The Environmental *Foodprint* of Obesity

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Emissions of greenhouse gases (GHG) are linked to global warming and adverse climate changes. Meeting the needs of the increasing number of people on the planet presents a challenge for reducing total GHG burden. A further challenge may be the size of the average person on the planet and the increasing number of people with excess body weight. We used data on GHG emissions from various sources and estimated that obesity is associated with ~20% greater GHG emissions compared with the normal-weight state. On a global scale, obesity contributes to an extra GHG emissions of ~49 megatons per year of CO_2 equivalent (CO_2eq) from oxidative metabolism due to greater metabolic demands, ~361 megatons per year of CO_2eq from food production processes due to increased food intake, and ~290 megatons per year of CO_2eq from automobile and air transportation due to greater body weight. Therefore, the total impact of obesity may be extra emissions of ~700 megatons per year of CO_2eq, which is about 1.6% of worldwide GHG emissions. Inasmuch as obesity is an important contributor to global GHG burden, strategies to reduce its prevalence should prioritize efforts to reduce GHG emissions. Accordingly, reducing obesity may have considerable benefits for both public health and the environment.

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Study Importance

What is already known?

- Food production and transportation systems are major contributors to manmade greenhouse gas (GHG) emissions.
- Obesity is associated with greater energy expenditure and energy intake to maintain greater body weights.

What does this review add?

- Obesity is associated with ~20% greater GHG emissions relative to the normal-weight state because of increased oxidative metabolism, food intake, and fossil fuel use for transportation.
- Globally, obesity contributes to an extra ~700 megatons per year of CO_2 equivalent, which is about 1.6% of global GHG emissions.
- Such data should not lead to more weight stigmatization.

Human Activity, Greenhouse Gases, and Global Climate Change

Human behavior involves usage and consumption of resources such as land, food, water, air, fossil fuels, and minerals. Accordingly, this leads to production of waste such as air and water pollutants, plastic, toxic materials, and not least emissions of greenhouse gases (GHG). A GHG is a gas that absorbs and emits radiant energy within the thermal infrared range. The primary GHG in Earth's atmosphere are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), along with water vapor and ozone (the latter two are not considered causes of man-made global warming) (Figure 1) (1). Each GHG has a different global warming potential and persists for a different length of time in the atmosphere; therefore the unit of CO_2 equivalent (CO_2eq) has been introduced to facilitate comparison between different GHG. Other GHG such as fluorinated gases are much less prevalent (Figure 1).

The emissions of CO_2 from the natural decay of organic material in forests and grasslands and from forest fires result in the release of about 440 gigatons of CO_2 every year, but the planet's vegetation is estimated to entirely counterbalance this CO_2 through the photosynthesis process (2). However, the atmospheric CO_2 content has been steadily rising in the past several decades, contributing to global warming and other climate changes. In fact, the present atmospheric CO_2 level is the highest in 800,000 years (3). Natural fluctuations between 180 and 280 ppm have existed, but atmospheric CO_2 started to rise following the industrial revolution during the mid-18th century, exceeding 415 ppm in 2019 (3,4). These observations imply that the increase in atmospheric CO_2 is most likely caused by man-made activities, including the burning of fossil fuels for heating, power generation, and transport; food and livestock production; and some industrial processes such as cement production and deforestation (Figure 1) (1). For instance, human development is estimated to have reduced the global number of forest trees to approximately half since the start of human civilization (5).

The planet's ecosystems can coexist in balance with large animal and human populations, but the maximum size of a sustainable human population without adverse effects on ecosystems and climate depends upon how we live. People around the world consume resources differently and unevenly. For example, the average middle-class American

