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Determinants of obesity in Latin America

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Obesity rates are increasing almost everywhere in the world, although the pace and timing for this increase differ when populations from developed and developing countries are compared. The sharp and more recent increase in obesity rates in many Latin American countries is an example of that and results from regional characteristics that emerge from interactions between multiple factors. Aware of the complexity of enumerating these factors, we highlight eight main determinants (the physical environment, food exposure, economic and political interest, social inequity, limited access to scientific knowledge, culture, contextual behaviour and genetics) and discuss how they impact obesity rates in Latin American countries. We propose that initiatives aimed at understanding obesity and hampering obesity growth in Latin America should involve multidisciplinary, global approaches that consider these determinants to build more effective public policy and strategies, accounting for regional differences and disease complexity at the individual and systemic levels.

Obesity (body mass index (BMI) ≥ 30 kg/m^2) is a major public health problem worldwide, resulting in comorbidities and premature death. The simple definition of obesity as a disease characterized by excessive body fat does not sufficiently express the devastating health damages for individuals or reflect the large financial costs the disease imposes on societies. Obesity is responsible for elevated rates of type 2 diabetes mellitus (DM), hypertension, dyslipidaemia, steatohepatitis, polycystic ovary syndrome, depression, certain types of cancer and several other disorders[1]. According to the 2023 World Obesity Atlas, in the next decade, the prevalence of obesity will continue to rise almost everywhere in the world. This increase is expected to happen regardless of the age group, although the steepest rise is expected to occur among children and adolescents[2]. Not surprisingly, obesity has become an important part of the public health agenda worldwide and has attracted investments from multiple sectors of society with the objective of finding ways to slow down this devastating health problem.

Nonetheless, the increase in obesity rates differs when populations from high-income and low- or middle-income countries (henceforth called developed and developing countries, respectively) are compared. Historically, the increases in obesity rates in developing countries occurred later; however, more recently, countries within these groups are the ones with the sharpest rise in obesity prevalence, especially among the youngest strata of the population[3]. This sharp increase cannot be simply explained by genetic factors or individual choices, but rather by a combination of structural and contextual factors, here called systemic determinants. In this Review, we will discuss the nature of what determines a higher susceptibility to obesity as an attempt to provide further understanding of the reasons behind the rapid increase in obesity prevalence in the developing world, with the focus on Latin American countries where this increase occurred more recently and at a strikingly fast pace. We will also propose ways to counteract this trend.

Despite the efforts and considerable advances in the current understanding of what influences the onset of obesity and how we can prevent and treat it, it is remarkable and at the same time unfortunate that obesity rates continue to grow rapidly, with some lower-income countries showing the highest increase, and

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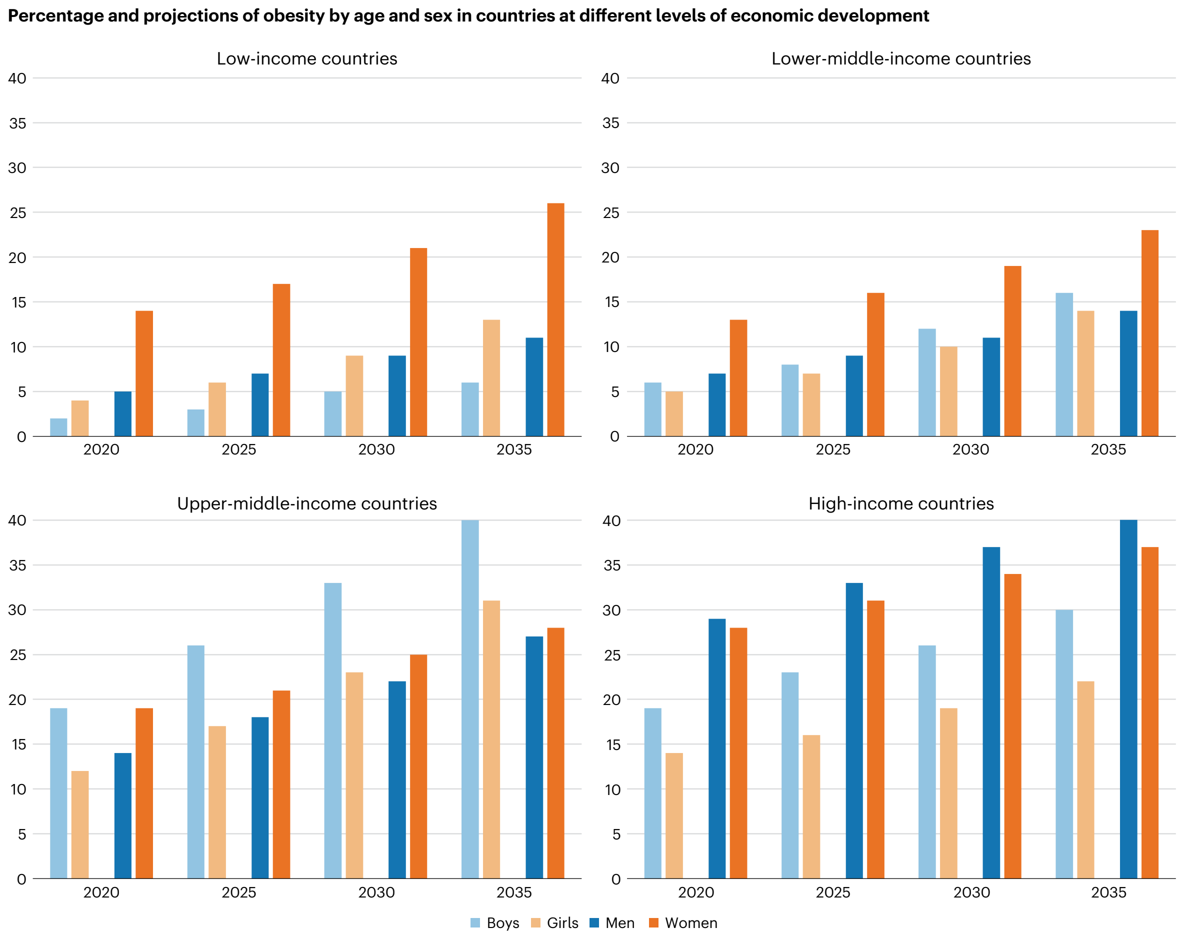

Fig. 1 | Percentage (current and projections) of people with obesity by age and sex in countries at different levels of economic development. Country classification was according to the World Bank. Obesity prevalence was obtained from the 2023 World Obesity Atlas from the Global Obesity Observatory.

no country showing a decrease in obesity prevalence[2]. Why is this happening? Is it that we do not know enough about obesity? Or the way we are applying this knowledge has not been effective or diffused enough? Are we neglecting certain populations of solutions that could slow down the obesity epidemics locally or even globally? These are important questions we, scientists working in the field of obesity and living in developing countries, ask ourselves more often than not.

There is plenty of evidence of a role for the environment and other systemic factors influencing body fat gain throughout life, being dietary practices and a sedentary lifestyle only part of the underlying determinants[4]. There have been important efforts from international organizations and individual countries to promote changes to counteract obesity, although clearly this has not been sufficient to overcome the increases in obesity prevalence in socially disadvantaged populations. With this in mind, important challenges arise: to (re)define what composes the main determinants of obesity in countries with high inequality rates and with diverse cultural and ethnic backgrounds, identifying these determinants, proposing strategies to decrease health disparities and anticipating ways that could lead to more effective prevention and treatment in these countries. To reach these goals, commitment of multiple sectors of society and between the developed world and developing countries seems to be imperative. Tailored, realistic actions should be coordinated locally with scientists, politicians, investors and the public opinion. Here we take a step towards a better understanding of the topic and raise awareness of this issue.

The burden of obesity in Latin America

Differences in obesity demographics in the world

In 2020, it was estimated that 14% of the world's population lived with obesity and by 2035 this is projected to be 24%, including children, adolescents and adults[2]. In the past decades, higher rates of obesity in children and adults from developed countries compared to developing countries have been reported[5]. However, when comparing the most recent trends in the prevalence of obesity[2,6,7], data have consistently shown a steeper rise in developing countries (Fig. 1). Indeed, as previously reviewed[8], the historical scenario of obesity has changed in this century in a manner that strongly relates with the socioeconomic status and sex distribution. In the developing world, a shift towards obesity within the lower socioeconomic strata has been observed as the country's gross national product increases, suggesting that inequality is an underlying contributor to the obesity trend in these countries.

According to the 2023 World Obesity Atlas[2], projections for the period between 2020 and 2035 show that obesity in children and adolescents from low- and middle-income countries will increase, and the projected numbers for obesity in boys living in upper-middle-income countries will be particularly alarming. Indeed, the increasing diagnosis of type 2 DM in younger ages in developing countries has been largely attributed to this increase in childhood obesity rates[9]. Among adults living in the developing world, obesity is usually predominant in women. Rates in both sexes are expected to increase everywhere, but among women, this increase is expected to be higher in less economically advantaged regions. The reasons behind this gender disparity associated with increased risk of obesity may be diverse, including: (i) the type of professional activity, as men from low-income countries are frequently involved in physical labour, whereas women are involved in domestic activities[10]; (ii) food choice, as in many low-income countries, women have higher refined carbohydrate intake, which has been associated with increased body mass gain and metabolic disturbances[11]; (iii) shorter stature found in women from low-income countries, because increased body weight has a stronger impact on BMI in people with short stature than in taller persons[12]; and (v), food insecurity, as lack of adequate and sufficient food is associated with higher rates of obesity and anaemia in women[13], which might also be related to women prioritizing healthier foods for other household members. As the income per capita increases, differences between sexes tend to be attenuated and, in upper-middle-income countries, similar rates of obesity are projected to the year 2035 due to a greater increase in obesity rates in men versus women, probably pushed by the higher prevalence of childhood obesity among boys in previous years.

Obesity demographics in Latin American countries: a proxy for the developing world?

Concerns about the rapid increase in obesity rates in developing countries go far beyond the prevalence of the disease itself, as the suboptimal access to healthcare by many individuals living in economically disadvantaged countries is expected to further reduce their life quality and expectancy. Long-term costs of treating comorbidities also limit compliance of patients and encumber the public health systems, thus contributing to lethal outcomes. Ineffectiveness in preventing and managing obesity has been widely reported, independently of economic development, but in the developing world this scenario is worse due to numerous reasons[14]. In this context, Latin American countries like Mexico, Brazil, Colombia, Argentina and Chile serve as good proxies to understand the behaviour of obesity in developing countries, not only because of the increasing trends of obesity in these countries, but also because of their most recent attempts to adopt measures to counteract these trends. All except Chile are upper-middle-income economies and among the most unequal countries in the world according to the World Inequality Database (Latin America is the region of the world with the highest inequality rate, where the top 1% of the population receives 23.5% of the national income share)[15]. They also have extensive territories and large populations (accounting for more than 70% of the population of Latin America and the Caribbean) with diverse racial and ethnic backgrounds. A large proportion of the population has overweight or obesity: 75% of adults in Mexico (2022)[16], 55% in Brazil (2019)[17], 57% in Colombia (2015)[18], 68% in Argentina (2019)[19] and 74% in Chile (2018)[20]; 39% of children and adolescents in Mexico (2022)[21], 30% in Brazil (2013)[22], 22% in Colombia (2015)[18], 41% in Argentina (2019)[19] and 53% in Chile (2022)[23]. While we are using these countries as proxies, we expect that other countries in Latin America behave in a similar manner, although regional differences are likely to occur. In 2016, except for Haiti, Paraguay and Nicaragua, all other countries in Latin America and the Caribbean had at least 50% of their population living with overweight[24].

