Clinica e Investigacion en Arteriosclerosis 34 (2022) 3–16

Sociedad Española de Arteriosclerosis

CLÍNICA E INVESTIGACIÓN EN ARTERIOSCLEROSIS

www.elsevier.es/arterio

SPECIAL ARTICLE

Challenges and perspectives of the double burden of malnutrition in Latin America

Ángela Hernández-Ruiz[a], **Casandra Madrigal**[a,b], **María José Soto-Méndez**[a], **Ángel Gil**[a,c,d,e,f,*]

[a] *Iberoamerican Nutrition Foundation (FINUT), Av. Del Conocimiento 12, 3.ª pta., Armilla 18016, Granada, Spain*
[b] *Department of Nutrition and Food Science, Faculty of Pharmacy, University of Granada, Granada, Spain*
[c] *Department of Biochemistry and Molecular Biology II University of Granada, University of Granada, Granada, Spain*
[d] *Institute of Nutrition and Food Technology ''José Mataix,'' Biomedical Research Center, University of Granada, Granada, Spain*
[e] *Biosanitary Research Institute IBS.GRANADA, Granada University Hospital Complex, Granada, Spain*
[f] *CIBEROBN (Physiopathology of Obesity and Nutrition), Instituto de Salud Carlos III, Madrid, Spain*

Received 12 November 2021; accepted 22 November 2021

KEYWORDS
Cardiovascular diseases;
Diabetes, type 2;
Malnutrition;
Overweight;
Obesity;
Undernutrition

Abstract Nutrition is a key factor in the development of non-communicable chronic diseases (NCCDs), especially cardiovascular diseases (CVD) and their risk factors. The ''double burden of malnutrition'' (DBM) is the coexistence of undernutrition and overnutrition in the same population across the life-course. In Latin America, the transition from a predominantly underweight to an overweight and obese population has increased more rapidly than in other regions in the world.

Undernutrition and the micronutrient deficiencies particularly iron, zinc, and vitamins A and D, present high heterogeneity in Latin American countries, and are currently considered important public health problems. In this region, NCCDs account for 50% of the disability-adjusted life-years, led by CVD. The most prevalent cardiovascular risk factors are overweight, obesity, hypertension, dyslipidemia and type 2 diabetes mellitus. Because of the cost of treatment and the potential years of life lost due to premature death, CVD is known to affect the poorest segments of the population, affecting communities, and governments. More than 80% of CVD deaths occur in low- and middle-income countries. The persistence of damage in some cells due to undernutrition may explain certain findings regarding the increase in NCCD. These aspects together with epigenetic changes have highlighted the importance of a lifelong approach to nutritional policy development.

* Corresponding author.
E-mail address: agil@ugr.es (Á. Gil).

Reducing DBM requires major societal interventions in public health and nutrition to achieve holistic change that can be sustained over the long term and spread throughout the global food system. The implementation of effective state policies of double impact actions should influence both sides of the burden and be considered an urgent priority, considering country-specific inequalities and socio-demographic differences in the Latin American region, using diverse and multidisciplinary strategies.

PALABRAS CLAVE
Enfermedades cardiovasculares;
Diabetes mellitus tipo 2;
Desnutrición;
Sobrepeso;
Obesidad;
Desnutrición

Desafíos y perspectivas de la doble carga de la malnutrición en América Latina

Resumen La nutrición es un factor clave en el desarrollo de las enfermedades crónicas no transmisibles (ECNT), especialmente las enfermedades cardiovasculares (ECV) y sus factores de riesgo. La ''doble carga de la malnutrición'' (DCM) es la coexistencia de desnutrición por defecto y por exceso de nutrientes en la misma población a lo largo del curso de vida. En América Latina, la transición de una población predominantemente desnutrida a otra con sobrepeso y obesidad ha aumentado más rápidamente que en otras regiones del mundo.

La desnutrición y las deficiencias de micronutrientes, especialmente de hierro, zinc y vitaminas A y D, presentan una gran heterogeneidad en los países latinoamericanos y se consideran actualmente importantes problemas de salud pública. En esta región, las ECNT representan el 50% de los años de vida ajustados por discapacidad, encabezados por las ECV. Los factores de riesgo cardiovasculares más prevalentes son el sobrepeso, la obesidad, la hipertensión, la dislipidemia y la diabetes mellitus tipo 2. Debido al coste del tratamiento y a los años de vida potencialmente perdidos debido a la muerte prematura, se sabe que las ECV afectan a los segmentos más pobres de la población, implicando a las comunidades y a los gobiernos. Más del 80% de las muertes por ECV se producen en países de ingresos bajos y medios. La persistencia del daño en algunas células debido a la desnutrición puede explicar ciertos hallazgos relacionados con el aumento de las ECNT. Estos aspectos, junto con los cambios epigenéticos, han puesto de manifiesto la importancia de un enfoque permanente en el desarrollo de políticas nutricionales.

La reducción de la DCM requiere importantes intervenciones sociales en materia de salud pública y nutrición para lograr un cambio holístico que pueda mantenerse a largo plazo y extenderse a todo el sistema alimentario mundial. La implementación de políticas estatales efectivas de acciones de doble impacto debe influir en ambos lados de la carga y ser considerada una prioridad urgente, teniendo en cuenta las desigualdades específicas de cada país y las diferencias sociodemográficas en la región latinoamericana, utilizando estrategias diversas y multidisciplinarias.

Introduction

At all stages of the life cycle, diet and nutrition, are key factors associated with the development of numerous non-communicable chronic diseases (NCCDs), including cardiovascular diseases (CVD), hypertension, type 2 diabetes mellitus (T2DM), and cancer.[1]

International public health has been successful in overcoming major deficiencies with health consequences. In Latin-American countries, there is a continuing struggle to fight the issues of undernutrition.[2] These countries are starting to have an even greater burden due to overnutrition. This situation is due to the nutrition transition and changes in dietary habits and lifestyles, which have resulted in new conditions with notable consequences on health. The variables associated with the nutrition transition and the obesity epidemics can be grouped into approaches, which include the following domains with respect to different environments: health/biological, economic/food, physical/built, and socio-cultural.[3]

In relation to ''severe acute undernutrition'' the World Health Organization (WHO) defines it as a weight-for-length/height below −3 *z*-scores of the median WHO growth standards or severe wasting; ''moderate to acute undernutrition'' is characterized by weight-for-age between −2 and −3 *z*-scores below the median growth standards and may refer to low weight-for-height or low height-for-age, or a combination. The term ''chronic undernutrition'' refers to linear growth failure, failure to thrive or stunting. This type of malnutrition is based on the child being

below −2 standard deviations for the length/height-for-age growth indicator. The term ''hidden hunger'' refers to lack of compliance with micronutrient intake targets.

The ''double burden of malnutrition'' (DBM) is the coexistence of undernutrition and overnutrition in the same population across the life-course.[4] DBM concerns all countries and is particularly worrying in regions with high levels of stunting. The consequences of DBM are huge and have important repercussions associated with impaired child growth and development, increased susceptibility to infectious diseases, and increased risk of overweight, especially in terms of increased risk of visceral fat and of NCCDs, later in life.

