

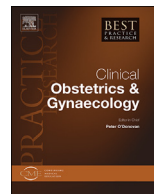


ELSEVIER

Contents lists available at ScienceDirect

## Best Practice & Research Clinical Obstetrics and Gynaecology

journal homepage: [www.elsevier.com/locate/bpobgyn](http://www.elsevier.com/locate/bpobgyn)



8

### The epidemiology of obesity in reproduction

Badreldeen Ahmed, MD, FRCOG, Professor of Obstetrics and Gynaecology <sup>a, b, \*</sup>,

Justin C. Konje, MBA, MD, FRCOG, Emeritus Professor of Obstetrics and Gynaecology, Professor of Obstetrics and Gynaecology <sup>a, c, d</sup>

<sup>a</sup> Feto Maternal Centre, Al Markhiya Street Doha, Qatar

<sup>b</sup> Qatar University and Weill Cornell Medicine, Qatar

<sup>c</sup> University of Leicester, UK

<sup>d</sup> Weill Cornell Medicine, Qatar



#### Keywords:

Obesity  
Epidemic  
Noncommunicable diseases  
Nutrition  
Reproductive consequences  
Genetics  
Endocrine factors

#### A B S T R A C T

Over the last decades, overweight and obesity rates have been rising exponentially and have now reached epidemic proportions. These are significantly higher in women than men, and indeed, data from 2022 show rates varying from the lowest (12%) in the South East Asian Region to the highest (82.8%) in the Western Pacific Region. This rise is mirrored by the increasing health cost of obesity and overweight. Recent estimates put the percentage of medical spending in various countries to vary from 3 to 21%. Obesity is associated with noncommunicable diseases, such as hypertension, diabetes mellitus, and cardiovascular disorders. It is associated with 13 cancers, among which are breast, endometrial, and ovarian. The reproductive consequences of obesity are variable and include but not exclusively menstrual disorders; fertility difficulties; recurrent miscarriages; gestational diabetes, hypertension, and pre-eclampsia; postpartum hemorrhage; and fetal macrosomia. Various factors are responsible for these increasing rates (which are more marked in middle- and low-income countries). These include genetic, epigenetic, environmental, physiologic, cultural, political, and socioeconomic factors that interact in most cases, making it challenging to develop effective interventions on both a local and global scale. In this article, we

\* Corresponding author. Fetal Maternal Centre, Al Markhiya Doha, Department of Obstetrics and Gynaecology, Qatar University and Weill Cornell Medicine, Qatar.

E-mail address: [profbadreldeen@hotmail.com](mailto:profbadreldeen@hotmail.com) (B. Ahmed).

review the epidemiology of obesity and the factors which modify rates, as well as an overview of the reproductive consequences of obesity. We discuss approaches to reduce the rates and that these should be at three levels: individual, national, and international.

© 2023 Published by Elsevier Ltd.

**Question 1:**

Consequences of increasing obesity and overweight worldwide include which of the following?

1. Cervical cancer (F)
2. Chronic obstructive airway disease (F)
3. Colon cancer (T)
4. Mental health disorders (T)
5. Multiple myelomas (T)

**Question 2:**

Reproductive consequences of obesity and overweight include which of the following?

1. Antepartum hemorrhage (F)
2. Dysfunctional labor (T)
3. Heavy menstrual bleeding (T)
4. Postpartum depression (T)
5. Primary amenorrhea (F)

**Introduction**

Obesity poses one of the greatest challenges to human health. It went from being an epidemic (when it affected a large number of people in predominantly high-income countries) to a pandemic (spreading to involve nearly all countries of the world). Globally, at least 2.8 million people die each year due to being overweight or obese. Once associated with high-income countries, obesity is now also prevalent in low- and middle-income countries [1]. In 2016, the World Health Organization estimated that there were about 1.9 billion overweight adults, of whom 650 million were obese (BMI  $\geq 30$  kg/m<sup>2</sup>) (340 million adolescents and 39 million children), implying that 39% (39% of men and 40% of women) of adults aged 18 years or older were overweight and 13% were obese. Between 1975 and 2016, the worldwide prevalence of obesity nearly tripled.

Obesity is currently rated as one of the top three social burdens caused by human behavior. Its global impact amounts to about USD 2 trillion annually or 2.8% of the global gross domestic product (GDP). This is nearly equivalent to the combined global cost of smoking, armed violence, and terrorism [2].

The World Obesity Federation (WOF) predicts that one billion people worldwide, including 1 in 5 women and 1 in 7 men, will be living with obesity by 2030 [3]. Interestingly, the largest number of people living with obesity are in low- and middle-income countries (LMICs), with numbers more than doubling across all LMICs and tripling in low-income countries compared with 2010. Furthermore, a review of the Obesity Non-Communicable Disease (NCD) Preparedness Index shows that the 30 most prepared countries are all high-income countries, whereas the 30 least prepared are lower middle- and low-income countries, adding to concerns about the impact of inaction on already vulnerable populations [4]. For example, in a study on the global trends of overweight and obesity, 26.9% of adults in

Africa were found to be overweight and obese. It also revealed that obesity was twice more common in women than men [5].