Obesity in Mexico. Among developing countries, Mexico has one of the highest rates of adult obesity. The geographical proximity and frequent migration between Mexico and the United States allow studies comparing populations of similar ethnic and racial backgrounds living in different environments, for instance. One of these studies revealed that migration to a developed environment is associated with a lower BMI in children born and raised in Mexico versus those who moved to the United States[25]. The north of the country, neighbouring the United States, is wealthier, while the south is the poorest region. Interestingly, the regions with the highest adult obesity rates (>40%) are the north-west (Pacific North) and the south-east (Peninsula) with the south-east region also experiencing the highest rates of food insecurity[26]. Although these regions are ethnically and economically diverse, the similar rates of obesity have been attributed to the omnipresent obesogenic environment, with widespread exposure to low-cost sugar-sweetened beverages (SSBs) and calorie-dense products. Obesity is more prevalent in adult women (41%) than in adult men (32%), particularly in those living in urban populations. Moreover, 88% of adult women and 74% of adult men have abdominal obesity (that is, waist circumference of >80 cm in women and >90 cm in men), a parameter that reflects the amount of central rather than general adiposity, providing a stronger association with cardiometabolic risk[16]. If this scenario was not worrisome enough, overweight/obesity is high in children (39% in boys and 35% in girls) and adolescents (41% in both sexes). It is noteworthy that among children, obesity is more prevalent in boys (22%) than in girls (14%), and that adolescent boys showed a large increase in the rate of overweight/obesity from 2018 to 2022, going from 36% to 41%, whereas the prevalence remained relatively constant in other groups (children, adults and adolescent girls)[21]. Moreover, adolescents from rural areas had a steep increase in obesity burden during the last decade, although higher rates were registered in urban areas[21,27,28]. This drastic change in obesity prevalence will certainly have devastating consequences on the development of obesity-associated diseases in the next decades, particularly among the least-privileged individuals.

Obesity in Brazil. Brazil is a large and economically heterogeneous country, with an ethnically diverse population, providing a scenario for comparative evaluations of the factors that influence obesity rates within the country[29]. The current prevalence of obesity in Brazil is similar between adult men and women (20%); however, when both overweight and obesity are added together, the prevalence is slightly higher in men (57%) than in women (54%). Education level has a strong association with obesity prevalence, with those in the lower-education (0–7 years) group showing a higher rate (25%) than those in the higher-education (>12 years) group (17%). Also, a higher prevalence of obesity was observed in people from ethnic minorities and Black people (22%), compared to white people (19%)[17]. In teenagers (12–17 years old), the prevalence of overweight and obesity is similar in boys and girls (25%); however, boys have a slightly higher prevalence of obesity (9.2%) than girls (7.6%)[30]. Considering that the southern part of the country is more developed and richer than the northern part, data stratification according to geographical region allows hypothesizing on systemic determinants of weight gain. In teenagers, obesity and overweight are more prevalent in the south (30%) than in the north (22%). In children, the prevalence of obesity is 12%, and is higher in boys (12.3%) than in girls (10.8%); however, the difference between regions is large, ranging from 3% to 16%[31]. These findings draw attention not only to the challenge of identifying systemic determinants of obesity in unequal countries, but also to the necessity of finding regional solutions so that interventions can be more effective.

Brazil was also exposed to multiple waves of immigration in the past century, providing an opportunity to study how changes in the environment affect the predisposition to obesity in genetically similar populations. For example, cohort studies in Japanese migrants in Brazil have highlighted the impact of a Western environment on increasing body adiposity, which in turn contributes to metabolic disturbances, cardiovascular disease and increased mortality[32–34]. Continuous monitoring of this Japanese–Brazilian population revealed the expected role of dietary factors on the incidence of metabolic disorders, as well as the benefits of a lifestyle intervention[35,36], although other factors are likely to contribute to the outcomes.

Obesity in Colombia. Colombia and Argentina are the third and fourth most populated countries in Latin America, respectively. National surveys in Colombia showed that excess BMI (overweight and obesity) increased by 10% in adults during a decade, reaching 57% in 2015.

The burden of overweight and obesity is more aggravated in women (60%) than in men (53%) and in middle- and high-income citizens compared to low-income ones. Also, regardless of their ethnic origin, overweight and obesity are prevalent in more than 50% of the population identified as Afro-descendant (57%), indigenous (51%) and those without a self-identified ethnic belonging (57%)[18], supporting systemic rather than genetic factors as the drivers of the disease. Of note, obesity determinants in Colombia had a stronger impact on children than on adolescents. Similarly to the situation in adults, children's excess weight increased from 14% to 24% from 2005 to 2015, without major differences between sexes (25% in boys and 24% in girls). In adolescents, the increase was less steep (from 13% in 2005 to 18% in 2015); however, it showed a strong sex difference, with 21% of girls and 15% of boys having overweight or obesity[18].

Obesity in Argentina. Excess body weight registered in Argentina is slightly more prevalent in adult men (70%) than in women (66%); however, when only obesity is considered, this pattern slightly inverts (35% in women and 33% in men). A higher education level was associated with protection from obesity in Argentina, as people with a middle-school degree had an obesity prevalence of 28%, compared with a 40% prevalence in less-educated individuals. The household income was also associated with obesity, as shown by a higher obesity prevalence in the lowest income quintile (37%), compared to the highest income quintile (29%). The scenario is even more worrisome in the age group between 5 and 17 years old, in which 40% of girls and 42% of boys had excess weight. Obesity was more prevalent in boys (23%) than in girls (18%) and, in contrast to the scenario in adults, household income was not inversely associated with obesity prevalence in this age group, as those in the middle-income quintile exhibited the highest rate[19].

Obesity in Chile. According to the 2016–2017 health survey in Chile, 74% of the adult population have overweight or obesity with similar rates in women and men. When only obesity was taken into account, prevalence was higher in women than in men (38% versus 30%). Of note, among adults aged 30 to 64 years (representing the most economically active age group), the prevalence of overweight/obesity reached 84%. A higher obesity rate was observed in people with less years in school (47%) compared to those with a higher education level (30%)[20]. Among children and adolescents, Chile has the most dramatic situation in Latin America. According to data from 2022, 55% of boys and 51% of girls between 4 and 15 years old had overweight or obesity, with obesity more prevalent in boys than in girls (29% versus 23%). Regional differences also have an impact on the prevalence; children from rural areas exhibited a higher rate of obesity than those from urban settings[23].

In summary, higher prevalence rates of obesity in boys were detected in Chile as well as in Argentina, Mexico and Brazil, while in Colombia the opposite was observed among adolescents. In contrast, among adults, obesity is more prevalent in disadvantaged groups, especially women. These findings suggest that the factors that determine obesity may vary or impact individuals in different ways depending on the age group and the country, whereas boys, women and underprivileged individuals are usually at a higher risk of developing obesity in Latin America.

Determinants of obesity and their impact in Latin America

Despite the evidence of genetically determined cases of obesity, monogenic disease is uncommon and does not explain the rapid increases in obesity rates worldwide. Similarly, the global trend towards increased obesity cannot be simplistically attributed to the individual's preference for an energy-dense diet or reduction in energy expenditure related to modern occupations and sedentary leisure activities. A fallacious argument disproportionately puts all the burden of obesity on individuals rather than systemic factors, some of which inevitably place these individuals in inequitable obesogenic conditions. Latin American countries feature characteristics that make individuals particularly exposed to these factors, which in turn appear to explain the dramatic rise in obesity burden in these countries.

Here we enumerate these features and propose eight determinants of obesity in Latin America (and probably other developing regions): the physical environment, food exposure, economic and political interest, social inequity, limited access to scientific knowledge, culture, contextual behaviour and genetics (Fig. 2). They have been listed in no particular order and not balanced or prioritized by the level of evidence. Although some are attributable to a certain extent to the individual, the majority relates to the context where the individual lives and, therefore, can be considered systemic. Since the individual determinants interact with and are superimposed by the systemic determinants, the limited freedom of choice of individuals ends up having little impact on the obesity trends[37]. On the other hand, society-related and structural conditions play a major role.

Considering the wide and diverse geographical, ethnic, political and cultural backgrounds of Latin American countries, and acknowledging the complexity of comprehensively defining the aspects that influence obesity rates in every country of Latin America, in the next section we provide examples of specific countries as surrogates to describe the contribution of each determinant to the rate of obesity in Latin America. Nevertheless, we believe that some of the lessons learned from these countries may also apply to other developing countries, particularly within the Americas.

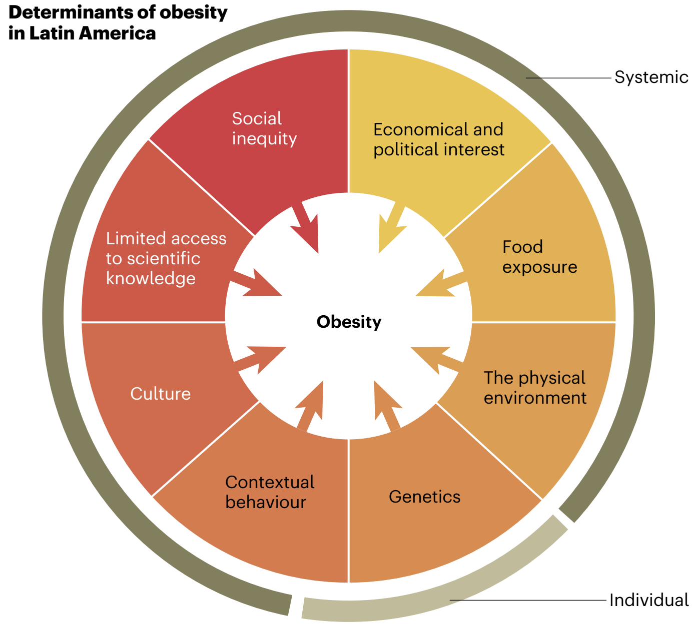

Fig. 2 | Determinants of obesity and their interactions. There are eight determinants of obesity in Latin America: the physical environment, food exposure, economic and political interest, social inequity, limited access to scientific knowledge, culture, contextual behaviour and genetics; inner circle). They can be classified as systemic and/or individual (outer circle).

The physical environment

During the past 50 years, the world's prevalence of obesity has almost tripled[38], and by 2035, most of the population will live with overweight or obesity[2]. Such a dramatic change in the human phenotype can only be attributed to equally abrupt modifications in our living conditions. Among the many factors influencing the obesogenic environment,

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there is plenty of research that supports the role of changes in the physical environment in contributing to the obesity epidemic.

Latin America has faced unique and interconnected challenges related to pollution, water and food contamination with endocrine-disrupting chemicals (EDCs), climate change, deforestation and urbanization. These challenges are particularly impactful in this region due to a combination of factors, including rapid industrialization, urbanization, agricultural practices and environmental vulnerabilities[39]. Latin American countries often grapple with air and water pollution, driven by factors such as industrialization, vehicle emissions and inadequate environmental regulations[40–42]. Furthermore, agricultural practices in many Latin American countries involve the use of pesticides, herbicides and fertilizers that may contain EDCs[43]. These chemicals can contaminate soil and water, entering the food supply chain. Latin American countries may be particularly susceptible to this issue due to extensive agricultural activities. Moreover, Latin America is highly vulnerable to climate change impacts, including rising temperatures, extreme weather events and altered precipitation patterns[39,44]. Deforestation is also a critical issue in Latin America due to agricultural expansion and urban development[39]. Finally, Latin America has experienced rapid and unplanned urbanization in recent decades, leading to numerous changes in the built environment, lifestyle and dietary habits[39]. Below, we describe how the changing physical environment could be impacting obesity rates in Latin American countries.

Pollution and food contamination. Air pollution is a complex mixture of particulate matter, ground-level ozone, volatile organic compounds, heavy metals and other environmental contaminants. Most populations living in urban areas are subject to air pollution exceeding the World Health Organization (WHO) limits, particularly those from the developing world. WHO air quality guidelines were not met by 98% of cities in developing countries with over 100,000 inhabitants in contrast to 56% in developed countries[45]. Various epidemiological studies have investigated links between exposure to air pollutants and health outcomes, mainly respiratory diseases but also obesity. Especially, fine particulate matter ($PM_{2.5}$) can penetrate deep into the respiratory system, enter the bloodstream and trigger metabolic dysfunctions. Underlying mechanisms that could affect body adiposity are increased oxidative stress and adipose tissue inflammation, hepatic lipid accumulation and decreased glucose utilization in skeletal muscle[46–48]. Exposure to air pollutants like black carbon, a $PM_{2.5}$ component, has also been linked to insulin resistance, a key mechanism in the development of type 2 DM[49,50]. It was proposed that air pollution may also favour sedentary behaviour thus favouring weight gain[51]. A systematic review of studies conducted in the developed and developing world on the association of ambient air pollution and body weight status provided heterogeneous results, which may differ according to sex, age group and type of air pollutant[52]. Whether pollution-dependent reduced energy expenditure could translate into weight gain in humans remains to be clarified.

