Overnutrition During Pregnancy
And Its Link to Childhood Obesity

The purpose of this fact sheet is to discuss the mechanisms by which overnutrition during pregnancy, defined as a high fat diet, high-calorie diet, or both, predisposes children to obesity and to offer recommendations for physicians and public health professionals to reduce in utero exposure to maternal overnutrition and the intergenerational cycle of obesity.

Problem Definition and Epidemiology

In the United States, childhood obesity has reached epidemic proportions: in the past three decades alone, the prevalence of childhood obesity has more than doubled in children ages 6-11 and more than tripled in adolescents ages 12-19, reaching 18% and 21%, respectively. Childhood obesity is a threat to the future health of Americans, resulting in long-term and severe health consequences: in one study, 60% of obese children had at least one cardiovascular disease risk factor.1 But childhood obesity is also putting a large dent in America’s healthcare costs: childhood obesity alone accounts for $14.1 billion in direct costs.2

Obesity, defined simply as having excess body fat,3 results from a relative excess of energy intake in relation to energy expenditure. Alterations to either side of this equation—from environmental factors, behavioral choices, a genetic predisposition, and other factors—can result in maternal overnutrition and, in time, overweight and obesity.4,5

Initially, in utero exposure to undernutrition and its link to a predisposition to obesity was the focus of research, but today’s environment favors overnutrition, which may also play a role in the development of obesity through both epigenetic and hormonal/metabolic pathways.5

Epigenetics refers to changes in gene activity and expression that occur without alteration in DNA sequence and that are heritable. Although the genome remains relatively stable, it may be reversibly modified by exposure to a range of nutritional and environmental factors.5,7
Etiology

There are a number of factors that play a role in the development of obesity, and no single factor can be isolated as the sole or most important cause. But recent research suggests that a mother’s pregnancy diet, and the resulting in utero environment, can affect a child’s predisposition to obesity before he takes his first bite of food. And because over 60% of all pregnancies in the US are to women who are either overweight or obese, targeting overnutrition in pregnant women is paramount.

Recent research has suggested a number of mechanisms by which overnutrition can lead to epigenetic modifications or hormonal/metabolic changes that lead to a predisposition to obesity in children.

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<th>Hormonal/Metabolic</th>
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<td>A maternal high fat diet increases maternal serum leptin levels, exposing offspring to elevated levels of leptin. Leptin acts on the hypothalamus to regulate food intake and energy balance; offspring who are exposed to increased levels of leptin show altered hypothalamic structures that lead to overeating.</td>
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<td>Exposure to a maternal high fat diet leads to epigenetic changes in DNA. Methylation of certain genes modulates these changes. The X receptor-alpha gene, which acts on sugar and fat metabolism, is one such gene that has been shown in research to link maternal diet and her offspring’s risk for obesity. Other genes that may be affected include insulin receptor substrate 1 and PPARγ.</td>
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Overnutrition during pregnancy alters the fetal hormonal and metabolic environment, affecting glycemic control, inflammation, insulin resistance, metabolic syndrome, and glucose tolerance, leading to a “hyperphagic/overeating phenotype.”

A maternal high fat diet suppresses the expression of metabolic (PPARα and SIRT1) and circadian (CLOCK, BMAL1, REV-ERBα, CRY, PER) genes that engender programming of obesity in offspring.

Other research has found that maternal overnutrition may predispose offspring to obesity in other ways:

- Offspring born to mothers fed a high fat diet show reduced muscle mass and muscle function, which affects whole-body energy expenditure.
- Offspring born to mothers who were exposed to a maternal junk food diet show an exacerbated taste for

Obesity, Long-Term Health Problems, and the Increasing Strains on Health Care

Obese and overweight children face many of the same negative health consequences as adults, including hypertension, cardiovascular disease, diabetes, asthma, poor self-esteem, and certain types of cancers. Preventing or limiting the upward trajectory of childhood obesity would have a profound impact on the overall health of the nation. If each state could reduce the average BMI of its residents by just 5% --for a 5’6”, 190-pound woman, that’s a loss of just 10 pounds--millions could be spared from disease. According to Trust for America’s Health, the related savings would amount to billions of dollars every year.
Risk Factors

There are three main risk factors that affect an infant’s epigenetic predisposition to obesity: a pre-existing high pre-pregnancy BMI; high maternal weight gain; and an obesogenic diet. Because high maternal weight gain and an obesogenic diet can affect any mother, it is important for interventions and prevention strategies to target all maternal populations.