**Definition and classification of obesity**

Overweight and obesity are conditions where there is either abnormal and/or excessive fat accumulation in the body that predisposes to adverse health especially through its effects on the heart, liver, joints, and the reproductive system [6]. Obesity was traditionally defined as an increase in body weight greater than 20% of an individual’s ideal body weight—the weight associated with the lowest risk of death, as determined by age, height, and sex. Based on these factors, overweight was defined as a 15–20% increase over the ideal body weight. Because of the difficulties in defining the baseline for extrapolation, this was difficult to adopt. More objective measures that have been used include skinfold thickness, especially in children [7], waist-to-hip ratio [8], perihepatic fat thickness on MRI and BMI [9]. The BMI is the most commonly used tool to classify overweight and obesity. It is a ratio of weight (kilogram) to the square of height in meters (kg/m<sup>2</sup>). For women in the reproductive age group and in adults, the WHO recommends the following standardized definitions [10]:

- Underweight BMI <18.5 kg/m<sup>2</sup>
- Normal weight: BMI 18.5–24.9 kg/m<sup>2</sup>
- Overweight: BMI ≥25–29.9 kg/m<sup>2</sup>
- Obesity: BMI 30–39.9 kg/m<sup>2</sup>
- Morbid obesity: BMI ≥40 kg/m<sup>2</sup>

Although this provides the most useful population-level measure of overweight and obesity because it is the same for both sexes and for all ages of adults, there are limitations, especially because it is now recognized that this may not be universally applicable. Modifications have been suggested for Asians as follows [11]:

- Normal weight BMI 18–22.9 kg/m<sup>2</sup>
- Overweight BMI 23–27.4 kg/m<sup>2</sup>
- Obese BMI 27.5–37.9 kg/m<sup>2</sup>
- Morbidly obese ≥38.0 kg/m<sup>2</sup>

When using BMI, it is important to recognize that it has limitations and should, therefore, be regarded as a rough guide because it may not correspond to the same degree of fatness in different individuals even of the same BMI. Table 1 shows the use of BMI to define various classes of obesity with reference to normal weight for Asians and non-Asians [11].

**Worldwide (global) perspective**

Over the last decades, there has been an exponential increase in the rate of obesity, more so in the middle and low-income countries. In 2005, about 1.1 billion adults were considered overweight and by 2016, this had risen to 1.9 billion. Although the rate of increase appears to be slowing in the high-

**Table 1**  
Classification of BMIs according to WHO.

Class	BMI (kg/M <sup>2</sup> )range for Non-Asians	BMI (kg/M <sup>2</sup> )range for Asians
Undernutrition	<18.5	<18.0
Normal	18.5–24.9	18.0–22.9
Overweight	25–29.9	23–27.4
Obesity class I	30–34.9	27.5–32.9
Obesity class II	35–39.9	33–37.9
Obesity class III (Morbid obesity)	≥40	≥38.0

income countries, the same cannot be said of the LIC and MIC countries. If this rate of growth remains unchecked, it is projected that by the year 2030, over 1.0 billion people over the age of 18 years will be obese (i.e. with a BMI of  $\geq 30$ ). Fig. 1 shows the prevalence of obesity worldwide, as estimated by the World Obesity Federation in 2022 [12].

Table 2 shows the World Bank projections for the rates of obesity in adults from low-, middle-, and high-income countries through 2030 if the current growth rate is not controlled. In 2010 for example, 1:5 and 1:10 adults were obese in upper middle- and high-income countries, respectively. It is projected that by 2030, this will rise to 1:3 and 1:5 respectively. In the lower middle- and low-income countries, the increase will be from 6.7% to 6.4%–11.7% and 11.1%, respectively. Table 3 shows the estimated global population prevalence and numbers living with obesity between 2010 and 2020, rising from 511 million to 1.025 billion. When these percentages are projected as actual numbers (Table 4) from the top 20 countries worldwide, it is obvious that for some of these countries, especially those from the middle-income countries, the prevalence of obesity, if unchecked, will reach 40–50% for women (Mexico - 41%, Iran - 42%, Iraq - 45%, Algeria - 46%, United States - 47%, South Africa and Turkey - 50%) and 40–50% for men (Saudi Arabia - 41% and United States - 47%). Table 5 shows that by 2030, the rate of obesity will be 50% or more for women and 40% or more for men in the top 20 countries worldwide. Interestingly, in the top 20 countries with the highest projected rates of obesity for women, there are no high-income countries, although there are middle high-income countries, such as Qatar, the United Arab Emirates, and Saudi Arabia, whereas for the men, four high-income countries (New Zealand, Australia, Canada, and USA) will have obesity rates of 40% or more for men.

Adult obesity trends reflect those in children and these tend to be a continuum. In 2019, for example, it was estimated that 38.2 million children younger than 5 years were overweight or obese and projected to rise over the coming decades, with a higher rise more likely in low- and middle-income countries, especially in urban settings. The estimated number of overweight children younger than 5 years in Africa, for example, has risen by about 24% since 2000, whereas in Asia, in 2019, about 50% of children younger than 5 years were overweight or obese. In 2016, more than 340 million children and adolescents aged 5–19 years were overweight or obese. The prevalence of overweight and obesity among children and adolescents aged 5–19 years has risen dramatically from just 4% in 1975 to just over 18% in 2016. The rise has occurred similarly among boys and girls: in 2016, 18% of girls and 19% of boys were overweight. Although just under 1% of children and adolescents aged 5–19 years were obese in 1975, more 124 million children and adolescents (6% of girls and 8% of boys) were obese in 2016 [3,4].