Solutions to fight the effects of DBM are well recognized in each of its aspects, both undernutrition and overnutrition. However, at the present time the solutions have not been combined with each other and with the overall policy and programmatic frameworks.[5] Awareness raising, and joint study and research in each approach is therefore essential to avoid serious future consequences, especially for low- and middle-income countries.

Although malnutrition in all its forms and the DBM have been studied for decades, they continue to be public health problems of great importance that affect different countries of Latin America in widely differing levels. Indeed, it seems necessary to update the main issues and solutions to these problems in the region. Therefore, the objective of the present perspective study is to compile the latest evidence on undernutrition in all its forms and the DBM in the main countries of Latin America, as well as to describe the main lines of action and opportunities to intervene comprehensively on these issues, with a special focus in the prevention of NCCDs.

Undernutrition

Origin and causes

Since 1980 the United Nations system, guided by the framework created by UNICEF, has described the manifestations of undernutrition. The basic causes include the lack or inadequate distribution of resources. Lack of resources impairs access to food, the provision of care, and the availability of health services, which are referred to as underlying causes. Immediate causes include insufficient food consumption and the occurrence of disease. The six possible causes of all nutrient deficiencies have been defined globally: insufficient intake, reduced absorption, increased expenditure, increased destruction, inadequate utilization, and increased requirements.

The issue is extremely complex because of the synergistic and adverse interactions between nutrient limitations and inflammation-infection stress, e.g., energy intake during infections could decrease due to insufficient caloric intake, poor appetite or to impaired nutrient absorption; in addition, malnourished children are more likely to suffer from infections which, in turn, lead to increased malnutrition.[6,7]

The research approaches to malnutrition have focused on undernutrition in terms of insufficient energy or protein intake, micronutrient deficiencies or food insecurity.[4] Undernutrition in the first years of life is an underlying cause associated with one third of young child deaths. Among survivors who are stunted in the first two years of life, their ability to resist disease, perform physical labor, and progress in school is impaired throughout life.[3]

Prevalence of undernutrition and micronutrient deficiencies

With regard to stunting, it is notable that children in marginalized areas are most affected by linear growth failure, starting from pregnancy until 24 months of age. Living in a poor community increases the risk of stunting in children under 5 years of age.

In 2015, a study on the prevalence of stunting using data from Latin American countries was published.[2] Haiti and Honduras had a high prevalence (30–39%) and Guatemala a very high prevalence (>40%) of stunting. Peru, El Salvador, Belize, Nicaragua, Saint Vincent and the Grenadines, Bolivia, and Ecuador had a medium prevalence of stunting (20–29%). In a review published in 2017,[8] comparing Brazilian regions. The northern region had the worst living conditions, and children under five years of age had significant height-for-age, weight-for-age, and weight-for-height deficits.

According to the publication of López de Romaña et al. in 2015[9] micronutrient deficiencies, especially iron, zinc, and vitamins A and D are of enormous importance in Latin American countries and are issues of great public health relevance. More details of the specific deficiencies are provided in different studies and reviews.[9–15] Data of undernutrition and the main micronutrient deficiencies observed in Latin America is shown in Table 1.

Early life programming

Exposure to undernutrition early in life, with subsequent excess weight gain, increases the risk of developing NCCDs. This situation is due to the establishment of a high metabolic burden based on a depleted homeostasis capacity. These trajectories through the stages of the life cycle are defined by social factors, including rapid changes in dietary patterns and physical activity.[4] In 2015, it was suggested that the higher prevalence of CVD and metabolic diseases in Latin American countries may be the result of the disparity between a restrictive nutritional environment during fetal development and infancy, and a nutritionally abundant environment later in life.[16] Consequently, Latin American populations may be more vulnerable to the health consequences of obesity than individuals with similar lifestyles in high-income countries. These negative effects may be mediated by an increase in pro-inflammatory markers and a decrease in muscle mass and strength, conditions that can be observed in subjects with low birth weight.

In a study that followed 7.3 years (642,552 person-years), 1372 incident cases of T2DM were identified.[17] Participants exposed during childhood to hunger showed an increased risk of developing T2DM later in life. The coexistence of prenatal undernutrition and abdominal obesity in adulthood has been associated with an increased risk of T2DM.

Table 1 Prevalence of stunting and micronutrient deficiency in different Latin American countries by age group.

Country	Total population % Stunting	Children (<6 y) % Anemia	Adolescent (11 y) % Zinc	Women (12–51 y) % Anemia	Women (20–49 y) % Zinc
Argentina[2,10]	8	16.5	–	18.7	–
Bolivia[2,10]	27	61.3	–	38.3	–
Brazil[2,10,11]	7	20.9 23.1–80.6	–	29.4 16.1–81.8	–
Chile[2,10]	2	4.0–14.0	–	5.1	–
Colombia[2,10]	13	27.5	41.4–56.3	7.6	–
Costa Rica[2,10]	6	4.0	–	10.2	–
Cuba[2,10]	4.6	26.0	–	–	–
Dom Republic[2,10]	10	28.0	–	34.0	–
Ecuador[2,10]	29	25.7	19.1–44.4	15.0	56.1[a]
El Salvador[2,10]	21	26.0	–	10.0	–
Guatemala[2,10]	48	47.7	24.8–41.8	21.4	–
Haiti[2,10]	30	60.6	–	45.5	–
Honduras[2,10]	30	37.3	–	18.7	–
Mexico[b,2]	14	19.9–23.7	25.4–29.2	15.5	28.1
Nicaragua[2,10]	23	20.1	–	11.2	–
Panama[2,10]	19	36.0	–	40.0	–
Peru[2,10]	20	32.9	–	17.7	–
Uruguay[2]	15	–	–	–	–

y: years old.
[a] 12–46 y old women.

In a study published in 2020, underweight was found to be negatively associated with systolic and diastolic blood pressure.[18] In this research, stunting was associated with lower systolic blood pressure levels and underweight was associated with increased diastolic blood pressure. Stunting and underweight were associated with lower school performance.

Epigenetic modifications are a mechanism leading to early disease programming. Recent research has examined environmental factors that interact during critical windows in early life and would indicate epigenetic signals related to hypertension.[19] These mechanisms include malnutrition, oxidative stress, inflammation, and microbiota modification. Some epigenetic keys are related to DNA methylation, histone covalent modifications and the potential relationship of microRNAs in blood vessels.

A systematic review and meta-analysis concluded that fetal and childhood exposure to famine (respectively) were positively associated with the risk of diabetes (RR 1.37, RR 1.33), metabolic syndrome (MS) (RR 1.26, RR 1.24), hypertension (RR 1.30; RR 1.33), hyperglycemia (RR 1.27; RR 1.25), dyslipidemia (RR 1.48; RR 1.27), obesity (RR 1.19; RR 1.13), overweight (RR 1.17; RR 1.07), coronary heart disease (RR 1.22; RR 1.21) and moderate to severe non-alcoholic fatty liver disease (RR 1.66; RR 1.68).[20]

A review has recently been published on the effects of micronutrient deficiencies in relation to metabolic health.[21] The stress response due to amino acid deprivation and dyslipidemia and how these conditions modulate diseases such as atherosclerosis have been described. Metabolic starvation and inflammation are strongly regulated by environmental (nutrition of the gut microbiome) and non-environmental (genetics) factors. The relationship between nutritional status and the risk of atrial fibrillation has also been shown to be U-shaped.[22] Individuals who are obese or underweight or who had a low birth weight may have an increased risk associated with atrial fibrillation.

