating habits, determining the daily diet through observation. Thus, these patterns can become protective or risk promoting factors to curb or promote the vicious circle of malnutrition.

As indicated in previous paragraphs, adult epidemiology is strongly influenced by NCDs, for which nutritional interventions have been quite success. In that sense, a low-sodium low-fat diet, rich in fibre and vegetable products, is health promoting during a stage in life when energy expenditure tends to decrease.

During this stage, the nutritional risks inherent to fertile women are maintained and increase due to their high specific micronutrient requirements such as iron. Pregnant women also represent an important case. Studies conducted in Guatemala show that children born to mothers who received nutritional supplements rich in calories and proteins during their childhood, were significantly taller at age 3 than the children of mothers who only received a calorie-rich supplement (Martorell, 1995; Ruel et al., 1995). It was concluded that the effects of adequate nutrition may also be expressed in the next generation, thus, cutting a vicious circle of poverty-malnutrition-underweight.

The "modern" lifestyle of adults, characterized by low levels of physical activity and the consumption of foods rich in saturated fats, calories and salt, complements the phenomenon of malnutrition during the adulthood stage. Nearly 70 % of adults in Latin America and the Caribbean are overweight or obese. In most countries, women are more overweight than men; for example, in Mexico, 74 % of women and 70 % of men over age 19 suffer from overweight and obesity.

Diagram 1: Malnutrition in the life cycle
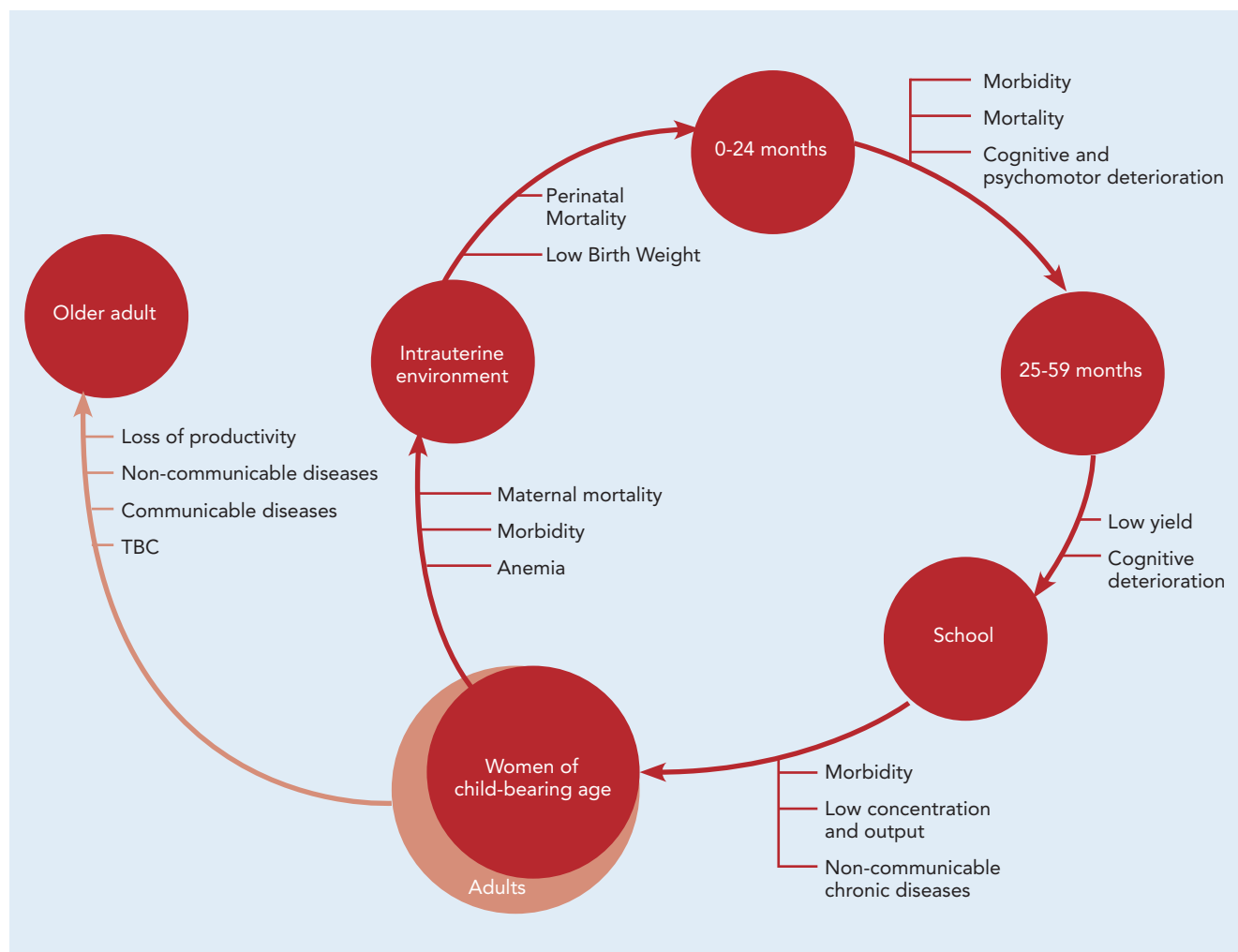
Source: Martínez and Ferrari, 2006, adapted from Branca, F. and Ferrari, M. (2002).

The subset of older adults also merits special attention. Normally, their nutritional deficiencies derive from a predominantly sedentary lifestyle that results in a constant loss of lean mass (musculature) replaced by fatty tissue. Their situation is associated to the NCDs characteristic of their own age, that feed into the different existing pathologies and make their treatment more difficult and expensive. This translates into specific requirements of vitamins and other micronutrients to counteract the natural physical and mental deterioration that comes with old age.

The three elements indicated here (FNS, transitions and life cycle) refer to the context and key conceptual basis that affect the nutritional situation in the region and are, in turn, associated with a group of variables that characterize the causes and consequences of the phenomenon in the population. Each of these variables merits a detailed description to understand their interactions and the different causal chains, for which the available empirical evidence available is mounting[7]. However, considering the objectives of this paper, this document is focused on the analysis of the consequences and associated costs, discussed in detail below.

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7   Greater detail on these causal chains and bibliographic sources can be found in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

Effects and economic consequences of malnutrition

Malnutrition has significant negative consequences on morbidity and mortality, on capacity development and on educational outcomes; in social and labour inclusion, the environment and productivity. These effects, in turn, have economic consequences.

In Diagram 2 the effects of undernutrition with those of overnutrition are combined in a graph.

Diagram 2: Effects of malnutrition
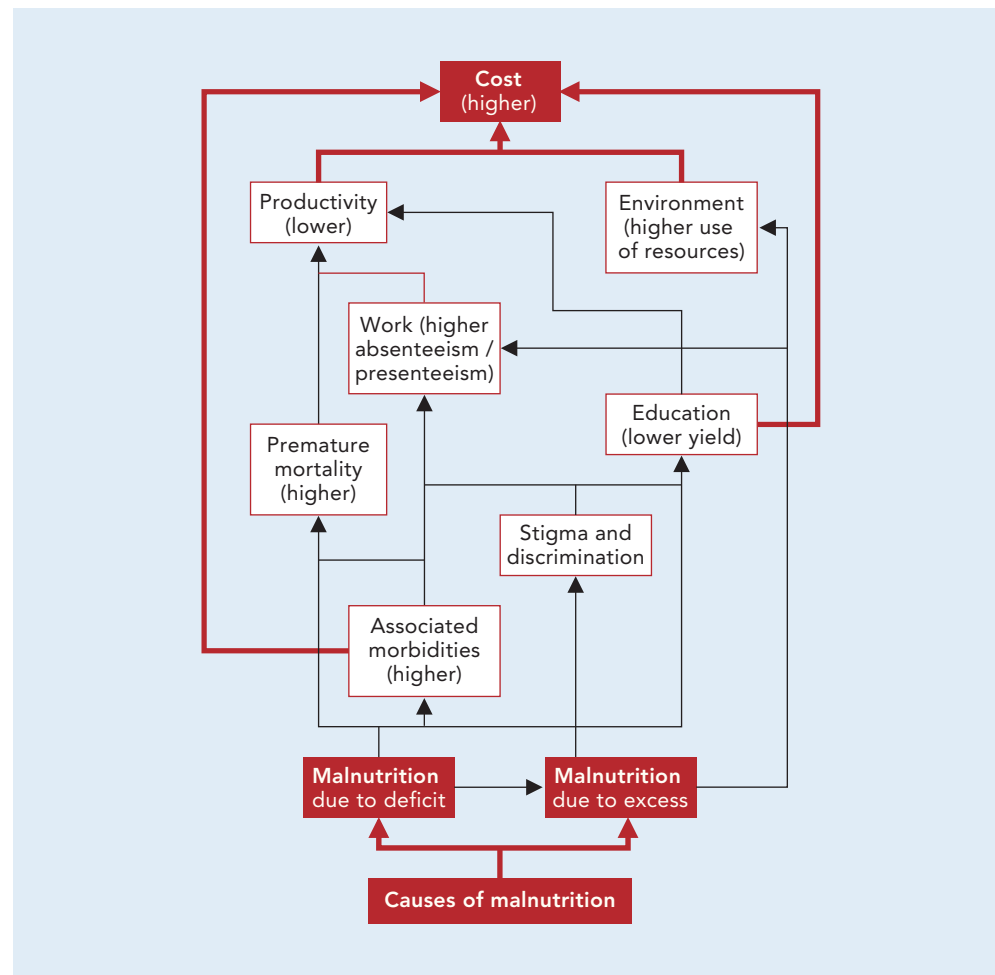
Source: Own development

In the first level, the effects are classified into mortality, morbidity and education. From these, new effects are generated that translate, directly or indirectly, into low productivity and health, education and environmental costs. For example, while premature deaths lead to losses in the workforce, people with chronic diseases associated with overweight/obesity generate increases in health costs.

Undernutrition

Undernutrition has negative effects on different dimensions of people's lives, including health, education and economic impacts (public and private costs and expenditures, and productivity), and leads to social integration problems and an increase or deepening of poverty and indigence in the population, reproducing a vicious circle by increasing vulnerability to undernutrition.

These effects may occur immediately or throughout an individuals' life, increasing the likelihood of subsequent malnutrition among those who have suffered of undernutrition in the early stages of the life cycle as well as the incidence of other consequences. Thus, intrauterine undernutrition can lead to difficulties from birth to adulthood.

Effects on health

The most serious effect of undernutrition in children younger than five is the increased risk of death. Information collected on the cost of hunger collected within the framework of the study indicates that "the greatest impact occurs in the womb and in the first years of life. A direct consequence of foetal malnutrition is low birth weight, which results in a higher probability of perinatal mortality. The risk of neonatal death of children weighing 2,000 to 2,499 grams is four times higher than in children weighing 2,500 to 2,999 grams, and 10 to 14 times greater than in children weighing 3,000 to 3,499 grams". (Martínez and Fernández, 2006)

A meta-analysis of 10 longitudinal studies in children under five indicates that 35% of deaths are attributable (directly or indirectly) to malnutrition (WHO, 2004). In turn, chronic malnutrition increases the lethality of many infectious diseases in the developing world.

WHO data indicates that undernutrition contributes 60% of deaths in pre-school-aged children (3.4 million). UNICEF (1998) estimates that 55% of the 12 million deaths among children under five are due to malnutrition. Pelletier et al. (1995) estimated 56% of pre-school deaths attributable to the effects of malnutrition, out of which 83% are categorized between moderate and severe, and 17% to severe cases.

Micronutrient deficiencies also have significant effects. Longitudinal studies indicate that the risk of death from diarrhoea, malaria, or measles, increase by 20–24% in children with vitamin A deficiency. For the same diseases, zinc deficiency causes between a 13 and 21% risk.

Additionally, nutrition problems increase the incidence of several pathologies in different stages of the life cycle. The longitudinal studies mentioned above indicate that the fraction of disease attributable to low weight is 61% for diarrhoea, 57% for malaria, 53% for pneumonia, and 45% for measles. In turn, iron deficiency has a direct effect on maternal, infant and school-age anaemia, vitamin A deficiency causes blindness, and lack of iodine results in goitre or cretinism.

These associations are not unidirectional. Just as undernutrition is an important factor in the manifestation and lethality of those pathologies, they feedback into the existing undernutrition, generating a vicious cycle.

Undernutrition has direct effects on neurological and psychomotor development during the first years of life, particularly resulting from micronutrient deficiencies, such as iron and zinc, or folic acid deficiency, during the neonatal period when it is most critical.

Iron deficiency anaemia, on the other hand, is one of the most prevalent nutritional deficiencies in the world. Iron deficiency is not exclusive to childhood. It is estimated that 50% of women of child-bearing age and 60% of pregnant women are anaemic. This deficiency may continue throughout the child-bearing years and is reversible with a proper diet.

A woman who is anaemic during pregnancy will pass on little iron to the foetus who, in turn, will be born with low iron deposits. In lieu of external iron contributions and existing infections, the child exhausts these deposits very quickly; if the child also suffers from undernutrition he will most likely become anaemic. The analysis of the contribution of nutrition to NCD and communicable diseases in women of child-bearing age is similar to that of adults in general.

In this group of pathologies, the prevalence of AIDS, malaria and tuberculosis (TB) stands out. In the case of AIDS, the state of terminal malnutrition suffered by some patients is usually secondary to the infectious condition. In TB and malaria, however, it appears that the level of immunodeficiency of populations subject to prolonged malnutrition plays a role in the risk of acquiring the disease.

Osteoporosis, defined as the loss of bone mineral content, occurs primarily in post-menopausal women in a progressive process that worsens over time. The main nutrients involved in bone mineral metabolism are calcium and vitamin D. In the western diet, after 10 years of age, calcium intake decreases to values close to half of those recommended.

The risk of osteoporosis decreases significantly when the diet includes adequate levels of calcium during the longitudinal growth phase of the skeleton, between 9 and 25 years. This then makes osteoporosis a disease that can be prevented long before it occurs, with adequate food when the calcium in the body are consolidated.

Effects on education

Undernutrition affects school performance because of the deficits generated by the diseases and by the limitations in learning capacity associated with lower cognitive development. This translates into a greater probability of late entry, repetition, dropout, and low educational level.

The relationship between undernutrition and lower educational outcomes, like in the case of health, depends on the level of undernutrition and two different processes are observed. The first results from development problems—a process within the scope of health—and a later effect on the educational outcome. This process begins in the first two stages of the life cycle (intrauterine and up to 24 months).

The second is directly derived from a food deficit, which affects the ability to concentrate in the classroom and limits learning. This is concomitant with the pre-school and school-age stage, and although the imprint of the first years of life is very determinant, it does not necessarily require prior nutritional damage; rather, it may only reflect low intake during the same stage.

Micronutrient deficiencies, especially iron, zinc, iodine and vitamin A, are related to cognitive deterioration that leads to compromised learning. As an example, using data from INCAP looking at rural Guatemalans, Berhman and Knowles showed that receiving nutritional supplements between 6 and 24 months of age had a significant positive effect on school performance (Alderman, Berhman and Hodinott, 2003).

Productivity and costs

Studies in Zimbabwe show that the loss of 0.7 grades of schooling (less than one year) and a 7-month delay in school enrolment results in a 12 % loss of wealth over a lifetime. Contrastingly, studies in Ghana showed that for every year of delay in school enrolment, there was 3 % loss of wealth over a lifetime (Alderman, Berhman and Hodinott, 2003).

The cost of hunger studies carried out by ECLAC and WFP in Central America, Andean countries and Paraguay, concluded that undernutrition—measured as low weight for age (global undernutrition)—generated costs in health, education and especially productivity due to lower educational attainment and premature mortality (Martínez and Fernández, 2009 and 2007).

For those years, it was estimated that the cost for the 11 countries studied was approximately US$11.0 billion, around 4.6% of aggregate GDP. The cost exceeded US$6.6 billion in Central America, and US$4.0 billion in Andean countries and Paraguay, which was 6.4% and 3.3% of GDP, respectively.

Adapting these studies to the African context has allowed for estimates to be made in Ethiopia, Swaziland, Uganda, Egypt, Ghana, Rwanda, Burkina Faso, Mali, Chad, Lesotho and Madagascar. The estimated cost varies between 3.1% and 16.5% of GDP, depending on the epidemiologic, nutrition and economic context of each country.[8]

Overweight and obesity

The effects of malnutrition by excess are classified in the dimensions of health (morbidity and mortality), education and economics (labour and productivity). However, unlike undernutrition, the scientific literature shows that there are also added environmental effects associated with an increase in the use of resources (energy and consumption of food).

Effects on health

The direct effects of overnutrition are evident in people's health, increasing the risk of associated, and therefore, increasing the incidence of NCD as well as the probability of death.[9] Although the health effects may be of slow onset, but protracted in duration, they are long-lasting and the leading cause of adult mortality and morbidity worldwide.

In Latin America and the Caribbean, cardiovascular diseases are the main cause of death,[10] although with significant variations between countries. For example, while in Guyana and Honduras the mortality rate per 100,000 inhabitants due to cardiovascular diseases is 372.9 and 337.7, respectively, in Peru it is 127.5. These figures are high in comparison to high income countries. For example, in Canada the mortality rate from cardiovascular diseases is 118.6 (Bonilla, 2014). It is worth noting that its prevalence is related to family income: 30% of premature deaths due to cardiovascular disease occur in the poorest quintile, while only 13% occur in the highest income quintile (WHO, 2010).

Malignant neoplasia is the second leading cause of death. Among them, lung, stomach, colon and breast cancers are the most prevalent. As in other pathologies, there is a greater incidence in middle and low income countries (PAHO, 2012).

Another important pathology is diabetes mellitus. Mortality due to diabetes mellitus behaves differently in countries in the region, with increases observed in some and decreases in others, with 8% of deaths occurring in people under 50 years of age.

In Latin America and the Caribbean, pathologies associated with malnutrition account for a high proportion of the morbidity and mortality burden, reaching up to 49% of years of life lost. Although these affect the population transversally, there are significant differences in terms of gender, socioeconomic level and geographic area (Bonilla, 2014).

The effects of overnutrition can be both, immediate and have repercussions in later stages of a person's life cycle. In this sense, a substantial increase in the prevalence of overweight and obesity in children and adolescents has consequences both in the present of these children, as in their future as adults. Like adults, obese children and adolescents are more prone to obesity-related diseases (Friedemann, et al., 2012). In addition, having suffered from overnutrition during childhood or youth also increases the risk of obesity,

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8   www.costofhungerafrica.com/country-reports.

9   Mortality due to diseases associated with malnutrition is equal to the concept of premature death present in other studies (for example: Gutiérrez Delgado & Guajardo Barrón, 2008).