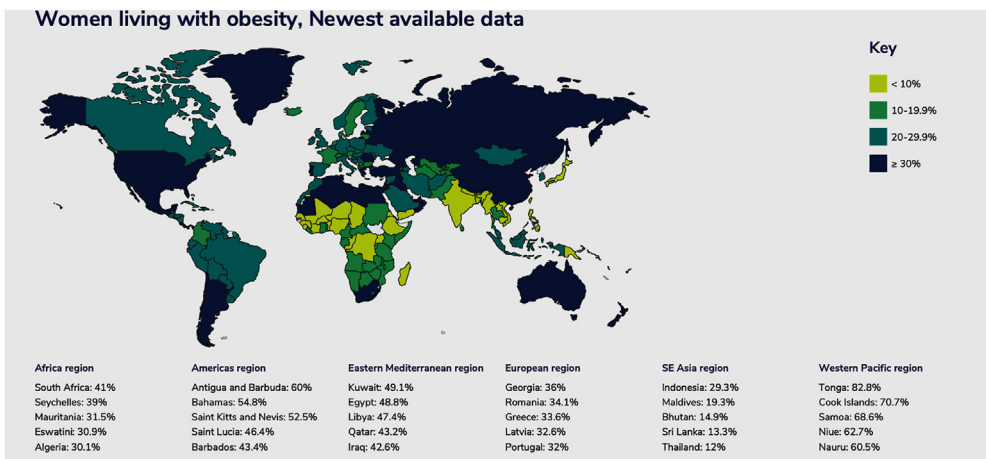


Fig. 1.

**Table 2**  
World Bank data on the projected trends of world obesity from 2010 to 2030.

	No of countries	2010 OB30+ prevalence	2025 OB30+ prevalence	2030 OB30+ prevalence	2010 OB30+ number	2025 OB30+ number	20,230 OB30+ number
High income	61	21.8%	28.9%	31.5%	191,093,859	279,686,212	310,033,422
Upper middle income	54	11.2%	17.0%	18.8%	189,751,964	329,816,019	373,081,815
Lower middle income	54	6.7%	10.7%	11.7%	111,290,435	238,274,062	283,296,858
Low income	26	6.4%	10.0%	11.1%	14,435,572	36,521,181	47,412,188
Unclassified	5	24.7%	31.0%	33.3%	4,728,429	7,477,582	8,912,331
Global	200	11.4%	16.1%	17.5%	511,300,259	891,755,056	1,024,736,614

OB30+ refers to BMI of  $\geq 30\text{kg/m}^2$ .

**Consequences of increasing obesity: economic and health**

Overweight and obesity contribute significantly to noncommunicable diseases (NCDs) such as cardiovascular disease, hypertension, stroke, type 2 diabetes, cancer, and mental health. Worldwide, noncommunicable diseases kill as many as 41 million people annually (contributing to 71% of all deaths worldwide). Of these, obesity-related NCDs account for 70%, made of 17.9 million from cardiovascular disease, 9.3 million from cancers, and 1.5 million from diabetes [13]. More recently, the UN Health Agency stated that obese people with COVID-19 are three times more likely to be hospitalized and more likely to die of complications. Furthermore, the restrictions imposed by control measures are likely to lead to significantly increased worldwide obesity rates [14]. Obesity and overweight, therefore, affect health directly and indirectly.

In the USA the National Institutes of Health Statistics (USA NHS) show that obesity and overweight together are the second leading cause of preventable deaths, close behind tobacco use [15,16]. An estimated 300,000 deaths per year are because of the obesity epidemic [17]. By 2022, the mean estimate for deaths due to obesity was 324,940, using data from the CPS1 and USA NHS. When these were controlled for pre-existing disease, the mean annual number of obesity-attributable deaths was estimated to be 374,239 (330,324 based on CPS1 data and 418,154 based on USA NHS data) [18].

Obesity and overweight are significant drains on health resources. Much of the cost comes from the associated comorbidities. The third most significant risk factor contributing to the burden of disease in high-income countries is obesity [19]. It is estimated that nearly 45% of the health costs of diabetes are associated with obesity and nearly 25% of the burden of cardiovascular disease, specifically ischemic heart disease, is related to overweight and obesity [20]. Obesity increases the risk of noncommunicable diseases (NCDs) such as hypertension, diabetes, venous thromboembolism (VTE), dyslipidemia, coronary artery disease, ischemic strokes, and arthritis, and has significant implications for reproductive health throughout the course of life. Furthermore, the burden associated with several cancers can also be attributed to obesity, with an estimated 10% of 13 different types of cancers (uterus, breast, colon and rectum, esophagus, gallbladder, stomach, kidneys, liver, pancreas, meningioma, multiple myeloma, ovaries, and thyroid) correlated with obesity [21,22]. It is likely to be directly responsible for at least 200,000 of all new cancer cases annually in high-income countries, and this figure is set to rise further in the coming years [23].

In the UK, the social annual cost of obesity in 2020 was around £58 billion, equivalent to around 3% of the GDP. The estimated annual cost of the National Health Service (NHS) on obesity-related diseases was £6.5 billion. This is equivalent to around 40% of the total budget allocated to police forces in England and Wales for 2021/2022. During the COVID-19 pandemic, the estimated annual cost of obesity-related risks of COVID-19 was £4 billion, almost 50% more than the amount the UK spent for securing 267 million doses of vaccines over 2020 and 2021 [24].

In Europe, the regional World Health Organization (WHO) in March 2022 stated that obesity rates have reached “epidemic proportions across Europe and are still rising”. Recent data show that nearly two-thirds of adults (59%) and almost one in three children (29% of boys and 27% of girls) are either overweight or obese [25]. Being chronically overweight and obese are among the leading causes of

**Table 3**

Estimated prevalence and number of adults living with obesity of BMI ≥ 30kg/m2 in 2010–2030 (Courtesy of the World Obesity Federation 2022).