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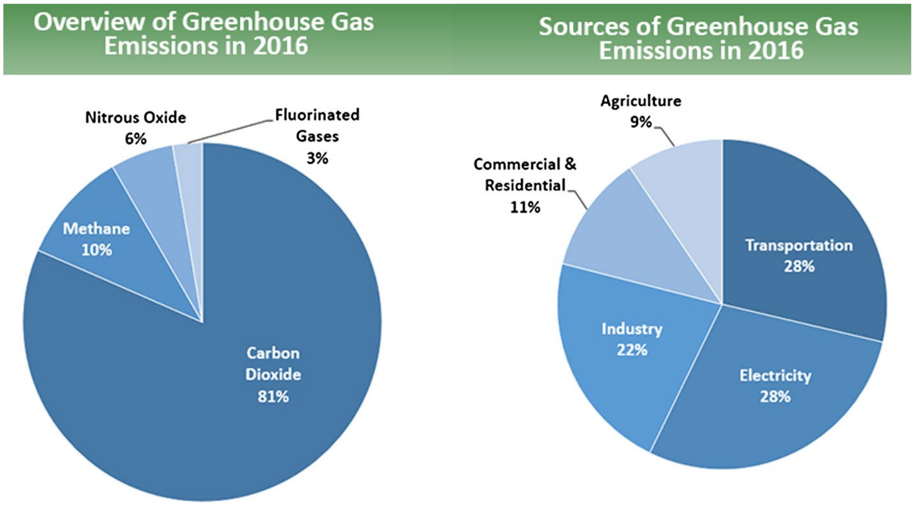

Figure 1 Total greenhouse gas emissions by type (left) and economic sector (right) in the US. Reproduced from US Environmental Protection Agency Inventory of US Greenhouse Gas Emissions and Sinks (https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks).

consumes 3.3 times the subsistence level of food and almost 250 times the subsistence level of clean water (subsistence level is the minimum level necessary to meet the bare necessities of life) (6). Therefore, if everyone in the world lived like a middle-class American, the planet would have a carrying capacity of only about 2 billion people (6). Furthermore, in the US but also on a global scale, a third or more of all food produced and a quarter of all freshwater are either lost or wasted along the food supply chain from production to consumption (7,8). What is more, food waste has been increasing over the past 4 decades (8). Given that producing 1 kcal of food requires using at least 3 kcal of fossil fuel energy (8), it has been estimated that the GHG emissions associated with food waste have also increased during the same period of time (by ~threefold) (9) so that, globally, the amount of food and drinks lost or wasted corresponds to ~8% of total GHG emissions (7). Apparently, simply minimizing food loss and waste could bring about a substantial reduction in the global GHG burden (9).

Not surprisingly, consumption patterns and resource use vary considerably in different parts of the world. A study undertaken in 2009 showed that countries with the fastest population growth also had the slowest increases in carbon emissions (10). The reverse was also true; for example, the population of North America grew by only 4% between 1980 and 2005, while its GHG emissions grew by 14% (10). The US and Russia are regions in the upper end of GHG emissions per capita, whereas resource-poor countries like India and Nigeria are in the lower end (Table 1) (11-13). The world's most rapidly growing populations also have the lowest per capita GHG emissions today, but with increasing economic growth, they may eventually convert to the same high consumption pattern as, for example, in China. Nevertheless, the existence of large differences in GHG emissions per capita between countries and regions with similar development, e.g., between the US and the European Union (EU) (more than two times greater in the former; Table 1), is also strongly suggestive for potential drastic reductions in the emissions from some big developed countries. There is an urgent need to reduce the dependence on, and use of, fossil energy sources and replace them with energy sources that are neutral in terms of GHG emissions. However, merely reducing the use of fossil energy will not meet the demand for reduction in GHG emissions to maintain the 1.5°C scenario according to the Intergovernmental Panel on Climate Change (14). Substantial reductions in emissions from food crop and livestock production will be required simultaneously.

Fulfilling the needs of the increasing number of people on the planet presents a challenge for reducing total GHG emissions because the size of the world's population is a major determinant of global GHG emissions. Population growth has been exponential during the past century. The world population was around 2.5 billion in 1950, exceeded 5 billion in 1988, is currently 7.7 billion, and is projected to reach 9.8 billion in 2050 and plateau at 11.2 billion by the year 2100 (15,16). Here we argue that a further challenge will be the body weight of the average person on the planet and the increasing number of people with obesity (17). This argument draws from the fact that the energy requirement of any species, including humans, is a function of the number of organisms (i.e., population size) and their average mass (i.e., body weight) (18).

