

Obesity pandemic: causes, consequences, and solutions—but do we have the will?

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Obesity has become pandemic owing to an obesogenic environment (inexpensive calorie dense food, technologies and structure of communities that reduce or replace physical activity, and inexpensive nonphysical entertainment) and excessive emphasis on low fat intake resulting in excessive intake of simple carbohydrates and sugar. Effects are greater for women owing to their smaller size and extra weight gain with each pregnancy, with 38% of American adult women being obese. Women are responsible for more than three-fourths of the more than 400 billion dollars of excess direct health care expenditures due to obesity. They are less likely to conceive naturally and with fertility treatments, more likely to miscarry, and have more prematurity and other complications with their pregnancies. We describe the many causes, including key roles that a dysbiotic intestinal microbiome plays in metabolic derangements accompanying obesity, increased calorie absorption, and increased appetite and fat storage. Genetic causes are contributory if these other factors are present but have limited effect in isolation. The numerous health consequences of obesity are discussed. The authors itemize ways that an individual and societies can mitigate the pandemic. However, individual will power, the will of society to enact change, and willingness of the public to accept outside intervention frustrate efforts to stabilize or reverse this crisis. The most promising strategies are education and efforts by individuals to make responsible choices several times every day to protect, most effectively by prevention, their most valuable asset. (Fertil Steril® 2017;107:833–9. ©2017 by American Society for Reproductive Medicine.)

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EPIDEMIOLOGY OF OBESITY AND THE SCOPE OF THE PROBLEM

The American Medical Association voted in 2013 to recognize obesity as a disease (against the advice of its Public Health and Science Committee). The AMA defended its action as a way to confer legitimacy to the condition, allowing for greater attention and better treatment. It also facilitates insurance coverage. Whether it is a condition that leads to disease or a disease itself, there is a strong worldwide consensus that obesity is pandemic and needs to be treated and

more importantly prevented (especially in children) owing to its significant comorbidities, mortality, and costs.

Although there are several more accurate methods to measure the amount and location of fat tissue in the body, the body mass index (BMI) is most commonly used because of its simplicity. BMI is calculated by dividing body weight in kilograms by height in meters squared. A BMI of ≥ 30 kg/m² is considered to be obese (grade 1), with severe and morbid obesity defined as BMIs of 35 to <40 kg/m² (grade 2) and ≥ 40 kg/m² (grade 3), respectively. A well recognized problem with the use of BMI to

define and detect obesity is its inability to differentiate dangerous adiposity (such as waist-line intra-abdominal fat) from potentially less harmful fat in other areas of the body or healthy “nonfat” body mass such as muscle. Recently, the concept of normal-weight obesity has been proposed (1) to allow for the identification of “at risk” individuals who do not meet the standard criteria according to BMI but have comorbidities associated with excess dangerous fat resulting in metabolic dysregulation (metabolic syndrome) and other sequelae. The World Health Organization defines obesity as excessive body fat accumulation that is associated with clear risks to health.

Obesity is considered to be largely preventable and mostly caused by recent changes in the so-called obesogenic environment (2) such as the highly processed and sugar-laden food supply (more calories in) and

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automated technologies that reduce or replace physical activity (fewer calories expended). Genes and gene expression have been implicated as significant cofactors (3, 4).

The prevalence of obesity is increasing worldwide. The estimated U.S. prevalence in 2013 was 90 million obese in a population of 315 million (28.6%). In that year, 78 million were adults and 12 million were children. The U.S. incidence during the past two decades has been higher in women (38.3%) than in men (34.3%; HCHS Data Brief no. 219, November 2015), in part because of their smaller size (relative to meal portions) and excess weight gain with each pregnancy. Prevalence in the U.S. varies markedly by locale and is higher in black and Hispanic adults (www.cdc.gov/obesity/data/prevalence-maps.html). The prevalence of obesity varies widely among nations as well (www.worldobesity.org/resources/world-map-obesity). It has been projected (based on current incidence figures) that by 2030 nearly 40% of the world's population will be overweight and one in five people will be obese (5).