Adult obesity prevalence	2010	2010	2025	2025	2030	2030
	% Adults	Number of adults	% Adults	Number of Adults	% Adults	Number of Adults
Obesity (class I, II & III) BMI ≥ 30kg/m2	11.4%	511 m	16.1%	892 m	17.5%	1,025 m
of which severe obesity (class II and III) BMI = >35 k/m2	3.2%	143 m	5.1%	284 m	5.7%	333 m
and of these severe obesity (Class III BMI ≥ 40kg/m2)	0.9%	42 m	1.7%	93 m	1.9%	111 m

**Table 4**

Estimated number of adults (men and women) with BMI ≥ 30 kg.m2 in the top 20 countries globally.

Women-country	Women- numbers	Women-prevalence (%)	Men country	Men numbers	Men prevalence (%)
Global	586 m	20	Global	434 m	15
USA	64 m	47	USA	61 m	47
China	60 m	10	China	55 m	10
India	40 m	8	India	24 m	4
Brazil	29 m	33	Brazil	21 m	26
Mexico	21 m	41	Mexico	15 m	32
Egypt	18 m	52	Russian Federation	12 m	24
Russian Federation	18 m	30	Egypt	11 m	31
Turkey	16 m	50	Turkey	11 m	34
Indonesia	14 m	14	Germany	10 m	32
Iran	14 m	42	United Kingdom	10 m	37
Pakistan	13 m	17	Iran	9 m	28
Nigeria	13 m	20	Indonesia	8 m	8
South Africa	11 m	50	Pakistan	7 m	9
United Kingdom	10 m	37	France	7 m	29
Germany	9 m	25	Saudi Arabia	7 m	41
Algeria	7 m	46	Italy	6	26
France	7 m	26	Canada	6 m	39
Colombia	7 m	34	Spain	6 m	32
Argentina	6 m	36	Argentina	6 m	25
Iraq	6 m	45	South Africa	5 m	23

death and disability in Europe. Estimates suggest they cause more than 1.2 million deaths annually, which corresponds to more than 13% of total mortality in the region [25].

In the United States, the total health care costs that are because of overweight and obesity have been predicted to double each decade and reach as much as \$956 billion by 2030, representing 18% of total health expenditure [26]. In the European Union, an overview of obesity trends of member states before 2004 estimated the direct and indirect costs of obesity to be nearly €33 billion [27]. A meta-analysis in Canada found that the total health care cost of obesity (including physician, hospitalization, and medication costs) by 2004 estimates was \$4.3 billion yearly, with obesity representing 2.2% of total health care costs and an additional 2.5% of health care costs attributed to physical inactivity [28]. These amounts had more than doubled that in the previous decade, rising to \$8.8 billion in 2021 [29].

**Why the high rates of global obesity and overweight?**

In most cases, obesity and overweight are caused by an energy imbalance between calories consumed and calories expended. Factors accountable for this imbalance include:

- 1 Nutrient availability
- 2 Genetics
- 3 An enhancing environment

**Table 5**  
Globally estimated number of adults (men and women) with BMI  $\geq$  30kg/m<sup>2</sup> - Top 20 countries.

Women Country	Women - Prevalence	Women - Number	Men Country	Men - Prevalence	Men - Number
American Samoa	69	17	Nauru	67	3.3
Cook Islands	69	3.4	Cook Islands	66	3.3
Nauru	68	3.4	American Samoa	66	16
Palau	68	3.5	Palau	65	3.2
Tuvalu	67	3.4	Tuvalu	61	3.1
Niue	66	0.3	Marshall Islands	60	3.0
Marshall Islands	65	3.3	Niue	58	0.3
Samoa	65	39	French Polynesia	58	63
Tonga	65	22	Tokelau	54	2.74
French Polynesia	63	69	Kiribati	54	20
Tokelau	63	3.2	Tonga	54	17
Micronesia (Federated states of)	62	24	Micronesia (Federated states of)	52	20
Kiribati	61	25	Samoa	52	33
Kuwait	52	706	United Arab Emirates	47	61,100
Jordan	52	1730	Qatar	43	906
Egypt	52	18,425	Kuwait	42	960
Saudi Arabia	51	5790	Saudi Arabia	41	6840
Qatar	51	314	New Zealand	40	756
United Arab Emirates	50	1209	Australia	39	4080
Turkey	50	16,346	Canada	39	6265

4 Insulin and leptin resistance  
5 Medical disorders

*Nutrient availability*

In most cases, weight gain occurs when caloric intake exceeds expenditure through relative inactivity. This imbalance is the greatest contributor to weight gain. The readily available processed tasty foods engineered to be tasty by including refined ingredients mixed with additives allow these to last long on the shelf, taste so incredibly good that they are hard to resist, and are sold cheaply to increase consumption. The intake of diets with added sugar increases weight through the impact of these on hormones and altered biochemistry that leads to weight gain. These added sugars are 50% glucose and 50% fructose, and when combined with fructose, these result in insulin resistance with elevated insulin levels, contributing to increased energy storage and, ultimately, overweight and obesity [30,31].

Compounding the availability of unhealthy foods is the explosion of uncontrolled/unverified information; consumers are continuously being misinformed about health and nutrition. Many websites/news outlets (often with hidden agendas) may contain inaccurate or even incorrect information about health and nutrition, and some oversimplify or misinterpret the results of scientific studies, occasionally taking the results out of context. The unsuspecting consumer buys into this and is encouraged to eat unhealthily [32].