Methodological Approach to Complexity of Environmental Effects of Obesity

To assess the impact of obesity on the environment, we calculated the extra CO_2 emissions (in CO_2eq) due to a person having obesity rather than being lean. We used the standard definitions of obesity ($BMI \geq 30$ kg/m^2) and normal weight ($BMI < 25$). Even though these cutoffs may differ across populations, this should not affect our calculations because the relative differences between obesity and normal weight would be approximately similar regardless of the absolute values and the fact that these may vary by age, sex, or ethnicity. We did not specifically consider overweight ($25 \leq BMI < 30$) or severe obesity ($BMI \geq 40$) in our analysis. We calculated the extra CO_2 emissions from the increased oxidative metabolism, the increased food intake, and the increased fuel

TABLE 1 Total CO_2 and GHG emissions and contribution from obesity in selected regions around the world

Country/region	Population[a] (n)	Obesity prevalence[b] (%)	Obesity prevalence[b] (n)	Total CO_2 emission per capita[c] (tons)	Total CO_2 emission[c] (kilotons)	Total GHG emissions per capita[c] (tons CO_2eq)	Total GHG emissions[c] (kilotons CO_2eq)	Contribution of obesity to total GHG emissions[d] (kilotons CO_2eq)	Contribution of obesity to total GHG emissions[d] (% of total)
Australia	18,136,855	29.0	5,259,688	17.219	414,989	26.36	602,100	6,043	1.0%
Brazil	143,376,677	22.1	31,686,246	2.226	462,995	5.59	1,121,000	36,407	3.2%
Canada	28,277,503	4.7	1,329,043	18.620	675,919	20.56	717,500	1,527	0.2%
China	1,057,044,790	6.2	65,536,777	7.452	10,432,751	8.80	12,102,000	75,302	0.6%
European Union	405,691,728	23.3	94,526,173	6.753	3,431,656	9.05	4,577,402	108,611	2.4%
India	826,963,161	3.9	32,251,563	1.919	2,533,638	2.50	3,166,000	37,057	1.2%
Korea	41,175,599	29.4	12,105,626	11.891	604,044	13.09	653,900	13,909	2.1%
Mexico	78,557,541	28.9	22,703,129	3.449	441,413	6.01	725,000	26,086	3.6%
Nigeria	84,755,151	8.9	7,543,208	0.444	82,634	1.82	304,200	8,667	2.8%
Russia	113,123,333	23.1	26,131,490	11.541	1,661,899	15.87	2,280,800	30,025	1.3%
United Kingdom	50,312,425	27.8	13,986,854	5.591	367,860	8.72	559,700	16,071	2.9%
United States	240,307,050	36.2	86,991,152	15.564	5,011,687	19.56	6,125,000	99,953	1.6%
World, total	4,898,556,125	13.1	641,710,852[e]	4.796	35,753,306	6.52	46,423,330	737,326[e]	1.6%

To generate this table, we used our estimate of the "extra" GHG emissions in CO_2eq for a single person with obesity compared with a person of normal weight (see text) and inferred the total additional burden of obesity in absolute terms, based on global and regional obesity prevalence rates and the size of the population (for adults); we then calculated the total additional burden of obesity in relative terms, based on global and regional CO_2 and GHG emission data. Countries were selected at random, without any particular methodology, to provide some examples that span across the range of development stage, emission rates, and obesity prevalence rates.
[a]Demographic data for the number of adults aged ≥ 20 years (circa 2016) are from the World Bank (13).
[b]Prevalence of obesity (age-standardized BMI ≥ 30 kg/m^2) by country among adults aged ≥ 18 years are from the World Health Organization (11).
[c]Emission data for CO_2 (circa 2016) and all GHG (circa 2012) are from The European Commission: http://edgar.jrc.ec.europa.eu (12).
[d]Calculated based on an estimated "extra" GHG emissions of 1.149 tons/y of CO_2eq for a single individual with obesity on top of the GHG emissions for a normal-weight person (see text).
[e]Obesity-associated total GHG emission cost is slightly greater in the table than in the text (737 vs. 700 megatons, respectively) because of the somewhat different estimates of the total number of people with obesity globally (642 vs. 609 million, respectively).
CO_2eq, CO_2 equivalent; GHG, greenhouse gas.