10   Percentage of causes of mortality due to diseases, adjusted by age.

as well as for suffering from obesity-related morbidity in adults, even when the excess weight has been lost (Lehnert, et al., 2013).

Overnutrition also has an inter-generational effect, defined as those factors, conditions and exposures of one generation that is associated to the health, growth and development of the next. Thus, parental overweight and obesity would be associated to obesity in their children.

Similarly, foetal growth would be associated with the nutritional status of the mother, even before pregnancy. Additionally, maternal overnutrition during pregnancy would be associated with inadequate foetal development. In line with the hypothesis of foetal programming, several studies have investigated the relationship between maternal obesity and the origin of cardio-metabolic risks in the child. One potential pathway would be through gestational diabetes, where increased levels of nutrients result in an overload of circulating sugars, lipids and growth hormones, which could cause diabetes and other NCDs later in life (Fall, 2013).

Finally, the effects of obesity mental health have also been documented. Obesity is specifically associated to low self-esteem and a negative body image, which in turn would be influenced by discrimination in different social contexts, such as school and work (Frone, 2007).

Effects on education

The evidence regarding the effects of overnutrition on education is less conclusive compared to the evidence on undernutrition. However, there is research that has systematized the different types of association between overweight and obesity, with different educational dimensions.

It has been suggested that obesity could be correlated with lower school attendance and decreased accumulation of human capital during childhood and adolescence. After controlling for intervening variables, Geier, et al. (2007) found that children with normal weight missed fewer days of school compared to obese children. It has also been observed that overweight adolescent women have lower educational levels and wages compared to those who are not overweight (Parsons, et al. 1999; Gortmaker, et al., 1993).

Another study reports a significant association with academic outcomes, identifying up to a 10% variation in academic performance that would be explained by comparing the obese and non-obese populations (Caird, et al., 2011).

Kaestner, et al. (2009), using the 1997 National Longitudinal Youth Survey cohort in the United States, found that 15-year-old adolescents in the 90th percentile or higher Body Mass Index (BMI) would be 3.3 percentage points more likely to drop out of school the following year, compared to adolescents who were in the second and third BMI quartiles. On the other hand, in the same study, 16-year-old female adolescents in the 90th or higher percentile were 12 percentage points less likely to complete the next grade.

Despite the above, it is important to note that the evidence is not conclusive. In fact, a meta-analysis of studies conducted in this area shows that the clear majority of them do not find significant relationships when controlling for intervening variables such as socioeconomic status. Moreover, there is also evidence to support that there is an inverse causal relationship, from education to obesity (Caird, et al., 2011).

Effects on labour

Presenteeism, or reduced productivity, is defined as the inability to work at maximum capacity due to workers showing up to work sick. Although there is no concrete evidence linking excess weight and reduced work productivity, recent studies report a positive association between obesity and presenteeism (Lehnert, et al., 2013). Janssens, et al. (2012), through a 2004 representative sample of workers from private companies and the public sector in Belgium, found a positive relationship between BMI and presenteeism in men. Another study, conducted in Kentucky, United States, found that workers with

moderate or severe obesity (BMI ≥35) experienced greater health limitations, requiring more time to complete their tasks.

On the other hand, studies on work absenteeism, primarily using the attributable fraction approach, have established that overweight workers, especially the obese, are absent from work more days per year due to illness, regardless occupation type. The studies also show that there is a greater risk of absenteeism due to illness as a person's obesity increases (Lehnert, et al., 2013). A study in Sweden found that obese women had a 1.5 to 1.9 times greater risk of absenteeism due to illness for a one year period than the rest of Swedish women. A relationship has also been observed between school absenteeism of obese school children and adolescents, and absenteeism of their parents, due to the care requirements of their offspring (Hammond & Levine, 2010; Kaestner, et al., 2009).

In addition, it should be noted that certain ECAMs lead to disabilities, which, in turn, result in absenteeism and, sometimes, long-term absenteeism. In Lehnert, et al. (2013), a systematic review is carried out, suggesting that most research indicates that excess weight is related to both short- and long-term absenteeism, as well as to the delivery of disability payments and pensions.

Environmental effects

Weight gain in people has environmental consequences due to greater use of infrastructure resources, fuel and food, as well as the higher amount of emissions produced by industries.

That is, heavier people would consume more fuel and use larger vehicles, which would lead to higher greenhouse gas emissions. Additionally, obesity would also have an impact on this type of through the increase in food production necessary to meet the increased demand of this segment of the population. It would also increase organic matter disposal generated by the overweight population (Dannenberg, et al., 2014; Michaelowa & Dransfeld, 2008).

Costs

Economic impact is linked to the consequences of NCD associated with nutrition, including the intermediate conditions that cause them, the deterioration of the mental health of the population with overnutrition, the loss of accumulated human capital, and the greater pressure on the environment and the private and public costs that these generate. The scientific literature generally distinguishes between direct and indirect costs to classify these impacts. Therefore, while medical and non-medical costs derived from morbidity are defined as direct costs, the costs in diminished productivity are indirect. The classification of transportation costs, loss of human capital, lower wages, and environmental costs varies between direct and indirect depending on the research. In this document, however, the classification used by ECLAC for the analysis of the social and economic impact of child malnutrition is maintained (Martínez & Fernández, 2006).

Research suggests that obese patients have between 25 and 52 % more medical costs than people of normal weight. In terms of total national health expenditure, the medical costs attributed to obesity are between 2 and 7 % in developed countries (Kang, et al., 2011). This is a cause for concern, considering that the evidence shows a sustained and exponential increase in the costs incurred by health systems because of overnutrition, especially obesity.

By 1995, the direct cost of obesity in the United States was estimated to be approximately US$70.0 billion, which would exceed the direct cost of coronary artery disease, hypertension and diabetes mellitus (Kang, et al., 2011). The costs assumed by people and families must be added to the latter, product of the time and quality of life lost due to these pathologies.

Results of an estimate of the financial impact of obesity and overweight on the health of the Mexican population in 2014 conducted by Nicte-Ha and Gutiérrez (2015) indicate that it reaches 72.5 billion pesos (0.4 % of GDP) in indirect costs (mortality, absenteeism,

disability) and to 151.9 billion pesos (0.9 % of GDP) in direct costs, that is, medical care for new cases of diseases attributable to the risk factor.

Studies on environmental costs have focused on higher fuel expenses, higher CO_2 emissions from food production, and increased methane emissions from an increase in organic waste attributable to the rise in the overweight and obese population (Michaelowa & Dansfeld, 2008).

Dannenberg, et al. (2004) estimated that the average weight increase in the United States population was 4.5 kg during the 1990s, which, together with changes in US air traffic regulation, resulted in a 2.4 % increase in fuel usage, as well as higher annual CO_2 emissions of 3.8 million tonnes since 2000. In addition, estimates from the same study for Germany, Europe (25 countries) and OECD countries, indicate that a 5 kg increase in the average weight of citizens increases the total cost of transport (all types) by EUR 0.3, 1.9 and 5.49 billion, respectively.

The estimate of the additional cost for increased food production associated to obesity is based on changes in global food consumption patterns, been described in the nutrition transition section of this document. CO_2 emissions to produce different types of meat (beef, chicken, pork), cheese and flour, are compared and the associated economic cost is calculated. It is estimated that the price for one tonne of CO_2 would be equivalent to EUR 15, and beef production would have the greatest environmental impact. However, greater specificity is still required for the incremental cost ratio associated with obesity, both to calculate increased food consumption and the waste produced.

Two key components have been identified regarding the loss of productivity: premature deaths, on one hand, and presentism, absenteeism and disability of the active population, on the other. These effects would be added to the eventual educational achievements, but, as already noted, the evidence is not conclusive.

There is some evidence of a relationship between wages and BMI, although the direction is not as clear. It is argued that obesity could reduce wages due to lower productivity, but also due to work discrimination. On the other hand, lower wages could be a cause of obesity as the poorest people tend to consume cheaper food with high energy content (Cawley, 2004).

On the other hand, several studies analyse the impact in terms of the opportunity costs associated with the medical care required by people with diseases associated to food. To that end, costs are measured as productivity losses due to the time required for outpatient or hospital treatment, transportation of patients, and care staff (Kang, et al., 2011).

Methodology[11]

Dimensions, horizons and universes of analysis

As already noted, the malnutrition situation in a country, as well as its effects and consequences, are the result of a dual process of epidemiological and nutrition transition. It is possible to differentiate between two temporal dimensions, which in turn lead to two types of analysis: the first, intended to estimate the current impacts generated by past and present malnutrition and, second, to project the impacts that are expected to occur in the future given current malnutrition, based on existing knowledge.

Additionally, it must be kept in mind that both the universes and the horizons of analysis vary per the type of effect to be estimated, as well as its duration and different economic consequences.

Given the inter-temporality of the malnutrition process and its effects, we distinguish two dimensions of analysis: *retrospective incidental* and the *prospective.* The first allows us to estimate the effects and costs generated by the malnutrition that has affected the population of a country in a given year. Thus, in the case of undernutrition, the effects and costs are estimated in: health for pre-school children who are malnourished in the year of analysis, education derived from undernutrition experienced during the first five years of life in children now of school age, and the losses in productivity among people of working age who were exposed to undernutrition before the age of five.

For overweight and obesity, the consequences that arose in the year of analysis are estimated based on the prevalence observed among adults in that year, which include a history of malnutrition. This way, the incidence or prevalence of associated morbidities and their costs for health services are estimated, as is the lost productivity—due to premature mortality and absenteeism in the workplace—that occurred in year (x)[12] for the population older than 19 years of age.

The prospective dimension allows projecting, for a given time horizon, the future effects and costs associated with health treatments, years of school repetition and productivity losses, resulting from the malnutrition affecting the population of each country in year (x).

Based on this, potential savings can be estimated by implementing actions necessary to achieve nutritional objectives, such as those formulated in the Sustainable Development Objectives.

This temporal horizon, in its maximum expression, is defined in this model by four components: (a) the cohort studied, (b) the type of effect, (c) the moment it occurs, and (d) the duration. Therefore, given that for undernutrition the cohort of 0 to 4 years of age is analysed in year (x), and that the costs for lost productivity, arising both from premature morality as well as lower educational attainment extend throughout the entire potential working period (from 15 to 64 years of age),[13] the horizon is defined as $x + 64$. Note that *loss of productivity* is the effect of longer duration, compared to effects on morbidity $(x + 4)$ and effects on education $(x + 18$, considering 12 years of schooling from age 6).[14]

The same horizon is used for overweight and obesity, that is, $x + 64$. However, note that in this case the effects on health produce costs that accumulate throughout the period of analysis due to the chronicity of morbidity associated with overnutrition.

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11 A detailed formalisation of estimation procedures is presented in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

12 Henceforward year (x) will mean the year of analysis.

13 It is assumed that retirement age for men and women in all countries is 65 years of age.

14 This horizon is $x + 11$ for those countries that have 11 years of primary and secondary school education.

To analyse the effects and costs in defined periods, it is possible to make "truncated" projections using shorter periods. In the results presented below, we use an intermediate horizon established for the year 2030, coinciding with the SDG mentioned above. Additionally, for overweight and obesity, a horizon called the *point of inflection* is introduced to highlight the future year in which the morbidity-mortality burden and costs start to decrease in response to the decrease in the size of the population analysed.

A difficulty presented by *prospective analysis* relates to the decision of how to project the existing epidemiology in year (x), both in terms of malnutrition rates and associated pathologies (Rtveladze, 2013; Butland, et al., 2007), given the behaviour of historical trends, which is not necessarily linear, as well as the availability of data to adjust parameters in eventual regression models. It should be noted that this model does not consider those born after year (x), and the epidemiology of that year remains constant. Therefore, in the future estimate of general morbidity and mortality burden, only the demographic projection available for each country is used as a variable.[15]

As already indicated, malnutrition, its effects and its consequences, are present in all stages of the life cycle. In some, the phenomenon is more visible due to the presence and effects of undernutrition, while in others it is due to overweight or obesity. For this reason, the estimates are carried out by segmenting the population into age groups.

For child undernutrition, considering the characteristics of the phenomenon in the first years of life and its effects throughout the life cycle, estimates are made for the following age groups: the effects on health are analysed (morbidity and mortality) for newborns, infants and pre-school children (0 to 59 months old); the effects on education are analysed for 6 to 18 year olds; and losses in productivity are analysed for individuals 15 to 64 years of age.

In the case of overweight and obesity, both in terms of the magnitude of the effects and the availability of data, the population is limited to include only those older than 19 years of age; for the effects on morbidity and mortality, all age groups 20 years and older are included; for the effects on productivity, in contrast, only the population between 20 and 64 years of age is considered.

It should also be noted that the universes of analysis are different depending on the dimension of the analysis and the type of malnutrition. For the *incidental-retrospective* analysis of undernutrition, the entire population between 0 and 59 months that has suffered from undernutrition is considered, as is that the year of analysis (x = 0)[16] is between 0 and 64 years of age. That is, the available historical series for undernutrition rates is considered. For the analysis of future effects and costs the *prospective* analysis only considers the population of 0–59 months of age in the year of study and its demographic projection until those who are 0 years old on the year of analysis turn 65 years old.

For the *incidental* analysis of overnutrition, only the population older than 19 years of age who are overweight or obese during the year of study is considered. To analyse the effects and future costs, the *prospective* analysis considers the entire population (0 and older) in the year of study and its demographic projection; however, the effects and future costs are only estimated for when the younger age groups reach 20 years of age.

The prospective analysis, both for undernutrition and overnutrition, starts in year x + 1, which in this case is the year 2015. The total horizon of the prospective analysis, as already noted, is x + 64 years; however, intermediate periods may be established based on specific analytical requirements (see diagram 3).

The synthesis represented by this diagram illustrates the relationship between the dimensions of analysis and the age of the population for which the costs are measured. For example, for the year of analysis (incidental dimension), the health costs associated

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15 Both the sizes of the population by age groups, as well as their demographic projections for each country match those published by the United Nations Department of Economic and Social Affairs.

16 The year of analysis in this study is 2014.

with undernutrition are measured in the 0 to 4 age group (vertical axis), while those associated to overweight and obesity are measured in the population aged 20 and over. Consider, in this second case, that there is an intersection with lost productivity, which is only measured up to 64 years of age.

Diagram 3: Age and year in which the costs of malnutrition occur, per analysis size
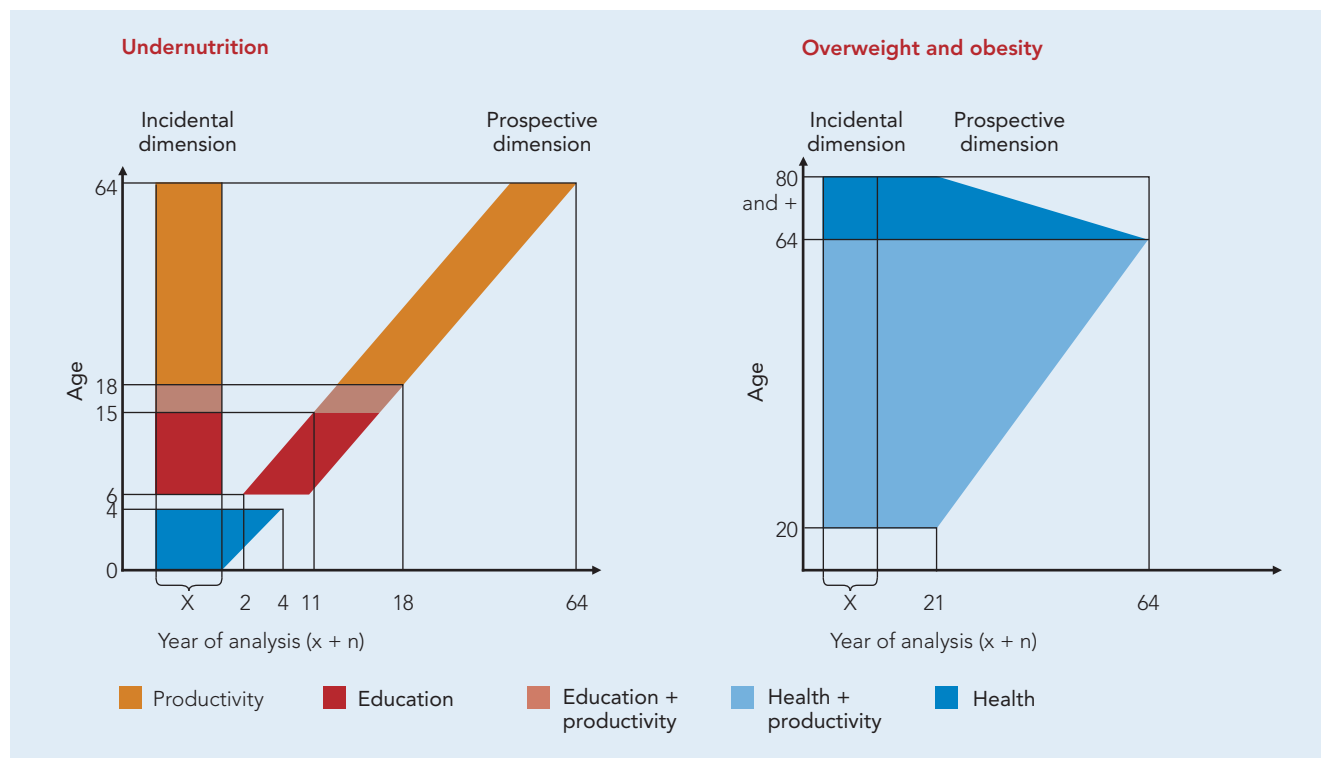
Source: Own development

An additional example is that for future costs (prospective dimension) the education costs associated with undernutrition begin in year $x + 2$, that is, when the first group of children in the 4-year-old segment are old enough to initiate primary education. Further, the diagram shows that the age of the population considered when estimating the health costs associated with overweight and obesity begin to decrease starting in year $x + 21$.[17] This is because the model does not consider those born after the year of analysis. The latter has an impact on the estimated loss of productivity, meaning that from $x + 21$ there is no longer a population of 20 years of age.

Inductive method

Two methods can be used to estimate the effects: the *deductive,* which from known effects estimates the proportion of cases that could be due to malnutrition, and the *inductive* which, conversely, estimates the probability of occurrence of the effects based on malnutrition prevalences.

The deductive approximation predominates in this type of study, particularly using population attributable fractions (PAF, or another deductive type of indicator). However,

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17 The demographic estimates used group those older than 79 years of age (80 and +) into one single age group.

it should be used with caution given that if the particularities of the epidemiological profiles of the populations studied and their variations over time are not considered, the estimates obtained can be biased (Llorca, et al., 2000).

In this model the magnitude of the effects is estimated using an *inductive* approximation. That is, the basis of analysis is comprised of the malnourished population for whom a "burden of effects" is estimated based on the use of relative risks.