**Genetics**

Obesity is a complex, heritable trait influenced by the interplay of genetic, epigenetic, and meta-genomic perturbations and the environment. Genetic causes can be broadly classified into (a) monogenic obesity: those caused by a single gene mutation, primarily located in the leptin-melanocortin pathway, (b) syndromic obesity, such as Bardet-Biedel syndrome and Prader-Willi syndrome, and (c) polygenic obesity: caused by the cumulative contribution of a large number of genes whose effect is amplified in a ‘weight gain promoting’ environment [33]. Although these interactions determine individual susceptibility to obesity, environmental and dietary factors or gut microbiota can influence the epigenetic programming, leading to the development of obesity and obesity-related comorbidities.

Epigenetic modifications include DNA methylation, histone modifications, and microRNA-mediated regulation [34,35].

### **An enhancing environment**

Included in this category are provisions or lack of that influence the ability of individuals to maintain a healthy weight. These include the lack of facilities for exercise (e.g. area parks, sidewalks, and affordable gyms), thus making it hard for people to be physically active.

The increasing prevalence of stress, emotional distress, and poor sleep have been linked with obesity and overweight. Studies have shown that the less people sleep, the angrier they get, or the more stressed they are, the more likely they are to be overweight or obese. This is partly because hormones that are released during these emotional disruptions help control appetite and the body's use of energy [36].

### **Insulin and leptin resistance**

Insulin and leptin are important hormones that regulate energy storage. Resistance to both has been implicated in the genesis of obesity. Most highly refined carbohydrates promote insulin resistance in many overweight and obese individuals. This elevates insulin levels, causing energy to get stored in fat cells instead of being available for use. Although insulin's role in obesity is controversial, several studies suggest that high insulin levels have a causal role in the development of obesity [37]. Leptin is produced by fat cells and blood levels increase with higher fat mass; hence, levels are especially high in people with obesity. High leptin levels in healthy people are linked to reduced appetite. In obese individuals, there is leptin resistance, which contributes to the pathogenesis of obesity [38].

### **Medical disorders and medications**

Endocrine disorders, such as hypothyroidism, Cushing syndrome, and polycystic ovary syndrome, are associated with overweight and obesity. The abnormal hormonal milieu associated with these disorders either precipitate fat accumulation or the consequences, as is the case with hypothyroidism, where there is a reduced metabolic rate and energy utilization.

Although diet is a critical factor in the development of overweight and obesity, many pharmaceutical drugs (e.g. antidepressants, corticosteroids, antipsychotics, seizure medications) are associated with weight gain as a side effect. Most of these function by reducing the metabolic rate and increasing appetite [39].

### **Combating the obesity epidemic**

Overweight and obesity, in most cases, are noncommunicable conditions. Enabling factors, such as supportive environments and communities, are fundamental to influencing individual choices by making them opt for healthier diets and regular physical activity: the easiest choice, which is most accessible, available, and affordable and therefore prevent overweight and obesity. This can be addressed at three levels: individual, national, and global/international [40].

At the individual level, this involves:

- limiting energy intake from total fats and sugars;
- increasing consumption of fruit and vegetables, as well as legumes, whole grains, and nuts; and
- engaging in regular physical activity (60 min per day for children and 150 min spread throughout the week for adults).

At the national level this involves:



- sustained implementation of evidence-based and population-driven policies that make regular physical activity and healthier dietary choices available, affordable, and easily accessible to everyone, particularly to the poorest individuals;
- increasing taxes on sugar-sweetened beverages and high-fat foods;
- ensuring that there are regulatory mechanisms that govern the food industries production and promotion through advertisements of healthy diets by, for example:
- reducing the fat, sugar, and salt content of processed foods;
- ensuring that healthy and nutritious choices are available and affordable for all consumers;
- restricting marketing of foods high in sugars, salt, and fats, especially those foods aimed at children and teenagers; and
- ensuring the availability of healthy food choices and supporting regular physical activity practice in the workplace;
- Imposing penalties, including taxes on industry where these are not adhered to;
- Inculcating an education program in schools, starting very early through to university, on the benefits of a healthy diet and exercise and co-opting these in pre-pregnancy counseling.

At the international level, policies by bodies, such as the WHO and the UNO, must drive initiatives that will cascade down to nations and individuals. For example:

- In 2004 and in 2011, the World Health Assembly in a declaration on noncommunicable diseases (NCDs) titled “WHO Global Strategy on Diet, Physical Activity and Health”, prescribed the actions needed to support healthy diets and regular physical activity. It called on all nations to act at the global, regional, and local levels to improve diets and physical activity patterns.
- In its latest policy recommendations, the WOF/WHO advocates for implementing fiscal interventions, such as greater taxation of sugar-sweetened beverages or subsidies for healthier foods, restricting the marketing of unhealthy foods to children, and improving access to obesity and overweight management services in primary health care. Efforts to improve diet and physical activity across the life course are also suggested, including preconception and pregnancy care, promotion of breastfeeding, and school-based interventions, as well as creating environments that improve access to healthy food and physical activity. Although there are no sustainable development goals (SDGs) targeting obesity and overweight, SDG 2 and 3 have implied in them the need to address these. NCDs and obesity are no longer a challenge only for high-income regions; most of the world’s population now live in countries where overweight/obesity is responsible for more deaths than underweight. Furthermore, although NCDs are the focus of an SDG target, obesity is not explicitly alluded to, making it even less likely to be the recipient of development assistance. Implied cover is in SDG3: Ensure healthy lives and promote well-being for all ages. Obesity is both an NCD in its own right and a fundamental driver of many others (e.g. type 2 diabetes). This SDG recommends a reduction by one-third by 2030 of premature mortality from NCDs through prevention and treatment and promoting mental health and well-being. SDG 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture. Under this SDG is the recommendation to work toward ending all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children younger than 5 years and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons. SDG 12: Ensure sustainable consumption and production patterns.
- The WHO’s “Global action plan on physical activity 2018–2030: more active people for a healthier world” provides effective and feasible policy actions to increase physical activity worldwide. The WHO published ACTIVE as a technical package to assist countries in planning and delivery of their response to this 2018–2020 initiative. New WHO guidelines on physical activity, sedentary behavior, and sleep in children younger 5 years were also launched in 2019.
- The report of the World Health Assembly’s Commission on Ending Childhood Obesity (2016) and its six recommendations to address the obesogenic environment and critical periods in the life course to tackle childhood obesity. The implementation plan to guide countries in taking action to

