The Obesity Epidemic: Challenges, Health Initiatives, and Implications for Gastroenterologists

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Abstract: Obesity is the next major epidemiologic challenge facing today's doctors, with the annual allocation of healthcare resources for the disease and related comorbidities projected to exceed $150 billion in the United States. The incidence of obesity has risen in the United States over the past 30 years; 60% of adults are currently either obese or overweight. Obesity is associated with a higher incidence of a number of diseases, including diabetes, cardiovascular disease, and cancer. Consumption of fast food, trans fatty acids (TFAs), and fructose—combined with increasing portion sizes and decreased physical activity—has been implicated as a potential contributing factor in the obesity crisis. The use of body mass index (BMI) alone is of limited utility for predicting adverse cardiovascular outcomes, but the utility of this measure may be strengthened when combined with waist circumference and other anthropomorphic measurements. Certain public health initiatives have helped to identify and reduce some of the factors contributing to obesity. In New York City and Denmark, for example, such initiatives have succeeded in passing legislation to reduce or remove TFAs from residents' diets. The obesity epidemic will likely change practice for gastroenterologists, as shifts will be seen in the incidence of obesity-related gastrointestinal disorders, disease severity, and the nature of comorbidities. The experience gained with previous epidemiologic problems such as smoking should help involved parties to expand needed health initiatives and increase the likelihood of preventing future generations from suffering the consequences of obesity.

Obesity has been defined as a body mass index (BMI) greater than 30 kg/m^2, with extreme obesity defined as a BMI greater than 40 kg/m^2. Obesity is rapidly becoming the leading cause of preventable death in the United States, with obesity-related deaths projected to soon surpass deaths related to tobacco abuse. The incidence of obesity has doubled in the United States since 1960, with one third of the adult population currently

obese.[1,2] Perhaps more alarming is the increase in overweight children; over the past 25 years, this rate has risen from 6% to 19%.[3,4]

Numerous comorbid conditions have been associated with obesity, including type 2 diabetes, hypertension, hypercholesterolemia, hypertriglyceridemia, and nonalcoholic fatty liver disease. As a result of these comorbidities, the medical costs directly related to obesity are difficult to determine, but a conservative estimate would place the healthcare burden for obesity at approximately $150 billion per year in the United States.[4-6] The increase in mortality among obese individuals is likely related to comorbid conditions, rather than obesity per se; because of their various obesity-associated conditions, obese patients present challenging and complex issues in medical and surgical intensive care units. In the current debate over healthcare reform in the United States, no proposed solution can reasonably ignore or minimize the role that obesity plays with regard to economic and health consequences.

This article will give an overview of the epidemiology of obesity, provide measures of defining obesity, and discuss the impact of public health and environmental factors associated with the marked increase in obesity. Potential health initiatives that might be successful in preventing obesity and its associated consequences in future generations will also be discussed. Finally, this article will address the implications that obesity has for gastroenterologists.

Obesity Epidemiology

In 2001, the US Surgeon General released a report raising concerns about the growing obesity epidemic; this report was the first to note that obesity and obesity-related diseases might soon overtake smoking as the leading cause of preventable death in the United States. The number of overweight (BMI ≥25 kg/m^2) and obese (BMI ≥30 kg/m^2) adults has increased dramatically in recent years.[4,7,8] The rate of adults between the ages of 20 and 74 years who were classified as either obese or overweight has risen from 44.9% in 1960–1962 to 66.2% in 2003–2004, with similar trends for both men and women.[4,7,8] The rate of individuals who were overweight but not obese ranged between 31.5% and 33.4% over the same time period.[4] The major shift in the prevalence of obesity occurred between 1980 and 2004, effectively doubling in just 25 years (from 15.0% in 1980 to 32.9% in 2004). The number of people who were classified as extremely obese (BMI ≥40 kg/m^2) increased from 0.9% in 1960 to 5.1% in 2004.[4,7]

More concerning than the rise in obesity among adults is the increased prevalence of obesity among children.[3,4,8] In the United States, the prevalence of obesity in children has tripled in just 30 years; not surprisingly, rates of dyslipidemia and type 2 diabetes among children have shown a corresponding increase over the same time period.[9] In children, obesity is defined based on growth charts from the Centers for Disease Control and Prevention. For children aged 19 years or younger, obesity is defined as a weight at or above the 95th percentile for age; overweight children are those whose weight is between the 85th and 95th percentiles for age. In 1974, 5.1% of children were considered obese and 10.4% were considered overweight by these definitions. In 2008, 14.6% of children were considered obese.[4,8,10,11]