As illustrated in Martínez & Fernández (2006), the estimation of the effects, which is the primary input for estimating costs later, is based on the difference of the probability (ΔP) of occurrence between those who are and those who are not exposed to a certain risk, malnutrition in this case, which in turn is obtained from relative risks (RR) estimated by meta-analysis of international studies. Then, the ΔP of contracting a disease, of dying, of dropping out of school, etc., is multiplied by the size of the population that presents malnutrition, distinguishing by sex and age when applicable.

Given the methodological differences, the results obtained through inductive approximation, as in this case, are not directly comparable with results of studies in which the deductive approach has been used.

Malnutrition variables and indicators

Malnutrition has been analysed considering different variables. The most frequently used approach refers to anthropometric relationships that combine weight, height and age indicator, and which is used in the model described herein. This does not mean that the study of undernutrition is exhausted by using anthropometrics; the literature highlights the role of micronutrient deficit, however evidence available on the subject matter does not allow for the weight of each indicator and its interactions to be isolated with confidence, thus, it is impossible to avoid any double counting that this might generate. For this reason, the analysis was circumscribed to relationships resulting from anthropometric relationships and their effects.

- Low birth weight (LBW): indicator used to measure intrauterine undernutrition corresponding to live newborns weighing less than 2,500 g. LBW has two sources of variation: intrauterine growth restriction (IUGR) and prematurity.

Since the latter it not clearly associated with undernutrition, it is advisable to specifically estimate the LBW_{IUGR}, that is, the proportion of live newborns whose weight is below the tenth percentile for gestational age. This proportion was estimated using the model by De Onis and collabourators (1998), based on the incidence of LBW:

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

- Anthropometric relationships for undernutrition: these correspond to the ratios between weight, height and age of children under five years of age, using the distribution of the World Health Organization standard as point of reference. Three indicators are used:

  1. global or weighted undernutrition: corresponds to cases in which the weight/age ratio is lower than average, per the reference standard.

  2. chronic malnutrition (stunting): cases in which the height/age ratio is lower than average.

  3. acute undernutrition (wasting): includes cases in which the weight/height ratio that is lower than average

All three indicators are used in this study, considering that all children with a measurement below -2σ are considered undernourished compared to the average of the reference standard (moderate or severe). Global undernutrition is used to estimate the

burden of morbidity; chronic malnutrition is used for mortality, effects on education, and on loss of productivity; acute undernutrition is used to estimate the recovery costs of undernourished children.

- Anthropometric relationships for overnutrition: the categories of overweight and obesity are obtained using body mass index (BMI), which reflects the relationship between weight (in kilograms) and height squared (in metres) as follows: ($BMI = p/t^2$). The different categories that are obtained with BMI are presented in the following table.

Table 2: WHO International classification of adult underweight, overweight and obesity according to body mass index (BMI)

Classification	BMI (kg/m²)
Low weight	<18.50
Severe thinness	<16.00
Moderate thinness	16.00—16.99
Mild thinness	17.00—18.49
Normal	18.5—24.99
Overweight	≥25.00
Pre-obese	25.00—29.99
Obese	≥30.00
Obese class I	30.00—34.99
Obese class II	35.00—39.99
Obese class III	≥40.00

Source: WHO, http://www.who.int/features/factfiles/obesity/facts/es/

For the purposes of this study, all those with a BMI between 25.00 and 29.99 are considered overweight, and those with a BMI ≥ 30.00 are considered obese.

Estimate of the effects and costs of undernutrition in the year of analysis

Key operating definitions for estimating the effects and costs of malnutrition in the year of analysis (x), called *incidental-retrospective* analysis, are described below. As explained above, the estimation of effects results from the probability of exposure to undernutrition (present or past), between 0 and 59 months of age, of the entire population that is 0 to 64 years of age in the year of analysis (x), as well as the costs derived therefrom.

Effects on health

To estimate the incremental effects of undernutrition on morbidity and mortality, official records of prevalence and incidence in each country were used, applying the differential risks for each pathology and to general mortality.

The burden of disease in year (x) corresponds to the total number of acute diarrhoeal events (ADE) and acute respiratory infections (ARI), for which the prevalence of global undernutrition (weight/age) is used for that year, the relative risk[18] (RR) corresponding to each pathology and a national probability of multiple occurrences estimated during the calendar year.

Specific cases of acute undernutrition and low birth weight with intrauterine growth restriction (LBW-IUGR) are added to the latter. In both cases, 100 % of affected individuals require health care; therefore, they are part of the cost and burden of disease in the year of analysis.

The estimated burden of mortality is obtained by using the prevalence of chronic malnutrition (weight/height) and applying the respective mortality RR to it.

Unlike the burden of disease, which is estimated only for the year of analysis, the mortality burden in year (x) corresponds to the accumulation of deaths occurring because of a "history" of undernutrition, that is, from x-64. This difference responds to the fact that, for the incidental-retrospective analysis, the loss of productivity in the year of analysis is a result of the deaths associated with undernutrition that occurred in the past.

Effects on education

To estimate the effects of undernutrition on educational outcomes, the official indicators and administrative records available in each country were used to evaluate the differential risks of passing, failing and dropping out during primary and secondary school for children who suffered from undernutrition before age 5.

The effects of undernutrition on school performance may be expressed in different indicators. Base on the objectives of this study, this analysis considers the following indicators.

Grade repetition rate

A student who fails a grade is one who does not meet the academic requirements necessary to be promoted to the next one. Thus, the failure rate is calculated as the quotient of the number of children who failed a given grade or level relative to the total enrolment in that grade or level in the same school year.

To estimate the composition of the population repeating a grade per the nutritional status in year (x), the incidence of failure and repetition are considered for the population by school grade, the population size with and without chronic malnutrition (height/age) by school grade and the differential relative risk of grade repetition.

Since the rate of repetition in the total population of a given grade is a weighted average of the rate of repetition by undernutrition status, with an estimate of the ratio of probability of repeating (RPr), it is feasible to estimate the incidences for the undernourished population and the population that is not, and their difference.

Lost academic years

Corresponds to the *additional number of academic years* that the system must operate annually due to the repetition attributable to chronic malnutrition (height/age) that occurs before age five.[19]

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18 The relative risks used in this study are included in the annex to the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

19 The estimate of effects on the education sector considers the highest value of prevalence (mode) of chronic malnutrition seen among the different ages of the cohort of 0 to 59 months.

Level of schooling

This indicator reflects the last grade passed in school. Therefore, students who drop out in a certain grade reach a level of schooling equivalent to the previous grade.

The indicator of the effect of undernutrition on schooling corresponds to the differential percentage distribution of years of schooling attained. Thus, there is a distribution for the universe of those who are undernourished, and another for those who are not. The differences in each grade (0, 1, 2… 11, 12 years of study) and in the general average reflect the effect.

To estimate the schooling differential, an indicator of differences in proportions or in probabilities specific to each grade and for each year is required. For the effects of undernutrition, these differences tend to be negative at low levels, and positive at higher levels.

All educational levels may be used for this variable. However, in the case of this study only primary and secondary levels are considered. The situation of tertiary education is not estimated as there is no reliable data on the impact that young child undernutrition has on them.

School dropout rate

It is equivalent to the proportion of students who abandon the educational system during the school year or between different years, whether this occurs during the basic cycle (primary) or middle cycle (secondary) (CEPAL 2003).[20]

To estimate desertion rates among the undernourished, the same procedure used as in the case of grade repetition, using a probability of attrition rate estimator applied to students who suffered from chronic malnutrition before age of five.

Desertion is estimated for each of the years of the educational cycle, starting from the average years of schooling reported in household surveys, identifying all those who have not completed secondary school as deserters. The distribution of the total number of deserters by type of malnutrition is estimated by means of an optimization function that generates differential risks of average desertion in each grade, thus adjusting it to the total desertion estimated for the entire cycle.

Costs

Undernutrition and its effects on health and education translate into economic costs for society *(Total costs derived from undernutrition = TC^U)*. That is: higher costs for health treatments (HC^U), costs for inefficiencies in educational processes (EC^U) and costs for lower productivity (PC^U). Therefore,

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

Health care costs

The economic consequences of the effects of undernutrition translate into higher costs (real or potential) derived from diagnoses, treatments, medicines, tests, use of infrastructure, management of human resources, people's time, etc.

In acute pathologies, which can affect the entire population and are short-lived, such as respiratory infections (ARI), or an acute diarrhoeal episode (ADE), the effects are related to a greater or lesser number of events of illness.

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20 Panorama Social, 2001/2002, Santiago.

The higher probability resulting from the epidemiological profile of undernourished people increases proportionally the public costs in the health sector (HSCU), which at an aggregate level is equal to the sum of interactions between the probability of undernutrition in each human group, the probability that the group in question suffers each disease due to said undernutrition, and the costs of care of said pathology (diagnosis, treatment and control) in each population group.

In addition, the private health costs incurred by families because of the health care requirements of these diseases are added (HPCU). Therefore,

$$HC^U = f\ (HSC^U,\ HPC^U)$$

It should be noted that the cost identified herein does not consider the effectiveness of the treatments. The capacity of remission from care varies according to the intensity of the problem, the technology and the resources involved, which could mean that lower cost of care also include higher costs as a result of lower effectiveness. For a more accurate evaluation, the cost-effectiveness of the different alternatives would have to be analysed.

The unitary cost of health care is reported by the relevant public authorities.[21] This includes outpatient and inpatient care, depending of the potential frequency of events and the probability of the different stages of each pathology. These include fixed costs (infrastructure and equipment) and variable costs (human resources and supplies), in the diagnostic, treatment and control phases of the levels of primary and hospital care required by each pathology. The latter includes the costs of intensive treatment, applied to the proportion of cases that require them, per the corresponding care protocol.

Estimated private costs include the out-of-pocket expenses (or co-payments) of health care, the value of the time used for these services—in terms of minimum hourly wages—and the estimated transportation costs as the average value equivalent to two trips in urban public transportation in each country.

The cost estimate for the health care system and for the education system (below), considers the entire population, not including a correction for effective coverage of public and private systems. Doing so would only reflect the expenditure rather than cost, which in addition to biasing the analysis would make it impossible to compare the results. This type of adjustment would imply that in a country without service coverage, the cost of malnutrition would be zero, and inversely in a country with high coverage the cost would be very high.

Educational costs

The effects of undernutrition on school performance lead to loss of resources due to decreased ability to pay attention, repetition, delay and dropout.

The decreased ability to pay attention and to learn increases public sector costs (ESC^U). Repeating one or more years increases the demand to be covered by the education system by an equal amount, with the consequential extra costs on infrastructure, equipment, human resources and educational inputs.

On the other hand, delayed schooling (late entry or grade repetition) increases these costs to the extent that, by increasing the age heterogeneous age in each grade level, greater difficulties are imposed on the process, either by making it necessary to design a special curriculum or by having to reconcile the interests and capacities of the different ages.

The costs to be assumed by the education system are compounded by the private costs (of the student and his family) derived from the greater quantity of supplies, external educational reinforcements, and additional time dedicated to resolving or mitigating lower performance (EPC^U). Therefore,

$$EC^U = f\ (ESC^U,\ EPC^U)$$

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21 The data sources from each country used in this study are included in the annex to the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

Public costs are reported by the competent authorities. These include remuneration, materials and supplies, payments for basic services, infrastructure, and various existing support programs such as meals, school supplies and textbooks, technology introduction, etc.

Loss of productivity

The consequences of undernutrition at the productive level are directly associated with low levels of schooling and learning difficulties already described.

The impact of undernutrition on productivity is equivalent to the loss of human capital it generates for a society. On one hand, undernutrition leads to lower productivity due to the lower educational attainment of people who are undernourished (LEC^U). On the other hand, there is a loss of productive capacity in the population due to the mortality associated with undernutrition (MMC^U).[22] So,

$$PC^U = f\,(LEC^U,\ MMC^U)$$

A central assumption of the model is that wage is a good estimator of labour productivity and that the education level plays a significant role in it. There is thus a transitive effect between undernutrition, education and productivity.

The effect of lower schooling on productivity is estimated from the income differentials that affects people who would have suffered from undernutrition before the age of five. To do so, the differences in the distribution of schooling levels due to undernutrition are considered (estimated for effects on education)[23] and their relation to expected average income.

The loss of productivity due to mortality corresponds to annual potential income that individuals would have received had they not died of undernutrition before reaching age five. These correspond to the average income of each cohort per the level of education of people who did not suffer from undernutrition, estimated in the previous procedure.

The information on income and employment rate by level of educational and experience comes from the household surveys of each of the countries.

Estimate of effects and costs of overweight and obesity in the year of analysis

Effects on health

The estimated burden of morbidity considers 13 pathologies, including diabetes mellitus type 2 (DM2) and hypertension (HTA).[24] The estimate is calculated for the population 20 years of age or older, differentiating by sex and level of excess, since RR are different for men and for women, as well as for overweight and obesity. In turn, the estimation of the RR for obesity is derived from those for overweight using the most conservative alternative available.[25]

On the other hand, the events of mortality that occurred among people 20 years of age or older are estimated by applying the relative risk for all causes of death due to obesity,[26] differentiating by sex and age.

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22 A working period of 50 years is considered, between 15 and 64 years of age.

23 If there is information that allows the differences in that distribution to be estimated for each of the population groups, it should be considered. Here only the estimate for the population that is currently being studied is used (as a proxy for the others), due to the lack of reliable data for the different cohorts.

24 In addition to DM2 and AHT, included are ischemic heart diseases, cerebrovascular diseases, heart failure, cancer (oesophageal, breast, endometrial, pancreatic, colon and rectal, kidney) and osteoarthritis.

25 $RR^o_{\,i} = 1 + ((\,RR^s_{\,i} - 1)\,{*}\,2)$

26 The RR of mortality for overweight is 1.00, therefore it is not included in the estimate.

Effects on employee absenteeism

The estimate of the number of unpaid annual workdays is applied to the population 20 to 64 year, adjusted by the work participation rate, differentiating by sex and age. The method used considers the burden of morbidity (by pathology and age group), the annual number outpatient care,[27] the probability and annual average of days of hospitalization, and the probability and average annual outpatient rest days, all based on official protocols of medical care and/or records available in each country.

It should be noted that this estimate is made separately for each sex only to the extent that the records available for days of hospitalization and outpatient care allows.

It must also be noted that, due to lack of available data, it has not possible to estimate the burden of presentism.

Costs

As indicated above, overnutrition has effects on health (morbidity—mortality), education, work and the environment, and these translate into costs for society. However, based on the evidence and the available data to make the estimates, the total costs of overnutrition (TCO) in this study only include higher costs for health care treatment (HCO) and costs of lower productivity (PCO) derived from both the effect on mortality and absenteeism. That is,

$$TC^O = f(HC^O, PC^O)$$

Health care costs

Health care costs resulting from the effects of overnutrition translate into higher costs for the health care system (HSC^O) derived, for each of the associated diseases, from a greater need for clinical diagnoses, complementary tests, periodic controls and exams, treatments and medications, use of infrastructure and human resources. To this must be added the costs assumed by individuals and their families in terms of alternative cost of time, transportation costs and out-of-pocket expenses due to health care requirements (HPC^O). Therefore,

$$HC^O = f(HSC^O, HPC^O)$$

To estimate the costs derived from the burden of morbidity it is necessary, in turn, to estimate the costs for health care expenses incurred by the public system, as well as those incurred by the families and/or patients as direct out-of-pocket expenses or for cost of care. That is,

The cost estimate for the health care system in the year of analysis (x) comprises the number of cases (burden disease) of each pathology associated with overweight and obesity and the average unit cost of care in the health system per event of pathology, differentiating by sex and age group.

The average unit cost is calculated and reported by the appropriate administrative entity in each country, based on the care protocols and available records. This includes all costs incurred by the public system, for outpatient as well as hospital treatment, according to each pathology evolutionary stage. The possibility of differentiating by sex and age will depend on the disaggregation of the available records

The private cost of health is obtained from the sum of out-of-pocket expenses incurred for health care (outpatient and hospital) and the cost of care derived from the accompanying requirements and patient care provided by relatives.

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27 For the purpose of using the principle of conservative estimation, the number of days of absenteeism was adjusted as a function of the probability of hospitalisation due to disease, estimated as the quotient between hospital expenses and population with prevalence for the pathology. In addition, under the conservative principle, each event of outpatient care is used only as a daily average of employee absenteeism.

The out-of-pocket expenditure is estimated based on the burden of disease, the average health care expenditure for each outpatient visit, and the average annual cost for hospital care assumed by the patient or his family. Co-payments, medications and transportation are included. The average expense incurred by families, whether for outpatient or hospital care, is estimated from official data from each country.

The cost of care, on the other hand, always based on the burden of disease, is estimated based on the average time spent accompanying a patient in outpatient care, to the average time dedicated spent accompanying a patient in hospital care, and the average time dedicated to accompanying a patient put resting once discharged from the hospital.

As for undernutrition, the value of time corresponds to the minimum hourly wage.

Loss of productivity

The estimated cost of loss of productivity includes two components: costs due to premature death and costs for employee absenteeism. The cost of premature death corresponds to the sum of average annual income not received, broken out by sex and age, from the burden of annual mortality previously estimated.

The estimated cost due to absenteeism is obtained by multiplying the average annual number of days of estimated disability (annual burden of absenteeism) for each age range by the average expected daily income for that same group, differentiating by sex.

Estimation of future effects and costs

For the estimation of future effects and costs, *prospective dimension,* the same indicators explained in the two previous sections are used, but adapted to the corresponding periods of study (from $x = 1$ to $x = n$). For them, the following general criteria are considered:

- the epidemiology of the country remains constant; that is, there are no projections of variations in the prevalence or incidence rates that the countries reported for the year of analysis.

- population and general mortality demographic projections provided by the Department of Economic and Social Analysis of the United Nations are applied.

- estimates do not incorporate new population; that is, they do not include births after the year of analysis.

- the horizon of analysis considers, mainly, two periods: the first, from the year following the year of analysis $(x + 1)$ to 2030, coinciding with the date of the Sustainable Development Goals (SDG). The second is from $x + 1$ until $x + 64$, to include the entire potential loss of productivity associated with child undernutrition in the year of analysis (x).

- the flow of future costs is expressed in terms of net present value (NPV) and in terms of annual equivalent cost (AEC) or annuity. For both, two discount rates are used: 3 %, usually used in health sector evaluations, and 6 % corresponding to the lowest rate currently applied in the region for social project evaluation. In this summary, only the estimates obtained using the 3 % rate are presented.

2

Results of the pilot study

To test the feasibility of application and to analyse the reliability of results of the methodological proposal described in the first chapter, in 2016 the procedures described above were applied in three countries of the region: Chile, Ecuador and Mexico. This chapter describes the results of this experience.

