

## Review

# Obesity, a disease of the modern society

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## Abstract

**Background:** Nowadays, the aging of society, the lifestyle changes at the population level, the modern dietary pattern, and the low level of physical activity have an adverse effect on the waist line and the Body Mass Index (BMI). **Methods:** Based on scientific literature, we have drafted a review on excess weight and obesity around the world. The mean BMI is an important determinant of health at the population level. We used the WHO database for the years 1975–2016 as starting point and we predicted the average BMI around the world until the year 2100 using Microsoft Excel trendline equation. **Results:** Our findings are the first that estimate excess weight and obesity trends globally until 2100. This study adds growing evidence that the weight status will significantly affect all continents. We identified regions known with a low rate of obesity: East Mediterranean, South-East Asia, Western Pacific, and Africa will encounter severe weight issues. Generally, our data shows that the underdeveloped countries are less likely to report significantly higher rates of obesity by 2100, compared to the developed countries. **Conclusions:** There is growing evidence that weight gain at the population level is associated with a modern lifestyle and the psychosocial environment.

**Keywords:** adipose tissue, energy expenditure, BMI, obesity, pandemics, lifestyle.

## Problem Statement

Obesity is currently considered a complex, recurrent, chronic multifactorial disease, arising as a consequence of genetic factors, obesogenic environment [1], and neuroendocrine mediation [2]. Obesity is linked to socioeconomic factors such as the behavioral model, lifelong experiences and the perceived environment. The modern lifestyle, including sedentary use of time, over-eating behavior, hedonic output, and the environmental factors disrupt the metabolic efficiency and predispose the individuals to weight gain. Excessive body weight is one of the major leading causes of preventable and premature death worldwide and increases the risk of morbidity and mortality [3], leading to

cardiometabolic diseases, chronic respiratory diseases, and cancer. For the first time in human history, life expectancy is declining for the present generation compared to the previous one [3].

By 2050, more than 462 million new cases of cardiovascular disease and 212 million new cases of diabetes will occur due to overweight and obesity [4]. Although over time, obesity has been linked to genetic and biochemical mechanisms, the non-genetic risk factors strongly modulate the individual risk of weight gain. The main determinant of the obesity pandemic is chronic overeating and the high-calorie intake. Obesity is closely related to the economic status of the population. Globalization, together with sedentary behaviour, and the low energy expenditure are important drivers of the obesity pandemic. Data currently



available show that there are regional differences in both excess weight and obesity trends [5]. In developing countries the arising prevalence of obesity occurs due to chronic stress, common inappropriate habits such as physical inactivity, unhealthy diet, and hypercaloric food consumption [6]. A lower Socioeconomic Status (SES) is related to restricted healthy lifestyle opportunities that could lead to more stress and consequently increase in stress hormones, which increase fat deposition and visceral fat [7]. Lifestyle changes should start with effective control of the most common risk factors: smoking, sugar intake, alcohol consumption, sedentary behaviour [8].

## Background

The hypotheses of the adipose tissue expansion have evolved over time. The genetic factors alone are not responsible for the rising prevalence of obesity, but rather, the negative lifestyle changes of the entire population and the obesogenic environment are the starting point [9]. The mismatch between energy expenditure and energy intake leads to lipid storage in the human body. Abnormal or excessive fat accumulation may impair health. The modern lifestyle leads to low level of energy expenditure due to unhealthy eating behavior associated with screen-based sedentary time, low cardio fitness levels and lack of sleep [10]. The nutrition transition- modernization, urbanization, and economic development- increased, worldwide, the shifts in diet, which means that local seasonal food has been replaced with tasteful, non-perishable, easy to procure, transport, store and easy to prepare high-density meals [11, 12]. It is well known that the cheapest calories come from food oils and carbohydrates, and on the other hand, healthy food, rich in vitamins, macronutrients and micronutrients is more expensive. The main energy storage of the body is fat, which can be stored in large amounts, unlike proteins and carbohydrates [13]. Overeating and weight gain at the population level is achieved through increased content of kilocalories, lipids, carbohydrates, and a low dietary fiber content [14]. Sedentary behavior as total sitting time,