The prevalence of obesity shows striking disparities with regard to race and ethnicity in both adults and children.[2,3,7,8,12] Between 1999 and 2004, the prevalence of obesity in non-Hispanic white adult women was 30.5%, compared to 39.8% in Mexican American women and 50.6% in non-Hispanic African American women.[4] Obesity rates in adult men showed no significant differences between ethnic groups.[4] The distribution of obesity among children aged 2–19 years with regard to race showed trends similar to those seen in adults. The prevalence of obesity was lower among non-Hispanic white children (13.9%) compared to non-Hispanic African American children (18.8%) and Mexican American children (19.7%). When gender and race were considered, significantly higher rates of obesity were seen in Mexican American boys (22.7%) than in non-Hispanic white boys (14.8%) or non-Hispanic African American boys (16.1%). Non-Hispanic African American girls had significantly higher rates of obesity (21.6%) than non-Hispanic white girls (13.0%).

While obesity is clearly a major public health issue in the United States, the increased prevalence of obesity is not limited to this country; indeed, obesity is now a global epidemic. Over the past 10 years, the World Health Organization (WHO) has recognized the increasing number of people who are overweight or obese, and attention is now being given to the global implications associated with this trend. In an analysis of the leading causes of global mortality and burden of disease, obesity and being overweight were among the top 10 causes for each.[13] The presence of a worldwide epidemic is suggested by the fact that in various regions of the world—North America, Central America, South America, most of Western Europe, the Middle East, and Eastern Europe—the majority of countries report that at least 40% of their population between the ages of 45 and 59 years are overweight or obese.[14] East Asian countries such as China, Japan, Vietnam, and India report lower rates of obesity, but the use of BMI alone may be problematic due to cultural and ethnic variability in adipose proportion and distribution.[15] In the latter geographic areas, rates of diabetes and cardiovascular

disease (CVD) are increased at BMIs below the WHO cutoff for being overweight (25 kg/m^2), a phenomenon most likely linked to proportionate increases in body fat in these populations.[16,17]

Body Mass Index as an Estimate of Obesity and Mortality

Using BMI alone to define obesity has been problematic in some settings, given differences in genetics, fat distribution, and percentage of body adiposity among various countries. Because Asian populations have a higher proportion of body fat, for example, lower BMIs have been proposed to identify individuals in these populations who are overweight or obese.[14,15,18] A cross-sectional study looking at 3 different ethnic groups in Singapore (Chinese, Malays, and Indians) demonstrated the limitations of using BMI alone to estimate body fat percentage. Compared to white subjects, BMI underestimated body fat percentage in Chinese, Malay, and Indian subjects, with the error ranging from 2.7% to 5.6%. Furthermore, Asians had a higher risk of developing diabetes and CVD and had increased mortality at normal BMIs compared to other ethnic groups.[15,19]

Further problems occur when epidemiologic studies use self-reported data to calculate BMI. Many of the larger international studies used to estimate the number of overweight and obese individuals in foreign countries have used surveys involving self-reported heights and weights.[4] However, the use of self-reported data often results in inaccurate estimations of weight and height and, subsequently, inaccurate BMI values.[4] A study of 16,000 individuals examined the validity of self-reported data for BMI calculation.[20] In this study, subjects were asked to report their weight and height, after which these estimates were compared to measured values. On average, BMIs in older individuals were 1 unit lower when calculated using self-reported values compared to BMIs calculated using measured values. Furthermore, this self-reporting bias worsened as true BMI values increased. In a subsequent study of 6,000 individuals in the National Health and Nutrition Examination Epidemiological Study (NHANES), researchers found that every 1-unit increase in BMI correlated with a 2-lb underestimation of weight.[21] When gender was considered, men were found to overestimate their weight by 5.0 lbs, and women underestimated their weight by 1.8 lbs, on average. In an earlier French study of 7,250 individuals, values for both self-reported weight and height were inaccurate.[22] Weight was significantly underestimated (by a mean of 0.54 kg among men and 0.85 kg among women). In contrast, height was significantly overestimated (by a mean of 0.54 cm among men and 0.40 cm among women). This combination of errors led to an underestimation of BMI—by 0.29 kg/m^2 in men and 0.44 kg/m^2 in women—and an underestimation of the rate of individuals who were overweight, by 13% in men and 17% in women.[22]