After a brief description of the situation of malnutrition in the three countries, the estimates obtained for the year of analysis and for future years are presented in three sections. The first describes the effects and costs of child undernutrition, the second presents the effects and costs for overweight and obesity and, the last section describes the total costs associated with the double burden.

Each section, details the results for the year of analysis, the *incidental dimension,* and exposes a counterpoint with estimates for future years, the *prospective dimension.* It should be noted that the model of analysis is keep constant for the estimation of future effects and costs, and for all parameters used for the year of analysis, except for population projections and particularly mortality rates.

In this summary, the projections are carried out to the year 2078, corresponding with the 64-year period necessary for a complete analysis of the potential productivity losses of the population born in the year of analysis, that is, throughout their working life. Occasionally a shorter period is used for comparison or specific analysis.[28]

Summary of the nutritional situation in the countries

Following a widespread trend in the region, the prevalence of undernutrition in the three countries studied shows a downward trend in the last 20 years, much more pronounced in Ecuador and Mexico, given their higher initial rates compared to Chile. This trend is equally important for low weight for-age and low height-for-age. However, more evident in the case of global undernutrition, there is a deceleration of the rate of decline starting in 2006 (see graph 1). Even so, global undernutrition in Mexico is very close to eradication, with a prevalence of 2.8 % in 2014. For that same year, chronic malnutrition reached 13.6 %.

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28 See the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social, for additional comparisons between the 2030 and 2078 horizons.

In Ecuador, the prevalence of global undernutrition declined to 4.8 % in 2014 (from 12.5 % in 2000) while chronic malnutrition, which shows a more persistent decrease in recent years, was 23.9 %, also in 2014.

The situation in Chile is different because global undernutrition was eradicated in 1994,[29] with a prevalence of low-weight for age that affects less than 1 % of the population, and chronic malnutrition, which in that year, affected less than 5 % of children fell below 2.5 % around 2003. The undernutrition observed in Chile is mainly secondary and due to other pathologies. For this reason, this study does not include estimates of the effects and costs of undernutrition for Chile

Conversely, the trend of overnutrition is on the rise (see graph 2). The latest available data for the population aged 20 and over show a prevalence of overweight and obesity around 70 % in Chile and Mexico, and slightly more than 65 % in Ecuador. A relevant fact is that in Mexico the relative weight of obesity, in relation to overnutrition, is the highest among these three countries, which will be reflected in the estimates of effects and their economic consequences.

Graph 1: Trend of the prevalence of undernutrition in the countries analysed, 1988–2014
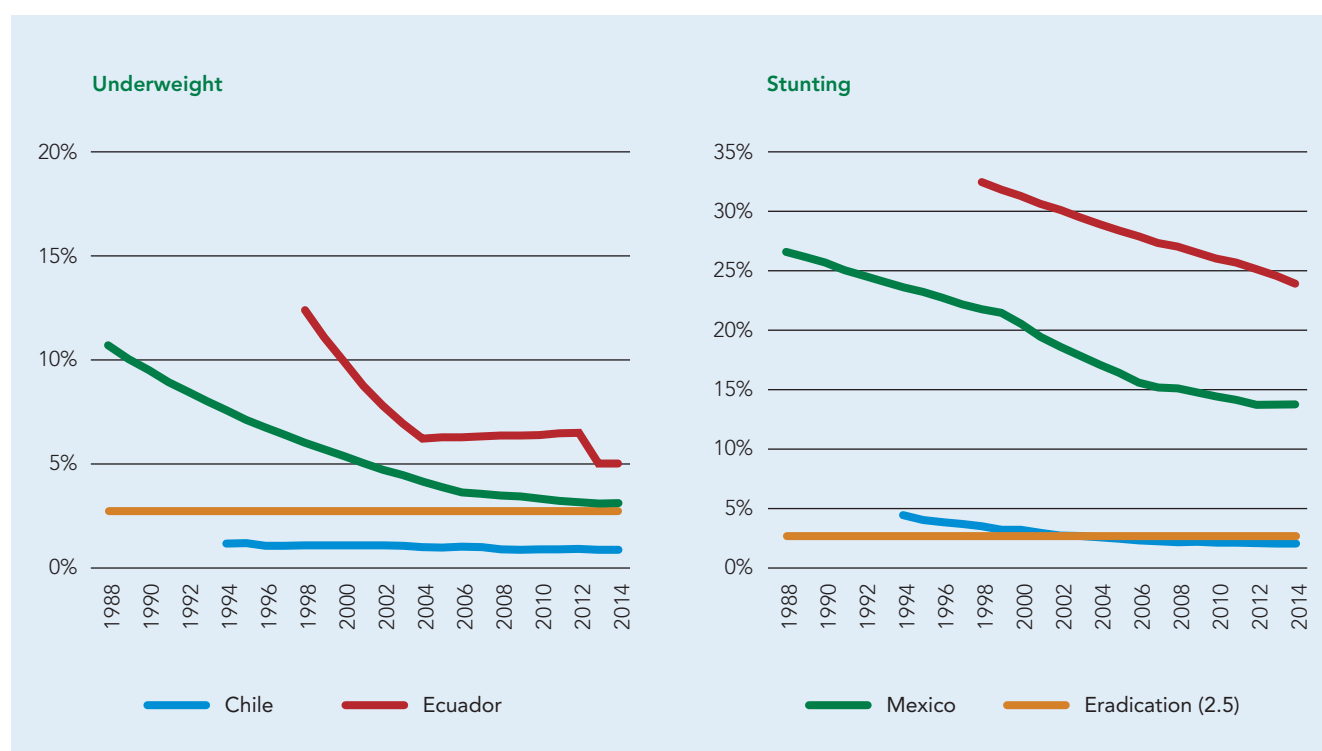
Source: Prepared by the authors based on official data from countries.[30]

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29 Considering the normal distribution with which the indicator is constructed, a prevalence below 2.5 %, undernutrition is eradicated.

30 Details of the sources used for each table and graph in this summary are in Annex No. 4 of the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

It should also be noted that in all three countries the prevalence of obesity is higher among women. Compared to men, the prevalence of obesity is 60 % higher in Chile, 50 % in Ecuador, and 40 % in Mexico, based on the latest surveys in each country. The prevalence of overweight, in turn, is higher among men in these countries.[31, 32]

Graph 2: Prevalence of overweight and obesity (different years)

(As a percentage)
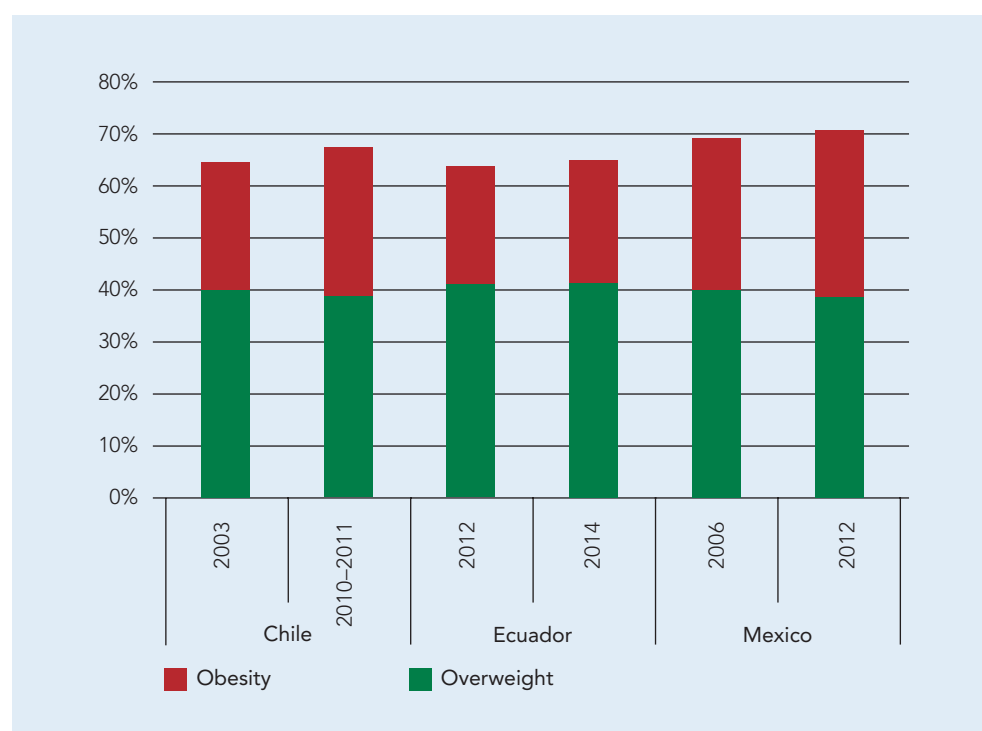
Source: Prepared by the authors based on official data from countries.

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31 For information broken down by sex, see the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

32 In undernutrition, the differences by sex are not significant.

Effects and costs of undernutrition

As noted in chapter I, child undernutrition generates effects on health and education, and these on productivity, all with economic consequences. The diseases referred to here, in addition to acute malnutrition which generates direct costs of care, correspond to acute diarrhoeal disease (ADE) and acute respiratory infection (ARI). In the case of education, the effect is related to the greater frequency of grade repetition among undernourished children. Both types of effects are then valued as additional costs associated with undernutrition. The effects on productivity result from additional deaths[33] associated with undernutrition, whereby people do not become part of the economically active population, and because of the lower level of education of those who have suffered from undernutrition and do become part of the working-age population (WAP) with this deficit. The cost associated with these effects is estimated as a loss in potential productivity. It should also be remembered that these estimates are made for Ecuador[34] and Mexico, in the absence of undernutrition in Chile.

Effects on health

The effects of undernutrition on health are estimated from the probability differential of morbidity and mortality among those who were and were not exposed to undernutrition before age five.

Burden of disease

The total number of children affected by diseases associated to low-weight-for-age differs between countries as a function of the size of the population aged 0–4 and the prevalence of each pathology. As shown in table 3, both in Ecuador and Mexico the highest burden, after undernutrition itself, corresponds to ARI, with 13,000 and 50,000 cases, respectively, in 2014. The burden of ADE, about one fourth of what was recorded for ARI, is explained by the greater differences in prevalence of this pathology.[35]

Table 3: Differences in prevalence and burden of morbidity, 2014
(In percentage and number of cases)

Pathology	Differences in Prevalence		Number of Cases	
	Ecuador	Mexico	Ecuador	Mexico
ADE	3.8%	3.2%	3 029	11 254
ARI	16.4%	13.8%	13 161	50 618
Undernutrition[a,b]	100%	100%	38 987	291 792

Source: Prepared by the authors based on official data from countries

[a] Includes acute undernutrition and low birth weight (IUGR).
[b] The difference of prevalence is 100%, because the total number of cases must be considered as the burden of disease.

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33 Note that we use the expression "extra" to highlight that only the cases that result from applying a differential probability are used, that is, the probability associated with those who are not undernourished.

34 In the Technical Report, available in electronic format, there is also a comparison of the results from Ecuador 2014 with those obtained in the study done in 2005, explaining the differences observed.

35 Included in this category are cases of acute undernutrition and low birth weight (LBW).

The future burden of morbidity associated with undernutrition (ADE and ARI) is estimated in 1,594 additional cases of illness and 7,910 cases of medical care due to low weight-for-height in Ecuador, totalling 9,505 cases in the period 2015–2018.[36] In the case of Mexico, a morbidity burden of 9,000 additional cases is estimated of ADE and ARI, and nearly 53,000 cases of acute undernutrition (see table 4).

Table 4: Morbidity burden, 2015–2018
(In number of cases)

Pathology	Country	
	Ecuador	Mexico
ADE	300	1 689
ARI	1 294	7 307
Acute undernutrition	7 910	52 913
TOTAL	9 505	61 909

Source: Prepared by the authors based on official data from countries.

Burden of mortality

Based on the evidence provided by Olofin, et al. (2013), for the relationship between mortality and chronic malnutrition, it is estimated that more than two million deaths in Mexico from 1950 to 2014, and nearly 340,000 deaths in Ecuador are a consequence of the prevalence of chronic malnutrition[37] (see table 5).

Table 5: Burden of mortality in children under five years of age associated with chronic undernutrition and adjusted for survival rate

(Number of cases)

Period	Ecuador	Mexico
1950–1959	59 614	461 907
1960–1969	71 156	493 975
1970–1979	71 593	465 170
1980–1989	57 392	329 977
1990–1999	40 588	217 326
2000–2009	27 819	117 487
2010–2014	10 824	44 937
TOTAL	338 986	2 130 779

Source: Prepared by the authors based on official data from the countries.

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36 Remember that estimates are made only for the population that exists in the year of analysis; that is, those born subsequent to this year are not included.

37 The estimate for Ecuador in 2005 found nearly 445,000 deaths for an equal period of time. At that time, however, the estimate was done based on the prevalence of global undernutrition.

Based on census projections, it is estimated that among the members of the cohort of 0 to 59 months in 2014 in Ecuador and Mexico, there would be 4,000 deaths associated with low height-for-age in Ecuador and nearly 14,000 in Mexico for the 2014–2018 period (see table 6).

For both countries, the highest proportion of the deaths occurs in 2014, the year in which the entire cohort is accounted for. In the years following the size of the cohort decreases due to the age of its members.[38]

As indicated, the mortality associated with undernutrition has a direct effect on the productive capacity of the country, affecting the size of the working-age population (WAP). This effect is estimated at 3% for Ecuador and 2.4% for Mexico, in relation to the size of the WAP in 2014.

Table 6: Burden of mortality associated with undernutrition, 2014–2018

(Number of cases)

| Country	Age	Year					percent with respect to the total
		2014	2015	2016	2017	2018	
Ecuador	0 to 11 months	2 302					57.2%
	12 to 59 months	501	493	366	241	119	42.8%
Mexico	0 to 11 months	7 050					51.4%
	12 to 59 months	2 015	1 918	1 409	912	415	48.6%

Source: Own preparation based on official data from countries.

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38 Note that the deaths that occurred in 2014 must be counted because the cost associated with those deaths will be generated when the complete cohort reaches working age (WAP).

Effects on education

Graph 3: Repetition associated with chronic malnutrition, 2014
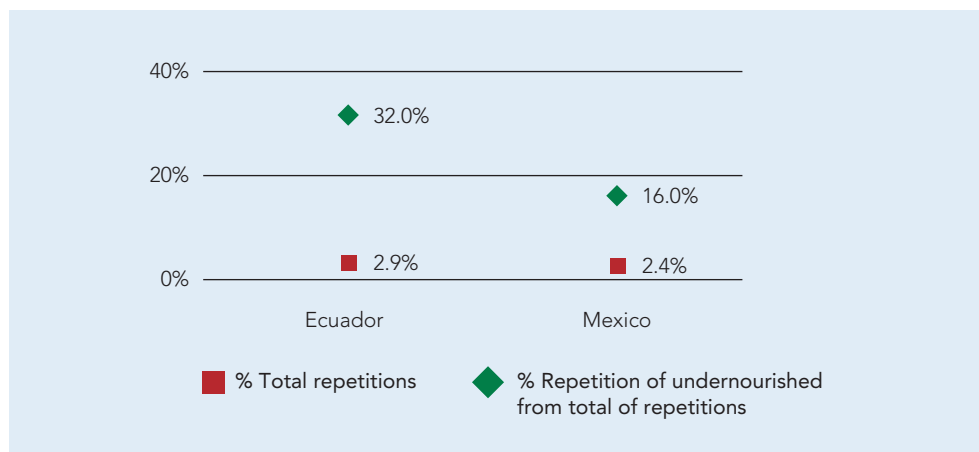
Source: Prepared by the authors based on official data from countries.

As noted earlier, undernutrition generates learning gaps that, in turn, lead to lower school performance, and generates a higher probability of grade repetition and desertion.

Based on official country information, a total repetition rate of 2.9 % is estimated in Ecuador and 2.4 % in Mexico, equivalent to 84,000 and 540,000 children repeaters, respectively, in 2014. Of these, 32 % of cases in Ecuador and 16 % in Mexico are associated with exposure to chronic malnutrition early in life (see graph 3).

The repetition rate associated with undernutrition rises in secondary school, compared to primary school, due to the higher probability of overall repetition that exists at that level. In Mexico, it reaches 82 % (in relation to the total repetition of that level), and in Ecuador 52 %.

Excluding from the analysis those who attained tertiary education, household surveys in Ecuador and Mexico allow estimating an average schooling of eight years among the population aged 20 to 64 in 2014. However, exposure to chronic malnutrition produces a differential of 2.3 years in Ecuador and 2.4 years in Mexico.

As shown in graph 4, even though the differential is similar in both countries, the educational profile among those exposed and not exposed to chronic malnutrition is very different. Thus, 20 % of those who suffered undernutrition in their childhood were unable to complete primary education in Ecuador, a figure three times higher than among those who did not suffer from undernutrition. This ratio is similar in Mexico, but the percentage of the population that did not complete primary education due to undernutrition is 26 %.

On the other extreme, while 45 % of the population not exposed to undernutrition in Ecuador completes secondary education, this is achieved only by 11 % of those who were exposed. In Mexico the situation is more dramatic: only 2 % of those exposed finishes secondary education.

These differences can generate very different impacts on the potential productivity of each country.

Graph 4: Level of schooling of the population between 20–64 years of age, 2014
(As a percentage)
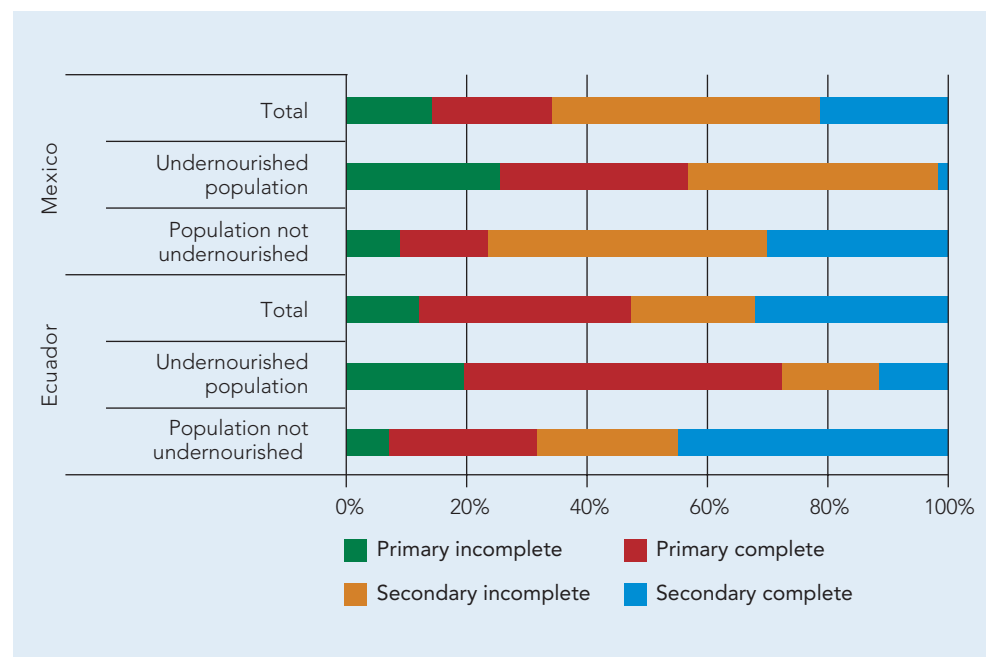
Source: Prepared by the authors based on official data from countries.