Recently there has been a leveling off of the incidence of obesity in children (6), owing in part to modifications of school lunch programs (including more nutritious foods and less sugary drinks) and increased physical activity. Unfortunately progress during the school season is lost during vacation time (6), showing that these healthful school measures are effective but must be sustained throughout the year. Persistent childhood obesity leads to an ever-increasing prevalence in adults, making efforts to reduce childhood obesity all the more urgent.

Much is known about individual risk factors for obesity, but little about how they may be interrelated (7). Knowing more about the confluence of the risk factors may hold the key for the development of better treatments and prevention. Industrialization of food production, providing inexpensive and highly processed food, is a major environmental cause. Culture and socialization also play a role. In the past (and even today in some cultures), fatness was seen as a sign of wealth and “well-being.” In more recent times the poor are at greater risk of being obese, with risk being inversely related to wealth and education (8). Social interaction seems to play a role with evidence of “contagion” as a result of direct human contact on social networks (9). When so many are overweight, one's perceptions of what is normal are altered. Even dress sizes are different: What used to be size 8 in the 1960s through 1980s are today listed as 00–2. A recent national poll in the U.S. found that although seven in ten Americans are overweight or obese, only 36% think they have a weight problem. Advertising of calorie-dense foods directly to children is a >10 billion dollars per year effort by industry to influence family diets and future consumers (10).

The role of genetics is much less than that of the environment. Rather than playing an independent role, genes seem to increase the risk of weight gain based on the way they interact with other risk factors, such as unhealthy diets and inactive lifestyles (11, 12). Bray et al. recently described the relationship between genes and the environment by stating, “genes load the gun—the environment pulls the trigger” (13). Tyrrell et al. (14) recently analyzed data from 120,000 adults in a large national data base using BMI as the outcome and

genetics (a 69-variant genetic risk score for obesity) and self-reported estimates of nine behavioral measures, such as TV watching, Western diet, and physical inactivity, as exposures. More TV watching and less physical activity were strongly associated with a higher BMI. They reported a significant gene-environment interaction with self-reported TV watching ($P=.00007$) and physical activity (P value for interaction .000005). The interaction between genes and the environment persisted with the use of a composite measure of the obesogenic environment (P value for interaction .0002). The role that genes play in obesity has always been considered to be the only nonmodifiable risk factor. However, with increasing knowledge about the role of the epigenome, gene expression may be modifiable based on environmental factors during life and even before birth (15).

In the United States the additional annual direct cost of health care per adult obese male was calculated to be \$1,152.00 and the additional annual cost per obese adult female was \$3,613.00, more than threefold that of obese males. Very recently, the additional total direct cost in national health care spending was calculated to be \$427 billion annually or >10% of total health care expenditures in 2014 (16). Employers are also burdened with extra costs. A company's annual health care cost and lost productivity (in 2012 values) in the highest versus lowest BMI groups was reported to be \$6,313 versus \$4,258, and days absent were 7.5 versus 4.5 days, respectively. Work place productivity was reported to be lowest in the obese group (17). The well documented prejudice of employers is understandable, resulting in lost income for the obese individual. A very recent study estimated the overall cost of obesity to the U.S. economy in 2014 to be more than \$1.4 trillion dollars (16).

ENVIRONMENTAL CONTRIBUTORS

The prevalence of obesity was relatively low until the 1980s, when a significant rise began (18). This increase occurred about 8–10 years after significant and widespread changes in the so-called “built environment.” The built urban environment has many physical features that reduce the need for physical activity, such as elevators, escalators and other labor-saving devices, along with passive entertainment such as video games, TV watching, and online news, socialization, and entertainment. Our “built environment” determines whether walking rather than driving is encouraged or discouraged, influencing whether physical activity is preferred or avoided. The built environment also includes the almost constant availability of inexpensive, highly processed, and sugar-laden food (19), which plays a predominant role in the increased prevalence of obesity (20). Before 1900, sugar was a rare treat. The average per-person consumption of sugar in the U.S. increased from 4–6 pounds per year in the early 1800s to 150–170 pounds today. Adding sugar is the least expensive way that the food industry can make everything tastier to increase sales. Environmental and behavioral factors act alone and in combination to create what has been referred to as the “obesogenic environment” of modern times.

In countries having the most obesity (U.S., Mexico, and increasingly parts of Europe and the Middle East),

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