implement the recommendations of the commission was welcomed by the World Health Assembly in 2017.

### **Reproductive consequences of obesity and overweight**

Women of reproductive age have higher rates of overweight and obesity and are more adversely affected by obesity-related complications than men. The worldwide increase in overweight and obesity is greatest in women in the reproductive age group. Obesity has adverse consequences on reproduction, which can be grouped into gynecological and obstetric effects.

Gynecological problems include menstrual dysfunction (precocity, amenorrhea, heavy and or irregular periods), ovulatory dysfunction (anovulation is more common), decreased natural fertility and fecundity rates, lower infertility treatment success rates, infertility treatment safety, and cancers, especially endometrial and ovarian. In addition, those who are morbidly obese (class III obesity) are a challenge regarding not only providing safe and optimal care but also imaging. The cumulative live birth rate from studies falls with increasing obesity [41]. In addition, investigating and managing obesity, especially those morbidly obese women with infertility, is challenging. For example, maintaining the airway during egg retrieval could be a challenge while performing an ultrasound scan (transabdominal or transvaginal), magnetic resonance imaging, pelvic examinations, and cervical cytology could be problematic and therefore fraught with inaccuracies.

In obstetrics, maternal obesity increases the risk of numerous complications during pregnancy (miscarriages, hypertensive disorders, diabetes, fetal macrosomia, difficulties imaging the fetus), labor and birth (prolonged or dysfunctional labor, increased operative deliveries, postpartum hemorrhage), and the puerperium (puerperal genital and wound infections, low breastfeeding rates, depression, deep venous thrombosis, and pulmonary embolism) and for the baby (neural tube defects, macrosomia, low APGAR scores, polycythemia, shoulder dystocia and associated trauma/injuries, and other complications related to the medical complications of pregnancy) [42].

### **Summary**

The global epidemic of overweight and obesity poses a significant public health and clinical challenge. It is a complex medical, epidemiological, social, and political issue with implications for reproduction (both gynecological and obstetrics). Stigmatization of obese women in many high-income countries, where thinness is currently portrayed as the ideal, though clearly not the norm, adds further complication and creates needless barriers to engaging in care. Little is acknowledged about the challenges of losing weight for those who are obese, even when they are motivated. Several factors are responsible for this epidemic, among which are food addiction, a changing and enabling environment (more sedentary), and a combination of genetic and epigenetic factors.

A cohesive and compressive approach, which includes the individual, nations, and international bodies, such as the UNO and WHO, is required to drive down the rising rate of overweight and obesity. Although individual structured weight loss programs show impressive results in the short term, long-term maintenance of a lower weight is much more difficult to achieve [43]. Developing health policies to effect change has thus far been limited by the complexity of the factors involved and ultimately by the poor quality of data on a global level regarding effective interventions, as well as the sheer cost because of the number of individuals affected [41,44]. Due to the diverse geographic and ethnic populations affected by obesity, targeted interventions for these different settings are critical, with an emphasis on indigenous and lower socioeconomic status individuals in both high-, middle-, and low-income countries. Earlier interventions and sustained approaches that are population-based and supportive are required. The WHO has introduced a population-based childhood obesity prevention strategy that requires policies and interventions at the government level, population-wide policies, and initiatives, as well as community-based interventions [45]. This illustrates the complexity of addressing the obesity epidemic. There are also other interesting approaches, including workplace obesity prevention programs, such as the one developed by the Centers for Disease Control [46]. It is unclear how effective or sustainable such programs may be. From a clinical obstetrical perspective, adjustments need to be made to provide high levels of care for women with overweight and obesity

who are at risk for several complications in pregnancy, including universal screening for disorders, such as diabetes mellitus [47]. Care providers should avoid judgmental attitudes and be encouraged to see pregnancy in women with overweight and obesity as an opportunity for engaging in lifestyle and dietary changes that will benefit both the women and their children in the long term, at a time when they may have additional motivation. The growing epidemic in LMICs that is now being recognized will require significant resources and political will to implement changes to health care delivery and health interventions to address overweight and obesity at early stages and prevent childhood obesity.

Appreciation of the role of culture is lacking in suggested interventions to date, including cultures where overweight and obesity are identified as positive attributes, especially for women. More research is needed into epigenetic factors and how they can be influenced, as well as the role of food addiction. Economic drivers of the food industry are serious impediments to progress, especially in global efforts to limit the intake of highly refined sugars.

The global obesity epidemic will require an intersectoral approach because it is more complex than tobacco smoking cessation, from which many lessons can be learned if interventions on a local and global level are to address this significant public health problem and reverse its impact. The World Obesity Federation has called for an end to the misunderstanding, fragmentation, underinvestment in, and stigmatization of obesity, which are the driving systemic failures to combat obesity, and governments around the world must work with the WHO to develop a comprehensive global action plan on obesity [48].