Research has identified other factors that may increase an infant’s predisposition to obesity:
- Easy availability and access to junk foods
- Sleep deprivation
- Night-shift work and timing of eating

Primary Interventions

**Individual**

Interventions that target a mother’s diet and exercise habits, as well as weight loss surgery, have been shown to reduce weight in obese women. Several interventions, which focused on gastric bypass surgery as a means to weight loss, have found that the genetic profiles of obese individuals became more similar to lean individuals following surgery, indicating that epigenetic changes that predispose an individual to obesity may be modifiable later in life.

Research has also found that children born to obese women who lost weight prior to pregnancy—even if they did not reach a healthy weight—showed a diminished risk for obesity. Primary interventions to target obesity in women of childbearing age include dietary interventions, exercise interventions, and behavioral interventions; research has shown that, regardless of the type of weight loss intervention, women do show improvements in body weight. According to a systematic review of weight loss interventions, women showed more weight loss success in interventions focusing on diet and behavioral changes (as opposed to exercise), indicating that a woman’s preference should be taken into consideration when deciding on a weight loss strategy.

**Community/Policy**

Community-based intervention programs typically focus on improving access and affordability of healthy foods and improving the access to and opportunities for physical activity and exercise, with the ultimate goal of reducing overall calorie intake and increasing physical activity. Researchers at the CDC identified the following strategies as the most effective in accomplishing these goals:

1. Increasing the availability of healthier food and beverage choices in public service venues
2. Improving the availability of affordable healthier food and beverage choices in public service venues
3. Improving the geographic availability of supermarkets in underserved areas
4. Providing incentives to food retailers to offer healthier food and beverage choices in underserved areas
5. Improving the availability of mechanisms for purchasing foods from farms
6. Providing incentives for the production, distribution, and procurement of foods from local farms
7. Restricting the availability of less healthy foods and beverages in public service venues
8. Instituting smaller portion size options in public service venues
9. Limiting advertisements of less healthy foods and beverages
10. Discouraging the consumption of sugar-sweetened beverages
11. Increasing support for breastfeeding
12. Requiring physical education in schools and increasing the amount of physical activity in PE programs at school
13. Increasing opportunities for extracurricular physical activity
14. Reducing screen time in public service venues
15. Improving access to outdoor recreational facilities
16. Enhancing infrastructure that support bicycling and walking
17. Supporting schools that are within easy walking distance of residential areas
18. Enhancing personal and traffic safety in areas where persons are or could be physically active
19. Participating in community coalitions or partnerships to address obesity
Recommendations for Physicians and Public Health Officials

For physicians and health professionals

- Encourage healthy eating habits before and during pregnancy.
- Adjust mother’s attitude that she is “eating for two.” According to experts, pregnant women need between 2,200 and 2,900 calories a day. In general, a woman in her first trimester doesn’t require any additional calories; a woman in her second trimester requires an additional 340 calories; and a woman in her third trimester should consume an additional 450 calories. These calories should come from nutritious foods, not junk foods.

For public health officials

- Encourage pre-pregnancy counseling during early pregnancy.
- Enforce good prenatal care, including supplementation with folic acid, which has been shown to inhibit DNA methylation.
- Enforce nutrition training programs for nurses in antenatal units.
- Improve face-to-face communication between healthcare providers and the expectant mother.
- Implement continuing education and staff development programs.

Important Issues to be Addressed

More research should be performed to address:

- Whether postnatal interventions in children can modify epigenetic markers that lead to a predisposition to obesity.
- Potential intervention strategies that target over-nourished mothers to attenuate offspring’s predisposition to obesity.
- Whether an individual’s risk of obesity can be predicted in infancy, and, if so, which interventions are most successful in introducing targeted strategies to prevent the development of obesity.

Research Challenges

Most studies that investigate the genetic and hormonal/metabolic effects of maternal overnutrition on offspring are performed on animal models; evidence that links maternal overnutrition and a predisposition to obesity in offspring is limited. Large randomized control trials on humans, however, would be unethical; for example, mothers who consume a high junk food diet show elevated leptin levels in their breastmilk, which increases exposure to leptin in fetuses--but is it ethical to restrict breastfeeding in these women? Future research should focus on longitudinal and prospective studies whereby an offspring’s epigenome and hormonal/metabolic profiles are followed from birth.

Human studies present another problem in that the shared environment between parents and children acts as a confounder; the influence of a parent’s eating habits and activity levels is not easily isolated. In addition, the invasive methodologies used to analyze tissue samples that indicate epigenetic changes are unable to be performed on humans.
References