The 2014 projection of educational results for children under five years for the 2016–2031 period indicates that, in association with the current rates of chronic malnutrition, there will be more than 13,000 additional cases of repetition in Ecuador,[39] and just under 29,000 in Mexico (see table 7). In Mexico, 82 % of these repetitions happen in secondary school,[40] while in Ecuador the rate reaches 53 %.

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39 For 2005, the number of children repeating grades was estimated to be 2,590, which is five times lower than the current estimate. This is explained by a combination of factors, notably the use of chronic malnutrition instead of global undernutrition, and update to the relative risk.

40 Secondary education in Mexico is divided into middle school and high school, where a diploma is received for completing high school.

Table 7: Number of future cases of grade repetition associated with chronic malnutrition (2016–2031)

(Number of cases)

	Ecuador	Mexico
Primary	6 205	5 186
Secondary	7 066	18 593
Tertiary	-	4 820
TOTAL	13 271	28 599

Source: Prepared by the authors based on official data from countries.

In addition to the effects on repetition, it is estimated that in the future, students exposed to chronic undernutrition in the 2014 0–4-year-old cohort will obtain on average 1.0 and 1.4 fewer years of education in Ecuador and in Mexico, respectively (see graph 5). In addition to the impact that these gaps generate in the individual development of every person, they are very relevant in the productive capacity of working-age population limiting its potential productivity.

Graph 5: Future educational achievements of the 2014, 0–4-year-old cohort of 2014

(Average number of years attained)
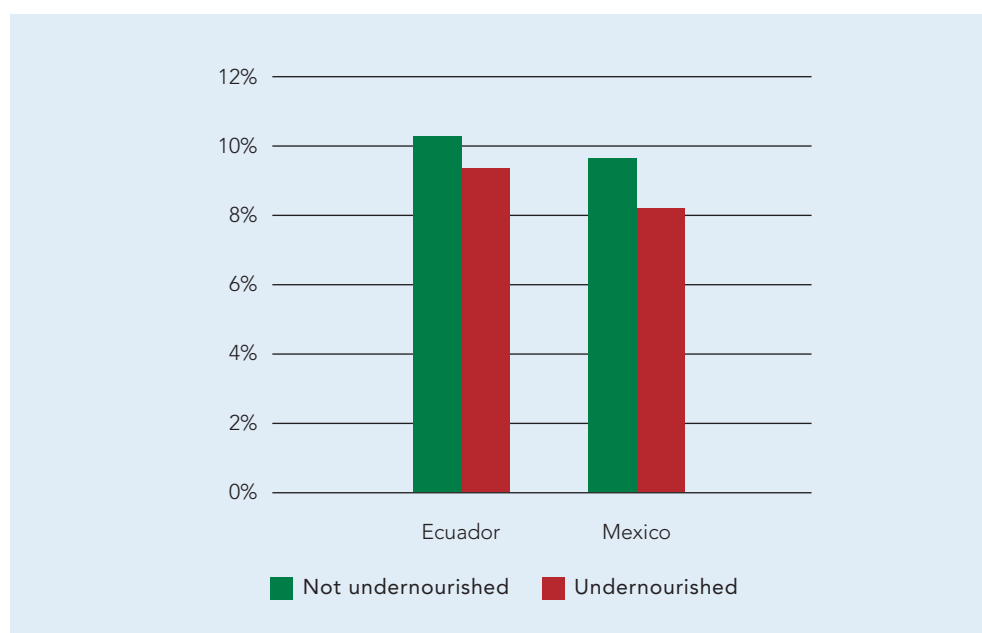
Source: Prepared by the authors based on official data from countries.

Economic consequences

Following are the costs for Ecuador and Mexico derived from the effects on health care and education, both in 2014 and for future years. The costs for the year of analysis are derived from a historical exposure to undernutrition, while future costs are derived from exposure to undernutrition of the 0–59 month cohort in 2014, which generates effects and costs at different ages until the year 2078.

It should be noted that, although the model of analysis allows estimating both public and private costs, already explained in chapter I, only total costs are presented in this analysis. Likewise, the estimates of future costs presented correspond to those calculated with a discount rate of 3%.[41]

Health costs

As shown in table 8, the total health cost for 2014 is nearly US$44 million in Ecuador, and just over US$900 million in Mexico, equal to 2.4% and 2.6% of GDP, respectively.

For Mexico the greatest cost is generated in the new-born population, that is, cases of low birth weight that requiring specialized care, with a day/bed cost of between US$509 and US$1,977 for hospitalisation and intensive care, respectively

On the other hand, both in Ecuador and Mexico, the highest cost is caused by the treatment of undernutrition, which represents nearly 90% of the total health cost.

Table 8: Total health cost associated with undernutrition, 2014

(In millions of dollars and percentage)

Disease	Country	
	Ecuador	Mexico
ADE	0.4	15.7
ARI	4.0	87.7
Undernutrition	39.1	803.6
TOTAL	43.5	907.1
Relative to GDP	0.04%	0.07%
Relative to social public health expenses	2.4%	2.6%

Source: Prepared by the authors based on official data from countries.

The future health cost, expressed as *net present value* (NPV), amounts to US$9.1 million in Ecuador in 2014, and US$49.1 million in Mexico. These numbers, stated as the *annual equivalent cost* (AEC) for the 2015–2030 period, are US$720,000 per year in Ecuador and US$3.9 million per year in Mexico. The AEC for the full period, 2015–2078, is 44% of the prior values.

The higher costs observed for the year of analysis, compared to future costs, are mainly explained by the costs generated in the first year of life. Note that these no longer apply as of 2015 since new-borns are not included in the prospective analysis.

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41 Disaggregation of total costs may be reviewed in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social. Also presented in this report are additional estimates, with a rate of 6%, and also using lower limits of confidence intervals (minimum cost).

Education costs

The additional grade repetition estimated for 2014 generated a cost of US$27.0 million for the education system of Ecuador, and US$151 million for Mexico, equivalent to 0.027 % and 0.01 % of GDP, respectively. Table 9 shows the distribution of this cost between primary and secondary education, observing that in both countries the higher cost occurs at the second level. This is because at the highest rate of differential repetition observed at this second level of education, the highest cost per student is added.

Table 9: Total education costs associated with undernutrition, 2014

(In millions of dollars and percentage)

	Ecuador	Mexico
Total cost	27.2	150.9
Cost in primary school	9.9	18.1
Cost in secondary school	17.3	132.8
Total cost in relation to GDP	0.027%	0.012%
Total cost in relation to social public expenses on education	0.59%	0.34%

Source: Prepared by the authors based on official data from countries.

The future cost of education, expressed as NPV, amounts to US$9.5 million in Ecuador in 2014, and US$35.0 million in Mexico. These numbers, expressed as AEC for the 2015–2030 period, are US 760 thousand annually in Ecuador and US$2.8 million annually in Mexico. The AEC for the entire period, 2015–2078, as with health costs, is 44 % of the previous values.

Loss of productivity

Undernutrition generates significant economic losses due to premature mortality and lower levels of schooling reached by the population. As indicated in chapter I, to estimate this cost, the differential of deaths associated with chronic malnutrition and the lower educational level of the population that suffered from this scourge in their childhood and who are of working age (15 to 64 years old) in the analysis year were counted. Both effects on potential productivity are weighted by the average income of those who did not suffer from undernutrition, thus estimating the alternative costs assumed both by the affected population and society.

The estimated total cost due to lost productivity for the year of analysis exceeds US$2.5 billion in Ecuador and US$20 billion in Mexico, which amounts are equal to 2.5 % and 1.6 % of GDP, respectively. In both countries, the effect on the level of education is more relevant, representing 60 % of the total in Ecuador, and 72 % in Mexico (see table 10).

Table 10: Costs due to loss of productivity, 2014

(In millions of dollars and percentage)

	Ecuador	Mexico
Total	2 530	20 458
Cost due to mortality	1 002	5 796
Cost due to lower level of education	1 528	14 662
Total cost in relation to GDP	2.5%	1.6%
Total cost in relation to social public expenses	31.3%	14.8%

Source: Prepared by the authors based on official data from countries.

The highest absolute cost observed in Mexico responds to the size of its population and economy. Accordingly, while the ratio is eight to one in the total amount, in relative terms to GDP the relationship is inverted: in Ecuador, it represents 1.6 times the proportion in Mexico (2.5 % and 1.6 % of GDP, respectively). These values, on the other hand, represent nearly one third of the resources destined to financing social policies in Ecuador and one sixth in Mexico.

The future cost of lost productivity, expressed as NPV, is US$1.8 billion for 2014 in Ecuador, and US$11.4 billion in Mexico, estimated for the entire period of analysis, that is until 2078, the year in which the analysed cohort turns 65 years old.[42] These figures, expressed as AEC, amount to US$60.4 million annually in Ecuador and US$403.9 million annually in Mexico.

Total cost

In summary, in 2014 undernutrition generated a total cost of US$2.6 million in Ecuador, and US$21.5 million in Mexico, when the three dimensions are added (health, education and productivity). Graph 6 shows the total cost distribution among the different dimensions. It can be observed that the higher cost is explained by loss of potential productivity, with more than 95 % in both countries.

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42 Remember that in order to estimate future productivity losses it is necessary to follow up on the entire working period of the cohort that is 0–4 years old in the year 2014.

Graph 6: Distribution of the total cost associated with undernutrition, 2014
(As a percentage)
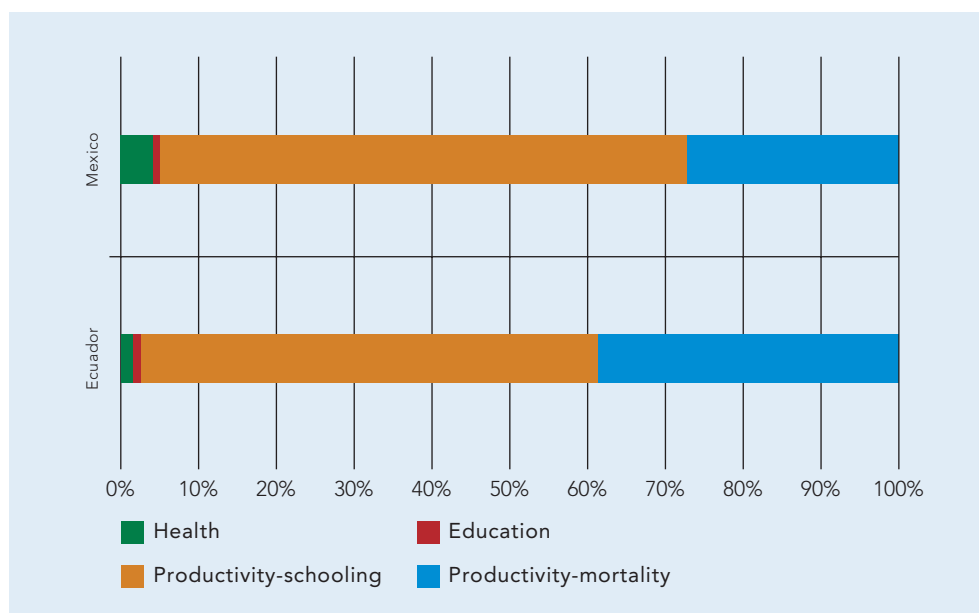
Source: Prepared by the authors based on official data from countries.

These costs are those that the countries are paying for in the year of analysis, and therefore, are not possible to reverse. Furthermore, they will continue to be replicated in the future, and the costs of future generations will be added while undernutrition is not eradicated.

The costs generated by lifetime undernutrition of a specific cohort (future costs) are potential savings from early interventions, working within the window of opportunity of 1,000 days with mothers and infants from gestation, in order to achieve the goals set forth in the Sustainable Development agenda by 2030. As we have seen, the highest cost corresponds to lost productivity and, within this, the lower levels of education reached by children who have suffered from undernutrition.[43]

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43 In this case, the different cost sources cannot be added together, as they use different periods of time for their estimates.

Effects and costs of overweight and obesity

As discussed in chapter I, overweight and obesity have an impact on both health and the work sphere and, in turn, on productivity, all with economic consequences. There are 13 pathologies considered in this study,[44] however, type II diabetes mellitus (DM2) and arterial hypertension (AHT) account for most of the burden of morbidity. The effects on mortality have been estimated from the relative risk for all causes of death associated with obesity, and the labour effects have been limited to the absenteeism derived from the same pathologies listed above.

As for undernutrition, the effects on productivity result from the additional deaths that are associated with overnutrition, with the difference that in this case people die while part of the WAP. To the above is added is the loss of working days, previously estimated as absenteeism.

Effects on health

Burden of disease

DM2 and AHT represent about 95% of the total burden of disease associated with overweight and obesity. All pathologies considered, in 2014 this burden amounts to 2.9 million cases in Chile, 900,000 in Ecuador, and 20.8 million in Mexico (see graph 7). It should be noted that the estimated burden of DM2 and AHT, in relation to total prevalence in each country, shows that 58% of the cases of diabetes and 55% of hypertension cases are related to overweight and obesity.[45]

It should also be noted that the burden of these two pathologies tends to be higher among women, however it is quite variable between countries since it depends on the differences of epidemiological profiles by sex in each of them.[46]

It should be noted that the low proportion of cases of "other diseases" in Mexico, compared to Chile and Ecuador, is due to a lower availability of data for these pathologies.[47]

As illustrated in graph 8, the future burden of DM2 and AHT presents a monotonous increase until reaching a turning point (between 2050 and 2070), which varies depending on the epidemiological and demographic profiles of each country, and combines with the start of a decrease—also monotonous—of the population under analysis. By 2030 the increase in the burden of DM2 and AHT, together, is estimated at 40% for Chile, 63% for Ecuador, and 46% for Mexico.

Note that this is a conservative projection given that overnutrition is in an expansive phase; however, the model keeps the epidemiology of 2014 constant.

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44 Diabetes mellitus type II, hypertension, ischemic heart diseases, cerebrovascular diseases, heart failure, cancer (oesophageal, breast, endometrial, pancreatic, colon and rectal, kidney) and osteoarthritis.

45 Hereinafter, the references to burden of disease always correspond to that associated with overweight and obesity, unless otherwise indicated.

46 More detailed results may be found in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social

47 No data on cerebrovascular diseases, oesophageal cancer, pancreatic cancer and kidney cancer were available for Mexico.

Graph 7: Distribution of burden of disease, 2014

(In percentages, and total in millions of cases)
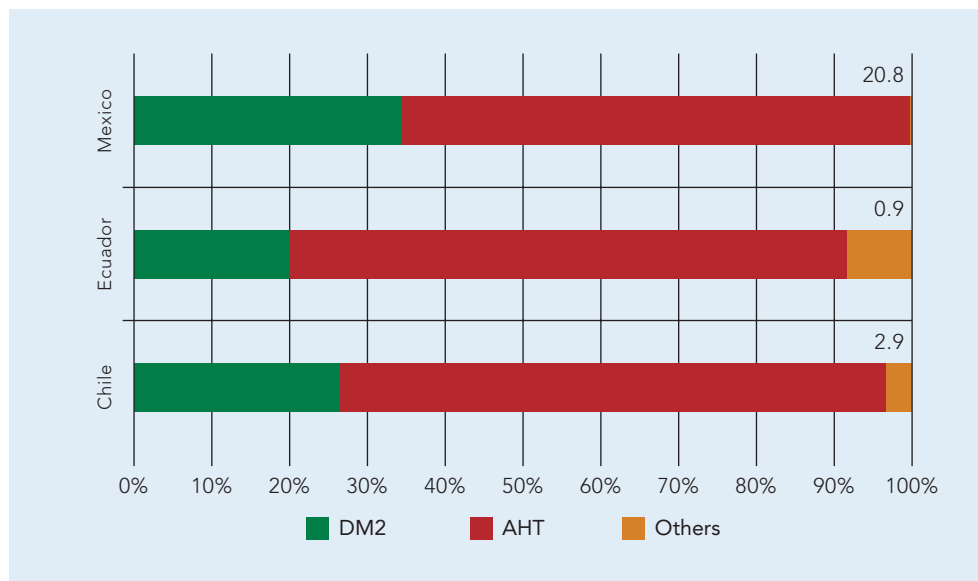
Source: Own preparation based on official data from the countries.

Graph 8: Burden of diabetes and hypertension, 2015–2078

(Millions of cases)
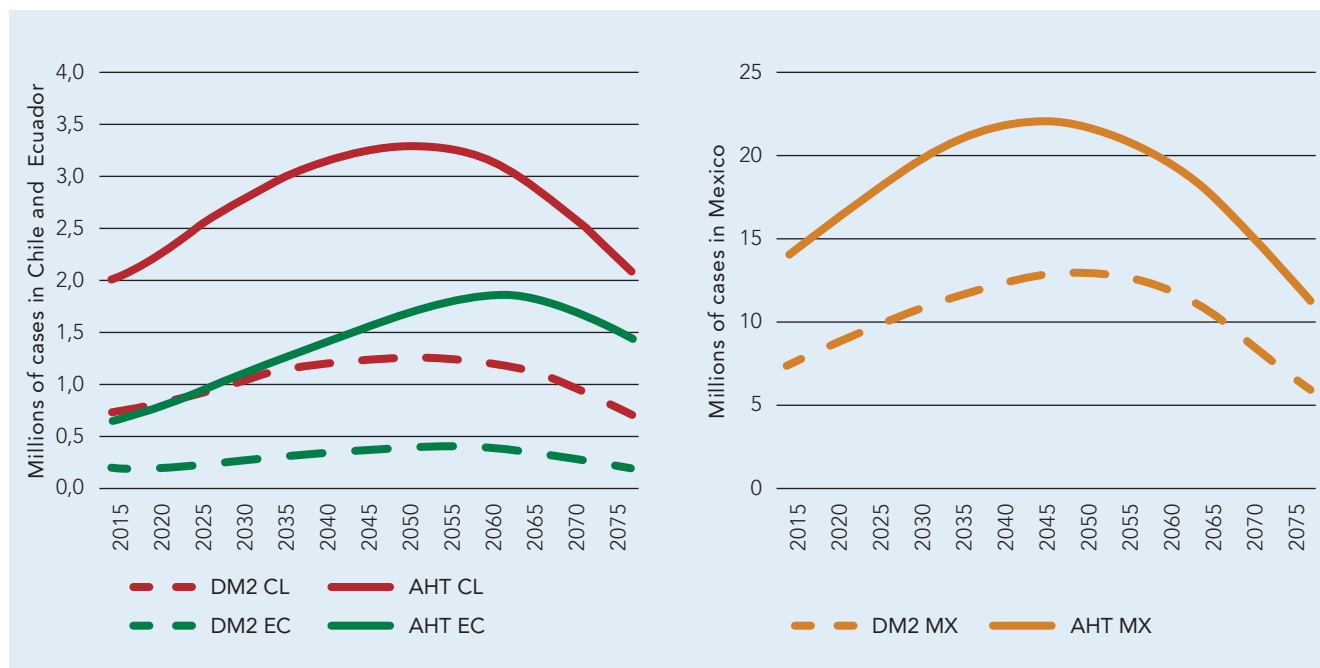
Source: Prepared by the authors based on official data from countries.