#### Practice Points

- Obesity rates are rising worldwide, with the greatest increase in low and middle-income countries.
- It has a complex multifactorial etiology involving interactions between genetic, epigenetic, and environmental factors.
- Women who are obese or overweight are at an increased risk of various reproductive complications that cover the pubertal, reproductive, and post-reproductive ages.
- Due to societal stigma, women who are overweight and obese may experience significant barriers to reproductive health.
- Effective approach to reducing the burden of obesity must focus at the individual, national, and international levels.

#### Research Agenda

- Accurate surveillance of obesity worldwide.
- The role of food addiction in obesity.
- Effective intervention programs locally and globally.
- *In utero* programming for later development of obesity.
- Role of genetics, metagenomics, and the epigenetics on the prevalence of obesity.
- Pharmacologic interventions to reduce the rate of obesity.

**Answer to question 1:**

Overweight and obesity contribute significantly to noncommunicable diseases (NCDs) such as cardiovascular disease, hypertension, stroke, type 2 diabetes, cancer, and mental health disorders. An estimated 10% of 13 different types of cancers (Uterus, breast, colon and rectum, esophagus, gallbladder, stomach, kidneys, liver, pancreas, meningioma, multiple myeloma, ovaries, and thyroid) correlated with obesity.

**Answer to question 2:**

Gynecological problems of obesity and overweight include menstrual dysfunction (precocity, amenorrhea, heavy and or irregular periods), miscarriages and cancers while those of obstetrics include hypertensive disorders, diabetes, fetal macrosomia, difficulties imaging the fetus), labor and birth (prolonged or dysfunctional labor, increased operative deliveries, postpartum hemorrhage) and the puerperium (puerperal genital and wound infections, low breastfeeding rates, depression, deep venous thrombosis, and pulmonary embolism) and for the baby (neural tube defects, macrosomia, low Apgar scores, polycythemia, shoulder dystocia and associated trauma/injuries and other.

**Declaration of Competing Interest**

The authors do not have any conflict of interests to declare.

**References**

- [1] WHO News. <https://www.who.int/news-room/facts-in-pictures/detail/6-facts-on-obesity>; 2021.
- [2] McKinsey Global Institute. <https://www.a-mansia.com/obesity-and-diabetes-in-the-world/>; 2014.
- [3] One billion people globally estimated to be living with obesity by 2030. Call for global action in obesity at World Health Assembly May 2022. <https://www.worldobesityday.org/resources/entry/world-obesity-atlas-2022>. Accessed 20th anuary 2023
- [4] World Obesity. World Obesity Atlas 2022. March 2022. [https://www.worldobesityday.org/assets/downloads/World\\_Obesity\\_Atlas\\_2022\\_WEB.pdf](https://www.worldobesityday.org/assets/downloads/World_Obesity_Atlas_2022_WEB.pdf). Accessed 20th January 2023.
- [5] National Academies of Sciences, Engineering, and Medicine, Helath and Medicine Division, Food and Nutrition Board, Roundtable on Obesity Solutions. editor. In: Callahan EA, editor. Current status and response to the global obesity pandemic: Proceedings of a Workshop. Washington (DC): National Academy Press (US); 2019. June 25.2, Global Trends in Obesity. <https://www.ncbi.nlm.nih.gov/books/NBK544130/>.
- [6] World Health Organization. Controlling the global obesity epidemic. <https://www.who.int/activities/controlling-the-global-obesity-epidemic>. Accessed 19th January 2023
- [7] Freedman Ds< Katzmarzyk PT, Dietz WH, Srinivasan SR, Berenson GS. Relation of body mass index and skinfold thickness to cardiovascular disease risk factors in children: the Bogalusa Heart Study. *Am J Clin Nutr* 2009 Jul;90(1):210–6. <https://doi.org/10.3945/ajcn.2009.27525>. Published online 2009 May 6.
- [8] Waist circumference and waist-hip ratio. Report of a WHO expert consultation Geneva. December 2008. p. 8–11. <https://www.who.int/publications/i/item/9789241501491>.
- [9] Thomas EL, Frost G, Taylor-Robinson SD, Bell JD> Excess body fat in obese and normal-weight subjects. *Nutr Res Rev* June 2012;25(1):150–61. <https://doi.org/10.1017/S0954422412000054>.
- [10] World Health Organization - Europe. A health lifestyle - WHO recommendations. 6th May 2010. <https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle--who-recommendations>. Accessed 10 January 2023.
- [11] WHO. Expert consultation Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies January 10. [https://doi.org/10.1016/S0140-6736\(03\)2004.15268-3](https://doi.org/10.1016/S0140-6736(03)2004.15268-3).
- [12] <https://data.worldobesity.org/maps/?action=pdf&area=trends&group=F&year=2020>. [Accessed 25 October 2022].
- [13] <https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/ncd-mortality>. 20/06/2022.
- [14] <https://news.un.org/en/story/2022/05/1117402>.
- [15] NHLBI Obesity Education Initiative Expert Panel on Identification, Evaluation, and Treatment of Obesity in Adults in Adults (US). Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults: The Evidence Report. Executive summary. Bethesda (MD): National Institute of Health. Heart, Lung and Blood Institute; Sep 1998. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK2003/>.
- [16] Executive summary of the clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *Arch Intern Med* 1998;158(17):1855–67 [PubMed] [Google Scholar].
- [17] US Department of health and human services. Overweight and Obesity: a major public health issue. *Prevention Report*. 2001. p. 16.
- [18] <https://www.wvdhhr.org/bph/oehp/obesity/mortality.htm>. [Accessed 20 June 2022].
- [19] Abegunde D, Mathers C, Adam T, Ortegon M, Strong K. The burden and cost of chronic diseases in low-income and middle-income countries. *Lancet* 2007;370:1929e38.