Large cohort studies have shown that elevated BMI has been associated with an increased risk of future cardiovascular events.[23,24] In the largest of these studies, over 1 million adults were prospectively followed for 14 years, and the cause of mortality was evaluated. When other risk factors such as smoking were removed from the analysis, higher BMIs were associated with an increased risk of mortality.[23] Among white men and women with a BMI above 40 kg/m^2, the relative risk (RR) for mortality was 2.58 and 2.0, respectively, compared to individuals with a BMI in the normal range (22.9–24.9 kg/m^2). In a similar group of African American subjects with BMIs above 40 kg/m^2, no increase in mortality was seen compared to normal-weight controls. When death from cardiovascular causes was evaluated, men with BMIs greater than 40 kg/m^2 had an increased risk of mortality compared to their lean counterparts (RR=2.90; 95% confidence interval [CI] 2.37–3.56).

In a subsequent large prospective cohort study of 527,265 US men and women between the ages of 50 and 71 years, researchers evaluated the association between BMI and death from any cause over a 10-year period (1996–2005).[24] Obesity was associated with an increase in mortality across all races and both genders. When individuals without preexisting cardiovascular conditions (including smoking) were isolated, overweight individuals still showed an increase in mortality. In a subcohort analysis of 50-year-old individuals who had never smoked, those who were morbidly obese (BMI >40 kg/m^2) had an increased risk of mortality (RR=3.82; 95% CI 2.87–5.08) compared to individuals with a BMI in the normal range (23–24.9 kg/m^2). While BMI is thus a useful predictor in some settings, how BMI compares to other anthropometric measurements in terms of accurately determining obesity, associated comorbid diseases, and respective mortality has been a topic of recent debate.

Central Adiposity

While the WHO still uses BMI to identify individuals who are overweight or obese, mounting evidence suggests that a pattern of central adiposity is more accurate in predicting obesity-related cardiovascular consequences.[25-33] In a large case-control study of 27,000 people in 52 countries, the correlation between myocardial infarction (MI) and either waist-to-hip ratio (WHR) or BMI was evaluated. WHR, waist circumference (WC), and hip circumference were individually associated with an increased risk of subsequent MI independent of other risk

factors, including BMI.[27] When other cardiovascular risk factors and WHR were taken into account, there was no significant association between MI and BMI (odds ratio 0.98; 95% CI 0.88–1.09). The attributable risk for MI in the top 2 quintiles for WHR was 24.3% (95% CI 22.5–26.2%), compared to 7.7% in similar quintiles for BMI (95% CI 6.0–10%).

A recent cohort study examined the possibility of using WC, WHR, and BMI in conjunction with Framingham risk scores to predict coronary heart disease (CHD) and CVD mortality. A total of 4,175 Australian men who were free of CVD, CHD, diabetes, and stroke at baseline were followed for 15 years.[34] Baseline Framingham risk scores were calculated, and WC, WHR, and BMI measurements were taken. Initial Framingham scores were strong predictors of CVD and CHD deaths 15 years later. WHR was found to be an independent predictor of CVD and CHD deaths, and WC predicted CVD deaths. BMI did not predict mortality due to either CVD or CHD.

Two different meta-analyses evaluated measures of abdominal adiposity and their relationship to cardiac events, as well as their ability to predict the development of associated cardiac risk factors. In the first of these meta-analyses, BMI was compared to measures of central adiposity—including WHR, WC, and waist-to-height ratio (WHtR)—to determine the best predictor for development of hypertension, type 2 diabetes, and hyperlipidemia. A total of 10 studies met the inclusion criteria, and a total of 88,514 adult subjects (54% female) in 9 countries were included in the meta-analysis.[35] WHtR was found to be the best discriminator for development of all 3 cardiovascular risk factors, while BMI was the worst. The majority of the patients included in this study were from Asia and the Middle East.

The second meta-analysis, which examined the association between WC or WHR and the incidence of CVD, included 258,114 patients from 15 randomized controlled trials (RCTs) or prospective cohort studies. For every 1-cm increase in WC, the RR of a cardiovascular event increased by 2% (95% CI 1–3%). WHR and WC were both associated with an increased risk of future cardiovascular events (WHR RR=1.95, 95% CI 1.55–2.44; WC RR=1.63, 95% CI 1.31–2.04).