screen time in absence of physical activity are an independent risk factor for weight gain, chronic diseases, and premature mortality [15]. The daily energy expenditure includes the basal metabolic rate, the energy expended through thermogenesis during physical activity and non-exercise activity thermogenesis (NEAT) [16]. NEAT is the caloric energy expended through activity outside of structured exercise. The molecular basis involved in the non-physical activity thermogenesis (NEAT) remains unknown and is closely related to excess weight. It is well known that a high proportion of individuals spend more than 70% of their daily energy expenditure as a result of the resting energy expenditure (basal metabolism) and a very low proportion of the caloric consumption as a result of the baseline fitness activity [17]. This hypothesis shows that a leading cause for excess weight nowadays may be linked to all bad habits of the modern lifestyle that lower the body's metabolism [18]. Eating patterns are involved in the aetiology of several chronic diseases including obesity. Visual and olfactory food stimuli contribute to weight gain. The level of physical activity can be adversely affected by weight gain. Countless studies have correlated an increased level of physical activity with a better health status, proving that aerobic activity reduces all causes of mortality [19]. Frequently, the built environment and its characteristics, such as walkability of the urban sprawl, the residential density, the street connectivity, and the land use mix correlate with a low cardio fitness level in the general population. The sedentary lifestyle was found to be positively associated with a downregulation of the metabolic rate and weight gain. Also, the lack of physical activity plays a big part in overall prognosis. Compared to rural areas, the urban environment, through its specific architectural design, discourages physical activity, such as walking or cycling, as more and more individuals spend their leisure time in screen-based sedentary activities [3]. Therefore this association modifies the eating habits and increases snack consumption in front of the screens. In modern society, circadian rhythm disturbances are more frequent and occur due to night shifts, irregular sleep schedule, exposure to artificial light at night and time zone

changes when flying to another time zone [20]. Short-term sleep deprivation causes weight gain through lipid metabolism disorders [20] and leads to long-term effects on cellular responses, called “metabolic memory” [21]. Clinicians commonly use in the medical practice the index of weight for height, known as Body Mass Index (BMI) in order to classify overweight and obesity in adults. A BMI greater than or equal to 25 is considered as overweight. A BMI greater than or equal to 30 indicates obesity [22]. As for the Asian and Indian populations, according to the latest classifications the cut-off point for the ideal weight BMI score is between 18.5 kg/m<sup>2</sup> and 22.9 kg/m<sup>2</sup> [23, 24]. A BMI between 26kg/m<sup>2</sup> and 31 kg/m<sup>2</sup> may predict a high risk [25]. High-calorie intake, sedentary lifestyle, and low level of energy expenditure have a detrimental effect on the BMI. The mean BMI is increasing across the world with an impressing rate along with globalization and urbanization level. According to CDC data, obesity has reached pandemic proportions [22]. Unfortunately, obesity is interconnected to noncommunicable diseases, such as cardiometabolic, respiratory, and oncological diseases, meaning that the impact of adiposity may be estimated by the NCDs mortality. Each year, non-communicable diseases kill 80% of people worldwide [3]. It is well known that obesity is closely

related to the economic status of the population. Anthropometric measures should take into account contextual environment in which individuals live [26].

## Aims and Research Method

Obesity is an expanding global health issue. Excessive intake of energy-dense food together with a low level of physical activity, has led to a pandemic of obesity and noncommunicable diseases [22]. This study provides data of excess weight and obesity in adults for the next decades using the latest WHO reported data. Our aim is to estimate worldwide trends in mean BMI and to predict obesity rates in adults from the year 2030 to the year 2100. The method of research analyzes the available data for the mean BMI between 1975 and 2016. Using Microsoft Excel trendline equation, we estimated the mean BMI rates across the world until 2100.