Contaminated water sources and chemical residues of packaging materials may introduce EDCs into the food chain. Elevated levels of EDCs, such as polychlorinated biphenyls, organochlorine pesticides, per- and polyfluoroalkyl substances, bisphenol A and phthalates can in turn disrupt the endocrine system[53]. These chemicals interfere with hormonal signalling, affecting the regulation of appetite, metabolism and fat storage[53,54]. Intriguingly, exposure to EDCs can have transgenerational effects, meaning that the adverse impacts on metabolic health may be passed from one generation to the next, potentially exacerbating obesity rates over time[53].

Climate change. Climate change is a complex, multifaceted environmental challenge that is having far-reaching effects on ecosystems, agriculture and human health. While its primary association is with extreme weather events, sea-level rise and temperature changes, climate change can indirectly contribute to obesity in various ways. Climate change has led to an increase in the frequency and intensity of extreme weather events, such as hurricanes, heatwaves and floods[39,44]. These events can disrupt food systems, leading to food scarcity and instability. Extreme weather events can damage crops and disrupt food production and distribution, leading to food shortages and increased prices. In response to food scarcity, individuals may be forced to rely on energy-dense, low-nutrient foods, which can contribute to overconsumption and obesity. Extreme weather events can cause economic hardships, making it more difficult for communities to access and afford nutritious food. Climate change can also lead to population displacement, forcing people to leave their homes and communities. Displacement can disrupt social networks and community support systems, which are important for maintaining healthy lifestyles.

Additionally, climate change can threaten food security by altering agricultural practices, crop yields and the distribution of food resources. Changing climate conditions can affect the timing and location of crop planting and harvesting. These changes may lead to decreased availability of fresh fruits and vegetables and increased reliance on processed, energy-dense foods. Climate change can also result in reduced crop yields due to factors like changing precipitation patterns and increased temperatures. Reduced crop yields can lead to higher prices for healthier foods[55], making them less accessible to lower-income populations such as in Latin American countries.

Moreover, climate change-induced migration can disrupt access to healthy food, as people may be forced to move away from their traditional sources of nutrition. This may lead to increased consumption of unhealthy, readily available foods. In addition, climate change can lead to changes in the nutritional content of food, with some studies suggesting that increased atmospheric CO_2 levels may change the nutritional content of crops, potentially worsening diet quality[56].

Deforestation. Deforestation is the process of clearing large expanses of forested land, often for agricultural or urban development purposes. While the immediate consequences of deforestation are related to habitat loss and biodiversity decline, it may also have indirect effects on obesity. Forests are crucial for biodiversity and provide a wide range of natural foods, including fruits, nuts and various wild plants. Deforestation can reduce access to these natural foods, leading to increased reliance on processed and energy-dense foods. Deforestation often involves the conversion of forested land into farmland. While this can increase food production, it may lead to monoculture practices where a limited range of crops are grown. This can reduce dietary diversity, as people become dependent on a smaller number of staple crops, which are often calorie dense but nutrient poor. In Brazil, deforestation has been historically driven by soy and beef producers[57]. Hence, deforestation can disrupt local food systems, particularly among local communities that rely on forests for subsistence, reducing food security[58,59]. Moreover, indigenous cultures and communities closely tied to forested areas may undergo cultural and behavioural changes as a result of deforestation. These changes can affect traditional dietary patterns, often leading to the adoption of less-healthy diets.

Urbanization and the built environment. The rapid urbanization of many regions in Latin America has led to changes in the built environment, potentially contributing to increasing obesity rates. Urban areas often feature environments that encourage sedentary lifestyles. The proliferation of motorized transportation, along with the design of cities that prioritize cars over pedestrians and cyclists, can reduce physical activity levels. Urbanization has been associated with lower total physical activity[60], which is a risk factor for obesity. Urbanization is often associated with the increased availability of fast-food outlets, convenience stores and other sources of high-calorie, low-nutrient foods. These readily available, energy-dense options can promote unhealthy eating patterns and contribute to obesity. Urban areas, especially in regions where cities grew in an unplanned manner such

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as in the main metropolitan areas of Latin America, may limit access to green spaces and recreational areas, which can discourage physical activity and outdoor leisure. A lack of green areas, parks, sidewalks, bicycle lanes, public sport facilities and safe spaces for exercise can further contribute to a sedentary lifestyle. Urban living can also be associated with increased psychosocial stress due to factors such as noise, pollution and overcrowding. Stress can lead to emotional eating and other unhealthy coping mechanisms that contribute to obesity[61]. Finally, urbanization can disrupt social networks and community ties, which can impact health behaviours, including diet and physical activity. As a consequence, traditional support systems for healthy living may be weakened.

Accumulated scientific evidence supports that the summation of these physical environment factors could play a role as a determinant of obesity. Whether particular conditions in developing countries, including political interests and precarious regulations, could put Latin American populations at higher risk for obesity in contrast with the developed world has to be clarified.

Food exposure

The burden of obesity in Latin America is dependent in part on the relatively rapid nutritional transition from the traditional diet to a 'westernized' one. It is recognized that an eating pattern governed by overconsumption of poor nutritional quality, calorie-dense, ultra-processed foods (UPFs) is considered a major driver of weight gain[62,63]. Feeding patterns changed rapidly with the development of agriculture and farming, but it was during the past few decades that several socioeconomic factors radically transformed feeding behaviour. Urbanization, globalization, women joining the labour force with less time for families to cook and share meals, and the development of a buoyant food industry to fulfil the needs of the growing and consumerist population changed the traditional human lifestyle including in Latin America.

The definition of UPFs together with the NOVA classification of foods based on their degree of processing[64] triggered investigations regarding their impact on health outcomes. Systematic reviews and meta-analyses showed that UPF consumption is linked to overweight, obesity and larger waist circumference in children, adolescents and adults[64–70]. UPF intake accounts for more than 50% of calories consumed in countries like the United States and the United Kingdom[71,72], whereas their consumption varies in Latin American countries, with high UPF calorie consumption rates in countries like Chile and Mexico[71,73], in parallel with the high prevalence of obesity in these countries, and not so high in Brazil and Colombia, which have intermediate rates of obesity among developing countries[71,72]. Consistently, annual retail sales per capita of UPFs and drink products in 2013 showed a high correlation with the prevalence of obesity in Latin American countries; Mexico and Chile were the highest consumers (around 200 kg of UPFs per year per person), being among the top 7 consumers in the world (from 80 countries), while Argentina was the 14th (185 kg), and Brazil (34th) and Colombia (51st) had less high consumption (around 100 kg)[74]. Of note, consumption of UPFs in Latin American countries is higher in children than in adults and is still on the rise, whereas in the United States and the United Kingdom, it has plateaued[74]. Contrasting scenarios in developed and developing countries support that they are at a different stage of the obesity epidemic and may need different strategies to achieve countermeasures against it.

The mechanisms that link UPF consumption to the development of obesity are not completely known, but relate mostly to their composition, affordability, accessibility and aggressiveness of marketing. UPFs are made of cheap nutrient sources (that is, palm oil and fructose corn syrup), providing an unbalanced nutrient profile (low in protein and fibre), and contributing to a condition that has been more frequently found in Latin America: obesity associated with malnutrition[75–77]. UPFs are engineered to be hyper-palatable, leading to less satiety and high consumption when compared to unprocessed or minimally processed foods[78]. Additionally, high-fat or high-sugar snacks rewire brain reward circuits, diminishing the preference for low-fat food and potentially promoting overeating[79]. In a controlled clinical trial, participants exposed to an UPF diet ate more calories each day and gained weight, while those exposed to a calorie-equivalent minimally processed diet consumed less calories and lost weight[78]. Also, their highly processed food matrices may contribute further to easier digestibility and increased eating rates, resulting in higher caloric absorption coupled with reduced energy expenditure (that is, thermic effect of food)[72,80,81]. In concert, recent evidence shows that basal energy expenditure, but not activity-related expenditure, has declined in humans during the last 30 years[82]. These studies have been performed in the United States and Europe, while similar studies are missing in Latin America and other developing regions. Of note, long-term dietary habits can be modelled by early feeding practices. For instance, breastfeeding is associated with offspring's adherence to a prudent dietary pattern[83], and in rodents, consumption of a high-fat diet during lactation reprogrammes dopaminergic circuitries leading to altered feeding behaviour[84]. Also, maternal consumption of low-calorie sweeteners changes hypothalamic circuits leading to altered metabolic homeostasis in the offspring[85]. Other mechanisms of UPF-induced obesity involve ingestion of neo-formed substances and migrated packaging materials that act as EDCs[72], as well as perturbations of the gut microbiota[86–88] and metabolomic profiles derived from the many industrial additives contained in UPFs[89]. Microbiota composition can be influenced by multiple factors since birth, but dietary habits are considered a major determinant[90]. A balanced microbiota contributes to maintaining body adiposity, while an imbalanced one may generate inflammation, favouring energy harvesting, fat accumulation and metabolic disturbances[91,92]. A diet enriched in whole plant foods, as compared to that enriched in UPFs, results in a gut microbiota composition and metabolomic and signalling molecule profile that favours satiety and protects from excessive weight gain[87,93]. Whether UPFs differentially affect microbiota profiles depending on the population studied needs to be further investigated.

Populations from the developed world usually consume higher quantities of healthy foods (such as vegetables and fruits) and have an overall more diverse diet[94]. In contrast, Latin America and the Caribbean are the largest sugar-consuming regions in the world on a per-capita basis[95]. They are also regions with high meat consumption (twice the world average) and low fish consumption (half the world average)[95]. This pattern is markedly different in most parts of Asia, including in developing countries of that region, where fish consumption is higher, and meat and sugar consumption is lower. These patterns coincide with higher obesity rates in Latin American countries compared to Asian ones. Consistently, Latin America is the region of the world with the highest consumption of SSBs, according to data from 2018 (ref. 96). While the average world consumption is 2.7 ounces per week, in Latin America the average is 7.8 ounces, with men consuming more than women, and intakes being higher in younger than in older adults.

Moreover, inadequate diets contribute to the development of obesity-associated diseases, such as type 2 DM. In 2018, dietary factors accounted for 70% of DM incidence worldwide. In Latin America, the scenario was even worse, and poor-quality diets explained 82% of incident DM cases. Among all world regions, Latin America had the highest burden of SSB-associated DM incidence, and a high burden of DM incidence was associated with processed meat consumption, like that seen in high-income countries[97]. The other notable dietary factors contributing to DM in Latin America were insufficient intake of whole grains and excessive intake of unprocessed red meat.

Economic and political interest

Drastic changes in the physical environment and in food exposure are intimately linked to economic interests and the market, making them systemic determinants. Globalization associated with the rapid population growth has allowed the consolidation of a small number of transnational companies that manufacture a large share of the world's foods and beverages; in this regard, ten companies known as the Big Food and Big Soda control 80% of the global store-bought products[98]. Their relevance for the current food systems and economic power, make them obvious lobbyists in food regulatory agencies in many countries, including Latin America. Unfortunately, their economic interest is not necessarily aligned with the health interest of the population; therefore, their participation and influence in public health policy constitutes a clear conflict of interest[99–102]. Despite this, the development and application of food policies by international and national efforts towards counteracting and preventing obesity has faced strong interferences from the food and beverage industry, at many levels[103]. For instance, by creating groups of interest represented by actors from the food and beverage industry to advise and foresee the creation and implementation of public policy, including lobbying at the government and at congress, and legally arguing against taxes on SSBs and the front-of-pack nutrition labelling (FOPNL) on UPFs, claiming economic adverse effects[104]. Their strategies also include greenwashing, healthwashing and sportswashing, to influence consumer perception that they are part of the efforts to counteract obesity. Moreover, as occurred with the tobacco industry, the UPFs and beverage industry finances institutions and researchers to disregard the harmful health effects of their products[102]. The influence of the food and beverage industry on public policy is such that, for instance, in Mexico (but certainly in other countries), political party leaders, former high-profile authorities from the health and government ministries and from the Mexican Food And Drug Administration, congressmen and even ex-presidents have been employees or advisors at the food and beverage industry before or after their jobs in public service[105,106]. Another example of economic interests not aligned with health needs are packaging materials for food products. Single-use plastics are economically convenient although they are harmful for the planet and for human health[107]. In general, the high-scale production associated with UPFs and their components (high-fructose corn syrup, palm oil and soy products) involves high profit at the cost of deteriorated human and planetary health. Therefore, it is critical to establish clear regulations to avoid the influence and interference of UPF transnational companies on public policy in Latin America, to protect the right of people to healthy food.