Mortality burden

Graph 9 describes the distribution of the burden of mortality associated with obesity,[48] differentiated by age groups. For the year of analysis, that burden is estimated to be 12,081 cases in Chile, 9,967 in Ecuador, and 87,027 in Mexico.

Graph 9: Burden of mortality by age group, 2014

(In percentage and total in number of cases)

Source: Prepared by the authors based on official data from countries.

When analysing the distribution of the burden of mortality it is observed that it increases more strongly at 50 years of age, with 35 % of total cases concentrated between the ages of 55 and 64. This is due to the general mortality pattern of the countries. In turn, this is between 2.5 and 3 times higher among men due to their higher relative risk and to their higher probability of death in general. In other words, obesity is a risk factor that incr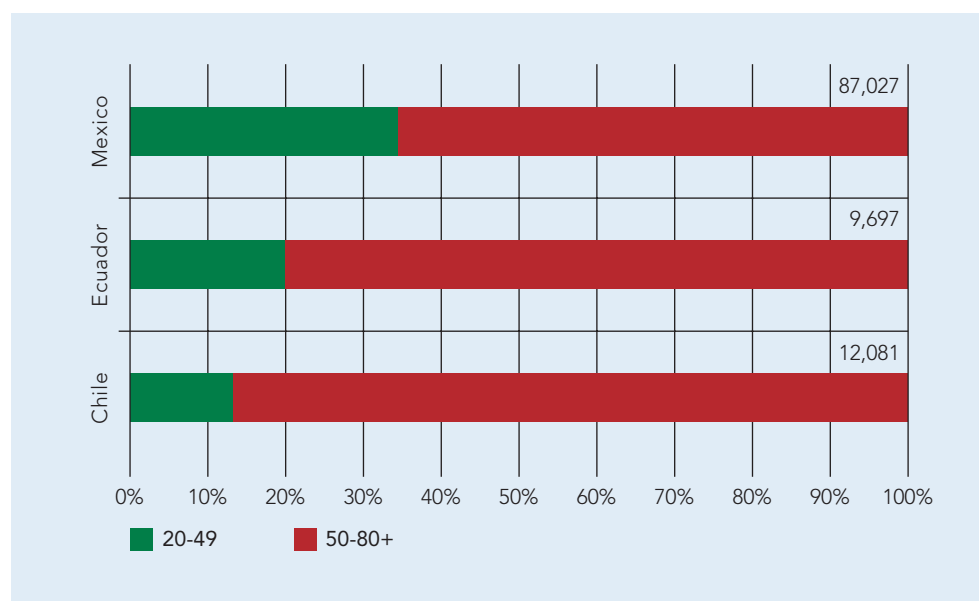eases the probability of death in men more than in women. It should be noted, however, that starting at age 65, no deaths are attributed in women because the relative risk of mortality is less than one as of that age.

Due to the demographic pattern of the countries, by 2030 the burden of mortality maintained an incremental trend. Regarding the year of analysis, it is estimated that the increase in the number of deaths will be 13 % in Chile, and 26 % higher in Ecuador and Mexico. The differences observed between countries are due to the particularities of the demographic profiles. For example, in Ecuador in Mexico, obesity associated mortality shows a higher growth tendency compared to Chile. In absolute terms, the total cumulative number of deaths associated with obesity between 2015 and 2030, will be approximately 204,000 in Chile, 182,000 in Ecuador, and 1.6 million in Mexico.

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48 The estimate was only for obesity, given that the RR of overweight is equal to 1.0 or lower.

Table 11: Burden of mortality and growth rate

(In thousands of cases and in percentage)

	Chile	Ecuador	Mexico
Cases in 2030	13.7	12.8	111.4
Accumulated cases 2015 / 2030	204	182	1 606
Increase 2030 / 2014	13%	26%	26%

Source: Prepared by the authors based on official data from countries.

Effects on employee absenteeism

The burden of absenteeism expressed the number of days that the working-age population fails to do so due to medical attention or prescribed rest (outpatient or inpatient) for the pathologies specified above. Evidently, due to its larger population size, the greatest burden is observed in Mexico, with nearly 32 million days of absenteeism in 2014 (see table 12). However, when controlling for differences in population size and labour participation the greatest relative burden occurs in Ecuador. In fact, the absenteeism rates for the year of analysis, stated as a percentage of the total potential workdays, are 0.09 % in Chile, 0.24 % in Ecuador, and 0.18 % in Mexico.

The relative weight of DM2 and AHT, although high, decreases in relation to the burden of disease seen above, although this varies between countries due to their practices and legislation. This how cancer and other pathologies account for nearly 26 % of total absenteeism in Chile and Ecuador. In Mexico, however, the relevance of cancer and other pathologies are much lower, about 6 %, but as noted earlier some pathologies could not be included.

Regarding the future burden of absenteeism, it should be noted that by 2030, it is estimated that it will increase to 21 % for Chile, 42 % for Ecuador, and 39 % for Mexico, compared to 2014.

Table 12: Burden of absenteeism, 2014 and 2030, and growth rate with respect to the year of analysis

(Thousands of days)

Pathologies	Chile			Ecuador			Mexico		
	Number of days 2014	Number of days 2030	Increase	Number of days 2014	Number of days 2030	Increase	Number of days 2014	Number of days 2030	Increase
DM2	192	234	22%	2 144	3 053	42%	14 506	20 715	43%
AHT	500	596	19%	1 873	2 666	42%	15 019	20 098	34%
Others	264	325	23%	1 543	2 148	39%	2 184	3 230	48%
TOTAL	956	1 156	21%	5 559	7 866	42%	31 708	44 043	39%

Source: Prepared by the authors based on official data from countries.
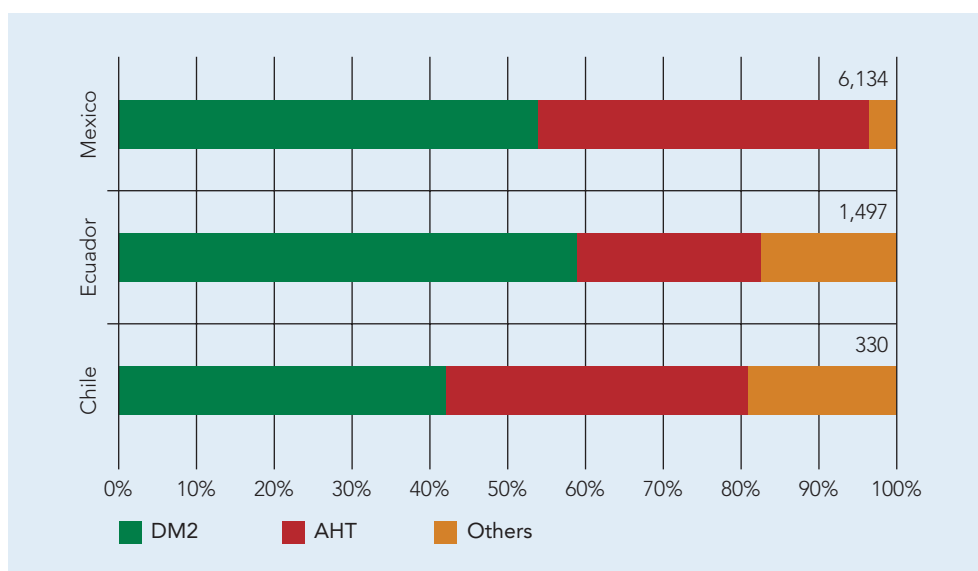
Economic consequences

Presented below are the costs resulting from the effects discussed above, both for the year 2014 and for future years. The future costs estimates presented here were calculated using a of 3% discount rate.[49]

Costs to the public health care system

The costs to the health system in 2014, derived from the extra burden of morbidity, amount to US$330 million in Chile, US$1.5 billion in Ecuador, and US$6.1 billion in Mexico. As would be expected, the distribution of costs per pathology follows the trend of the burden of morbidity (see graph 11). However, despite the lower burden, the costs for DM2 are higher than those for AHT basically because their average unit costs are about three times higher (on average for Chile and Mexico).

Graph 10: Distribution of costs to the health system, associated with overweight and obesity (2014)

(In percentage and total in millions of dollars)

Source: Prepared by the authors based on official data from countries.

When comparing the total costs estimates among countries, after controlling for the effect of population size and differential in the epidemiological profile, a first element that stands out is that the average treatment costs reported in Mexico are about 2.5 times higher than in Chile.[50] In the case of Ecuador, however, the situation is much more extreme, given that the average unit costs reported are about 16 times higher than in Chile, and nearly seven times higher than in Mexico. This magnitude is reduced in total costs due to the lower burden of disease in Ecuador.

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49 Disaggregation of total costs may be found in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social. Also presented in this report are additional estimates, using a rate of 6%, and also using lower limits of confidence intervals (minimum cost).

50 Calculations based on DM2 and AHT as a reference, due to their higher relative burden.

Table 13 shows the cost for the health system in relation to GDP and public social spending on health. Regarding health spending, Ecuador presents the highest cost with 83 %, followed by Mexico with 17.5 %, and then Chile with 3.1 %. Note that the higher cost is associated with obesity, rather than being overweight, which is explained by the higher burden of disease associated with this nutritional condition.

Table 13: Cost to the public health care system associated with overweight and obesity, relative to GDP and to the social public expenditure on health care, 2014

(As a percentage)

	Chile	Ecuador	Mexico
With respect to GDP	0.13%	1.48%	0.47%
With respect to the public social expenditure on health care	3.1%	83.0%	17.5%

Source: Prepared by the authors based on official data from countries.

The evolution of future costs to the health care system is equivalent to that of the burden of morbidity. Thus, as the cases of disease accumulate, so do the costs. It is essential to insist that the cost reduction occurring from the highest point of the curve is because the cohort analysed is limited by its own mortality and because the population born after the year of analysis is not included (see graph 11).

Notwithstanding the regularities described in the previous paragraph, there is also heterogeneity in terms of the slope or rate of increase of the burden of disease and the total costs associated with it. Thus, the increase is greater in Ecuador, followed by Mexico, and Chile. Although the epidemiological and nutritional profiles of each country affect the result, it is the demography of each context that specifically explains these differences. The less-advanced demographic transition in Ecuador creates greater population growth in the years analysed. Comparatively, the increase in the population at risk analysed in this model, is greater in Ecuador than in the other two countries.

By 2078, the future cost to the health care system, expressed in 2014 NPV, could reach up to US$13.4 billion in Chile, US$70.30 billion in Ecuador, and US$245.9 billion in Mexico. For the 2015–2030 period, the cost is on the order of 36 % of previous values.

Regarding the different pathologies, DM2 continues to be the one with the highest costs, followed by AHT; together they explain 80 % of future costs in Chile and Ecuador, and about 95 % in Mexico.

The annual equivalent cost for the health care system, estimated for the 2015–2078 period, amounts to US$475.0 million in Chile, US$2.5 billion in Ecuador, and US$8.7 billion in Mexico. This estimate does not include the population born after 2014. These figures, related to public social expenditure on health in each country reach 4.5 % in Chile, 138 % in Ecuador, and 24.9 % in Mexico.

Graph 11: Burden of disease and total costs for the health care system, all pathologies, 2015–2078

(In millions of cases and millions of dollars)

Source: Prepared by the authors based on official data from countries.

Private costs

The private cost is comprised of out-of-pocket (co-pay) expense and the cost of care that families incur for patient treatment and follow-up. Since only Chile reports out-of-pocket expenses, in Ecuador and Mexico private costs coincide with care costs.

Out-of-pocket costs for Chile, given the burden of disease associated with overweight and obesity, is estimated at US$20 million in 2014, with DM2 and AHT being the pathologies that explain most of the cost. In relative terms, this is equivalent to 0.19% of the public social expenditure on health.

Regarding the costs of health, evidently the relative weight of DM2 and AHT is higher compared to other pathologies due to the higher burden of disease. The estimates show an annual cost of US$35 million in Chile, US$126 million in Ecuador, and US$297 million in Mexico. Differences in the epidemiological profile and in the demographic structure between Chile and Mexico explain the absolute costs differential between these two countries. In Ecuador, however, the high estimated cost is basically explained by the higher number of medical leave reported (disability days), which is a determinant variable in the estimation of care costs.

In relation to the public expenditure on health, the weighted cost of health care is more than doubled in Mexico compared to Chile. In Ecuador, given the absolute figures already mentioned, the value is much higher (see table 14)

Future private costs for the 2015–2078 period increase to nearly US$2.3 billion in Chile, US$6.0 billion in Ecuador, and US$12.7 billion in Mexico, all stated in 2014 NPV. The annual equivalent cost of these amounts is US$81.0 million, US$213.0 million, and US$448.0 million for Chile, Ecuador and Mexico, respectively.

Table 14: Private costs of health care by pathology, 2014

(In millions of dollars and percentage)

Pathology	Chile	Ecuador	Mexico
DM2	16.5	44.7	137.7
AHT	25.4	50.4	137.8
Others	13.6	30.7	21.4
TOTAL	55.5	125.7	296.8
With respect to GDP	0.02%	0.12%	0.02%
With respect to the public social expenditure on health care	0.5%	7.01%	0.85%

Source: Prepared by the authors based on official data from countries.

Loss of productivity

Loss of productivity is estimated based on two components: premature mortality and absenteeism. The cost of lost productivity due to premature mortality in the year of analysis is estimated to be US$75 million for Chile, US$37 million for Ecuador, and US$355 million for Mexico (see table 15).

The difference in costs between Ecuador and Mexico is mainly due to differences in the size of their populations and, secondarily, differences in epidemiological profiles. However, the differences observed between Chile and Ecuador are better explained by the lower relative level of wages in Ecuador and partly because of a higher burden of mortality.

In all three countries, the greatest productivity loss occurs in men, which is explained both by the higher burden of mortality already described and by the higher levels of income compared to women. In turn, the greatest losses are concentrated in the older age groups, especially those between 50 and 59 years, basically because the burden of mortality increases at these ages.[51]

Table 15: Loss of productivity due to mortality and employee absenteeism, 2014

(In millions of dollars and percentage)

	Chile	Ecuador	Mexico
Mortality	75.3	36.7	354.5
Absenteeism	32.7	86.6	528.9
TOTAL	108.0	123.3	883.4
With respect to GDP	0.04%	0.12%	0.07%
With respect to the public social expenditure on health care	0.28%	1.53%	0.64%

Source: Prepared by the authors based on official data from countries.

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51 Age distribution is described in depth in the project document, available at www.cepal.org/es/areas-de-trabajo/desarrollo-social.

It should be noted that for the estimation of income in men and women, the average employment income based on the age bracket of the working-age population (WAP) was used. By definition, WAP includes the economically inactive population, whose income is equal to zero, decreasing the average income for the corresponding age group.

Absenteeism, in turn, contributes to lost productivity with another US$33 million in Chile, 87 million in Ecuador, and 529 million in Mexico. Note that both in Ecuador and Mexico these figures exceed mortality costs.

Future costs due to lost productivity, expressed as NPV for the 2015–2078 period, amount to US$14.5 billion for Chile, US$13.1 billion for Ecuador, and to US$114.8 billion for Mexico. These represent an annual equivalent cost of US$513 million, US$462 million, and US$4.1 billion for Chile, Ecuador and Mexico, respectively.

Total costs

In summary, the total costs of overweight and obesity for the year of analysis are estimated to be US$493.0 million in Chile, US$1.7 billion in Ecuador, and US$7.3 billion in Mexico. As can be seen in graph 12, in all three countries the cost for the public health system accounts for most of the total cost, around 67 % in Chile, and nearly 85 % in Ecuador and Mexico. The latter constitutes an important difference compared to undernutrition, where most of the costs are due to lost productivity.

The total cost associated with overnutrition for the 2015–2078 period, expressed as annual equivalent cost, is slightly exceeds US$1.0 billion in Chile, US$3.1 billion in Ecuador, and US$13.1 billion in Mexico. Although the heavy weight of the cost for the health system is maintained, it is observed that the relative weight corresponding to lost productivity due to premature mortality increases, although with differences between countries (see graph 13).

The graph also illustrates that private health costs and absenteeism, despite having a lower relative weight, contribute between 10–15 % to the total cost.

Graph 12: Distribution of total costs associated with overweight and obesity, 2014

(In percentage and millions of dollars)

Source: Prepared by the authors based on official data from countries.

Graph 13: Percentage distribution of the annual total equivalent cost associated with overweight and obesity, 2015–2078

(Total number in millions of dollars)

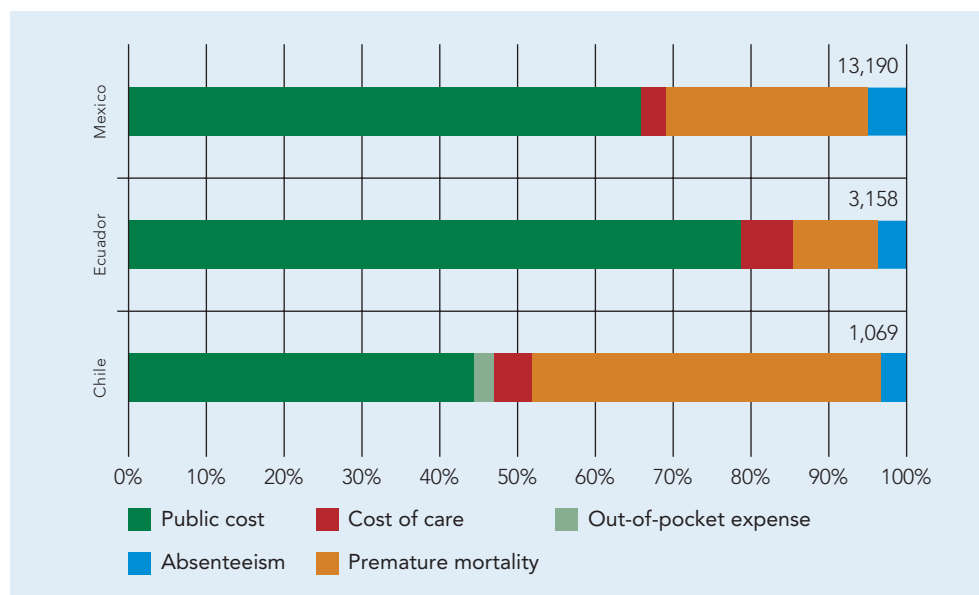Source: Prepared by the authors based on official data from countries.