Overweight and obesity

In adults, the WHO defines overweight as BMI $\geq$ 25 kg/m^2 and obesity as BMI $\geq$ 30 kg/m^2. For children under 5 years of age, overweight is defined as being more than two standard deviations above the median weight-for-height WHO child growth indicator and obesity is defined as being more than three standard deviations above the median weight-for-height WHO indicator. For children aged 5–19 years, overweight is defined as being more than one standard deviation above the median BMI-for-age growth indicator and obesity is defined as greater than two standard deviations above the median BMI-for-age WHO child growth standard.

In the last two decades, the prevalence of obesity has increased drastically worldwide, being one of the main causes of disability and mortality in the world.[23] In Latin America, the transition from a predominantly underweight to an overweight and obese population has increased more rapidly than other regions in the world and even more in lower-income individuals (prevalence > 60% overweight and obesity has been reported). In a 2016 consensus statement, the Latin American Federation of Obesity Societies (FLASO) reported that Bolivia, Mexico, and Guatemala were at the highest point of obesity prevalence of all the Latin American countries, each with prevalence above 30%. In contrast, Ecuador had the lowest prevalence of obesity (14.2%), although recent reports indicate higher levels in

this country. Overweight and obesity affected three out of four adults in the Southern Cone of Latin America.[24,25]

In addition, data presented by the Non-Communicable Diseases Risk Factor Collaboration show a more rapid increase in childhood and adolescent obesity than in adulthood.[26] However, the rise in prevalence in recent decades has affected all age groups. The prevalence of overweight in children under five years in Latin American and the Caribbean is currently at 7.5%, while globally, it is 5.9%.[26,27] Moreover, two out of every three overweight children in Latin America live in a South American country.[26]

This high prevalence is probably associated with changes in food systems and living environments, characterized by increased availability, accessibility, and affordability of ultra-processed foods, which have led to changing dietary patterns and diet quality, promoting excessive energy and critical nutrients intake (sugar, salt, and saturated and *trans* fat) across all age groups and socioeconomic levels.

Moreover, obesity is a major risk factor for several NCCDs, such as hypertension, MS, T2DM, CVD, and other health outcomes that affect adult's health but now are emerging within children and adolescents. In terms of disease burden in Latin American countries, NCCDs account for 50% of the disability-adjusted life-years (DALYs), led by CVD.[23,28]

Early life programming

Obesity during pregnancy has been proposed as a condition that impacts on the developing child through early life programming. Maternal obesity has been associated with the risk of obesity, metabolic dysregulation, hypertension, and dyslipidemia in child.[29] A review has indicated that undernutrition in utero alters the structure, and metabolism of the organism, increasing the risk of developing atherosclerosis and insulin resistance at later stages of life.[30] Disturbances between prenatal and postnatal environments have effects on body fat and insulin resistance. Insulin-like growth factor I mass concentrations and plasma lipoprotein levels in the neonatal period would be related to fat accumulation.

Obesity and Non-Communicable Chronic Diseases

Hypertension

Epidemiological data, show that obesity or overweight is highly prevalent among hypertensive populations, and that obesity could predispose people to hypertension and CVD,[31] the second being the main risk factor of death in Latin American countries.[32] By 2025, according to current projections, it is estimated that 80–90% of the Latin American urban population will be affected by hypertension and obesity.[32] Compared with other populations, Latin Americans seem to have a prevalence of clustering of hypertension with T2DM and lipid abnormalities. The prevalence of the MS in Latin America ranges from 25% to 45% and it is increasing. Finally, a systematic review [31]suggests that hypertension may be associated with socio-economic inequalities in Latin America and Caribbean populations.

Type 2 Diabetes Mellitus

Among the NCCDs, T2DM has become a global health challenge with particular effects in Latin America. T2DM prevalence has been steadily increasing in all Latin America and the Caribbean for the past three decades with special emphasis in the Caribbean region where it reaches 15%, causing it to become one of the most urgent public health problems to undertake in the region.[33] In 2019, it was estimated that the number of persons with diabetes in Latin America was 31.6 million and is predicted that by 2030, the number will increase to 40.2 million, and to 49.1 million by 2045.[34]

From 2005 to 2020, the prevalence of T2DM across Latin America has been assessed within individual countries and through multinational studies and ranged between 3 and 36.3%.[34] The International Diabetes Federation estimates that Brazil (with 16 million) and Mexico (with 12 million) contribute the highest volume of adults living with T2DM, followed by Colombia, Argentina, Venezuela, and Chile that contribute the second-highest amount of prevalent diabetes cases.[33]

Observational studies have characterized a higher prevalence of T2DM in women compared to men, although the underlying mechanisms are not fully understood.[35] T2DM risk increases significantly with age, especially in Latin America and the Caribbean. Also, obesity has a highly suggestive association with T2DM[33]; for instance, the increasing prevalence of overweight and obesity documented across Latin America has paralleled the rising prevalence of diabetes in the region. It is important to emphasize that childhood obesity, in turn, predicts the long-term risks of T2DM independently of adult obesity.

Dyslipidemia

Several studies have shown that lipid metabolism disorders are significantly associated with the pathogenesis of atherosclerosis, a key process for the development of CVD. One third of coronary artery disease cases are attributable to elevated serum low-density lipoprotein (LDL) cholesterol levels.[36]

The INTERHEART study ($n = 29,972$) showed that obesity, dyslipidemia and smoking together account for 78% of the population attributable risk in Latin American countries.[24] Data from the CARMELA study ($n = 11,550$) reinforces the concept, showing the high prevalence of these risk factors in Latin American cities (Barquisimeto, Bogota, Buenos Aires, Lima, Mexico City, Quito, and Santiago). These studies and other local research also suggested that low high-density lipoprotein (HDL) cholesterol was the most common dyslipidemia.[37]

Carrillo-Larco et al. reviewed about 200 previous studies from across Latin America and the Caribbean. They found that, since 2005, the most frequent and common dyslipidemia trait was low HDL-cholesterol in this region, followed by elevated triacylglycerols, and in third place, high LDL-cholesterol.[38]

Lipid biomarkers are key cardio-metabolic risk factors and successful improvement of these at the patient and population level could benefit reduced cardiovascular outcomes. Therefore, lipid profiles are relevant for public health and for clinical practice.[39] Indeed, they are a major risk factor for cardiovascular events, including ischemic heart disease and stroke.[40,41]

Table 2 Data of overweight/obesity and the main NCCDs observed in Latin America.