use to transport the greater body weight in a single person with obesity compared with a person of normal weight. Thereafter, we inferred the total additional burden of obesity (in absolute and relative terms) based on global and regional emission data, demographic data, and obesity prevalence estimates (11-13,19). Harmonizing data from epidemiology (prevalence rates of obesity), physiology (total energy intake and expenditure), and environmental science (CO_2 emissions from different sources) is not a straightforward task, and we emphasize that our estimates are not intended to be precise. They are crude estimates that involve the use of many assumptions and are only intended to be reasonable enough to demonstrate the potential impact of the effect of obesity on the environment.

Impact of Obesity on CO_2 Emissions from Metabolism

All human life depends on oxidative metabolism from which the energy stored in food (fat, protein, carbohydrate, and alcohol) but also that stored in the body (adipose tissue triglyceride, muscle and liver glycogen) is extracted during the oxidation of macronutrients (which requires oxygen consumption) and converted to ATP, a molecule that is able to store and transport chemical energy in cells while heat, water, and CO_2 are produced as by-products. Individuals of normal body weight with a metabolism of 9,000 kJ/d produce about 260 mL/min of CO_2 on average during a 24-hour period (20), which is equivalent to ~270 kg/y of CO_2. CO_2 production (and oxygen consumption) is higher in individuals with obesity compared with lean individuals, consistent with their greater total daily energy expenditure. This has been shown repeatedly by the use of 24-hour indirect calorimetry and techniques such as the doubly labeled water method (21-27). There are two reasons for the increased energy expenditure and CO_2 production in obesity. Weight gain from the normal-body-weight state to the obesity state consists of ~75% fat (range: 50%-90%) and ~25% lean body tissue (range: 10%-50%) (28,29); additional lean mass is needed to support the larger body size. The lean tissue is metabolically active, and total energy expenditure is therefore increased in parallel with increases in body weight and fat-free mass (25,30). Moreover, there is an increased energy cost of moving the extra weight of individuals with obesity.

Studies that have measured total energy expenditure in free-living people by using the doubly labeled water technique, which fully encompasses physical activity patterns in real life, have reported greater total energy expenditure of 20% to 42% in individuals with obesity compared with those with normal body weight (22,26). Studies that have used whole-body room calorimeters to measure total energy expenditure have typically reported differences in the lower end of this range, possibly because movement opportunities inside the respiration chamber are restricted and do not fully represent real-life differences in physical activity patterns between people with and without obesity. One such study reported total energy expenditure in the order of 8,439 kJ/d in men and women of normal body weight (BMI ~21) and 10,043 kJ/d in individuals with obesity (BMI ~38), i.e., a 19% difference (23). Assuming a more realistic average of 30% greater total energy expenditure in people with obesity compared with lean people during a typical 24-hour period (20), the extra CO_2 emissions by one individual with obesity would be approximately 81 kg/y of CO_2eq. In 2015, it was estimated that 609 million adults were suffering from obesity globally (19). Therefore, obesity could be roughly responsible for excess metabolic CO_2 emissions of 609 million × 81 kg = 49.1 megatons (Mt) of CO_2eq/y (1 Mt = 1 million tons). This is equivalent to the total fossil CO_2 emissions of an entire Scandinavian country such as Sweden, Finland, Norway, or Denmark (45-50 Mt CO_2eq in 2015) (31) or to the metabolic CO_2 emissions of 183 million people with normal weight. This constitutes the direct effect of the "accelerated" metabolism in people with obesity, and it may be considered a relatively small additional CO_2 emission burden compared with global figures; however, the indirect effects due to food consumption and transportation are quantitatively much more important.