Social inequity

Another pivotal factor contributing to the disparity in obesity burden between the developed and developing world is the profound influence of social inequity. Given that Latin America stands as the most unequal region globally in terms of income distribution[15], and considering its historical backdrop of colonization and slavery, it is evident that social inequity is poised to exert a profound impact on all the systemic factors under discussion, which in turn influence obesity rates in Latin American countries. Wealth disparities are related to essentially all structural factors leading to obesity, limiting individual choices to a healthy living condition and increasing the challenge of combating obesity. Below, we describe unequal conditions commonly found in Latin American countries and discuss their relationship with obesity.

Socioeconomic inequities. One direct consequence of unequal income distribution in developing countries is the access to adequate nutrition, where food is proportionally more costly. The more developed the country is, the lower the proportion of the individual's income spent on food for consumption at home[108,109]. Moreover, more favourable markets abroad encourage local farmers to use their limited resources to produce goods mainly to export, decreasing food diversity locally[95]. Even within low- and middle-income countries, a relationship between socioeconomic status and diet quality has been observed[110]. Thus, the least economically privileged people tend to be exposed to an overall quality of diet that is poorer and contributes to obesity and malnutrition. In addition, underprivileged people frequently have access to inadequate working conditions and lifestyles. Long working hours may result in stress, impose reduced time for leisure and physical activities and lead to poor sleeping habits. Stress-related hormonal disturbances have been associated with the risk for obesity[111]. Additionally, neighbourhood characteristics of disadvantaged populations contribute to explaining variations in physical activity and obesity risk[112]. Moreover, income inequality in Latin American populations may contribute to an even heavier burden due to the multiple obesity-related comorbidities, which imply health and financial costs and psychological damages, aggravating social inequity.

Education-related inequities. As mentioned previously, obesity prevalence exhibits a notable association with the level of education in many Latin American countries. In these regions, it is not uncommon for less-educated women to face a higher risk of obesity. Curiously, among men, a different pattern emerges in certain countries like Brazil, Colombia, Paraguay and Mexico, where obesity rates are elevated among the highly educated and wealthier[113]. Conversely, the situation varies for women, with those in middle levels of education and wealth exhibiting the highest obesity prevalence in Bolivia, Peru, Mexico and Colombia. In contrast, obesity rates are most elevated among the poorest and least-educated women in Argentina, Brazil, the Dominican Republic, Venezuela and Paraguay[113]. These data suggest that countries in Latin America are positioned at various stages along the spectrum of the obesity transition according to the socioeconomic stage and sex, as previously noted by Jaacks et al.[114]. Notably, education, especially among women, appears to serve as a protective factor in mitigating what has been termed the 'wealth effect'[115]. This 'wealth effect' may arise from a confluence of factors, including affluence, a historical backdrop of socioeconomic disparities and the pervasive influence of aggressive obesogenic marketing. Together, these elements tend to exacerbate obesity rates. Although education is a basic human right, the level of formal education varies dramatically among individuals in privileged versus underprivileged communities. Moreover, health literacy remains a challenge to many individuals in Latin America[116]. As children from poor families are less likely to have access to proper education[117], social inequity ends up perpetuating a scenario of disparities in educational levels in Latin America.

Barriers to healthcare and preventive strategies. Disparities in access to healthcare and preventive medicine is an important aspect of social inequity in developing countries. In developed countries, most people have access to healthcare, which can be either private or public, depending on the country. In the United States, 91% of the population are covered by health insurance[118], whereas in Japan and Germany, there is 98% coverage[119,120]. Conversely, in developing countries, these numbers are highly variable ranging from as low as 25% in India[121] to up to 100% in Brazil, which has a public universal healthcare system[122]. Nevertheless, even in countries with public systems covering most of the population, the actual capacity of offering rapid and qualified services is not always optimal. The Healthcare Access and Quality (HAQ) Index uses distinct causes of amenable mortality to estimate healthcare quality for all countries across the world[123]. The HAQ uses principal component analysis to create a single index on a scale of 0 to 100 (ref. 123). In 2019, Switzerland led the list with a HAQ index of 92. As a whole, middle-income countries had a HAQ index of 60, whereas in low-income countries this index was 39 (ref. 124). Specifically, for the countries mostly cited in this Review, Chile had a HAQ index of 71, Colombia 61, Argentina 60, Brazil 53 and Mexico 52 (ref. 124). The main reasons behind the low scores obtained by developing countries include lack of healthcare professionals, difficult access to services, long waiting lines and lack of programmes to provide low-cost medications. This scenario could impact obesity by delaying diagnosis and early interventions that limit gain of body fat. It could also impact obesity comorbidities by inappropriate screening and treatment of DM, hypertension and cardiovascular disease. Another barrier is the fact that obesity is not universally recognized as a disease. This situation compels individuals to live with a condition that may receive inadequate attention within healthcare systems. Such neglect places these individuals at a heightened risk of developing health-compromising comorbidities and hampers the implementation of strategies aimed at preventing and treating both obesity and its associated diseases.

Sex-related inequities. As the numbers presented previously in this Review indicate, men and women are differentially affected by obesity in developed and developing countries. Since 1985, the rise in BMI in the developed world has been larger in men than in women, whereas in many developing regions such as Latin America and the Caribbean, South Asia and Sub-Saharan Africa the rise in BMI has been larger in women than in men[125]. For instance, while increased BMI during this period in women from Latin America was 1.3 kg/m^2 in rural and 2.0 kg/m^2 in urban areas, increases in women from developed Western countries were only 0.4 kg/m^2 in rural and 1.4 kg/m^2 in urban areas.

This sex-related difference in the prevalence of obesity observed in developing countries highlights the role of sex as a contributing factor to obesity. The underlying mechanisms of the higher prevalence of women among individuals with overweight and obesity in Latin America are quite complex, involving education and other socioeconomic issues. In general, education has a protective effect in both sexes, but its influence in men and women from developing societies may differ. In a nation-based study in Brazil, education was associated with protection against obesity only in men from more developed regions, while in women the protective effect was independent of the economic level of the region[126,127]. Data collected in several populations have indicated that food consumption[128,129] and physical activity are gendered[130], and these differences could contribute to distinct obesity rates across countries. Even in wealthy regions where people have access to healthy diets and safe neighbourhoods, contrasting rates between sexes were detected[126]. Limited financial resources coupled with low education among women from developing countries could also make them less aware of the benefits of consuming healthy foods and practicing exercise during leisure time.

The social and political structure of some Latin American countries may also be unfavourable to women. In many social contexts, women are expected to be dedicated to household and maternal activities and, particularly in the developing world, they may be subjected to discriminatory practices in terms of occupational opportunities[131]. These conditions may constrain their choices for a healthier lifestyle. Hence, there is a complex myriad of factors influencing the insertion of women in Latin American societies that should be considered to explain sex differences in obesity in Latin America, including economic dependence in the household and reduced leisure time.

Ancestry-related inequities. A relationship of skin colour and social status in Latin America has been reported[132] and could potentiate inequity predisposing to obesity. In Brazil, the highest rates of obesity were reported in non-white women among the less economically privileged ones[133]. However, in that country the association of race with obesity was dependent on sex and socioeconomic status[134]. In a recent paper based on the Mexican Biobank project, the traditional hypothesis that indigenous ancestries had an intrinsically higher genetic risk for obesity has been refuted[135]. In fact, by evaluating 6,057 individuals from 898 rural and urban localities across Mexican states, the authors found that individuals with indigenous ancestries and speaking an indigenous language presented a lower BMI in comparison to the overall population. On the other hand, positive association between individuals that speak an indigenous language and higher BMI occurred only in urban environments, where these individuals tend to be marginalized. This suggests that rather than ancestry, inequity associated with the urban context is the main driver of obesity for certain minority groups.

Limited access to scientific knowledge

Limited scientific knowledge is yet another element related to education and inequity that we consider influencing the prevalence of obesity and its complications. It is somewhat obvious that the more we know about obesity, both at the biological and social aspects, the more we will be prepared to prevent and treat it. Although science is a global enterprise and scientific knowledge should be made open and accessible to everyone, we are not quite there yet. For reasons that go beyond the scope of this Review, access to scientific data is somewhat restricted outside the developed world[136–138]. Moreover, obesity a multifactorial condition, and knowledge concerning obesity obtained in certain countries with populations of specific ancestral backgrounds or subjected to particular environmental contexts does not necessarily apply to all countries and populations. Therefore, scientific evidence on obesity will be more generally applied only when research in the field embraces diversity and the multidimensionality of the theme. So far, this is not the reality, as long as clinical, biomedical and social sciences remain biased towards conclusions obtained from data collected in developed countries from individuals of European origin[139,140].

When it comes to research in the fields of 'endocrinology, diabetes and metabolism', the disparity between the scientific output comparing the developed world and the rest of the world is substantial. According to the SciVal platform, in most developed countries, particularly in Europe, the scholarly output in the field is much superior to that of developing countries when normalized by the number of inhabitants (Fig. 3). Curiously, when plotted against the percentage of adults with obesity in the population, there is an inverse correlation within developed countries (Pearson $r = -0.2936$; P value = 0.025). This inverse correlation is not found when considering the developing world (Fig. 3). Although this analysis cannot establish a cause–consequence relationship, it raises the hypothesis that the more a country generates scientific knowledge on research topics related to obesity, the less is the probability of this country to suffer from the obesity burden, at least in the developed world. It is somewhat obvious that the higher the rate of obesity the more urgently a country should invest in scientifically oriented ways to achieve countermeasures against this scenario; nonetheless, these data also indicate that countries should fund research on obesity as a means of maintaining their population's health regardless of their income. Clearly, other variables may influence these associations. The countries with the highest scholarly outputs in the field, especially in Europe, are well known to be highly committed to a welfare state and are also known to have strong policies against obesogenic environments. Investment in science might as well be considered one of these policies.

Promoting more equitable obesity research in Latin America may also help finding more efficacious interventions. As most obesity determinants are related to societal, political and environmental issues, investments in social sciences, targeting the prevention of obesity across the entire life course using a holistic approach, are needed to fill major gaps in knowledge. Ideally, scientific knowledge should be acquired locally to account for and address the relevant and specific problems of Latin American populations. Scientific evidence generated locally may also be relevant in the design and implementation of local policies. It may also help substantiate arguments against the influence of vested political or industrial interests with apparent conflicts. For example, when searching for the main factors associated with healthy aging in Latin America, researchers concluded that social determinants of health, mental health and cardiometabolic risks contributed more to healthy aging than age and sex, which are considered top contributors to pathological aging in developed countries[140]. Hence, interventions, research and public policies that are meant to be applied in Latin America should be tailored to address the particularities of the populations living in this region.

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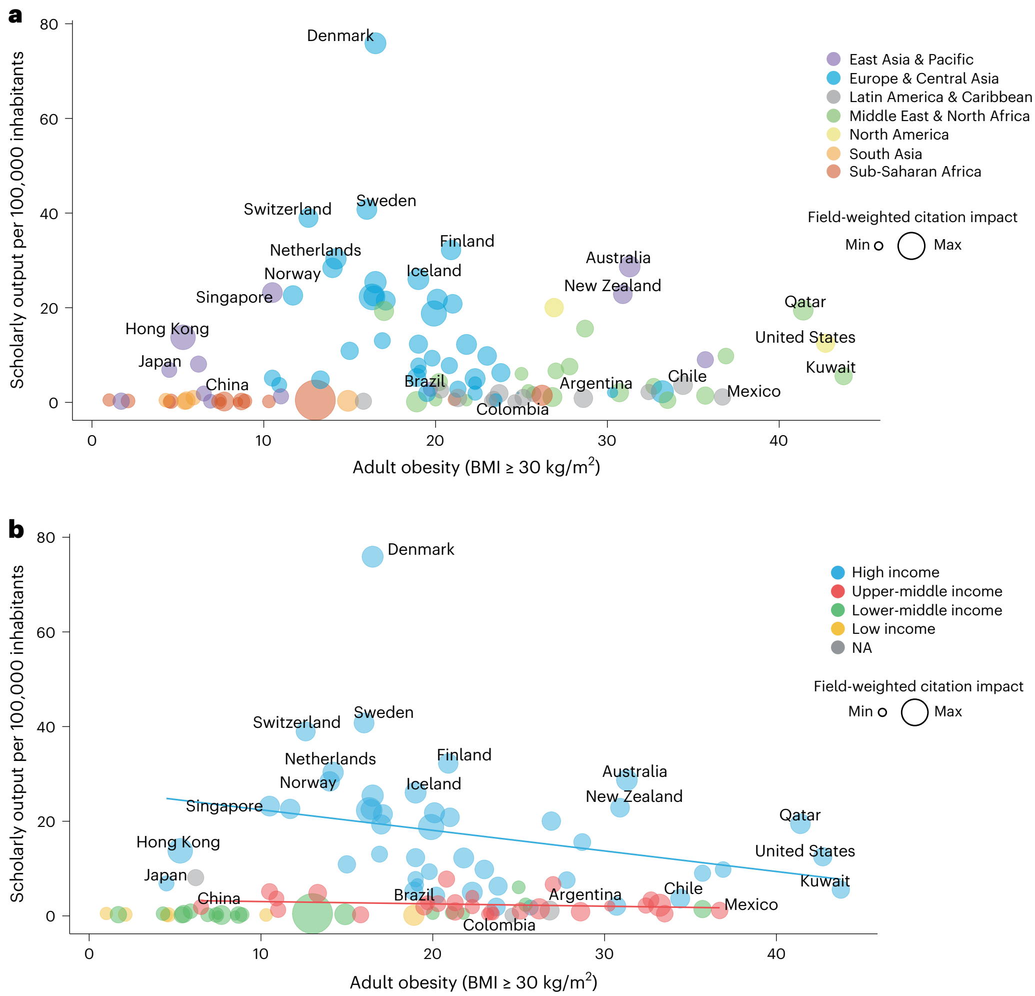