Author (reference)	Total population/adults (>18 y) %	Children (<5 y) %
Overweight and obesity		
Worldwide[26]	–	5.9
Latin America[45]	30.5 27. 7 (M) 33.1 (W)	–
Latin America[26,46]	62.5 28.6 (OB)	7.2–7.5
Latin American countries (Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, Guatemala, Jamaica, México, Peru, Trinidad and Tobago, Venezuela)[47]	70[a]	–
México, Argentina, and Brazil[48]	45.6	–
Argentina[37,49,50]	19.7 (OB) 23.1 (OB; M) 16.8 (OB; W)	33–42[b]
Bolivia[50]	–	8.2–12.0
Brazil[50]	–	31.4 (OW)[a] 7.3–22.2 (OB)
Chile[37]	26.6 (OB) 23.6 (OB; M) 29.4 (OB; W)	–
Colombia[37,50,51]	18.0 (OB) 12.8 (OB; M) 22.0 (OB; W)	16.7 (OW)[b] 3.4 (OB)[b] 4.3–18.9 (OW)[c] 0.5–5.2 (OB)[c]
Ecuador[37,50]	16.3 (OB) 10.3 (OB; M) 22.4 (OB; W)	29[c]
Guatemala[50]	–	4.9 (OB)[d]
Haiti[51]	25.3 (M) 7.8 (W)	–
Mexico[37,50,51]	–	21 (OW)[d] 10–31 (OB) 31.0 (OB; M) 30.4 (OB; W) 43.9 (OW)[b] 13.3 (OB)[b] 13.3–33.5 (OW)[e] 3.9–14.6 (OB)[e]
Peru[37,50]	22.3 (OB) 21.1 (OB; M) 23.4 (OB; W)	4.8–5.8 1.3 (OB) 19.8
Venezuela[37]	25.1 (OB) 23.5 (OB; M) 26.1 (OB; W)	–
Hypertension	Total population/adults (>18 y) %	Children (<5 y) %
Latin America[24,45]	20.2–29.1 21.1 (M) 19.4 (W)	–
Mexico, Argentina, and Brazil[48]	53.2	–
Argentina[37,44,52,53]	29.0–50.8 37.7 (M) 21.7 (W)	1.9 (pre-hypertension) 4.3–14.9[b]
Brazil[44,52]	52.5–52.6	8.5[e]

Table 2 (*Continued*)

Chile[37,44,52]	23.8– 46.7 27.3 (M) 20.7 (W)	–
Colombia[37,52,54]	13.4–57 14.6 (M) 12.4 (W)	–
Ecuador[37]	8.6 7.2 (M) 10.1 (W)	–
Mexico[37]	11.7 11.2 (M) 12.1 (W)	–
Peru[37,44]	12.6–19.3 14.4 (M) 10.7 (W)	–
Uruguay[44]	51.6	–
Venezuela[37]	24.7 27.5 (M) 22.9 (W)	–
Diabetes mellitus	Total population/adults (>18 y) %	Children (<5 y) %
Latin America[45]	5.0 5.1 (M) 4.8 (W)	–
Latin American countries (Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Peru, Trinidad and Tobago, Venezuela)[47]	12 (M) 10 (W)	–
Argentina[34,37,55]	6.2–12.7 7.9 (M) 4.8 (W)	–
Brazil[34,55]	7.4–8.7	–
Bolivia[55]	6.2	–
Chile[34,37,55]	7.2–12.3 6.8 (M) 7.6 (W)	–
Colombia[34,37,55]	8.1–11.2 7.4 (M) 8.7 (W)	–
Costa Rica[34,55]	9.5–10.8	–
Dominican Republic[34]	3.5	–
Ecuador[34,37,55]	2.7–5.9 4.6 (M) 7.3 (W)	–
El Salvador[34,55]	8.7–12.5	–
Guatemala[34,55]	8.4–11	–
Haiti[34]	14.1(W) 8.2 (M)	–
Honduras[55]	6.0	–
Mexico[34,37,55]	8.9–13.7 8.0 (M) 9.7 (W)	–
Nicaragua[55]	10.0	–
Paraguay[34,55]	7.4–9.7	–
Peru[37]	4.4 4.3 (M) 4.6 (W)	–

Table 2 (*Continued*)

Puerto Rico[34]	26.8[f]	–
Uruguay[34,55]	6.0–6.6	–
Venezuela[34,37,55]	6.0–8.0	–
	5.6 (M)	
	6.3 (W)	
Dyslipidemia	Total population/adults (>18 y) %	Children (<5) %
Latin America[24,38,45,48]	26.5–42 (High TG)	–
	29.9 (High TG; M)	
	23.3 (High TG; W)	
	8.9–40.5 (High TC)	
	8.2 (High TC; M)	
	9.6 (High TC; W)	
	8.5–20 (High LDL-C)	
	7.6 (High LDL-C; M)	
	9.3 (High LDL-C; W)	
	48–53.3 (Low HDL-C)	
	32.8 (Low HDL-C; M)	
	32.8 (Low HDL-C; W)	
Argentina[37]	18.7 (High TC)	–
	19.6 (High TC; M)	
	17.8 (High TC; W)	
Chile[37]	15.3 (High TC)	–
	15.9 (High TC; M)	
	14.8 (High TC; W)	
Colombia[37]	12.0 (High TC)	–
	12.4 (High TC; M)	
	11.7 (High TC; W)	
Ecuador[37]	20.2 (High TC)	–
	21.6 (High TC; M)	
	18.8 (High TC; W)	
Mexico[37]	16.4 (High TC)	
	17.5 (High TC; M)	
	15.4 (High TC; W)	
Peru[37]	11.6 (High TC)	–
	10.1 (High TC; M)	
	13.0 (High TC; W)	
Venezuela[37]	5.7 (High TC)	–
	4.5 (High TC; M)	
	6.5 (High TC; W)	
CVD	Total population/adults (>18 y) %	Children (<5 y) %
Worldwide[47]	16 (M)	–
	13 (W)	
Latin American countries (Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, Guatemala, Jamaica, Mexico, Peru, Trinidad and Tobago, Venezuela)[47]	10 (M)	–
	18 (W)	
Latin America[43]	13.8 (Macro)	–
	15.2 (Micro)	
Central America (Costa Rica and Panama)[43]	9.6 (Macro)	–
	4.1 (Micro)	

Table 2 (*Continued*)

Argentina[43]	13.0 (Macro) 10.0 (Micro)	–
Brazil[43]	15.3 (Macro) 19.2 (Micro)	–
Colombia[43]	18.0 (Macro) 21.4 (Micro)	–
Mexico[43]	13.0 (Macro) 17.1 (Micro)	–

Abbreviations. CVD: cardiovascular disease; M: men; W: woman; OB: obesity; OW: overweight; y: years old. Macro: Macrovascular Disease (Coronary Artery Disease, Myocardial Infarction, Percutaneous Coronary Intervention, Heart Failure, Angina, Stroke, Diabetic Foot, and Peripheral Artery Disease. Micro: Microvascular Disease (Peripheral Neuropathy, Retinopathy).

[a] <12 m.
[b] Adolescents.
[c] 5–14 y.
[d] 5–11 y.
[e] School-age children.
[f] >45 y.