Impact of Obesity on GHG emissions from Food Production

Energy requirements of humankind, and subsequently worldwide food demand, are expected to increase not only as a function of the growing population but also because of the increasing body weight (18). This will likely lead to increased food production. In fact, it has been demonstrated that global food availability has increased to a much greater extent than global food demand during the past 40 to 50 years, and it is projected to continue to do so in the foreseeable future (9). Ultimately, this leads to more food and water being wasted and thus increased GHG burden on the environment (8,9). It has been estimated that increasing body weight on a global scale could have the same implications for world food energy demands (and associated GHG emissions) as an extra half a billion normal-weight people living on Earth (18).

The growing proportion of the population with excess body weight influences food and drink consumption because the higher energy expenditure of these individuals causes a proportionate increase in energy requirements to maintain their greater body weight. Pradhan et al. (32) identified several distinct dietary patterns around the world, differing in food sources and diet composition as well as calorie content, and found that environmental impacts in terms of fossil fuel requirements and total GHG emissions generally increased as diets became more calorie rich but were similar across dietary patterns. This implies that the calorie content of the diet is a major determinant of its environmental footprint. Individuals with obesity consume, on average, ~30% more energy from food and drinks to match their higher energy expenditure and maintain their greater body weight. Accordingly, this gives rise to an increase in CO_2, CH_4, and N_2O emissions from food, crop, and livestock production. It has been estimated (circa 2005-2010) that, for every dietary calorie (1 kcal or 4.184 kJ) eventually reaching the table, the amount of food and drinks produced, including the amount being wasted (~30% of total production), is responsible for 2.21 g of GHG being emitted (in CO_2eq) (33). The average daily energy intake of a weight-stable man or woman without obesity is ~10,000 kJ/d (~2,450 kcal/d) (34), which would then contribute ~5.5 kg/d of CO_2eq or ~2 tons/y of CO_2eq. Assuming that the diet of a weight-stable individual with obesity provides ~30% more calories (i.e., ~13,000 kJ/d), the associated GHG emissions would be ~2.6 tons/y of CO_2eq, i.e., 593 kg/y of CO_2eq more than those of a normal-weight person. A rough estimate would then be that, on a global scale, obesity is responsible for excess CO_2 emissions due to greater food and drink consumption of 609 million people × 593 kg/y = 361 Mt/y of CO_2eq. This estimate is somewhat lower than that reported previously (an additional 736 kg/y per person or ~448 Mt/y CO_2eq for all people with obesity; circa 2000) (35) and may vary somewhat across different regions of the world because of differences in the efficiency of calorie production per unit of GHG emissions (32), but still it is comparable to the total CO_2 emissions of the United Kingdom (Table 1).

Impact of Obesity on GHG Emissions from Transportation

Fossil fuel consumption by modern transport systems (vehicles, aircrafts, etc.), and subsequently GHG emissions, depends on many factors, including the energy efficiency of the engine, the type of fuel, the aerodynamic design of the vehicle or aircraft, and the route and weather conditions, but also the weight being moved. An increase in cargo weight increases fuel usage and vice versa (36). Therefore, transporting heavier passengers is expected to raise GHG emissions. Transport accounts for about 14% of total GHG emissions. Fuel energy use can be expected to increase as the population becomes heavier. Edwards and Roberts (35) estimated that, compared with a hypothetical population of 1 billion people with an average BMI of 24.5 ("normal distribution" with an obesity prevalence of 3.5%, i.e., 35 million people with obesity), the same number of people with an average BMI of 29 ("overweight distribution" with an obesity prevalence of 40%, i.e., 403 million people with obesity) would require ~14 % more GHG emissions for their transportation, from 1,254 to 1,427 Mt/y of CO_2eq (circa 2000). Given that the two hypothetical populations differed by 368 million people with obesity (35), one can estimate the additional GHG emissions for the transportation of one person with obesity by car (on top of that associated with the transportation of one lean person) to be 470 kg/y of CO_2eq. This estimate is based on the assumption that people drive for 30 minutes daily at an average speed of 45 km/h and that individuals with obesity drive somewhat larger cars and are more likely to replace short walking trips with motorized transport (35).