Fig. 3 | Scholarly output versus the percentage of adults with obesity (BMI ≥ 30 kg/m²) in countries of different geographical regions and at different levels of income. a,**b**, Countries classified by geographical region (**a**) and income (**b**). Scholarly output and Field-Weighted Citation Impact were obtained using the SciVal platform and represent the total count of research output and the ratio of the total citations received by a country in a given field by the total citations expected based on the average of the subject field, respectively. The following inclusion criteria were used: year range 2017 to 2023; subject classification: all science journal classification—filtered by 'endocrinology, diabetes and metabolism'; types of publications: all publication types; self-citations included; data source: Scopus; date last updated: 8 March 2023; date exported: 15 March 2023. Countries were classified based on the World Bank classification system. The population was obtained from the United Nations. Obesity prevalence was obtained from the 2023 World Obesity Atlas from the Global Obesity Observatory. NA, not applied.

A notable example of how research with specific under-represented populations may contribute to the full understanding of a disease state and lead to more inclusive treatment is the development of PCSK9 inhibitors based on genetic information obtained from people of African descent[141]. The development of new pharmaceutical compounds is a complex and costly process, which combines advanced scientific methods with strategies to identify promising targets and test candidate drugs for safety and efficacy. As new drug candidates emerge from basic and translational research, which may take several years to be accomplished, they must undergo a multi-step clinical trial that generates the data needed for approval by regulatory governmental agencies. In an ideal scenario, both preclinical and clinical trials should provide evidence for safety and efficacy applied to people of different ethnic backgrounds living in all regions of the world, implying that testing should consider these variables. In addition, once shown to be safe and effective, drugs should reach developed and developing country populations at about the same time. However, studies have shown that due to a combination of factors, such as the rules and timing imposed by distinct regulatory agencies, location of pharmacological companies' headquarters, drug marketing, local patent protection rules and purchasing power, new drugs invariably reach the populations of developed countries much earlier than populations living in developing countries[142–144].

Apparently, this behaviour also applies to clinical research in obesity. As of March 2023, there were 891 active obesity clinical trials in the United States[145], a country with 330 million inhabitants; thus, there were 2.7 obesity trials per million inhabitants. In Brazil, the country with the second largest population in the Americas (210 million inhabitants), there were 87 active obesity clinical trials[145,146] resulting in 0.4 obesity trials per million inhabitants; and in Mexico, the country with the third-largest population in the Americas (130 million inhabitants), there were 57 active obesity clinical trials[145,147] resulting also in 0.4 obesity trials per million inhabitants. The number of published obesity clinical trials reinforces the difference between developed and developing countries in America. According to data extracted from PubMed, over time, researchers based in the United States have published 1,076 obesity-related clinical trials, resulting in 3.2 obesity trials per million inhabitants; Brazilian researchers have published 118 obesity-related clinical trials, resulting in 0.5 obesity trials per million inhabitants; and Mexican researchers have published

62 obesity-related trials, thus also resulting in 0.5 obesity trials per million inhabitants.

Looking at the problem from yet another perspective reveals that new obesity drugs reach developed countries earlier than Latin American countries. Liraglutide, the first glucagon-like peptide-1 analogue used to treat obesity, was approved in the United States in 2014, and in Europe in 2015. The approval in Brazil occurred in 2016, whereas in Mexico, it occurred only in 2018. Semaglutide, the second-generation glucagon-like peptide-1 analogue, was approved to treat obesity in the United States in 2022, whereas it still awaits approval in most Latin American countries. Hence, not only is research on obesity occurring at a disproportionately low magnitude in Latin American countries, considering the number of individuals with obesity living in these countries, but also obesity-related studies around the world that consider the particularities of Latin America are limited. Moreover, even when research conducted abroad based on evidence obtained from populations of different ethnic backgrounds results in promising drug candidates, clinical trials less often include participants living in Latin American countries. Finally, when some of these trials succeed and drugs are approved for clinical use, the treatment is made available later and at a higher cost proportionally in Latin American countries when compared to developed countries, leading to barriers to access these novel treatments and further increasing social disparities. Further studies addressing the role of limited access to scientific knowledge as a contributing factor for obesity in the developing world are needed.

Culture

Another systemic determinant contributing to the development of obesity is culture, understood as the traditional behaviour, values, beliefs and lifeway of a society. Most Latin American countries have ancient traditions regarding food and feeding behaviour; sharing meals with family and friends is part of life in Latin America, with almost all celebrations occurring around food. For instance, in Mexico, the traditional diet is nutritious and balanced, based on corn grains and enriched with all kinds of vegetables (including peppers), fruits, seeds, other grains and different types of meat and protein sources. However, during the last decades, Mexico and other Latin American countries have experienced a process of westernization and industrialization of the dietary habits, switching from traditional diets to the adoption of UPF ingestion patterns. For instance, in Mexico, between 1969 and 2016, consumption of beans dropped by 50%, whereas during the same period ingestion of SSBs increased 2.5 times[148]. This switch was influenced by commercial determinants, mainly the invasion of UPFs and its heavy marketing, including the industry-seeded ideas that ultra-processed products are linked to happiness, success, social status and overall wellness. In particular, sugary drinks are now part of the daily eating habits of children and adults in Mexico and are perceived as highly rewarding and used as comfort beverages in children, whereas in adults they are perceived even as a complement to traditional dishes[149].

Another example of how UPF products have permeated Latin American culture is that in Chiapas, Mexico, cola-flavoured soft drinks are used in certain religious and spiritual-traditional rituals. This region is the highest consumer of soft drinks in the world, besides being a region with high food insecurity associated with lack of guaranteed access to clean water. Moreover, there is a high prevalence of obesity and diabetes associated with increased risk of disability and death rates in the region[150]. Hence, regulating access to SSBs and securing clean water for consumption are likely to have a positive impact on the overall health status of these communities.

A more recent barrier towards fighting obesity are the movements denying obesity as a disease. These movements originated in North America but have permeated Latin America. While they have valuable arguments about body acceptance and against obesity stigma, their inattention to the scientific evidence pointing to obesity as a health-debilitating condition is worrisome, as it could prevent people from recognizing that obesity is a risk factor for the development of chronic diseases and premature death[151]. Moreover, these movements label efforts to counteract obesity as 'fatphobic' while promoting intuitive eating and anti-diet actions, questioning patients that wish to regain their healthy weight. Taking advantage of these arguments, the UPF industry has seeded messages such as 'there are no bad foods' and 'what matters is how much you eat', ultimately creating confusion and promoting obesity and its comorbidities.

The classification of obesity as a disease has sparked heated debates, with questions surrounding its implications and the potential benefits for those affected by obesity[152]. Amidst this ongoing discussion, some nations have already officially recognized obesity as a disease, while others have not[152]. Although further research is needed to illuminate these complex issues, there is a growing consensus on the importance of acknowledging patients' perspectives and dismantling the stigma associated with obesity. It is worth noting that discussions about stigma must also consider cultural variations, as certain societies historically associated excess weight with symbols of success, affluence and good health[153]. Nevertheless, it is undeniable that the persisting misconception of obesity as a mere lifestyle choice remains an important barrier to progress in obesity management across numerous cultures.

Contextual behaviour

The environment in which individuals find themselves, including their historical background, socioeconomic circumstances and technological advances, can drastically shape their decisions, alter their actions and ultimately influence their behaviour. This Review, which underscores the contextual nature of human behaviour, provides insights into how structural conditions and systemic factors impact various aspects of an individual's choice, including her/his level of physical activity, dietary options, circadian behaviour, screen time and workplace environment. For children, junk food advertisements, long periods of screen exposure and reduced outdoor recreation have contributed to an imbalance between energy consumption and energy expenditure[154–156]. This scenario, in turn, plays a pivotal role for the increasing trend of populational weight gain.

Physical activity. Considering that physical inactivity is a major risk factor for obesity-related non-communicable diseases[157], the WHO published the Global Action Plan on Physical Activity 2018–2030, aiming at favouring more active environments[158]. Urbanization and technological waves have shaped modern human behaviour not only incorporating conveniences but also promoting physical inactivity-related health concerns.

Latin America is the most urbanized region in the world, with approximately 80% of the population living in urban areas, not always in well-planned and secure regions[41]. Such conditions are believed to promote sedentary behaviour, as they can be linked to prolonged screen time, extended commutes and a rise in office-based work[60]. Moreover, urban environments in Latin America often prioritize motorized transportation over walking or cycling. The availability of technology and television, especially in urban areas, has also made sedentary leisure activities more accessible and popular. According to the Digital 2023: Global Overview Report, five of the top seven countries with the highest average screen time are Latin American (that is, Brazil, Argentina, Colombia, Chile and Mexico)[159–161]. The rapid proliferation of technology, including televisions, computers, smartphones and video games, has made sedentary entertainment readily accessible. Social interactions have also shifted to digital platforms, leading to an increase in sedentary leisure activities. Moreover, advertising and marketing campaigns often promote sedentary activities, such as watching TV or using electronic devices. This can normalize sedentary behaviour as a form of leisure. Governmental policies and environmental interventions play an important role to revert such scenarios.

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In this context, some political initiatives for changing the built environment in Brazil have shown encouraging results. The city of São Paulo implemented a Master Plan including guidelines for the city's development and growth by 2030. Local socioeconomic inequalities were considered when planning improvements in access to housing and jobs, in public transit and active transportation, and in availability of parks. Changes in the built environment related to leisure physical activity and commuting occurred from 2015 to 2020, with different magnitudes according to the income and residential area[162]. Marked increases were observed not only in outdoor gyms (+109.6%) and bike lanes (+67.7%) but also in train or subway stations, bus terminals (+15.4%), sports facilities (+12.0%) and public squares (+8.7%). It is expected that these changes could result in favourable health outcomes in the long term. This experience could be tailored for other developing countries from Latin America.

A recent systematic review evaluated the effectiveness of environmental interventions directed to changing the population's level of physical activity[163]. Among the 24 studies reviewed, two were conducted in Latin American countries[164,165]. Results showed that a variety of environmental social programmes can increase physical activity among children and adults, highlighting the role of public policies to promote physical activity at the systemic level, and reinforcing the approaches to fight obesity in Latin America should be focused mainly on the physical obesogenic environment.

Eating habits. As previously discussed, the increasing availability and marketing of UPFs and fast-food options may help shape dietary preferences in Latin American countries. In some areas, especially in low-income neighbourhoods, grocery stores and fresh, healthy foods are not easily accessible. This leads residents to rely on convenience stores and fast-food outlets, promoting the consumption of calorie-dense, nutrient-poor foods[166,167]. Workplaces, schools and recreational facilities often have vending machines and cafeterias that primarily offer processed snacks, sugary beverages and unhealthy options, making it easier for individuals to make poor food choices[168]. In addition, food companies often use aggressive marketing and advertising campaigns, specifically targeting children and vulnerable populations[149]. These campaigns usually promote unhealthy, high-sugar and high-fat products. The availability and prominent positioning of these food items in stores may also influence consumers' choices[169]. Importantly, considering the inequalities in Latin America, economic factors can substantially influence food choices, leading people to opt for cheaper, but less nutritious, options. In this context, affordability and convenience of fast-food chains and value meals can lead individuals to choose these options over healthier, more expensive ones[170]. Super-sized portions often seem like better value for money. Finally, family members and peers exert a strong impact on eating patterns, especially among children and adolescents, who are normally more susceptible to be influenced by peers towards increasing consumption of unhealthy foods[171,172].