Costs of double burden

This section presents the estimate of the total cost attributable to the double burden of malnutrition. To facilitate comparison, a summary of the costs due to undernutrition is presented first, followed by the costs due to overweight and obesity. The third section presents the aggregation of costs associated with undernutrition, and costs associated with overnutrition. For the future years, only the total costs are presented as an aggregate, since these occur in very different years in each case.

Comparatively, in the year of analysis the total cost associated with undernutrition is higher than that associated with overweight and obesity: in Ecuador, it is 1.5 times higher and in Mexico 3 times higher. This difference, as a percentage of GDP, is 0.85 % and 1.1 % in Ecuador and Mexico, respectively, which is basically explained by the higher costs generated by lost productivity associated with undernutrition. This, in turn, is based on the inter-temporal nature of the economic consequences of child undernutrition, either a result of mortality or to a lower level of education, both occurring in the past, and whose magnitude extends until the year of analysis affecting the potential productivity of the WAP.

Regarding health costs, the situation is opposite to that indicated in the previous paragraph. In fact, the costs for overweight and obesity are 38 times higher in Ecuador and 7 times higher in Mexico compared to undernutrition. The strong difference observed in Ecuador responds to the high unit costs reported, which was analysed above.

In summary, the total costs of the double burden of malnutrition for the year of analysis is US$493 million in Chile, US$4.3 billion in Ecuador, and US$28.8 billion in Mexico. Regarding GDP, these values are 0.2 %, 4.3 %, and 2.3 % in each country, respectively. On the other hand, it should be noted that while in Chile health care costs concentrate the greatest proportion of costs with respect to the total, in Ecuador and Mexico the greatest concentration of costs is in lost productivity, due to the impact of undernutrition.

Table 16: Total cost of undernutrition, 2014

(In millions of dollars)

	Ecuador	Mexico
Health care costs	43	907
Education costs	27	151
Loss of productivity	2 530	20 458
Premature mortality	1 002	5 796
Lower level of education	1 528	14 662
TOTAL	2 600	21 516
% of GDP	2.6%	1.7%

Source: Prepared by the authors based on official data from countries.

Table 17: Total cost of overweight and obesity, 2014

(In millions of dollars)

	Chile	Ecuador	Mexico
Health care costs	385	1 623	6 431
Public cost	330	1 497	6 134
Private cost	55	126	297
Cost to productivity	108	123	883
Premature mortality	75	37	354
Absenteeism	33	86	529
TOTAL	493	1 746	7 314
% of GDP	0.2%	1.7%	0.6%

Source: Prepared by the authors based on official data from countries.

Table 18: Total costs of the double burden of malnutrition, 2014

(In millions of dollars)

	Chile	Ecuador	Mexico
Health care costs	385	1 666	7 338
Education costs	-	27	151
Cost to productivity	108	2 651	21 341
Premature mortality	75	1 037	6 150
Lower level of education	-	1 528	14 662
Absenteeism	33	86	529
TOTAL	493	4 344	28 830
% of GDP	0.2%	4.3%	2.3%

Source: Prepared by the authors based on official data from countries.

As can be seen by comparing tables 19 and 20, and unlike in the year of analysis, overweight and obesity generate much higher future costs than those produced by undernutrition. This fact is basically explained by the difference in size between the populations analysed (0–4 years vs. 20 and older) and the type of pathologies (acute vs. chronic), therefore, the results should be interpreted with caution. An estimation of unit costs, as presented below, is a more adequate alternative for comparison.

At a rate of 3%, undernutrition is estimated to have an equivalent annual cost of US$62 million and US$407 million in Ecuador and Mexico, respectively. As a percentage of GDP, this represents 0.06% and 0.003%. For overweight and obesity, in these same countries, these percentages rise to 3.1% and 1%, respectively, reaching 0.4% in the case of Chile.

Table 19: Annual equivalent cost due to undernutrition, 2015–2078

(In millions of dollars and percentage)

	Ecuador	Mexico
Health care costs	0.32	1.73
Education costs	0.34	1.24
Cost to productivity	61	404
Premature mortality	7	20
Lower level of education	54	384
TOTAL	62	407
% of GDP	0.06%	0.03%

Source: Prepared by the authors based on official data from countries.

Table 20: Annual equivalent cost due to overweight and obesity, 2015–2078

(In millions of dollars and percentage)

	Chile	Ecuador	Mexico
Health care costs	556	2 696	9 135
Public cost	475	2 483	8 687
Private cost	81	213	448
Out-of-pocket expenses	29	-	-
Cost of health care	52	213	448
Cost to productivity	513	461	4 056
Premature mortality	478	350	3 412
Absenteeism	35	111	644
TOTAL	1 069	3 157	13 191
% of GDP	0.4%	3.1%	1.0%

Source: Prepared by the authors based on official data from countries.

Unit costs, defined as the quotient between NPV (2015–2078) and the affected population,[52] are shown in table 21. For undernutrition, the total unit cost increases to US$4,509 in Ecuador and US$7,285 in Mexico. For overnutrition, in turn, the total unit cost is US$3,475 in Chile, US$14,061 in Ecuador, and US$6,755 in Mexico.

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52 The population affected by malnutrition due to deficit is the total number of children between 0 and 4 years of age who present chronic malnutrition in the year of analysis. Malnutrition due to excess consists of all adults older than 20 who are overweight or obese, also in the year of analysis.

Expressed in this way, in Mexico the unit cost associated with malnutrition due to deficit is greater than that for malnutrition due to excess. In the case of Ecuador this relationship is reversed, at least in part, and explained by the greater average cost of treatment for higher-burden chronic pathologies.

Table 21: Unit cost of malnutrition, 2015–2078

(In dollars)

	Chile		Ecuador		Mexico	
	Under-nutrition	Overweight and obesity	Under-nutrition	Overweight and obesity	Under-nutrition	Overweight and obesity
Health care	-	1 807	24	12 008	31	4 678
Education	-	-	25	-	22	-
Productivity	-	1 669	4 460	2 053	7 232	2 077
TOTAL	-	3 475	4 509	14 061	7 285	6 755

Source: Prepared by the authors based on official data from countries.

3

Final comments and conclusion

The evidence gathered in the present study confirms how important and a priority it is to undertake the analysis of the double burden of malnutrition and, at the same time, consider the importance of public policies that address undernutrition and obesity jointly. From a social perspective, there is a considerable burden of disease and mortality associated with malnutrition, as well as its effects in educational and labour terms. These effects, in turn, constitute an important loss of economic resources for the countries.

The need to advance in the development of methodologies and in recording information to deepen the study of micronutrient deficiencies and nutritional imbalance is also evidenced. It will also be relevant to incorporate, in future analyses, the whole of the effects of early malnutrition, both intra and intergenerational (Black et al 2013). The methodological challenge is to measure these effects without an overestimation due to an overlapping of consequences. Environmental implications are also something that should be incorporated into an upcoming model of analysis.

Lessons learned and replicability

A review of the available evidence, as well as the exchange of experiences during the process of design and implementation of the model, revealed central elements of the phenomenon, both in relation to the degree of association between undernutrition and obesity, as well as its impact on non-communicable diseases throughout an adult's life. It is certainly not sufficient to identify such associations to estimate effects and costs in a national reality; it is essential to have relative risk estimators that are valid and reliable for the application of the model. In this regard, there is still a long way to go in the region to have own data in the different areas of relationships, but the validation of estimators at the global level has allowed forward progress in this area up to now, with a level of validity deemed acceptable for the purposes of this pilot study.

Both in the design phase of an analysis model and in its execution, is necessary to consider the correct way of interpreting its basic parameters and its limitations. For example, models using *population attributable fractions* (PAF), previously estimated, are based on prevalence of risk exposure for the years in which they were estimated. It is also key to be clear about the temporal horizons if used by alternative models, as well as in relation to the population considered in the analysis. In this sense, a model that follows population groups of certain ages is different from one that follows the same cohort for a certain period. Each model has advantages and disadvantages; they may coincide in some aspects, but their results must be interpreted considering their own characteristics.

Building the analysis model used in required systematic organization of evidence on associations, the identification of indicators appropriate to the reality of each country, and the availability of data. The fact that this model is inductive in nature has been very useful in this process. Access to meta-analysis allowed for the development of a list of estimators for risk parameters from which it was possible to estimate the magnitude of many of the effects associated with malnutrition, although not all of which are conceptually desirable. That is, the model does not include all the multiple associations and interactions between the variables identified. Nevertheless, it has been possible to validate a sufficiently reliable and replicable model, considering the availability of data in the countries in the region.

3. Final comments and conclusion

Among the difficulties encountered when designing the model, the following four are noteworthy:

- The need to discriminate between different sources of studies and to organize a conceptual framework that accounts for the diversity and complexity of the phenomenon. For example, the operative incorporation of the link between undernutrition and obesity in a cost model of malnutrition requires more consolidated evidence in this regard. Cohort-based studies are an interesting line of research that will likely allow for the expansion of the operational complexity of models such as the one designed.

- Harmonize disciplinary perspectives, from the world of nutrition and health through economic analysis and social policy.

- adjust conceptual models to the availability of possible to be used to estimate not only associations, but to infer effects and estimate costs in specific national realities.

- select valid relative risk estimators valid for different national contexts.

The implementation of the proposed model, on the other hand, has imposed significant challenges and resulted in various adjustments made. These include the limitations on operational data in the countries, both in relation to health care protocols and their costs, which has involved using, for example, aggregate cost estimators or estimators derived from other contexts.

Notwithstanding the former, the experience of this first pilot project has shown that the model can be adjusted to the limitations observed, and that it is feasible to implement it in different national contexts in the region. In turn, the magnitudes observed for some of the variables, both in the volume of effects and costs, would even allow the elabouration of simplified alternatives for their application, working with minimal sets of pathologies and some more aggregated estimators in education. This would allow gain in efficiency and adaptability in contexts with less available data, without major losses in reliability, but accepting that the resulting estimates would be more limited.

This pilot study has also allowed us to gain experience from the three participating countries, useful for designing future implementation processes to be used in other countries. In Chile, a similar study was under way, promoted by the Ministry of Health and the Universities of Chile and Santiago de Chile, which facilitated the installation and start-up of the study. There was also an information system available which, despite not being fully integrated, allowed the extraction of data on prevalence/incidence and on adequate costs for the model designed. The latter were not disaggregated, but sufficient to make estimates on average costs, differentiated by sex. On the other hand, the consolidation of a national technical team with experience in this type of studies facilitated the recording of data and the discussion of the results.

Mexico, has two studies of the cost of overweight and obesity (2008 and 2015) carried out by the Ministry of Health. This also allowed a national team with ample experience to be created. Mexico also has a good information system to complete the registrations required by the model.

The experience in Ecuador for this type of studies dates to 2005 and its participation in the Cost of Hunger; in addition, the country had advanced work in health care costing exercises. A technical team with recent experiences in this type of analysis was also available in addition to the high commitment of the government to develop the pilot study.

The characteristics indicated for the participating countries are relevant when carrying out this type of studies, and must be considered for their replicability. In this case, both the national experience and the commitment to the objectives of the study helped to facilitate the work and finishing and to do so within a reasonable time frame. After eight months, counting from the beginning of the field work, the preliminary data was already being validated with the national counterparts.

It is important to emphasize the value of having, in country, a health care economy area that is actively involved. This is particularly relevant for drawing up estimates of health care costs for chronic pathologies, more complex in comparison with acute diseases. This type of collabouration was obtained in the three participating countries. This is an area of specialty that must be provided to countries if they do not have it.

Having up-to-date epidemiological and cost, both consistent over time, was also a common characteristic in the pilot countries. The dated epidemiological reports, given the changes seen in recent years, is a matter to consider when undertaking this type of study in some of the countries in the region.

One of the suggestions that can be made considering the results obtained and given the possible restrictions that could be faced in some countries is the possibility of reducing the number of pathologies associated with overweight and obesity, as indicated above; DM2 and AHT represent nearly 90 % of the costs.

Findings and use

The following are some of the estimates reported here, which reflect the magnitude of the effects and consequences of malnutrition. However, we must first remember that there are significant differences in the temporal horizon of effects and economic consequences between undernutrition and overweight/obesity.

In fact, the most important economic consequence of undernutrition is related to lost productivity, and this does not occur until the affected population reaches the working age and then extends throughout the entire working period. In contrast, lost productivity associated with overweight and obesity occur simultaneously, since the population analysed is already of working age.

Among the main results observed, the following should be highlighted. It is estimated that during the last 65 years there were more than two million deaths associated with chronic malnutrition in children under five in Mexico and 300,000 in Ecuador. Similarly, 14 % and 16 % of episodes of acute respiratory infections (ARI), as well as 3 % and 4 % of cases of acute diarrheal disease (EDA) are associated with malnutrition in these two countries. In terms of its effects on education, it was observed that 32 % of school repetition in Ecuador and 16 % of this in Mexico is associated with malnutrition suffered before the age of five.

With respect to overweight and obesity, it was estimated that three million cases of chronic diseases in Chile, one million in Ecuador and 21 million in Mexico were associated with overweight in 2014. These figures are projected to increase to 2030 in 40 %, 63 % and 46 %, respectively. Overnutrition is also associated with a significant mortality burden that for the year of analysis amounted to about 12,000 cases in Chile, 10,000 in Ecuador and 87,000 in Mexico. By 2030, that burden will increase by 13 % in Chile and 26 % in Ecuador and Mexico.

For the year of analysis, *incidental-retrospective dimension,* the total costs of the double burden of malnutrition in relation to GDP, represent 0.2 % in Chile, 4.3 % in Ecuador and 2.3 % in Mexico. Disaggregated by type of malnutrition, the cost associated with malnutrition amounts to 2.6 % in Ecuador and 1.7 % in Mexico, while for malnutrition by excess this cost amounts to 0.2 % in Chile, 1.7 % in Ecuador and 0.6 % in Mexico.

The future cost of lost productivity, because of undernutrition, amounts to US$1.8 billion and US$11.4 billion in Ecuador and Mexico, respectively. In relation to overweight and obesity, the lost productivity is US$13.0 billion and US$114.8 billion for the same two countries.[53]

The differences for the same country seem enormous. A direct comparison between these figures reveals that overnutrition would have a higher cost than undernutrition, about 7.6 times in Ecuador, and nearly 10 times in Mexico. However, this gap is much lower if illustrated in relation to the size of the age ranges used. Note that in Ecuador, the population aged 20 and older is six times larger than the population aged 0 to 4 years; in Mexico, the ratio is equal to seven. Thus, relative to the size of the population analysed, overnutrition weights about 20 % more than undernutrition and 43 % more in Mexico.

The cost in health is particularly relevant for overnutrition, highlighting the derived from the burden of diabetes (DM2) and hypertension (AHT). The costs to the health care system associated with these two pathologies in 2014 reached US$330.0 million in Chile, US$1.5 billion in Ecuador, and US$6.1 billion in Mexico. Based on the projections, in the next 45 years these costs will grow around 70 % in Chile and in Mexico, and almost 150 % in Ecuador, only for the population in force in2014 and keeping constant the existing epidemiological profile from the same year.

Although the highest costs of the double burden are attributed to the increased burden of pathologies associated with overweight and obesity, nutritional and health policies cannot overlook the importance of undernutrition, especially given its irreversible impact throughout the life cycle. In fact, given the consolidation of the evidence regarding the link between undernutrition and obesity, policies must be oriented to multi-causal focuses of malnutrition (access to basic services and safe food, eating habits, etc.) that include interventions throughout the life cycle.

Although this linkage, overweight and obesity in the child population is not included in the model, because of the absence of indicators and to avoid possible double counting problems; it is a key issue both at the policy level and in estimating associated social and economic costs. In Ecuador, 19.1 % of school-age children were overweight and 12.1 % were obese, for a combined prevalence of 31.2 % in 2014. Comparing these values with prevalences in younger children, it seems that overnutrition becomes exacerbated starting at age 5. As other studies show, the cost associated with overnutrition in children is currently significant.

Malnutrition is related to the different types of inequalities that exist in Latin America. In this sense, policies should consider the concentration of undernutrition in different geographic areas and vulnerable groups. The lack of access to quality food has implications on overweight and obesity and this disproportionally affects lower-income families. A study conducted in 2015 by the Chilean Ministry of Health (MINSAL, et al., 2015), estimated that a basket of quality foods (BQF), which includes more fruits and vegetables, would cost 36.1 % more than a basic food basket, and that 27.1 % of the population would not have sufficient income to purchase it.

Policies that consider programmes and interventions are key for decreasing the prevalence of overweight and obesity. These policies should be designed considering the empirical evidence of their cost-effectiveness in other contexts. For example, long term interventions focused on high-risk, as well as the regulation of advertising aimed at children, are matters to keep in mind (Cecchini & Sassi, 2015).

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53 The numbers reported are for the NPV of the entire period (until 2078) with a discount rate of 3 %.

Chile shows some progress in this area in the last decades, with nutritional policies centred on overnutrition, after eliminating undernutrition. Among them is the increase from 13% to 18% in the sugar-sweetened beverage tax. Another policy, of a structural in nature, is the incorporation of regulatory elements into food advertising, by placing restrictions on advertising unhealthy foods directed towards children under 14 years.

In Ecuador, undernutrition has captured the most attention from the State. Following the Chronic Malnutrition Accelerated Reduction Project, which began in 2009, the purpose of which was to consolidate a strategy to coordinate sector interventions in prioritized territories, the nutritional policy continued through the National Strategy for Nutrition Action, which focused on institutionalising the interventions of the ministries involved, with funds from current expenses and investment, with the Coordination Ministry of Social Development as the coordinator. Some of its components are the increased coverage of child development services, guaranteeing accessibility, the consumption of micronutrients, and healthy foods, and improving access of homes to the basic services of potable water and sanitation. Regarding overnutrition, as of 2009, targets for reducing the prevalence of obesity in school children were included (reduction to 5%) in the National Plan for Good Living 2009–2013. Among the first interventions implemented to promote good eating habits and to prevent overweight and obesity, implemented between 2009–2011, included health promotion activities in private and public schools, in a joint effort between the Ministry of Health and the Ministry of Education.