## Findings

Our analysis shows that by maintaining the actual trends in growth of obesity all around the world, by 2100, even the regions with low

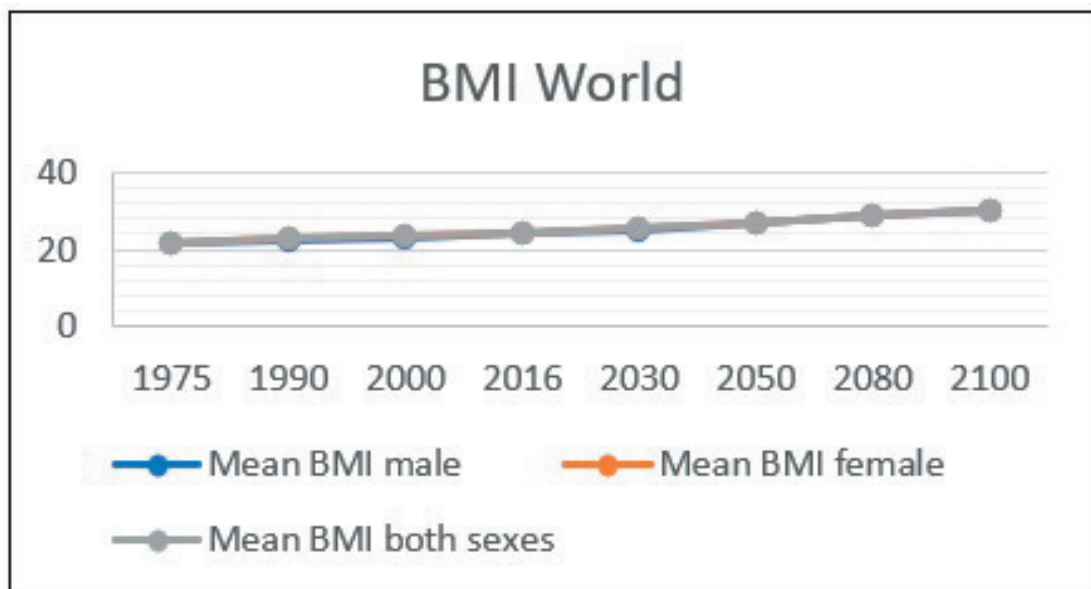


Figure 1: Mean BMI World (own calculations using WHO data). Source: WHO data [3].

rates of excess weight and obesity will be affected similarly to the ones with higher rates.

We predicted that weight gain will increase in all regions of the world, also affecting the areas with a low rate of obesity such as: East Mediterranean, South-East Asia, Western Pacific, and Africa. We also identified that the income of the population has a large impact on the ability of both men and women in maintaining a healthy weight. If the actual trends of weight gain maintain the same pattern at the population level, the mean BMI will increase worldwide. Generally, our data show that the upward trend of weight gain, a mean BMI score about 30 kg/m<sup>2</sup> globally for both sexes, both in low-income and high-income countries will be reached by 2100.

According to WHO data, the mean BMI remained relatively stable worldwide until 2016 with a maximum value of 24.5 kg/m<sup>2</sup> for both sexes. Our data shows gradually increasing rates between 2030 and 2100. Our estimated mean value of the BMI for 2030 is 25.4 kg/m<sup>2</sup>, while for 2050 the mean BMI increases at a value of 26.8 kg/m<sup>2</sup>. As for the year 2080 our estimated value is 28.9 kg/m<sup>2</sup>, showing that the European population may be affected by excess weight. We estimated that in 2100, the male population will be affected by obesity with a mean BMI value of 30 kg/m<sup>2</sup> for men and 29.85 kg/m<sup>2</sup> for women. The mean value for both sexes will reach 30.27 kg/m<sup>2</sup>. Thus, the cutoff values for BMI among populations such as the Asian or the Indian populations are different [23, 24]. For a better approach on the trend of excess weight and obesity, we analyzed separately the average BMI value in different regions of the world.

The strongest associations with weight gain are found for the social capital [27]. Nowadays, high income countries have a higher prevalence of obesity. The WHO data show that in the low income population, before 2016 the average BMI score was below 25 kg/m<sup>2</sup> for both sexes. The low income category of population is more likely to be overweight by 2100. According to our analysis, the female population is more susceptible to be overweight. Until 2016, the mean BMI value was 22.4 kg/m<sup>2</sup> for both sexes in the low income countries. In 2030 our estimated mean BMI value

for females reaches 24 kg/m<sup>2</sup>. Our data shows that the mean value of the BMI exceeds the normal cutoff values with a 25.6 kg/m<sup>2</sup> value beginning with 2050, in 2080 it reaches 28.1 kg/m<sup>2</sup>, while in 2100 it increases towards obesity cutoffs, with a mean value of 29.7 kg/m<sup>2</sup>. As for the male population living in low income countries, our data reveals that the men living in these countries might be overweight in the next decades. Their BMI values will increase from 22.6 kg/m<sup>2</sup> in 2030 at 23.6 kg/m<sup>2</sup> in 2050, 25.1 kg/m<sup>2</sup> in 2080 and 26.1 kg/m<sup>2</sup> in 2100.