- [20] WHO. Global health risks. Mortality and burden of disease attributable to selected major risks. Geneva: World Health Organization; 2009.
- [21] Haslam D, James W. Obesity. *Lancet* 2005;366:1197e209.
- [22] <https://www.cdc.gov/cancer/obesity/index.htm>.
- [23] United Nations health agency warns of obesity 'epidemic' in Europe. 12; May 04 2022. p. 37 [AM].
- [24] Estimating cost of obesity. A Report by Novo Nordisk; Frontier-Economics/Public. January 26 2022. <https://frontier-economics.com/media/5094/the-full-cost-of-obesity-in-the-uk.pdf>.
- [25] <https://www.who.int/europe/home?v=welcome>. [Accessed 22 June 2022].
- [26] Wang Y, Beydoun M, Liang L, Caballero B, Kumanyika S. Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. *Obesity* 2008;16(10):2323e30.
- [27] Fry J, Finley W. The prevalence and costs of obesity in the EU. *Proc Nutr Soc* 2005;64(3):359e62.
- [28] Katzmarzyk P, Janssen I. The economic costs associated with physical inactivity and obesity in Canada: an update. *Can J Appl Physiol* 2004;29(1):90e115.
- [29] <https://www.smartshape.ca/the-cost-of-obesity-to-canadas-healthcare-system-and-to-you/>. [Accessed 24 October 2022].
- [30] Wiechert M, Holzapfel C. Nutrition concepts for the treatment of obesity in adults. *Nutrients* 2022 Jan;14(1):169. <https://doi.org/10.3390/nu14010169>. Published online 2021 Dec 30.
- [31] Pedram P, Wadden D, Amini P, et al. Food addiction: its prevalence and sign!cant association with obesity in the general population. *PLoS One* 2013;8(9):e74832.
- [32] NIH Eunice Kennedy Shriver National Institute of Child Health and Human Development. Healthy Pregnancies, Healthy Children and optimal lives. What causes obesity and overweight. <https://www.nichd.nih.gov/health/topics/obesity/conditioninfo/cause>. Accessed 10 January 2023
- [33] Thaker VV. Genetic and epigenetic causes of obesity. *Adolesc Med State Art Rev* 2017;28(2):379–405.
- [34] Jaenisch R, Bird A. Epigenetic regulation of gene expression : how the genome integrates intrinsic and environmental signals. *Nat Genet* 2003;33(Suppl March):245–54 [PubMed] [Google Scholar].
- [35] Lopomo A, Burgio E, Migliore L. Epigenetics of obesity. *Prog Mol Biol Transl Sci* 2016;140:151–84 [PubMed] [Google Scholar].
- [36] Wakefield J. Fighting obesity through the built environment. *Environ Health Perspect* 2004 Aug;112(11):A616–8. <https://doi.org/10.1289/ehp.112-a616>.
- [37] Kahn SE, Hull RL, Utzschneider KM. Mechanisms linking obesity to insulin resistance and type 2 diabetes. *Nature* 2006;444:840–6.
- [38] Obradovic M, Sudar-Milovanovic E, Soskic S, Essack M, Arya S, Stewart A, et al. Leptic and obesity: rile and clinical implications. *Front Endocrinol* 2021. <https://doi.org/10.3389/fendo.2021.585887>. 18th May.
- [39] Center for Diseases Control and Prevention (CDC). Overweight and Obesity: Causes of Obesity. <https://www.cdc.gov/obesity/basics/causes.html>. Accessed 20th January 2023
- [40] Obesity Prevention Strategies. Turning Around the Epidemic (<https://www.hsph.harvard.edu/obesity-prevention-source/obesity-prevention/>). Accessed 23rd January 2023
- [41] Obesity and reproduction: an educational bulletin" last published in 2015. *Fertil Steril* 2015;104:1116–26 (*Fertil Steril* 2021;116:1266–85. 12021 by American Society for Reproductive Medicine.).
- [42] Denison FC, Aedia NR, Keag O, Hor K, Reynolds RM, Milne A, et al. On behalf of the royal college of obstetricians and gynaecologists. Care of Women with Obesity in Pregnancy. green-top guideline. 2018. No. 72. BJOG.
- [43] Anderson J, Konz E, Frederich R, Wood CL. Long-term weight-loss maintenance: a meta-analysis of US studies. *Am J Clin Nutr* 2001;74:579e84.
- \*[44] Canoy D, Buchan I. Challenges in obesity epidemiology. *Obes Rev* 2007;8. Suppl. 1):1e11.
- \*[45] Sacks G, Swinburn B, Xuereb G. Population-based approaches to childhood obesity prevention. Geneva: WHO; 2012.
- [46] DC.CDC'SLEANworks!. In: A workplace obesity prevention program. Centers for Disease Control and Prevention. <http://www.cdc.gov/leanworks/>; 2011.
- [47] Kapur A, Mahmood T, Hod M. The unmet need for universal testing for hyperglycaemia in pregnancy and the FIGO guideline. *BJOG. Int J Obstet Gynaecol* 2017;125:529–31. <https://doi.org/10.1111/1471-0528.14659> PMID. 28371344.
- [48] <https://www.worldobesity.org/news/one-billion-people-globally-estimated-to-be-living-with-obesity-by-2030>.