Cardiovascular disease

The CVD and diabetes mellitus are the leading cause of morbidity and mortality worldwide and in Latin America and the Caribbean, with ischemic heart disease and stroke being the leading cause of premature mortality and DALYs.[28,42] In terms of CVD, first myocardial infarction is the most common cause of death among all CVD deaths in Latin America and occurs 5–10 years earlier than in higher-income countries, such as the U.S.[28]

In Latin America, the most prevalent cardiovascular risk factors are overweight, obesity, hypertension, dyslipidemia, and T2DM. Multiple studies have identified the same risk factors for myocardial infarction or stroke in different populations, although other regions have different prevalence and burden of disease.[42]

The results of the CESCAS (*Centro de Excelencia en Salud Cardiovascular para el Cono Sur*) I study ($n = 7524$), indicate that behavioral and metabolic risk factors for CVD are high in the general adult population of the Southern Cone of Latin America (Argentina, Chile, Uruguay). Only 0.1% of the population met the seven criteria (no smoking, body mass index, physical activity, blood pressure, total cholesterol, glucose) that define the Ideal Cardiovascular Health.[42] In the DISCOVER study ($n = 1616$), developed in Mexico, Costa Rica, Panama, Colombia, Argentina, and Brazil, the prevalence of hyperlipidemia and hypertension was 45.9% and 55.55%, respectively, and the overweight or obesity was reported in 83.8% of the cases.[43]

Finally, CVD disproportionately affects the poorest segments of the population, affecting families, communities, and governments because of the costs of treatment and the potential years of life and productivity lost due to premature death and disability. More than 80% of CVD deaths occur in low- and middle-income.[44]

A detailed description of obesity and the main NCCDs observed in Latin America is shown in Table 2.

The double burden of malnutrition

Malnutrition has historically been investigated through two different approaches: focusing on undernutrition, food insecurity and micronutrient deficiencies, or on overweight, obesity and dietary excesses. Due to the rapid global nutrition transition, an increasing proportion of people are at risk of different forms of malnutrition throughout life.[4]

Although research on DBM is a leading area of interest, there is no global consensus on definitions. The DBM, defined as the coexistence of overnutrition (overweight/obesity) and undernutrition (stunting and wasting), needs to be approached at all levels: population-country, city, community, household, and individual. In addition, it is noteworthy that many Latin American countries indicate that multiple forms of malnutrition can coexist in the same country, household or individual.[56] Recently, a review of operational definitions proposed to organize DBM by three dimensions: level of assessment, target population, and forms of malnutrition. The most frequent definitions included coexistence of overweight/obesity and thinness, wasting or underweight ($n = 289$); overweight/obesity and stunting ($n = 161$); overweight/obesity and anemia ($n = 74$); and overweight/obesity and micronutrient deficiency ($n = 73$). The authors concluded that structuring these definitions could facilitate the selection of the most appropriate indicators to intervene on public health priorities more effectively.

Biological and social pathways are highly complex and interact with all forms of malnutrition.[57] The health impacts of DBM include remarkably those associated with undernutrition, impaired child development, and increased susceptibility to infectious diseases and those related to excess weight and an increased risk of developing NCCD.[56] Preventing malnutrition, especially in the first 1000 days of life, has health and economic benefits that impact all stages of life.[4]

Table 3 Double Burden of Malnutrition in different Latin American countries by age groups.

Country	Age groups											
	Children (<5 y) %				Adolescent girls (11–19 y) %				Women (20–49 y) %			
	Overnutrition		Undernutrition		Overnutrition		Undernutrition		Overnutrition		Undernutrition	
	Overweight /obesity	Wasting-underweight	Stunting/ short stature	Anaemia	Overweight/ obesity	Wasting-underweight	Stunting/ short stature	Anaemia	Overweight/ obesity	Wasting-underweight	Stunting/ short stature	Anaemia
Argentina[59]	9.9	1.6	7.4	15.2	22	1.2	6.2	15.2	43.8	0.4	10.5	19.8
Bolivia[62]	10.8	1.7	23.2	63.1	29.5	0.20	22.8	36.6	56.9	1.2	31.1	37.4
Brazil[68]	17.3	2.8	6.0	–	18.4 (W) 20.5 (M)	2.8 (W) 3.7 (M)	5.5 (W) 7.3 (M)	–	42.2 (W) 47.9 (M)	3.9 (W) 1.7 (M)	5.7 (W) 0.2 (M)	–
Chile[64]	–	–	–	–	–	–	–	–	75.5	1.2	12.4	7.2
Colombia[67]	5.2	1.2	13.8	27.4	16.2	1.8	11.0	7.8	45.2	2.9	11.3	12.4
Ecuador[60]	8.6	2.4	25.3	23.3	29.2	1.0	20.6	9.3	63.8	1.4	27.6	16.7
Guatemala[66]	4.9	0.7	46.7	–	28.4	0.3	52.4	–	56.6	1.3	–	–
Mexico[63]	9.7	2.8	13.6	23.3	36.0	1.6	13.1	7.7	70.6	1.5	–	–
Peru[61]	9.1	0.9	14.7	32.0	31.3	0.5	22.5	18.8	65.1	0.9	34.3	20.3
Uruguay[69]	9.8	1.0	4.6	–	–	–	–	–	54.8	2.1	2.11	–

Abbreviations. M: men; W: women; y: years old. Overweight/obesity: BMIZ > þ2 for children aged < 5 years; BMIZ > þ1 for girls/boys aged 11–19 years; and BMI ≥ 25.0 kg/m^2 for women/men aged 20–49 years. Wasting: WHZ < −2 for children aged < 5 years. Underweight: BMIZ < −2 for girls/boys aged 11–19 years; and BMI < 18.5 kg/m^2 for women/men aged 20–49 years. Stunting: HAZ < −2 for children aged < 5 years; HAZ < −2 for girls/boys aged 11–19 years. Short stature: height < 1.49 m for women/men aged 20–49 years.

Situation of the double burden of malnutrition in Latin American countries

An update on data in Latin American countries in the DBM (overnutrition, and undernutrition) has recently been published.[58] In these studies, national health, and nutrition surveys, it has been possible to evaluate the situation through cross-sectional analyses. Detailed data can be found in a number of studies and reviews.[59–66] A description of all forms of malnutrition in different Latin American countries by age groups is shown in Table 3.

All forms of malnutrition have shown a strong relationship with socio-economic and educational inequalities.[59] Malnutrition disproportionately affects individuals at the lowest levels of income, ethnic minorities, women, and those with lower levels of education.[60,62–64,66,67]

Public health challenges, policies, and future research

DBM is a major cause of disability and premature death, which could be targeted by comprehensive policies such as the Action Plan for the Prevention of Obesity in Children and Adolescents.[46] The current epidemiological situation and major policy developments provide an opportunity for all agencies involved to engage in collaborative efforts. This situation encourages the development of comprehensive, intersectoral policies to address DBM by strengthening national nutrition surveillance systems, incorporating detailed monitoring, evaluating the guidelines developed and encouraging increased investments in nutrition. Subsequently, the effectiveness of these actions should be evaluated with the aim of promoting robust long-term political commitment.[70]

The Sustainable Development Goals have as a global priority the goal of combating malnutrition in all its forms by 2030.[57] The UN Decade of Action on Nutrition (2016–2025) aims to accelerate these actions. Food systems must provide healthy, safe, accessible, and sustainable diets. The necessary changes require several actions: production, trade and distribution processing, price policy, marketing, front-of-package labeling and waste management.