Aviation is also an important component of transportation emissions. CO_2 emissions from aviation in the EU have increased by about 80% between 1990 and 2014, and they are forecasted to grow by a further 45% between 2014 and 2035, largely as the result of increasing numbers of flights to meet the increasing demand for air travel (37). In the EU, aviation represents ~13% of transportation-related GHG emissions and ~3% of total GHG emissions (circa 2012) (37). Likewise, in the US, aviation accounts for ~9% of transportation-related GHG emissions and ~3% of total GHG emissions (circa 2016) (38). Edwards and Roberts assumed that 5% of the population takes one short-haul flight totaling 3,000 km each year, equivalent to 150 billion passenger kilometers per year (35). The difference in mean body weight of their "overweight" and "normal weight" populations was assumed to be 13.4 kg (and the difference in mean BMI was ~5, i.e., equal to the difference between having normal weight and obesity), and therefore the additional jet fuel required to transport the extra weight was calculated to be approximately 187 million gallons per year, resulting in a further 2.04 Mt of CO_2eq (circa 2000). This corresponds to an additional ~5.5 kg/y of CO_2eq for the transportation of one person with obesity by air (on top of that associated with the transportation of one lean person).

Overall, therefore, obesity can be expected to increase GHG emissions from automobile and air transportation by 476 kg/y of CO_2eq per person. This corresponds to an increase by ~14% over the emissions associated with the transportation of a normal-weight person. On a global scale, therefore, the 609 million people with obesity could add roughly 290 Mt/y of CO_2eq to total GHG emissions.

Summing Up Contribution from Obesity to Total CO_2 and GHG Emissions

Compared with a normal-weight individual, an individual with obesity is "responsible" for an extra 81 kg/y of CO_2eq from higher metabolism (7% of total), an extra 593 kg/y of CO_2eq from greater food and drink consumption (52% of total), and an extra 476 kg/y of CO_2eq for car and air transportation (41% of total). Thus, obesity could account for an estimated total additional GHG emissions of 1.149 tons/y of CO_2eq for a single person, or ~20% greater than the emissions attributed to a lean person. This is not a negligible contribution given that average per capita GHG emissions among all people on the planet in 2012 was 6.52 tons/y of CO_2eq (12). Worldwide, for the 609 million people with obesity, this figure translates into an additional GHG emission "cost" of ~700 Mt/y of CO_2eq, which is more than the total GHG emissions from Australia or Korea (600-650 Mt CO_2eq in 2012) and equivalent to the total GHG emissions from Canada or Mexico (~720 Mt CO_2eq in 2012) (12). It can also be estimated, on the basis of GHG emission data, demographic data, and obesity prevalence statistics, that the additional emission burden of obesity accounts for 0% to 3.5% of total regional GHG emissions and ~1.6% globally (Table 1).