Circadian and work-related behaviours. Shift work, extended working hours, stress or excessive nocturnal use of technology and screen time can result in poor-quality sleep and influence behaviour associated with unhealthy practices. In 2021, the top four countries with the highest average labour hours per worker among OECD countries were Latin American (that is, Colombia, Mexico, Costa Rica and Chile)[173]. Irregular work schedules, such as shift work or long working hours may impair physiological regulation of circadian rhythms and alter sleep patterns. In turn, this increases the risk of cardiometabolic and mental health problems, results in hormonal imbalance and impairs decision-making abilities, thereby influencing eating/drinking behaviour and physical activity[174]. Furthermore, fast-paced lifestyles and inadequate sleep often leave people with limited time for meal preparation, leading to the convenience of fast food and takeaway food, or pre-packaged and processed foods. The stress associated with irregular or excessive work hours, the disruption of social life, and the challenges in balancing work and personal life can also compromise physical and mental health. Moreover, long hours at a desk, limited breaks and the expectation to remain seated can lead to prolonged periods of inactivity at the workplace. In combination, these elements create an environment that may favour unhealthy choices and lifestyles.

Psychosocial stress and mental health. A stressful context in which one might be exposed can impair mental health and impact decisions in daily life, thus potentially contributing to alterations in lifestyle that increase obesity susceptibility. Psychosocial stress, particularly occurring in childhood and adolescence, is associated with increased risk of obesity in adulthood[175,176]. Adverse childhood experiences (ACEs), such as psychological or physical abuse, or household dysfunction, including having a parent or a sibling with a problem of substance abuse or mental illness, household violence, a family member imprisoned or parent divorce/separation or death, are associated with overall poor physical and mental health later in life, including a higher prevalence of obesity and larger waist circumference[177,178]. A meta-analysis including 37 studies involving more than 200,000 individuals from high- and middle-income countries showed that there was a weak or modest association between having experienced four or more ACEs and overweight and obesity[179]. Another systematic review focusing exclusively on the impact of ACEs on childhood obesity (including 24 studies), found that there was an association between ACEs and childhood obesity in 21 of them[178]. Of note, none of the studies included in those two systematic analyses were from Latin American countries. The mechanisms to explain ACE association with obesity are related to chronic or severe stress leading to altered physiological responses to stress (dysfunctional hypothalamus–pituitary–adrenal axis), increased binge eating or appetite for hyper-palatable foods as a means for comforting, poor impulse control, altered sleep patterns and depression[178].

As occurs with other determinants, most studies analysing the effect of stress on obesity prevalence have been performed in populations outside Latin America. One of the few studies done in Latin America is the Mexican Teacher's Cohort involving more than 9,000 women[180]. In this study, women experiencing >4 ACEs had a higher odds ratio (1.37) of obesity compared to those not experiencing any ACEs. Thus, performing studies that consider the particular factors influencing mental health and stress-associated obesity in populations from the region is necessary.

Genetics

It is undisputed that the systemic determinants described so far in this Review play a major role in the increases in obesity rate in Latin American countries; however, it is also clear that genetics predisposes people to obesity when individuals are exposed to certain environments[181]. In fact, according to the thrifty phenotype hypothesis, which states that exposure to environments with limited nutritional availability imposes a selective pressure that predisposes future generations both genetically and epigenetically to be more efficient to conserve energy[182], it is expected that 'energy-conserving genes' would be frequent in the human gene pool. Hence, evolutionarily speaking, obesity in environments that rapidly transitioned from limited food availability to excess exposure to energy-rich foods is meant to be the rule, not the exception. People that are resistant to weight gain in such environments are perhaps lucky to carry genes that protect them from obesity, or else they must invest a lot of time, effort and money to prevent it, putting an overwhelming burden over the individual. Thus, identifying and functionally characterizing genes associated with obesity risk in distinct populations may provide mechanistic, diagnostic and therapeutic insights in the field, but it is unlikely to explain the sharp increase in obesity prevalence in the past decades.

The heritability of phenotypes related to obesity has been shown to vary from 6% to 85% depending on the population studied[183]. The earliest genetic studies identified genes involved in monogenic forms of obesity, which account for less than 5% of all obesity cases in the world[184], and include genes such as *LEP*, *LEPR*, *PCSK1*, *MC4R*, *BDNF* and *POMC*[185–190]. Thereafter, with the emergence of genome-wide association studies (GWAS) looking at the more common forms of obesity, new genes were identified, such as *FTO*, *ADCY3*, *CADM1* and *CADM2* (refs. 191–193). Genes associated with obesity in early studies raised the hypothesis that monogenic and polygenic forms of obesity were mostly diverse concerning the underlying mechanisms that promote positive energy balance[194]. However, after the publication of additional GWAS and following a deeper look into the tissue distribution and function of genes associated with either monogenic or polygenic obesity, a considerable functional overlap among these genes was found, as most genes were involved in central nervous system function, and particularly in the hypothalamic regulation of whole-body energy balance[194]. This concept was greatly supported by mechanistic studies that revealed the existence of functional and structural abnormalities in the hypothalamus of experimental models of obesity or humans with obesity[195–197]. The combined interpretation of the results obtained from the genetic and mechanistic studies revealed that certain mutations can lead to obesity by primarily affecting food intake and/or energy expenditure, without the need for great exposure to environmental factors, such as the consumption of calorie-dense foods[198]. Conversely, in diet-induced obesity, components of the diet, particularly the consumption of large amounts of saturated fats, can promote changes in the expression or function of genes/proteins that play important roles in the hypothalamic control of whole-body energy balance, and these genes/proteins do not need necessarily to be affected by genetic abnormalities[199]. Curiously, several of the genes/proteins affected by the diet are the same ones targeted by mutations that lead to monogenic obesity[198,199]. For example, in diet-induced obesity, there is hypothalamic resistance to leptin[200], abnormal regulation of hypothalamic BDNF expression[201], defective expression of POMC cleavage enzymes resulting in abnormal production of the MC4R ligand α-MSH[202] and reduced hypothalamic expression of IRX3, a long-range genetic target of FTO[203]. Thus, based on current data, it seems that certain genes/gene products can be affected by genetic mutations, environmental factors or a combination of both, resulting in the development of the obese phenotype.

However, most of the studies leading to these conclusions have been performed analysing people from developed regions of the world. As for 2020, there were approximately 60 GWAS published describing more than 1,100 loci associated with obesity. However, almost 90% of the people analysed in these studies were of European ancestry, almost 10% were of Asian ancestry, whereas only 1% or so were of African or other ancestries[194]. Hence, considering the scope of this Review, it is difficult to draw conclusions about the genetic determinants of obesity in the ancestrally diverse populations of Latin American countries based on results that reflect the genetic landscape of a narrow group of people exposed to region-specific environmental contexts. Exploring GWAS databases such as GWAS Central[204] and GWAS Catalog[205], and also performing PubMed searches for 'GWAS AND obesity', resulted in the identification of only one study evaluating Latin American infants living in Latin America. Most of the loci identified in this study reproduced findings of prior GWAS not related to ancestry; however, two new genetic associations were identified within the genes *CERS3* and *CYP2E1* (ref. 206). In addition, there are data obtained from Latin Americans living in developed countries. In a considerably large GWAS that analysed body fat distribution in 12,672 ethnic Latin Americans living in the United States, there was confirmation of several loci formerly reported; however, the study identified four new loci (rs79478137, rs13301996, rs3168072 and rs28692724), expanding the landscape of polymorphisms associated with the phenotype of obesity[207]. Another approach used to overcome the lack of information regarding the genetics of obesity in Latin Americans was the use of meta-analysis of anthropometric traits on an ancestrally diverse sample of adults[208]. The study identified four new genes associated with BMI or obesity-related traits: *PAX3*, *ARRDC3*, *DOCK2* and *TAOK3*. Although these studies are a first step towards understanding region-specific genetic predisposition and how the environment can make people from certain ancestral backgrounds become more prone to develop obesity, they are very limited in comparison to studies in populations from the developed world.

From a practical standpoint, it is recognized that the considerable ancestral diversity within Latin American populations poses a challenging factor, complicating genetic studies across various medical and biological domains. However, as large-scale GWAS become increasingly common and cost-effective, these constraints are gradually becoming less prohibitive. More recently, a large-scale GWAS including 6,057 ancestrally diverse individuals living in different regions of Mexico investigated the influence of genetics and the environment on BMI and other cardiometabolic parameters, concluding that the urban environment is dominant over genetically inherited traits to determine the risk of obesity in Mexico[135]. While we wait for more large-scale GWAS to be conducted in other Latin American countries, studies undertaken with original American populations, and exploring genetic traits that could be linked with propensity to obesity have identified some polymorphisms never described in other populations. This is the case for *DAO*, which encodes a D-amino acid oxidase involved in the synthesis of dopamine[209]; *GPR158*, which encodes an orphan G-protein-coupled receptor highly expressed in the brain in association with proteins known to regulate whole-body energy expenditure[210]; and, *MAP2K3*, a gene that encodes a serine/threonine kinase related to hypothalamic inflammation[211], which is a common feature of human and experimental obesity[195–197]. Thus, taken together, these findings reinforce the importance of advancing in genetic studies in under-represented populations as a means to identify new potential targets for mechanistic and pharmacological studies that account for the complexity of human obesity.

Perspectives on the increasing trend of obesity in Latin America

In the previous sections, we listed the primary factors contributing to the obesity epidemic in Latin America as the initial stride towards uncovering its root causes and formulating effective strategies for mitigation. In this section, we speculate on plausible explanations for the alarming surge in obesity rates across Latin American nations and outline key interventions that warrant priority in our collective efforts to combat obesity in this region, while potentially offering valuable insights applicable to other global contexts.

The potential role of epigenetics

Advances in the knowledge about epigenetics have contributed to the understanding of underlying mechanisms by which the modern environment may create a vicious cycle of obesity in humans. The theory of the Developmental Origins of Health and Disease[212,213] has stimulated this scientific branch through investigation of the ability of early-life events to influence disease vulnerability later in life. For Latin American countries in particular, this theory may help to explain some characteristics of the obesity epidemics related to insults during critical periods of life[214].

Non-genetic inheritable risk of obesity may start before birth. Observational evidence of positive associations between grandparents' and parents' BMIs and the risk of offspring obesity and cardiometabolic disturbances across lifespan[215] have been supported by experiments in animals[216], and the underlying mechanisms have been proposed to involve epigenetic changes[217].

Epigenetic changes can influence gene expression without altering the DNA sequence itself, and include DNA methylation, histone modifications and non-coding RNA inheritance[218]. Epigenetic programming shapes development and guides organismal fate and identity, allowing

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organisms to be phenotypically diverse at the same time as it is required for proper function[219]. It can occur as an intergenerational inheritance, which refers to epigenetic changes carried by the offspring (F1) and triggered by direct exposure of parents (F0) to an environmental stressor; or otherwise, it can occur as a transgenerational inheritance, when the offspring pass the trait to the following generation (F2) and potentially to the next ones[220].

Potential intergenerational effects of overnutrition on obesity risk. There is evidence that an unhealthy parental diet influences the risk of metabolic disturbances in the offspring. A meta-regression analysis showed adverse metabolic outcomes in animals whose mothers were exposed to a high-fat diet[221]. Maternal obesity during pregnancy has been shown to be associated with changes in the DNA methylation of several genes involved in metabolic processes and inflammation, thus increasing the risk of obesity and insulin resistance in the offspring[222–225]. Alterations in the maternal microbiome during pregnancy could also explain changes in offspring obesity risk[226,227]. At least one study performed in Latin America has shown that, in Chilean individuals, maternal obesity can induce, in a sex-specific manner, an epigenetic programming of blood monocytes that could contribute to disease later in life[228]. Obesity and metabolic disease traits may also be intergenerationally transmitted to the offspring via the paternal line[229,230]. While the studies that demonstrated this transmission were performed using animal models, there is evidence that similar processes may occur in humans. For instance, changes in paternal body weight result in alterations in DNA methylation and small non-coding RNA patterns in the sperm in humans[231]. Interestingly, exercise can reprogramme the sperm methylome[232], which might help explain the beneficial intergenerational effects of exercise[233,234]. Whether these epigenetic changes are inherited by the offspring and interfere with the risk of obesity in humans remains to be determined. However, regardless of the mechanism through which obesity may be potentially transmitted to the next generation in humans, maternal and paternal lifestyles are both strong independent predictors of offspring obesity[233,235].