Research is very limited in the Latin American region and lack of funding severely hampers tackling complicated nutritional problems. Some institutions have strengthened their commitment to improve research capacity, as well as to further identify opportunities for action to eliminate health disparities.[71] To evaluate the nutrition landscape in Latin American countries and to guide future efforts, the Pan American Health Organization and the Micronutrient Initiative identified knowledge gaps. Even though Latin American countries have made progress and have policies in place to address undernutrition and micronutrient deficiencies, comprehensive and intersectoral policies to address obesity are lacking. The support programs in some countries such as Brazil, Colombia and Mexico offer an opportunity to integrate nutrition actions into intersectoral platforms to improve health.[70]

It seems that T2DM is the cause and result of a risk cycle that is not interrupted and healthcare systems of the region will be overwhelmed by the combined snowballing of risk factors and complications.[33] While obesity and T2DM have a negative correlation with HDL-cholesterol, exercise positively affects this lipid fraction[72]; to successfully increase HDL-cholesterol in Latin American countries, it is also necessary to reduce obesity and diabetes while providing opportunities for physical activity.[55]

The economic, social, and environmental costs of hunger hinder the growth and development of individuals and societies. It is suggested that nutritional interventions should consider economic evaluation to target dual-function interventions as an alternative to separate stunting and overweight programming.[56]

Several countries are implementing the Caribbean Public Health Agency's Plan of Action, which is supported by the Ministries of Health, Education and Sport to develop nutrition policies and strategies. Examples include ''*Chile Crece Contigo*'', which integrates health, social development, and education activities to optimize children's growth and cognitive-motor development. Brazil is implementing policies to engage with international targets on food security, nutrition and risk factors and chronic diseases.[46] Eighteen countries have policies to address undernutrition and few nations maintain specific policies for overweight and obesity. Nutrition actions must be incorporated into food security policies and should be part of education, environment, agriculture, development, and employment policies. Integrated and specific nutrition promotion and chronic disease prevention policies need to be developed in each country through intersectoral engagement.[73]

Conclusions

1. The DBM represents a major risk factor for the occurrence of NCCDs in Latin America and the presence of those diseases represents a major public health burden.
2. Latin America is making progress in reducing undernutrition and micronutrient deficiencies. However, progress in the reduction of overnutrition is lacking overall.
3. There is a need of policies that integrate social, health, developmental, and educational aspects to impact both sides of the malnutrition burden with the determination that these actions can be sustainable, applicable to region-specific environments, and maintained over time.

Financing

This research has not received specific aid from public sector agencies, commercial sector or non-profit entities.

Conflict of interest

No author presents any conflict of interest with this research.

References

1. Organización Mundial de la Salud (OMS)Expertos C.d., Ginebra. Dieta, nutrición y prevención de enfermedades crónicas. Aliment Y Dieta, Consecuencias Habitos Aliment Ina Pdf. 2013;1:1–152.

2. Cediel G, Olivares M, Brito A, Cori H, López de Romaña D. Zinc deficiency in Latin America and the Caribbean. Food Nutr Bull. 2015;36 Suppl. 2:S129–38, http://dx.doi.org/10.1177/0379572115585781.
3. Shimpton R, Rokx C. The double burden of malnutrition – a review of global evidence; 2012.
4. Wells JC, Sawaya AL, Wibaek R, Mwangome M, Poullas MS, Yajnik CS, et al. The double burden of malnutrition: aetiological pathways and consequences for health. Lancet. 2020;395:75–88, http://dx.doi.org/10.1016/S0140-6736(19)32472-9.
5. Demaio AR, Branca F. Decade of action on nutrition: our window to act on the double burden of malnutrition. BMJ Glob Heal. 2018;3:1–4, http://dx.doi.org/10.1136/bmjgh-2017-000492.
6. Prentice AM, Paul AA. Fat and energy needs of children in developing countries. Am J Clin Nutr. 2000;72 Suppl.:1253S–65S, http://dx.doi.org/10.1093/ajcn/72.5.1253s.
7. Scrimshaw N. Energy cost of communicable diseases in infancy and childhood. Activity, energy expenditure and energy requirements of infants and children. Lausanne Switzerland; 1990.
8. Cunha MPL, Marques RC, Dórea JG. Child nutritional status in the changing socioeconomic region of the northern Amazon, Brazil. Int J Environ Res Public Health. 2018;15, http://dx.doi.org/10.3390/ijerph15010015.
9. López de Romaña D, Olivares M, Brito A. Introduction: prevalence of micronutrient deficiencies in Latin America and the Caribbean. Food Nutr Bull. 2015;36 Suppl. 2:S95–7, http://dx.doi.org/10.1177/0379572115585736.
10. Mujica-Coopman MF, Brito A, López de Romaña D, Ríos-Castillo I, Coris H, Olivares M. Prevalence of anemia in Latin America and the Caribbean. Food Nutr Bull. 2015;36:S119–28, http://dx.doi.org/10.1177/0379572115585775.
11. Lício JSA, Fávaro TR, Chaves CRMM. Anemia in indigenous women and children in Brazil: a systematic review. Cien Saude Colet. 2016;21:2571–81, http://dx.doi.org/10.1590/1413-81232015218.00532015.
12. Stevens GA, Bennett JE, Hennocq Q, Lu Y, De-Regil LM, Rogers L, et al. Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys. Lancet Glob Heal. 2015;3:e528–36, http://dx.doi.org/10.1016/S2214-109X(15)00039-X.
13. Brito A, Mujica-Coopman MF, López de Romaña D, Cori H, Allen LH. Folate and vitamin B12 status in Latin America and the Caribbean: an update. Food Nutr Bull. 2015;36 Suppl. 2:S109–18, http://dx.doi.org/10.1177/0379572115585772.
14. Pereira-Santos M, Santos JYGdos, Carvalho GQ, Santos DBdos, Oliveira AM. Epidemiology of vitamin D insufficiency and deficiency in a population in a sunny country: geospatial meta-analysis in Brazil. Crit Rev Food Sci Nutr. 2018;59:2102–9, http://dx.doi.org/10.1080/10408398.2018.1437711.
15. Martínez-Zavala N, López-Sánchez GN, Vergara-Lopez A, Chávez-Tapia NC, Uribe M, Nuño-Lámbarri N. Vitamin D deficiency in Mexicans have a high prevalence: a cross-sectional analysis of the patients from the Centro Médico Nacional 20 de Noviembre. Arch Osteoporos. 2020;15, http://dx.doi.org/10.1007/s11657-020-00765-w.
16. Lopez-Lopez J, Lopez-Jaramillo P, Camacho PA, Gomez-Arbelaez D, Cohen DD. The link between fetal programming, inflammation muscular strength, and blood pressure. Mediat Inflamm. 2015;2015, http://dx.doi.org/10.1155/2015/710613.
17. Meng R, Lv J, Yu C, Guo Y, Bian Z, Yang L, et al. Prenatal famine exposure, adulthood obesity patterns and risk of type 2 diabetes. Int J Epidemiol. 2018;47:399–408, http://dx.doi.org/10.1093/IJE/DYX228.
18. Du R, Zheng R, Xu Y, Zhu Y, Yu X, Li M, et al. Early-life famine exposure and risk of cardiovascular diseases in later life: findings from the REACTION study. J Am Heart Assoc. 2020;9:e014175, http://dx.doi.org/10.1161/JAHA.119.014175.
19. Guarner-Lans V, Ramírez-Higueras A, Rubio-Ruiz ME, Castrejón-Téllez V, Soto ME, Pérez-Torres I. Early programming of adult systemic essential hypertension. Int J Mol Sci. 2020;21:1–28, http://dx.doi.org/10.3390/ijms21041203.
20. Hidayat K, Du X, Shi B-M, Qin L-Q. Foetal and childhood exposure to famine and the risks of cardiometabolic conditions in adulthood: a systematic review and meta-analysis of observational studies. Obes Rev an Off J Int Assoc Study Obes. 2020;21:e12981, http://dx.doi.org/10.1111/obr.12981.
21. Golonka RM, Xiao X, Abokor AA, Joe B, Vijay-Kumar M. Altered nutrient status reprograms host inflammation and metabolic health via gut microbiota. J Nutr Biochem. 2020;80:108360, http://dx.doi.org/10.1016/j.jnutbio.2020.108360.
22. Anaszewicz M, Budzyński J. Clinical significance of nutritional status in patients with atrial fibrillation: an overview of current evidence. J Cardiol. 2017;69:719–30, http://dx.doi.org/10.1016/j.jjcc.2016.06.014.
23. Kankeu HT, Saksena P, Xu K, Evans DB. The financial burden from non-communicable diseases in low- and middle-income countries: a literature review. Heal Res Policy Syst. 2013;11, http://dx.doi.org/10.1186/1478-4505-11-31.
24. Lanas F, Avezum A, Bautista LE, Diaz R, Luna M, Islam S, et al. Risk factors for acute myocardial infarction in Latin America: The INTERHEART Latin American study. Circulation. 2007:1067–74, http://dx.doi.org/10.1161/CIRCULATIONAHA.106.633552.
25. Halpern B, Louzada MLdC, Aschner P, Gerchman F, Brajkovich I, Faria-Neto JR, et al. Obesity and COVID-19 in Latin America: a tragedy of two pandemics—official document of the Latin American Federation of Obesity Societies. Obes Rev. 2021;22:1–12, http://dx.doi.org/10.1111/obr.13165.
26. Food Agriculture Organization of the United Nations F. The State of Food Security and Nutrition in the World. Safeguarding against economic slowdowns and down_turns. Rome, FAO; 2019. Licence: CC BY-NC-SA 3.0 IGO.
27. De Benoist B, Cogswell M, Egli I, McLean E. Worldwide prevalence of anaemia 1993–2005; WHO global database of anaemia; 2008.
28. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. J Am Coll Cardiol. 2020;76:2982–3021, http://dx.doi.org/10.1016/j.jacc.2020.11.010.
29. O'Reilly JR, Reynolds RM. The risk of maternal obesity to the long-term health of the offspring. Clin Endocrinol (Oxf). 2013;78:9–16, http://dx.doi.org/10.1111/cen.12055.
30. Okada T, Takahashi S, Nagano N, Yoshikawa K, Usukura Y, Hosono S. Early postnatal alteration of body composition in preterm and small-for-gestational-age infants: implications of catch-up fat. Pediatr Res. 2015;77:136–42, http://dx.doi.org/10.1038/pr.2014.164.
31. Sarki AM, Nduka CU, Stranges S, Kandala NB, Uthman OA. Prevalence of hypertension in low- and middle-income countries: a systematic review and meta-analysis. Med (United States). 2015;94:1–16, http://dx.doi.org/10.1097/MD.0000000000001959.
32. Ruilope LM, Nunes Filho ACB, Nadruz W, Rodríguez Rosales FF, Verdejo-Paris J. Obesidad e hipertensión en Latinoamérica: perspectivas actuales. Hipertens y Riesgo Vasc. 2018;35:70–6, http://dx.doi.org/10.1016/j.hipert.2017.12.004.
33. Gallardo-Rincón H, Cantoral A, Arrieta A, Espinal C, Magnus MH, Palacios C, et al. Review: Type 2 diabetes in Latin America and the Caribbean: regional and country comparison on prevalence, trends, costs and expanded prevention. Prim Care Diabetes. 2021;15:352–9, http://dx.doi.org/10.1016/j.pcd.2020.10.001.