In the high income population, the average BMI score across the world had high values in 2016 with a value of 26.5 kg/m<sup>2</sup> for both sexes. Using the trendline equation, we identified that the male population will be more affected by obesity until 2100. In 2030 the mean BMI value will be 28 kg/m<sup>2</sup>, 29 kg/m<sup>2</sup> in 2050, 31.5 kg/m<sup>2</sup> in 2080 and 32.8 kg/m<sup>2</sup> in 2100. As for the female population living in high income countries, our prediction shows that in 2030 their mean BMI score will reach 26.9 kg/m<sup>2</sup>, 28.1 kg/m<sup>2</sup> in 2050, 29.7 kg/m<sup>2</sup> in 2080 and 30.4 kg/m<sup>2</sup> in 2100.

Until 2016, in the European region, the maximum average BMI score for both sexes was 26.4 kg/m<sup>2</sup>. Our prediction shows higher rates of average BMI for the male population with a value of 27.6 kg/m<sup>2</sup> in 2030, 29 kg/m<sup>2</sup> in 2050, 31.1 kg/m<sup>2</sup> in 2080 and 32.4 kg/m<sup>2</sup> in 2100. In the European female population, these rates may also increase between 2030 and 2100. Our analysis shows an average value of the BMI of 26.5 kg/m<sup>2</sup> for 2030, 27.1 kg/m<sup>2</sup> for 2050, 28.1 kg/m<sup>2</sup> for 2080 and 29.7 kg/m<sup>2</sup> for 2100.

Regions such as East Mediterranean and South-East Asia, known for a healthy lifestyle are also affected by excess weight and obesity. In 2016 in the East Mediterranean region, the average BMI for both sexes was 26.1 kg/m<sup>2</sup>. For women this score was higher, reaching the value of 27 kg/m<sup>2</sup> and 25.3 kg/m<sup>2</sup> for the male population. Data shown in our prediction reveal an ascending trend of obesity until 2100, when the average BMI in the East Mediterranean region will reach 33.4 kg/m<sup>2</sup> for both sexes. In 2030 the mean BMI score in the East Mediterranean population will

be 27.3 kg/m<sup>2</sup>. In 2050, the mean BMI will reach 29 kg/m<sup>2</sup> and 31.7 kg/m<sup>2</sup> in 2080 for both sexes. According to our estimations, the average BMI in 2100 will be higher in women than in men, reaching the average BMI value of 35.4 kg/m<sup>2</sup> for women and 32.6 kg/m<sup>2</sup> for men.

Regarding the South-Eastern region of Asia, the average BMI value for both sexes in 2016 was 24.5 kg/m<sup>2</sup>. The female population had a mean BMI score of 24.6 kg/m<sup>2</sup> and the male population a BMI score of 24.3 kg/m<sup>2</sup>. According to these values the Asian population is already overweight.

We estimated that in the further period of time in the Asian population the average BMI score will be 25.4 kg/m<sup>2</sup> for 2030, 26.8 kg/m<sup>2</sup> for 2050 and 28.8 kg/m<sup>2</sup> for 2080. If the weight gain continues with the present rates, by 2100 the Asian population will be severely affected by obesity with an average BMI value for both sexes of 30.2 kg/m<sup>2</sup>. This index will be slightly higher in the Asian male population with an average BMI value of 30 kg/m<sup>2</sup> and lower in female population with an average BMI score of 29.85 kg/m<sup>2</sup>.