Potential intergenerational effects of undernutrition on obesity risk. Studies have also demonstrated the effects of maternal or paternal famine on the offspring, potentially affecting the risk of obesity. For instance, the offspring of women who were exposed to famine during pregnancy had altered DNA methylation patterns in genes related to metabolism and growth[236]. These epigenetic changes are consistent with an increased risk of obesity and cardiometabolic disorders later in life in the offspring of mothers exposed to undernutrition during gestation[223,237,238]. Examples from long famine periods such as the Ukraine famine of 1932–1933, the Dutch famine of 1944–1945 and the Chinese famine of 1959–1962 support this association in humans[238–242]. In Latin American populations, data on the impact of epigenetic factors emerging from periods of famine are rare; however, in Pima Indians, who live in the United States–Mexico border, and were exposed to food scarcity in the recent past, obesity and diabetes have been related to epigenetic changes that impair the pancreatic beta cell function[243]. Paternal exposure to undernutrition is also associated with an increased risk of metabolic diseases in the offspring, potentially mediated by inherited alterations in DNA methylation patterns in genes involved in energy metabolism[223,244,245].

Currently, undernutrition is still a concern in several developing countries at the same time that obesity is a growing public health problem. This picture, when put into perspective with data presented in the previous paragraphs, raises the hypothesis that parental exposure to malnutrition combined with an obesogenic environment later in life may be connected to the increasing rates of obesity in developing countries. Findings obtained in populations from developing countries have supported that parental BMI and maternal gestational weight gain are independently associated with offspring body composition[246,247]. Also, early feeding practices can influence dietary habits, which are important factors influencing weight gain throughout life. We observed that breastfeeding is directly associated with adherence to a prudent dietary pattern[83], as well as with metabolic biomarkers in adulthood[248].

Potential intergenerational effects of stress on obesity risk. Stress is yet another potential epigenetic driver of obesity. There is a growing body of research indicating that maternal and paternal stress during pregnancy and early childhood may contribute to an increased risk of obesity in offspring. In underprivileged societies, food availability, environmental contamination and inadequate medical care may represent stressful factors. When pregnant rats are exposed to stress, their offspring are more likely to become obese[249]. Maternal separation during lactation also increases the risk of obesity later in life in rats[250]. In humans, a meta-analysis comprising 17 studies found that children whose mothers experienced stress were at greater risk for obesity[251]. There are several proposed mechanisms that may explain how maternal stress can contribute to obesity in offspring. These include changes in maternal and fetal hormone levels, alterations in maternal and fetal metabolism, and changes in the epigenetic regulation of genes involved in appetite control and energy balance.

Together, these studies provide evidence to suggest that epigenetic changes caused by malnutrition, stress or sedentarism may be involved in intergenerational transmission of obesity in humans. To what extent this inheritance, if it occurs, is due to simultaneous environmental insults and whether a higher risk of obesity can be transmitted transgenerationally are questions that remain to be answered. While more research is needed to fully understand the mechanisms underlying these relationships, these findings highlight the importance of promoting healthy lifestyles and preventing obesity to reduce the risk of obesity and related health problems throughout generations. Moreover, these observations raise the worrisome possibility that the steep increase in the prevalence of obesity in many Latin American countries has been pushed by the poor environmental conditions that certain populations in these countries have been exposed to throughout generations.

A global plan to target obesity epidemics in Latin America

Since 1997, the WHO has been advocating that the main drivers of the world obesity epidemic are consumption of energy-dense diets and sedentary lifestyles[252]. As discussed in this Review, these factors are influenced by multiple determinants, the majority of them systemic. However, the question arises as to why, if one understands its main drivers, obesity rates keep increasing.

Multilevel recommendations to counteract and prevent obesity have been established by the Pan American Health Organization (PAHO) and the WHO, especially during the past decade, with the PAHO being a spearhead in the matter with the publication of the 'Plan of Action for the Prevention of Obesity in Children and Adolescents' in 2014 (ref. 253). The plan consisted of a call for implementation of a set of policies, laws, regulations and interventions by the member states in five strategic lines: (a) primary healthcare and promotion of breastfeeding and healthy eating; (b) improvement of school food and physical activity environments; (c) fiscal policies and regulation of food marketing and labelling; (d) other multisectoral actions, including provision of urban spaces for physical activity and measures to increase access to nutritious foods; and (e) surveillance, research and evaluation. This plan was followed up in 2022 by WHO's 'Acceleration Plan' to help member states to implement recommendations for the prevention and management of obesity over the life course[254]. The goal was to 'consolidate, prioritize and accelerate country-level action against the obesity epidemic through coherent and harmonized efforts' to help set out 'an achievable scenario for global action that addresses the multiple drivers of obesity'. The WHO chose front-runner countries to serve as models whose leadership is expected to stimulate similar actions

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in other parts of the world. Among the 28 front-runner countries, the majority are developing countries and 9 are from Latin America and the Caribbean, including Brazil, Mexico, Argentina and Chile[255].

The bottlenecks for implementation of this plan

Principles advocated by these plans mainly involve implementing programmes to promote: (1) the intake of healthy foods while reducing the consumption of unhealthy products; this includes changes in the food systems to provide access to affordable and sustainable healthy diets; (2) physical activity and reduced sedentary lifestyles; and (3) healthy school environments, including health literacy[256]. To achieve these goals, governmental agencies dedicated to the prevention and treatment of obesity are needed to establish policies to promote healthier environments, develop official guidelines to achieve healthy lifestyles and promote community-based interventions[257]. Indeed, according to the WHO, the success of these initiatives 'will rely on country leadership, political commitment and the adoption of a whole-of-society approach where everyone, including people living with obesity and their families and communities, plays a part in tackling obesity'[254]. If obesity is considered a major public health issue worldwide, taking coronavirus disease 2019 as an example, there must be political involvement everywhere, and obesity should be part of all national agendas in coordination with global policies on the issue.

In Latin America, two major factors impose obstacles to a healthy lifestyle: the availability, aggressive marketing and affordability of UPFs and the inadequacy and insecurity of the environment to practice physical activity. Violence causes a stressful way of living, and it is considered a global public health problem; this can contribute to obesity from the moment it limits outdoor physical activities and promotes stress. In unprivileged populations from the developing world, there is a recognized link between poverty and violence.

Specific interventions that have shown favourable results are those targeting a reduction in the consumption of unhealthy food products, including warning FOPNL, increased taxes to SSBs and UPFs[258] and regulations for their marketing[259]. Most Latin American countries have implemented obesity prevention initiatives[257,260], but they are still limited, and broader multilevel, multicomponent strategies are still needed.

The International Food Policy Research Institute analysed the global food system from the consumer perspective by estimating the relative caloric price of a given food[261]. Food systems from the developed world can provide healthier foods cheaply, but not those from less developed countries where the people dedicate more of their per-capita income to purchasing food[108,109]. This is somewhat paradoxical considering that agriculture remains an important part of the economy in many developing countries, further evidencing the strong influence of the food industry not only over food consumption, but also over food production, distribution and price. Interestingly, when looking at individual countries, it turns out that the cost of a healthy diet can be more affordable than UPF-rich diets. This is the case in Mexico, where a diet based on the EAT-Lancet healthy reference is around 29% to 40% less expensive than the current diet (in which 30% of the calories come from UPFs)[262]. Even when the healthy diet includes a higher intake of fruits, vegetables, legumes and nuts, which can be more expensive, the lower cost of this type of diet comes from reduced consumption of SSBs, UPFs and animal proteins.

Governmental efforts to offer subsidized traditional food to the general population have been insufficient to act as a countermeasure against the overwhelming exposure to high-calorie, UPF-rich diets in Latin American countries, so that an enhanced collaboration from health organizations and international food manufacturing companies is desirable to improve food quality and make healthy food more accessible to the population. Also, a commitment of all sectors of society to preserve a healthy nutritional status of populations should occur, counting on the support of the private sector and the mass media. It is a consensus that providing education, access to information, food security, affordability and availability of high-quality foods, and an environment that is safe and welcoming for the practice of physical activity is crucial to improve health.

Table 1 | Overview of measures aimed at reducing the rise of obesity prevalence in Latin America

Community-based lifestyle interventions	Science and education
• Offer healthier diet options • Increase nutritional and health literacy • Promote physical activity • Reduce social inequality	• Increment studies and enhance visibility of science from developing countries • Promote more ethnic/racial diversity in human studies • Stimulate international cooperation • Foster open-access publication • Increase participation of developing-world scientists in international organizations dedicated to obesity control • Promote education and scientific literacy • Disseminate scientific knowledge
Food regulation and policy	**Strategic focus: women and children**
• Provide subsidies for production and distribution of healthy foods • Ensure access to clean water to promote healthy hydration • Create and disseminate healthy eating guidelines • Ban industrial trans-fat • Limit influence of food industry on public policy • Introduce and disseminate warning type FOPNL • Tax SSBs and UPFs • Regulate children-directed publicity of UPFs • Ban unhealthy food from schools • Engage the public and the media on the matter	• Promote healthy eating habits for women at reproductive age and during pregnancy • Promote exclusive breastfeeding • Regulate the promotion and marketing of breast milk substitutes • Incentive cooking and family meals • Invest in healthy cafeterias • Reinforce healthy habits in schools • Promote physical activity at schools and at home • Educate and disseminate information concerning the hazards of UPFs • Create and increment policies to prevent consumption of unhealthy food by children

Examples of how these measures are being implemented in Latin American countries have been presented and discussed in this Review.

Particularly in Latin American countries, inequity is a major concern that limits reaching the goals of public policies evenly throughout the whole territory. Inefficient or limited investment in science, education, awareness or public policies further aggravates the scenario of obesity in the region. Therefore, in Latin America, coordinated actions between the public and private sectors with the effective participation of academics seems to be necessary to orient evidence-based strategies to optimize the application of limited monetary and human resources to reduce the burden of obesity and its comorbidities in the long term and in a systemic manner. As developed countries have more financial and human resources to deal with health and nutritional problems, knowledge exchange may also help mitigate the increasing rates of obesity in the developing world. This could be achieved by accessible open-access policies and by promoting academic exchange programmes between developed and developing countries to help create leadership in the field of obesity in underprivileged countries, as well as to promote research with under-represented populations and addressing local questions.

Considering the inexistence of a simple solution to deal with such a complex disease like obesity, especially in underprivileged populations, there is an urgent need for strategies that account for the particularities of Latin America and other developing regions of the world. Some of these particularities, examples of initiatives directed to Latin America and important aspects that could nurture strategies in this region and set examples for other regions are discussed in the following section and summarized in Table 1.

Proposed measures to tackle obesity in Latin America

The potential impact of community-based lifestyle interventions. At small scales, strategies that combine nutritional literacy, promotion of increased physical activity and changes in the obesogenic food environment have shown to be the most effective in Latin American children[263]. Beyond specific diets, there is consensus based on extensive studies that the optimal diet (for human and planetary health) must be focused on eating more vegetables and fruits, whole grains, nuts and legumes, eating small-to-moderate amounts of fish, poultry, eggs and dairy foods, reducing the intake of refined grains (wheat and rice), while avoiding the intake of SSBs, processed meats and UPFs in general[97,264–266]. Also, recently, the WHO has advised against the use of non-sugar or non-calorie sweeteners as the long-term use of these substances is associated with increased risk of obesity, type 2 diabetes, cardiovascular diseases and mortality[267].

Of note, the current dietary principles for patients with obesity from the 2023 Obesity Medicine Association Clinical Practice Statement advises to avoid ultra-processed and high-energy-dense foods, and limit sodium and simple carbohydrate intake[268]. These are the same recommendations from the WHO and the EAT-Lancet Commission[264,269] for the general population. Therefore, a healthy diet should be prescribed, encouraged and secured as one of the main preventive and therapeutic measures against obesity and non-communicable diseases. Nonetheless, considering the social inequities present in most Latin American countries and the costs associated with adopting a healthy diet and exercise, any policy involving promotion of a healthy lifestyle should account for how accessible these measures will be to underprivileged populations. Regardless, treating obesity is even less affordable than preventing obesity to most of these populations, so the focus should be on prevention. This should not exclude the necessity of strategies to make pharmacological and/or surgical interventions more accessible to individuals in the developing world. Overall, it is expected that reducing inequities will have a large impact on obesity prevalence.