34. Aviles_Santa_2020_Current State of Diabetes Mellitus Prevalence, Awareness, Treatment, and Control in Latin America.pdf. s. f.
35. Cominato L, Di Biagio GF, Lellis D, Franco RR, Mancini MC, de Melo ME. Obesity prevention: strategies and challenges in Latin America. Curr Obes Rep. 2018;7:97–104, http://dx.doi.org/10.1007/s13679-018-0311-1.
36. Lanas F, Bazzano L, Rubinstein A, Calandrelli M, Chen C-S, Elorriaga N, et al. Prevalence distributions and determinants of obesity and central obesity in the Southern Cone of America. PLoS ONE. 2016;11:e0163727, http://dx.doi.org/10.1371/journal.pone.0163727.
37. Schargrodsky H, Hernández-Hernández R, Champagne BM, Silva H, Vinueza R, Silva Ayçaguer LC, et al. CARMELA: assessment of cardiovascular risk in seven Latin American cities. Am J Med. 2008;121:58–65, http://dx.doi.org/10.1016/j.amjmed.2007.08.038.
38. Carrillo-Larco RM, Benites-Moya CJ, Anza-Ramirez C, Albitres-Flores L, Sánchez-Velazco D, Pacheco-Barrios N, et al. A systematic review of population-based studies on lipid profiles in Latin America and the Caribbean. Elife. 2020;9:1–13, http://dx.doi.org/10.7554/ELIFE.57980.
39. Grundy SM, Stone NJ, Bailey AL, Beam C, Birtcher KK, Blumenthal RS, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines. Circulation. 2019;139:e1082–143, http://dx.doi.org/10.1161/CIR.0000000000000625.
40. Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, Halsey J, et al. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. Lancet (Lond, Engl). 2007;370:1829–39, http://dx.doi.org/10.1016/S0140-6736(07)61778-4.
41. Di Angelantonio E, Chowdhury R, Sarwar N, Ray KK, Gobin R, Saleheen D, et al. B-type natriuretic peptides and cardiovascular risk: systematic review and meta-analysis of 40 prospective studies. Circulation. 2009;120:2177–87, http://dx.doi.org/10.1161/CIRCULATIONAHA.109.884866.
42. Seron P, Irazola V, Rubinstein A, Ponzo J, Gutierrez L, Elorriaga N, et al. HHS Public Access. 2019:132–9, http://dx.doi.org/10.1016/j.puhe.2017.12.017.Ideal.
43. Chen-Ku CH, Gonzalez-Galvez G, Vásquez M, Fuente G, Nakazone MA, Silva Giordano AI, et al. Vascular complications in patients with type 2 diabetes: prevalence and comorbidities in 6 countries of Latin America (a cohort of the DISCOVER study program). Endocr Pract. 2019;25:994–1002, http://dx.doi.org/10.4158/EP-2018-0473.
44. Rubinstein AL, Irazola VE, Calandrelli M, Elorriaga N, Gutierrez L, Lanas F, et al. Multiple cardiometabolic risk factors in the Southern Cone of Latin America: a population-based study in Argentina Chile, and Uruguay. Int J Cardiol. 2015;183:82–8, http://dx.doi.org/10.1016/j.ijcard.2015.01.062.
45. Miranda JJ, Herrera VM, Chirinos JA, Gómez LF, Perel P, Pichardo R, et al. Major cardiovascular risk factors in Latin America: a comparison with the United States The Latin American Consortium of Studies in Obesity (LASO). PLoS ONE. 2013;8:1–10, http://dx.doi.org/10.1371/journal.pone.0054056.
46. Grajeda R, Hassell T, Ashby-Mitchell K, Uauy R, Nilson E. Regional overview on the double burden of malnutrition and examples of program and policy responses: Latin America and the Caribbean. Ann Nutr Metab. 2019;75:139–43, http://dx.doi.org/10.1159/000503674.
47. Balkau B, Deanfield JE, Després JP, Bassand JP, Fox KAA, Smith SC, et al. International day for the evaluation of abdominal obesity (IDEA): a study of waist circumference, cardiovascular disease, and diabetes mellitus in 168,000 primary care patients in 63 countries. Circulation. 2007;116:1942–51, http://dx.doi.org/10.1161/CIRCULATIONAHA.106.676379.
48. José Gagliardino J, Arechavaleta R, Goldberg Eliaschewitz F, Iglay K, Brodovicz K, Gonzalez CD, et al. Dyslipidemia: the untreated metabolic dysfunction in people with type 2 diabetes in Latin America ARETAEUS study outcomes. J Clin Transl Endocrinol. 2019;15:76–80, http://dx.doi.org/10.1016/j.jcte.2019.01.002.
49. Consenso de hipertensión arterial. Rev Argentina Cardiología. 2013;81(Supl 2):1-80. Available from: https://www.sac.org.ar/wp-content/uploads/2014/04/Consenso-de-Hipertension-Arterial.pdf
50. Shimabuku RL, Delgado CA, Nakachi G, Teruya AA, Velasquez PM. Double burden of excess weight and anemia in Latin American children up to 2019. Tohoku J Exp Med. 2020;252:159–68, http://dx.doi.org/10.1620/tjem.252.159.
51. Galicia L, Grajeda R, De Romaña DL. Nutrition situation in Latin America and the Caribbean: current scenario, past trends, and data gaps. Rev Panam Salud Publica/Pan Am J Public Heal. 2016;40:104–13.
52. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, et al. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. JAMA. 2013;310:959–68, http://dx.doi.org/10.1001/jama.2013.184182.
53. Hipertensión Arterial. Rev Soc Argentina Hipertens Arter. 2012;1.
54. Camacho PA, Gomez-Arbelaez D, Molina DI, Sanchez G, Arcos E, Narvaez C, et al. Social disparities explain differences in hypertension prevalence, detection and control in Colombia. J Hypertens. 2016;34:2344–52, http://dx.doi.org/10.1097/HJH.0000000000001115.
55. López-Jaramillo P, Barbosa E, Molina DI, Sanchez R, Diaz M, Camacho PA, et al. Latin American Consensus on the management of hypertension in the patient with diabetes and the metabolic syndrome. J Hypertens. 2019;37:1126–47, http://dx.doi.org/10.1097/HJH.0000000000002072.
56. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet. 2020;395:65–74, http://dx.doi.org/10.1016/S0140-6736(19)32497-3.
57. Branca F, Demaio A, Udomkesmalee E, Baker P, Aguayo VM, Barquera S, et al. A new nutrition manifesto for a new nutrition reality. Lancet. 2020;395:8–10, http://dx.doi.org/10.1016/S0140-6736(19)32690-X.
58. Batis C, Mazariegos M, Martorell R, Gil A, Rivera JA. Malnutrition in all its forms by wealth, education and ethnicity in Latin America: who are more affected? Public Health Nutr. 2020;23(S1):S1–12, http://dx.doi.org/10.1017/S136898001900466X.
59. Zapata ME, Soruco AI, Carmuega E. Malnutrition in all its forms and socio-economic indicators in Argentina. Public Health Nutr. 2020;23(S1):S13–20, http://dx.doi.org/10.1017/S1368980019003124.
60. Ramírez-Luzuriaga MJ, Belmont P, Waters WF, Freire WB. Malnutrition inequalities in Ecuador: differences by wealth, education level and ethnicity. Public Health Nutr. 2020;23(S1):S59–67, http://dx.doi.org/10.1017/S1368980019002751.
61. Curi-Quinto K, Ortiz-Panozo E, De Romaña DL. Malnutrition in all its forms and socio-economic disparities in children under 5 years of age and women of reproductive age in Peru. Public Health Nutr. 2020;23(S1):S89–100, http://dx.doi.org/10.1017/S136898001900315X.
62. Miranda M, Bento A, Aguilar AM. Malnutrition in all its forms and socioeconomic status in Bolivia. Public Health Nutr. 2020;23(S1):S21–8, http://dx.doi.org/10.1017/S1368980019003896.