In the United States of America, in 2016, the obesity rates were very high with a maximum average BMI score of 29 kg/m<sup>2</sup> for both sexes. By 2100 the values of the average BMI will be among 35 kg/m<sup>2</sup>, higher in women than in men. The male population living in the USA will reach increasing BMI values, starting from 28.5 kg/m<sup>2</sup> in 2030, increasing gradually. We determined a 30.16 kg/m<sup>2</sup> value for 2050, 32.6 kg/m<sup>2</sup> for 2080 and 34.2 kg/m<sup>2</sup> for the year 2100. As for the female population living in the Americas, our prediction shows that in 2030 their average BMI score will reach 28.5 kg/m<sup>2</sup>, 30.16 kg/m<sup>2</sup> in 2050, 32.6 kg/m<sup>2</sup> in 2080 and 34.2 kg/m<sup>2</sup> in 2100.

According to WHO data, in 2016, in Africa and in the Western Pacific regions, the average BMI score was 24 kg/m<sup>2</sup> for both sexes. Thus, if the trends remain stable, in 2100 the rates of obesity will also reach these areas.

Our analysis also shows that in Africa, the female population will be more affected than men by obesity. In 2030 black women living in Africa may be overweight. The maximum mean BMI for them shown in our data is 25.2 kg/m<sup>2</sup> for 2030

and 26.86 kg/m<sup>2</sup> for 2050. If the weight gain will continue with the present rates, the values of the average BMI for the black women will increase at 29.3 kg/m<sup>2</sup> for 2080 and 30.92 kg/m<sup>2</sup> for the year 2100. We identified a lower value of mean BMI in black men living in Africa. For 2030 our estimated mean BMI value is 23.1 kg/m<sup>2</sup>. As for 2050 the average BMI score doesn't surpass the cutoff value for healthy body weight (24.1 kg/m<sup>2</sup>). Beginning with 2080, the average BMI score will be surpassing the cutoff values for ideal weight and reaching the value of 25.6 kg/m<sup>2</sup>, while in 2100 the our estimated score is 26.4 kg/m<sup>2</sup>.

In the Western Pacific area until 2016, the average BMI for both sexes was in the normal cutoff values (23.7 kg/m<sup>2</sup>). Our predictions show that the obesity rates will be higher in the male population compared to the female population. We predicted that in 2030 the average BMI score will be 25.3 kg/m<sup>2</sup> for the male population. Thus, in 2050 the value might increase at 27.18 kg/m<sup>2</sup>.

As for the year 2080, the average BMI in the Western Pacific area might pass the cutoff value of 30 kg/m<sup>2</sup> for obesity. Also, for the year 2100, we determined an average BMI value of 31.87 kg/m<sup>2</sup> for men. For the women living in this area, the estimated average BMI value for 2030 is 24.27 kg/m<sup>2</sup>. Starting with the year 2050, the mean BMI value might reach overweight cutoffs with a 25.52 kg/m<sup>2</sup> value, 27.4 kg/m<sup>2</sup> for 2080 and 28.5 kg/m<sup>2</sup> for 2100.

## Strengths and Limitations

Strengths: New perspective on excess weight and obesity until 2100, in comparison with the existing studies and meta-analysis in the field. Limitations: There are a lot of variables which may affect the quality of the study including other BMI classifications for the Asian and Indian populations. Also, sociologic, demographic, and economic characteristics of individuals are associated with misreporting of height and weight. This may indicate that the real average BMI scores may be higher than those studied. Also the differences in reporting the BMI may