Promoting science. To address inequalities, it is crucial to expand access to science and education for Latin American populations. This can be achieved through a three-tiered approach: (i) fostering the generation of local scientific knowledge; (ii) promoting education and enhancing scientific literacy among Latin Americans; and (iii) disseminating scientific knowledge throughout the Latin American region.

A restriction to successful interventions to prevent or treat obesity in Latin America is the limited number of studies using populations of this region or considering the particularities of its countries. Hence, efficacious interventions will require investment in science done at least partially in Latin American countries. International partnerships are welcome, also to promote human resource exchange and globalization of knowledge. Funding agencies have been paying more and more attention to this issue and opening calls that prioritize research done at least partially in collaboration with researchers based on developing countries. Human studies have also been encouraged to include individuals from under-represented regions, while the US Food and Drug Administration has established requirements to researchers and companies to include racial and ethnic minorities among clinical trial participants[270]. These initiatives are recent and still limited. Hence, their impact on obesity research in Latin American countries remains to be seen.

Another way to help advance science in Latin American countries is through promoting science communication. Access to information is considered a human right by the organization of American States[271], it is included as a core component of the right to health by the WHO[272] and is key to scientific progress and healthcare development[138,273]. In contrast, limited access to knowledge has historically hindered knowledge-based healthcare advances in developing countries[138,273]. While Plan S and other initiatives such as preprinting are designed to make science more accessible, they help expose the inequities in the publishing process, which particularly affect lower-income countries[136,137,274]. Article-processing fees can deter researchers from the global south to publish open-access papers[137]. On the other hand, research from lower-income countries deposited in preprint platforms is not converted into papers as often as it is when they come from high-income countries[275]. Hence, specific strategies to make science from Latin America and the developing world more visible and accessible will be required at the same time open-access initiatives are promoted around the world.

Food regulation. One key obstacle to implementing public policy to change obesogenic environments, particularly directed to limiting and regulating the availability and publicity of ultra-processed products, while favouring availability and affordability of healthy food, has been the commercial interests of the unhealthy food industry and their influence on governmental agencies and policies. This occurs equally in developed and developing countries; however, as discussed previously, the overall negative impact and the vulnerability is higher in developing countries such as those in Latin America.

Chile has led the way for other Latin American countries by implementing successful policies to reduce consumption of UPFs and beverages with the goal to prevent and reduce obesity prevalence. Chile was the first country to introduce a comprehensive law to implement mandatory FOPNL in black octagons for products high in calories, sugar, sodium and saturated fats, regulating and restricting their child-directed marketing, and forbidding their sales at schools[276]. The policy aims to help consumers make healthier choices[259,277,278] and has reduced the sales of products high in critical ingredients, for instance, reducing by 24% the sugary beverage purchases 1 year after its implementation. Chile's food law was also the first to prohibit marketing directed to children under 14 years old of products high in critical nutrients, and the use of children-directed movie or cartoon characters, and free gifts and toys to engage children. This law also includes banning the advertising of products high in energy, saturated fat, sugar or salt from 6:00 to 22:00 (ref. 276). Importantly, the successful example of Chile led to the implementation of similar FOPNL in many Latin American countries including Mexico, Argentina, Colombia and Brazil[279].

In Mexico, an ambitious multicomponent effort towards reducing obesity prevalence is being implemented, which if successful, given the large population of the country and its high obesity prevalence, could set an example for other countries. The main components of this campaign are: (i) Black octagon 'excess of' warning FOPNL including special warnings directed to children when the product contains non-caloric sweeteners and caffeine were implemented in 2020. The Mexican FOPNL included mini numerical labels to add in very small packaging; this was an innovation in the region and was adopted by countries like Argentina. Also, as done in Chile, this strategy includes marketing regulations such as banning the use of children-directed characters on unhealthy products[259]. Mexico is the largest consumer of ultra-processed products in Latin America, and it is estimated that over the course of 5 years, this policy will reduce obesity prevalence by 14%[278]. (ii) Increasing taxes on SSBs and energy-dense, nutrient-poor foods[280,281]. This policy has shown positive results in many countries[282]. Two years after the implementation of this policy, SSB sales were reduced by 36% in Mexico[283,284]. (iii) Increasing health literacy. A media campaign created by a multisectoral government group to promote the consumption of healthy foods while educating about the harmful health effects of UPFs and SSBs. (iv) At the end of 2023, law reforms were approved to prohibit the sales and advertising of junk food and sugary drinks at schools and their surroundings. (v) A recent ban on industrial trans-fat on foods and beverages[285]. (vi) Promoting exclusive breastfeeding with information campaigns, for instance, at the clinic during prenatal care and after delivery of babies[286]. This campaign already resulted in a 20% increased exclusive breastfeeding practice from 2012 to 2022 (refs. 287,288). (vii) New healthy eating guidelines were presented recently with up-to-date information based among other sources, on the EAT-Lancet Commission on healthy diets from sustainable food systems, an international effort of experts in which Mexico took part[264]. (viii) More involvement of local researchers in international organizations devoted to preventing obesity (free of conflict of interests). For instance, besides the participation of Mexican researchers on the EAT-Lancet Commission, the recently appointed president-elect of the World Obesity Federation is also Mexican. (ix) Strong efforts from civil organizations to influence public policy and food corporations' behaviour to counteract the obesogenic environment. Organizations such as 'The Alliance for Healthy Food', Colansa (Latin American and Caribbean Nutrition and Health Community of Practice) and 'The Consumer's Power' have been fundamental to achieve some of the public policy transformations listed above. (x) The creation of an intersectoral governmental group (GISAMAC) towards four goals: increasing the production of agricultural and farming products in a local and sustainable way, making efficient the processing, distribution and commercialization of healthy foods, improving access (physical and economical) to healthy sustainable diets for all people, and reducing malnutrition by promoting healthy eating habits[289]. (xi) Probably one of the most important efforts during the last few years has been to limit the influence of the food industry on the development of public policies against unhealthy food[290].

In 2014, Brazil took the lead in promoting healthy eating by using a holistic approach in their dietary guidelines. Whereas many dietary guidelines consider only nutrient balance, the Brazilian guideline appraises food as an integral part of physical and mental health, as well as disease prevention. Moreover, it considers feeding behaviour and diets as part of a multidimensional system, with biological, cultural, socioeconomic and environmental levels[291]. The principles of Brazilian dietary guidelines are: (i) diet is more than intake of nutrients; (ii) dietary recommendations should accommodate changes in food supplies and consider population health and well-being; (iii) healthy diets derive from socially and environmentally sustainable food systems; (iv) dietary advice should rely on multiple sources of knowledge; and (v) guidelines derived from reliable information contribute to people's autonomy in making the right food choices. At the same time, knowledge empowers people to demand their right to healthy food. The guidelines also recommended eating regularly and carefully, in appropriate environments, and in company, to acquire and share culinary skills, to dedicate time and effort to prepare food and share meals, while supporting farmers' and municipal markets and preferring food produced by agro-ecological methods[291].

Being the NOVA food classification, including the concept of UPFs, a game-changer contribution from Brazilian scientists to the world, Brazil was the first to make official recommendations to avoid UPFs, while recommending making naturally or minimally processed foods the basis of the diet[291].

Besides integral dietary guidelines, Brazil established the first world national school food programme that included a farm-to-school rule requiring that 30% of the school food was provided by local smallholder farmers. The programme includes regulations promoting the consumption of a healthy diet and bans the marketing of UPFs in schools[259,292].

Strategic focus: women and children

Given the relevance of education and early-life biological programming of health and disease, policy and multicomponent efforts to change the obesogenic environment should focus on children and pregnant and lactating women. According to the PAHO, this focus is likely to render better results considering a number of reasons, including the effect of breastfeeding on weight loss after pregnancy and on preventing obesity in children, the higher risk of overweight children to develop obesity when they reach adulthood, the long-lasting adverse health consequences of obesity when presented at early stages of life, the establishment of dietary habits early in life, and the fact that children are more vulnerable to persuasive marketing[253]. Measures include: (i) promoting healthy eating habits in women at reproductive ages as part of their prenatal care (or even before); (ii) creating policy to facilitate exclusive breastfeeding such as extended paid maternity leave (as it occurs in Scandinavia, Canada and other developed countries); (iii) reducing working hours to facilitate families cooking and eating healthy meals together; (iv) promoting the existence of healthy eating cafeterias at day care and schools; (v) promoting the existence of school subjects to teach children about healthy eating and physical activity; and (vi) diffusing the overwhelming scientific evidence about the deleterious health consequences of consuming UPFs. It is imperative to generate policy to prevent children from consuming unhealthy food products (as occurs with tobacco and alcohol). In this regard, eating a healthy diet is part of the rights of children according to UNICEF and, therefore, offering them unhealthy food products (for example, UPFs and SSBs) could be considered a violation of their rights[293]. Along with changes to the obesogenic food environment, it is critical to promote increased physical activity at schools and at home. Although changing the environment of certain crowded cities will not be simple or quick, more physical activity at schools can be implemented. Moreover, it is crucial that public policies are clearly separated from the economic interest of the unhealthy food industry. Finally, all these policies and guidelines need to account for the unequal conditions of underprivileged populations living in Latin America, particularly among women and children, thus providing subsidies for these populations to have access and benefit from them.

Conclusion

Here we discussed the main determinants of the obesity epidemics in Latin American countries and how specific characteristics of these countries should be considered for interventions to be effective to slow down the increasing rates of the disease. Latin American countries are themselves very diverse both ethnically and culturally. Some of them even have distinct regional differences and are among the most socioeconomically unequal countries in the world. Therefore, when it comes to fighting obesity in Latin American countries, a 'one-size-fits-all' solution to introduce the measures proposed here is a challenging task. On the other hand, isolated initiatives are expected to have limited impact. Blaming the individual rather than facing the overwhelming systemic issues that make some populations in Latin American countries exceptionally more susceptible to obesity is yet another common mistake. The action plans and guidelines set up by the PAHO, WHO and World Obesity Federation, the recommendations proposed by the EAT-Lancet Commission on Food, Planet, Health and the food classification established by the NOVA system provided a framework for countries to invest efforts towards preventing and counteracting obesity in a more effective level. However, there is a need to reinforce those organizations locally, in a way that is free from conflict of interest, with country representatives from academia (researchers from the basic, clinical, epidemiological and social science areas) and involvement of the civil society, public policymakers and other stakeholders, resulting in policies that are more accessible and widespread.

Hence, we propose the creation of a local 'Task Force on Obesity' in each Latin American country. These task forces are expected to be led by local public health leaders in association with academics from scientific and medical societies to collectively address urgent challenges related to obesity and establish the country's road maps in its fight against the obesity epidemics. These collaborative efforts would serve to clarify pressing issues, prioritize effective interventions, establish scenarios to track progress, outline engagement strategies for country-level stakeholders, including funding agencies, and identify appropriate reporting mechanisms. As proposed by the WHO in the 'Acceleration Plan'[254], these road maps should include: (a) a better understanding of obesity epidemiology and the underlying levers for obesity across different populations in each country; (b) strategies and integration with other areas, including other non-communicable diseases and universal health coverage rollout; (c) existing gaps and bottlenecks for designing country-specific solutions; (d) relevant objectives, targets and indicators; (e) resources required for implementation; (f) a local acceleration plan with clearly defined actions and supporting activities. The WHO also proposes structured workshops held to engage government officials and country offices around the issue. The task forces could spearhead these meetings. These initiatives could help identify the knowledge gaps from each region and promote science locally. They could also foster local leadership in the field.

The local task forces should also be congregated around a Latin American network built to promote intercountry exchange and dialogue. This interaction would help transfer experiences, recognize regional similarities and differences, build a support network and come up with efficient plans tailored for each country. That effort would also benefit from the commitment of countries across the globe, including from the developed world, to provide human, intellectual and material resources, considering that fighting the continuous growth of obesity in the world, as explained here, needs to account for the complex problems of Latin America. We hope this Review provides sufficient elements to guide efforts towards more effective, local solutions, while at the same time defending a holistic approach targeting the obesity crisis in Latin America, with potential impacts on the way obesity is perceived, prevented and more equally treated across the globe.

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