63. Batis C, Denova-Gutiérrez E, Estrada-Velasco BI, Rivera J. Malnutrition prevalence among children and women of reproductive age in Mexico by wealth, education level, urban/rural area and indigenous ethnicity. Public Health Nutr. 2020;23(S1):S77–88, http://dx.doi.org/10.1017/S1368980019004725.
64. Mujica-Coopman MF, Navarro-Rosenblatt D, López-Arana S, Corvalán C. Nutrition status in adult Chilean population: economic, ethnic and sex inequalities in a post-transitional country. Public Health Nutr. 2020;23(S1):S39–50, http://dx.doi.org/10.1017/S1368980019004439.
65. Ruel MT, Menon P. Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the Demographic and Health Surveys. J Nutr. 2002;132:1180–7, http://dx.doi.org/10.1093/jn/132.6.1180.
66. Mazariegos M, Kroker-Lobos MF, Ramírez-Zea M. Socio-economic and ethnic disparities of malnutrition in all its forms in Guatemala. Public Health Nutr. 2020;23(S1):S68–76, http://dx.doi.org/10.1017/S1368980019002738.
67. Cediel G, Perez E, Gaitán D, Sarmiento OL, Gonzalez L. Association of all forms of malnutrition and socioeconomic status, educational level and ethnicity in Colombian children and non-pregnant women. Public Health Nutr. 2020;23(S1):S51–8, http://dx.doi.org/10.1017/S1368980019004257.
68. Canella DS, Duran AC, Claro RM. Malnutrition in all its forms and social inequalities in Brazil. Public Health Nutr. 2020;23(S1):S29–38, http://dx.doi.org/10.1017/S136898001900274X.
69. Medina M, Barreto P, Natero V, Moratorio X, Severi C. Prevalence of malnutrition among children and women of reproductive age in Uruguay by socio-economic status and educational level. Public Health Nutr. 2020;23(S1):S101–7, http://dx.doi.org/10.1017/S1368980020000804.
70. Galicia L, De Romaña DL, Harding KB, De-Regil LM, Grajeda R. Tackling malnutrition in Latin America and the Caribbean: challenges and opportunities. Rev Panam Salud Publica/Pan Am J Public Heal. 2016;40:138–46.
71. Latin VII, Workshop A. Proposal and actions to decrease malnutrition in Latin America and the Caribbean. Food Nutr Bull. 2018;39:290–5, http://dx.doi.org/10.1177/0379572118769265.
72. Rashid S, Genest J. Effect of obesity on high-density lipoprotein metabolism. Obesity (Silver Spring). 2007;15:2875–88, http://dx.doi.org/10.1038/oby.2007.342.
73. Tirado MC, Galicia L, Husby HM, Lopez J, Olamendi S, Pia Chaparro M, et al. Mapping of nutrition and sectoral policies addressing malnutrition in Latin America. Rev Panam Salud Publica. 2016;40:114–23.