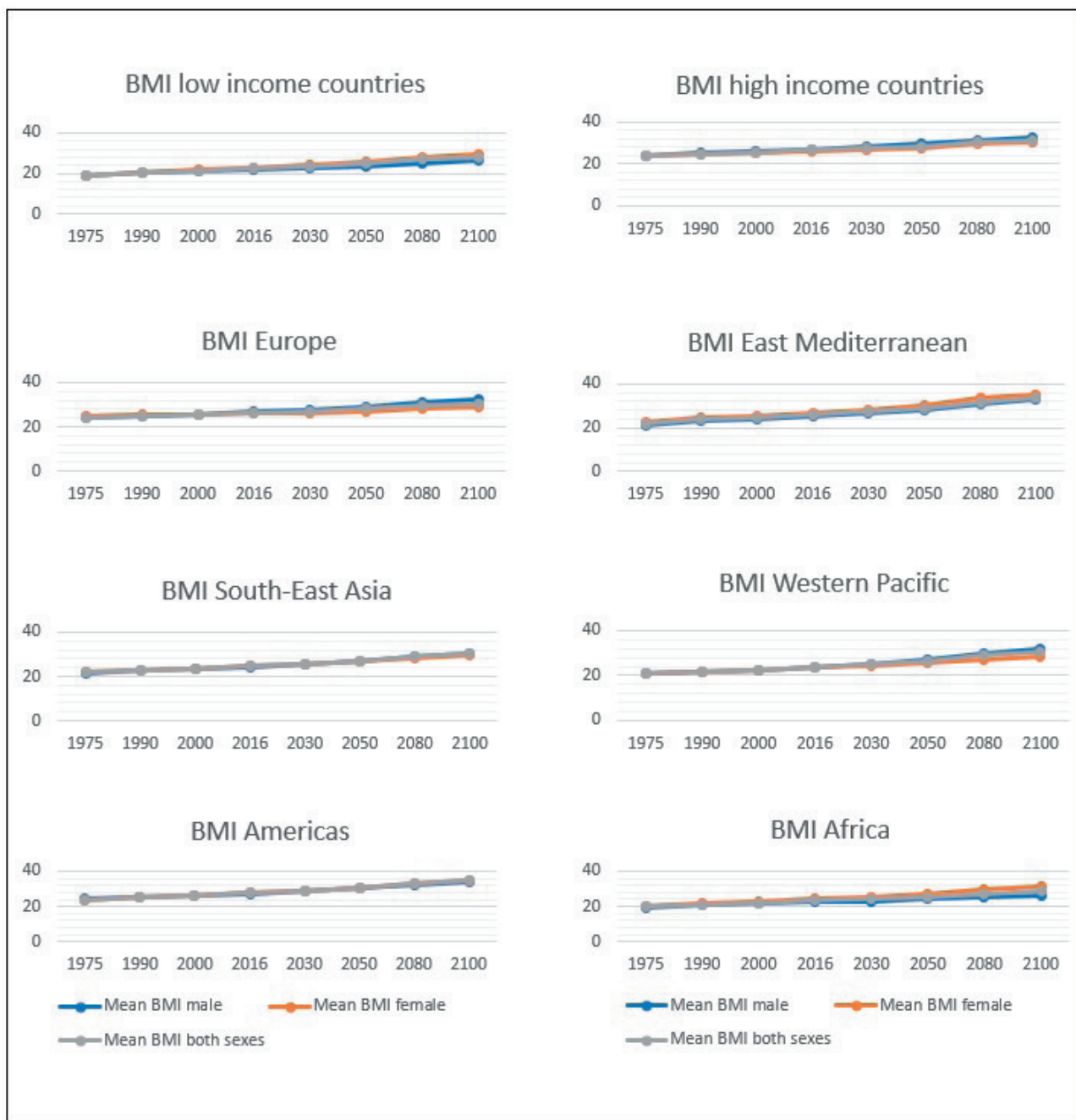


Figure 2: Mean BMI (own calculations using WHO data). Source: WHO data [3].

be affected by characteristics such as income inequality and the education level. Based on our results, future studies on obesity and the regional drivers and differences are needed.

### Discussions

Little is known about the anthropometric measures and the relationship with the contextual

environment in which individuals live, including social, demographic, and economic determinants.

Individual factors associated with weight gain in the general population may be avoided, thus in order to stop the further expansion of the obesity pandemic, the individual control of the main obesogenic risk factors (unhealthy diet, low level of physical activity/sedentarism) without visible obesity interventions at the community level, such as active decisions, involvement and

coordinated efforts of local authorities to improve the local environment may be insufficient.

## Conclusions

Obesity is nowadays a leading concern and a huge responsibility for the health systems worldwide. The public sector, along with the civil society and also the private sector play a key role in shaping a new paradigm to benefit society. In order to tackle the obesity pandemic there is an urgent need to find an effective perspective in building health through healthy behaviors, healthy lifestyle, food security, healthy nutritional transition, not only by providing access to healthier choices, but also by encouraging people to make those healthy choices. A sustained focus on wellbeing education, on physical activity opportunities and initiatives for healthy behavior may improve health outcomes at the population level. Additional studies are needed in order to establish the precise causality in this field and provide accurate recommendations in order to tackle obesity pandemics.

## Conflict of Interest

The authors declare no conflict of interest.

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