Finally, during the last decade in Mexico, PROGRESA (named Opportunities 2007–2012), nowadays called PROSPERA (2013–2018) has been the axis of social policy and the main food programme in Mexico (Ávila-Curiel A., et al., 2011). Among the federal food aid and capacity creation programmes with greater coverage is the Programme for Social Inclusion–PROSPERA, which serves slightly over six million families throughout the country, the Food Support Programme serves nearly one million homes, the Social Programme to Supply Milk with 3.3 million beneficiary households, and the Rural Supply Programme that covers 15,000 locations throughout the country. Among policies aimed at overnutrition are the National Agreement on Food Health, a strategy against overweight and obesity (ANSA), promoted by the Ministry of Health in 2010. Under this agreement, the Ministry of Public Education and the Ministry of Health developed a programme within the school context with components to improve nutritional information, promote physical activity and regulate food and beverages in schools.

The information presented here provide solid grounds for the debate and formulation of policies and strategies that are sustainable in the medium and long term, that reduce the effects of malnutrition on the population and its negative and increasing economic consequences for the country.

List of Acronyms

ADE Acute Diarrhoeal Event
AEC Annual Equivalent Cost
AHT Arterial Hypertension
ANSA National Agreement on Food Health
ARI Acute Respiratory Infection
BQF Basket of Quality Foods
DM2 Diabetes Mellitus Type 2
EC^U Educational Costs due to undernutrition
ECLAC Economic Commission for Latin America and the Caribbean
EPC^U Educational Private Costs due to undernutrition
ESC^U Educational System Costs due to undernutrition
FNS Food and Nutrition Security
GDP Gross Domestic Product
HC^U Health Costs due to undernutrition
HPC^O Health Private Costs due to overnutrition
HPC^U Health Private Costs due to undernutrition
HSC^O Health System Cost due to overnutrition
HSC^U Health System Cost due to undernutrition
IUGR Intrauterine Growth Restriction
LBW Low Birth Weight
LEC^U Lower Educational Costs due to undernutrition
MMC^U Mortality Costs due to undernutrition
NCD Non-Communicable Disease
NPV Net Present Value
PAHO Pan-American Health Organization
PAF Population Attributable Factor
PC^O Productivity Costs due to overnutrition
PC^U Productivity Costs due to undernutrition
RPr Ratio of Probability of Repetition
RR Relative Risk
SDG Sustainable Development Goals
TC^U Total Costs due to undernutrition
TC^O Total Costs due to overnutrition
WAP Working-Age Population
WFP World Food Programme
WHO World Health Organization

Bibliography

Adair, et al. (2013). Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. Lancet.

Albala, C., Olivares, S., Salinas, J. and Vio, F. (2004), Bases, prioridades y desafíos de la promoción de salud. Universidad de Chile, Instituto de Nutrición y Tecnología de los Alimentos. Santiago. [Bases, priorities and challenges of promoting health. University of Chile, Institute of Nutrition and Food Technology. Santiago.]

Alderman, H. and Behrman, J. (2006). Reducing the Incidence of Low Birth Weight in Low-Income Countries has Substantial Economic Benefits. World Bank Research Observer. 21:1, Washington D.C.

Arcand, Jean-Louis (2001). Undernourishment and Economic Growth. The Efficiency Cost of Hunger". In: FAO Economic and Social Development Paper 147, Rome.

Ávila-Curiel, A., Flores Sánchez, J., Rangel Faz, G. La Política Alimentaria en México. Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria. Ciudad de México: Cámara de Diputados; 2011. [Food Policy in Mexico. Centre for Sustainable Rural Development Studies and Food Sovereignty. Mexico City: House of Representatives; 2011.]

Barker, D.J.P. (2004). The Developmental Origins of Adult Disease. Journal of the American College of Nutrition 23.

Barker, et al. (2005). Trajectories of Growth among Children Who Have Coronary Events as Adults. N Eng J Med 353;17. 27 October 2005.

Bhutta, et al. Lancet series: What works? Interventions for maternal and child undernutrition and survival. Lancet, January 2008.

Bhutta, et al. Lancet series: Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost. Lancet, June 2013.

Black, et al. Lancet series: Maternal and Child Nutrition 1. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet, June 2013.

Bloom, et al. 2011. The Global Economic Burden of Non-Communicable Diseases. Geneva: World Economic Forum

Bonilla, M. Promoting Healthy Living in Latin America and the Caribbean. Governance of Multi-Sectorial Activities to Prevent Risk Factors for Non-Communicable Diseases. World Bank 2014.

Brabin, Hakimi and Pelletier (2001). An Analysis of Anaemia and Pregnancy-Related Maternal Mortality Journal of Nutrition. 2001;131:604S-615S.).

Branca, F. and Ferrari, M. (2002). Impact of Micronutrient Deficiencies on Growth: The Stunting Syndrome. Annual of Nutrition and Metabolism. Vol. 46, (sup.1).

Butland, B., Jebb, S., Kopelman, P. et al. (2007). Foresight Tackling Obesities: Future Choices–Project Report. London: Government Office for Science.

Caird, J., Kavanagh, J., Oliver, K. et al. Does being overweight impede academic attainment: A systematic review. EPPI-Centre, Social Science Research Unit, Institute of Education, University of London. 2011; report no. 1901.

Cawley, J. (2004) The Impact of Obesity on Wages. Journal of Human Resources; 39(2): 451–74.

Cawley, J. & Meyerhoefer, C. (2012). The medical care costs of obesity: an instrumental variables approach. Journal of Health Economics; 31(1): 219–230.

Cecchini, M., Sassi, F. (2015). Preventing Obesity in the USA: Impact on Health Service Utilization and Costs. PharmacoEconomics (2015) 33: 765.

CEPAL, (2016). Plan para la seguridad alimentaria, nutrición y erradicación del hambre de la CELAC 2025. Naciones Unidas, Santiago. [ECLAC (2016). Plan for food security, nutrition, and eradication of hunger, CELAC 2025. United Nations, Santiago.]

_____ (2003), Panorama Social de América Latina 2001–2002. Santiago, Chile. [Social Panorama of Latin America 2001–2002. Santiago, Chile.]

CEPAL, FAO, ALADI (2016). Seguridad Alimentaria, nutrición y erradicación del hambre, CELAC 2025. Naciones Unidas, Santiago. [ECLAC, FAO, ALADI (2016). Food security, nutrition and eradication of hunger, CELAC 2025. United Nations, Santiago.]

Dannenberg, A., Burton, D., Jackson, R. Economic and environmental costs of obesity: the impact on airlines. Am J Prevent Med. 2004; 27(3): 264

Dietz, W.H. (1993). Critical periods in childhood for the development of obesity. Am j clin nutr. 59: 955–959.

Drake, A.J., Walker, B.R. The intergenerational effect of foetal programming: non-genomic mechanisms for the inheritance of low birth weight and cardiovascular risk. Journal of Endocrinology, 2004; 180: 1–16.

Emmanuel, I. Maternal Health during Childhood and Later Reproductive Performance. Annals of the New York Academy of Science; 1986: 477: 27–39.

Estabrooks, P., Lee, R., Gyurcsik, N. (2003). Resources for physical activity participation: Does availability and accessibility differ by neighbourhood socioeconomic status? Annals of Behavioural Medicine 25: 100–104.

Fall, C. (2013). Foetal Programming and the Risk of Non-Communicable Disease. Indian Journal of Paediatrics.

Flegal, K., Graubard, B., Williamson, D. (2014). Methods of Calculating Deaths Attributable Fraction. American Journal of Epidemiology, 160: 331–338.

FAO (2006). The double burden of malnutrition: case studies from six developing countries. Rome (Italy) FAO.

_____ (2003). Nutrition intake and economic growth. Studies on the cost of hunger. Rome (Italy).

Freire, W., Silva-Jaramillo, K., Ramirez-Luzuriaga, M., Belmont, P., Waters, W. (2014). The double burden of undernutrition and excess body weight in Ecuador. The American Journal of Clinical Nutrition, 100: 1636S–43S.

Friedemann, C., Heneghan, C., Mahtani, K., et al. (2012). Cardiovascular disease risk in healthy children and its association with body mass index: systematic review and meta-analysis. British Medical Journal (BMJ); 345: e4759.

Frone, M.R. (2007). Obesity and absenteeism among US workers: do physical health and mental health explain the relation? J Workplace Behav Health; 22(4): 65–79.

Geier, A.B., Foster, G.D., Womble, L.G., et al. The relationship between relative weight and school attendance among elementary schoolchildren. Obesity (Silver Spring). 2007;15(8):2157–2161.

Gutiérrez-Delgado, C., Guajardo-Barón, V. (2008). Impacto financiero de la obesidad en la salud de la población Mexicana. Versión preliminar al 30 de septiembre del 2008. [Financial impact of obesity on the health of the Mexican population. Preliminary version dated 30 September 2008.]

González-Gross, M., Meléndez, A. (2013). Sedentarism, active lifestyle and sport: Impact on health and obesity prevention. Nutrición Hospitalaria [Hospital Nutrition], 2013.

Gortmaker, S.L., Must, A., Perrin, J.M., Sobol, A.M., Dietz, W.H. Social and economic consequences of overweight in adolescence and young adulthood. New Engl J Med 1993; 329: 1008 ± 1012.

Guilkey, D. and Riphahn, R. (1998). "The Determinants of Child Mortality in the Philippines: Estimation of a Structural Model." Journal of Development Economics.

Hammond, R. A., & Levine, R. (2010). The economic impact of obesity in the United States. Diabetes, metabolic syndrome and obesity: targets and therapy, 3, 285.

Hoffman, et al. (2000). Why are nutritionally stunted children at increased risk of obesity? Studies of metabolic rate and fat oxidation in shantytown children from São Paolo, Brazil. American Journal of Clinical Nutrition, 72: 702–707, 2000.

Horton, S. and Ross, J. (2003). The Economics of Iron Deficiency. Food Policy 28.

INCAP, OPS (2002). La iniciativa de seguridad alimentaria nutricional en Centroamérica. 2da edición. [INCAP, PAHO (2002). The initiative of nutritional food security in Central America. 2nd edition.]

Lightwood, J., Phibbs, C., and Glantz, S. (1999). Short-term Health and Economic Benefits of Smoking Cessation: Low Birth Weight". Paediatrics". Vol. 104 No. 6 December.

Jae Heon Kang, Baek Geun Jeong, Young Gyu Cho, Hye Ryoung Song and Kyung A. Kim. (2011). Socioeconomic Costs of Overweight and Obesity in Korean Adults.

Janssens, H., Clays, E., Kittel, F. et al. The association between body mass index class, sickness absence, and presenteeism. Journal of Occupational and Environmental Medicine 2012; 54(5): 604–609.

Kaestner, R., Grossman, M., Yarnoff, B. (2009). Effects of weight on adolescent educational attainment. National Bureau of Economic Research. Working Paper 14994.

Koning, A. M. H., Kuchenbecker, W. K. H., Groen, H., Hoek, A., Land, J. A., Khan, K. S., & Mol, B. W. J. (2010). Economic consequences of overweight and obesity in infertility: a framework for evaluating the costs and outcomes of fertility care. Human reproduction update, 16(3), 246–254.

Kroker-Lobos, M., Pedroza-Tobías, A., Pedraza, L., Riversa, J. (2014). The double burden of undernutrition and excess body weight in Mexico. The American Journal of Clinical Nutrition, 100: 1652S–8S.

Lehnert, T., Sonntag, D., Konnopka, A., Riedel-Heller, S., & König, H. H. (2013). Economic costs of overweight and obesity. Best Practice & Research Clinical Endocrinology & Metabolism, 27(2), 105–115.

Llorca, J., Fariñas-Álvarez, C., Delgado-Rodríguez, M. (2001). Fracción atribuible poblacional: cálculo e interpretación. Gaceta Sanitaria, 15(1): 61–67. [Population attributable fraction: calculation and interpretation. Sanitary Gazette, 15(1):61–67.]

Martínez, R., Fernández, A. (2006). Modelo de análisis de impacto social y económico de la desnutrición infantil en América Latina. Serie Manuales. División de Desarrollo Social. CEPAL, Naciones Unidas. Santiago. [Analysis model of the social and economic impact of young child undernutrition in Latin America. Series of Manuals. Division of Social Development. ECLAC, United Nations. Santiago.]

_____ (2007). El costo del hambre: Impacto social y económico de la desnutrición infantil en Centroamérica y República Dominicana. División de Desarrollo Social. CEPAL, Naciones Unidas. Santiago. [The cost of hunger: The social and economic impact of young child undernutrition in Central America and the Dominican Republic. Division of Social Development. ECLAC, United Nations. Santiago.]

_____ (2009). El costo del hambre: Impacto social y económico de la desnutrición infantil en el Estado Plurinacional de Bolivia, el Ecuador, Paraguay y el Perú. División de Desarrollo Social. CEPAL, Naciones Unidas. Santiago. [The cost of hunger: The social and economic impact of young child undernutrition in the Pluri-National State of Bolivia, Ecuador, Paraguay and Peru. Division of Social Development. ECLAC, United Nations. Santiago.]

Martínez, R., Palma, A. (2016). Seguridad alimentaria y nutricional en cuatro países andinos. Serie Políticas Sociales. División de Desarrollo Social. CEPAL, Naciones Unidas. Santiago. [Food and nutritional security in four Andean countries. Social Political Series. Division of Social Development. ECLAC, United Nations. Santiago.]

Martorell, Reynaldo. (1995). Results and implications of the INCAP follow-up study. Journal of Nutrition 1995; 125(suppl).

Michaelowa, A., Dransfield, B. (2006). Greenhouse gas benefits of fighting obesity. Ecolog Econ. 2008;66 (2–3): 298–308.

Ministerio de Salud de Chile, OPS, CEPAL (2015). Estudio sobre el cálculo de indicadores para el monitoreo del impacto socioeconómico de las enfermedades no transmisibles en Chile. [Chilean Ministry of Health, PAHO, ECLAC (2015). Study on calculating indicators for monitoring the socio-economic impact of non-communicable diseases in Chile.]

Narbro, K., Jonsson, E., Larsson, B., Waaler, H., Wedel, H., Sjostrom, L. Economic consequences of sick leave and early retirement in obese Swedish women. Int J Obes Relat Metab Disord 1996; 20: 895–903.

Nicte-Ha, D., Gutiérrez, C. (2015). Impacto financiero del sobrepeso y la obesidad en México 1999–2023. Secretaría de Salud. Unidad de Análisis Económico. [Financial impact of overweight and obesity in Mexico 1999–2023. Secretary of Health. Economic Analysis Unit.]

OPS, (2002). Informe sobre la salud en el mundo, Ginebra. [WHO, (2002). Report on worldwide health. Geneva.]

OPS, (2012). Observatorio Regional de Salud (en línea). [PAHO (2012). Regional Observatory of Health (online).]

Painter, et al. (2005). Micro albumin in Adults after Prenatal Exposure to the Dutch Famine. J am Soc Nephrol 16: 189–194.

Parsons, T.J., Power, C., Logan, S., Summerbell, C.D. Childhood predictors of adult obesity: a systematic review. Int J Obes 1999; 23: S1–S107.

Pelletier, D.L., et al. (1995). "Malnutrition and Child Mortality". http://www.basics.org/pdf.

Pichón Riviere, A., Bardach, A., Caporale, J., Alcaraz, A., Augustovski, F., Caccavo, F., Vallejos, V., Velazquez, Z., De La Puente, C., Bustos, L., Castillo Riquelme, M., Castillo Labourde, C. Carga de Enfermedad atribuible al Tabaquismo en Chile. Documento Técnico IECS N° 8. Instituto de Efectividad Clínica y Sanitaria, Buenos Aires, Argentina. Abril de 2014. [Burden of disease attributable to tobacco use in Chile. IECS Technical Document No. 8. Institute of Clinical and Sanitary Effectiveness, Buenos Aires, Argentina. April 2014.]

Popkin, et al. (1996). Stunting is Associated with Overweight in Children of Four Nations that are undergoing the Nutrition Transition. J Nutr; 26:3009–16.

Ramarskishnan, U., Martorell, R., Schroeder, D.G., Flores, R. Role of intergenerational effects on linear growth. J Nutr 1999; 129: 544S–549S.

Rivera, J. Gonzalez, T., Pedraza, L., Aburto, T., Sanchez, T., Martorell, R. 2013. Childhood and adolescent overweight and obesity in Latin America: a systematic review. Lancet Diabetes Endocrinol 2013.

Rivera, J., et al. (2015). The double burden of malnutrition: the combined economic impact of undernutrition and obesity in Latin America and the Caribbean (Concept note of the project, not published).

Rockhill, B., Newman, B., Weinberg, C. (1998). Use and misuse of Population Attributable Fractions. American Journal of Public Health, 88(1): 15–19.

Roseboom, et al. (2000). Coronary heart disease after prenatal exposure to the Dutch famine 1944–45. Heart 84: 595–598.

Ruel, M., Rivera, J., Habicht, J. and Martorell, R. (1995). Differential response to early nutrition supplementation: long-term effects on height at adolescence International Journal of Epidemiology, 1995 Apr;24(2).

Sarmiento, O., Parra, D., González, S., González-Casanova, I., Forero, A., García, J. (2014). The dual burden of malnutrition in Colombia. The American Journal of Clinical Nutrition, 100: 1628S–35S.

Victora, et al., Lancet series: Maternal and child undernutrition: consequences for adult health and human capital. Lancet, January 2008.

Victora, et al., Lancet series: Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effects. Lancet, January 2016.

Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L. & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. The Lancet, 378(9793), 815–825.

WFP, (2002). VAM Standard Analytical Framework. www.wfp.org.

WHO, (2004). Comparative Quantification of Health Risks. Global and Regional Burden or Disease Attributable to Selected Major Risk Factors. Edited by Ezzati, M., López, A., Rodgers, A. and Murray, C. Geneva.

WHO (2005). Preventing chronic diseases: a vital investment. (http://www.who.int/chp/chronic_disease _report /part2_ch1/en/index2.html) (Accessed 2 May 2014).

WHO, PAHO (2007). Alcohol and public health in the Americas.

WHO (2010). Global Status Report on Non-communicable diseases, Geneva.

Withrow, D. & Alter, D.A. (2010). The economic burden of obesity worldwide: a systematic review of the direct costs of obesity. Obesity Reviews; 12(2): 131–141.

Uauy, R., Kain, J., Rojas, J., Corvalán, C. Nutrition, child growth and chronic diseases prevention. Annals of Medicine, 2008: 40: 11–20.

UNICEF, (2005). Child mortality statistics. http//www.childinfo.org/cmr/revis/db2.htm.

Web References

WHO, 2016. http://www.who.int/healthinfo/global_burden_disease/tools_software/en/. Accessed on 19 January 2016.

_____http://www.who.int/topics/millennium_development_goals/child_mortality/es/. Accessed on 26 January 2016.