Food for Thought and for the Future

The present analysis highlights the important contribution of obesity to humankind's footprint on the environment in terms of CO_2 emissions, which calls for special attention to prevention and management of obesity in any strategy to reduce GHG emissions, and vice versa, both on a national scale and globally. It is important to note that the figures we came up with in our analysis are rough estimates, and a series of more comprehensive analyses are needed to stratify into different categories of age groups, sex, and degrees of obesity; consideration should also be taken of regional differences in food and drink consumption and transportation patterns. In order to clearly identify the impact of increasing obesity rates on global CO_2 emissions, there is also a need to produce more accurate models of how the size of the human body affects CO_2 production. These models should consider people with overweight ($25 \leq BMI < 30$) but also severe obesity ($BMI \geq 40$), as well as physical activity behaviors of the population. For example, Pontzer et al. have suggested that most people can achieve similar high levels of energy expenditure (and therefore metabolic CO_2 production) either through increased physical activity or increased body mass (39). Physical activity increases energy expenditure several fold above resting values, particularly during and immediately after exercise but also throughout the day (40). Accordingly, people who are more physically active require more food to maintain their current weight. Therefore, metabolic CO_2 production, but also GHG emissions associated with food production, are greater in people who are more physically active than those who are sedentary. Still, our analysis suggests that oxidative metabolism accounts for a small part (7%) of the extra GHG emissions associated with obesity; the majority is attributed to food and drink production (52%) and transportation (41%). It is therefore unreasonable to argue against more physical activity in this regard. Nevertheless, it is necessary for future studies to use modeling approaches that take physical activity patterns into account. These limitations notwithstanding, we believe our estimates are adequately reasonable and rather conservative (e.g., we did not consider the additional effect of overweight), so the true global environmental impact of excess body weight may be greater than what can be inferred from our calculations. For instance, our estimates suggest that obesity is responsible for roughly 1.6% of global GHG emissions (Table 1), whereas Springmann et al., in their analysis of the environmental impact of reducing overweight and obesity rates based on modeling of data from 150 countries, concluded that a complete normalization of body weight among all individuals with excess weight (i.e., all those with overweight and obesity) would reduce GHG emissions by 10% to 15% (41). Therefore, the benefits for the environment from reducing excess body weight may be significantly greater.

It is critically important that this novel information does not lead to more weight stigmatization. People with obesity already suffer from negative attitudes and discrimination against them, and numerous studies have documented several prevalent stereotypes, e.g., that individuals with obesity are lazy, weak-willed, lack self-discipline, have poor willpower, and are noncompliant with weight loss treatments (42,43). These stereotypes create stigma, prejudice, and discrimination against people with obesity in multiple domains of living. However, there has been accumulating evidence suggesting that weight stigmatization is, in fact, what makes individuals with obesity be more vulnerable to health risk behaviors and outcomes that can exacerbate poor health and obesity, such as binge eating, increased food consumption, avoidance of physical activity, stress, weight gain, and poor weight loss outcomes (44). To avoid this, it is important to recognize that the positive energy balance leading to obesity is mainly established by environmental factors that are so powerful that more than two-thirds of the population in the US and the EU currently suffer from overweight and obesity despite all resources devoted to prevention and treatment (17). For those who are predisposed to obesity, it is clearly very difficult to reduce body weight and maintain the reduced body weight over time. This is not to say that obesity is merely the result of unhealthy dietary choices and poor "navigation" in the modern food environment. Obesity should be seen as a societal health problem that needs policies and improved management programs instead of blaming the individual. To this end, increased awareness of weight stigma and its consequences is urgently needed in the fields of medicine, public health, obesity, nutrition, and physical activity (44). Accordingly, careful consideration should be given to messages communicated in public health media campaigns disseminating research findings and targeting obesity prevention to ensure that messages intended to promote optimal weight-related health behaviors do not simultaneously stigmatize or shame individuals with obesity (44). Nonetheless, there is an increasing need to move beyond interventions that simply aim to raise awareness, deliver health information, and raise skills and competencies among health professionals (45). In the third Canadian Weight Bias Summit, the following three key messages were identified: (i) weight bias and obesity discrimination should not be tolerated in education, health care, and public policy sectors; (ii) obesity should be recognized and treated as a chronic disease in health care and policy sectors; and (iii) in the education sector, weight and health need to be decoupled (45). Weight stigmatization is just another facet of discriminating against people based on appearance.

Conclusion

Inasmuch as obesity is an important contributor to global GHG emissions, any strategy to reduce its prevalence should prioritize efforts to reduce GHG emissions, and vice versa. Current dietary guidelines advocate more plant-based, sustainable diets based on scientific evidence about diet–health relationships but also to address environmental concerns (46). However, and despite considerable efforts to date (32), the evidence base regarding the environmental impact of various dietary patterns is largely incomplete (47). Our analysis indicates that, in future sustainable diet modeling, more attention needs to be given to the contribution of CO_2 emissions from obesity per se, and sustainability aspects should also be included in the diet–health relationship estimations. One can eat sustainably and healthily, but one can also eat sustainably and unhealthily, or healthily but not sustainably. **O**

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