In comparing these different measures of central adiposity, it is important to note that technical limitations can make it difficult to measure WHtR consistently. Although visceral adipose stores can be directly measured by computerized axial tomography, magnetic resonance imaging, or dual energy x-ray absorptiometry, the high cost of these tests limits their applicability in large epidemiologic studies.[36,37] In contrast, WC and WHR can be measured easily in the clinical setting and are not limited by cost or technical issues.

Health Burden and Obesity-associated Diseases

Several studies have shown a relationship between elevated BMI and chronic medical conditions such as diabetes mellitus, hypertension, hyperlipidemia, and obesity-related cancers.[38-40] Epidemiologic studies have also shown an association between adult obesity and premature death from all-cause mortality.[23,41] One study found that obesity was associated with a 7-year decrease in life expectancy for women and a 6-year decrease for men, which is similar to findings from past studies on smoking.[41] Furthermore, pediatric obesity is associated with many of the same cardiovascular risk factors as adult obesity, including hypertension, diabetes, metabolic syndrome, and hyperlipidemia.[42]

Conversely, other studies have shown reduced mortality due to cardiovascular causes in obese patients compared to lean controls. These latter studies appear to reflect an increase in the diagnosis and early treatment of cardiovascular risk factors in this high-risk group more so than a decreased incidence of obesity-related comorbid conditions such as diabetes, hypertension, and hyperlipidemia.[43] These clinically significant outcomes are not restricted to medical fields, but also complicate surgical outcomes. Postoperative complications occur more frequently in obese patients than lean controls, with an increased incidence of MI, peripheral nerve injury, wound infection, and cardiac arrest.[44]

In addition to the potential impact on mortality, the overall morbidity seen in this growing patient population remains a key issue contributing to decreased quality of life in overweight and obese individuals. Impairment in activities of daily living—such as eating, dressing, and transferring to and from a bed or wheelchair—occur at a younger age in obese patients compared to nonobese controls.[45] If overall mortality decreases but the diagnosis and treatment of obesity-related conditions continue to increase, the cost of managing the obese patient population could be overwhelming.

While the hazards of obesity have long been known, the benefits of weight loss and exercise have only recently become more apparent. One study investigated 3,234 nondiabetic patients with elevated fasting glucose levels and randomly assigned them to treatment with placebo, metformin, or lifestyle modification (including weight loss and exercise). Metformin reduced the likelihood of developing diabetes by 31%, whereas lifestyle modification reduced the chance of developing diabetes by 58% (with weight loss ≥7%).[46] A subsequent meta-analysis examining the effect of weight loss on blood pressure showed that for every 1 kg of weight lost, blood pressure dropped by 1.1 mmHg systolic/0.9 mmHg diastolic.[47] Additional meta-analyses have also demonstrated

improvements in cardiovascular risk factors related to weight loss.[48] Loss of only 1 kg was shown to be associated with improvement in serum cholesterol (–1.0%), low-density lipoprotein cholesterol (–0.68%), triglycerides (–1.9%), and high-density lipoprotein cholesterol (+0.2%). Furthermore, loss of 5 kg was associated with a decrease in fasting plasma glucose levels of 18 mg/dL, an improvement similar to that achieved from treatment with current oral hypoglycemic agents.[48]

Fast Food and Trans Fat

The parallel between the national and international expansion of fast food companies over the past 50 years and the growth of the obesity epidemic is no coincidence. The United States now has approximately 250,000 fast food restaurants, and total fast food consumption has risen from 2% to 10% of total energy intake per person over a 20-year period.[49,50] Surveys have revealed that the top 3 reasons US consumers choose fast food over healthier alternatives are: fast food is quick (92% of respondents), restaurants are easy to visit (80%), and the food tastes good (69%).[51] There remains debate about the degree to which fast food companies, with their provision of high trans-fat foods, are responsible for the obesity epidemic.[52-54] In a large, multicenter, prospective cohort study, 3,031 adults between the ages of 18 and 30 years were followed for 15 years to evaluate their fast food habits, development of insulin resistance, and changes in body weight.[50] Participants were drawn from 4 major US cities, included an equal number of African Americans and whites, and had variable levels of education. This study found a strong positive correlation between visits to fast food restaurants and weight gain with development of insulin resistance.[50] The average frequency of fast food intake was 1.3 times per week among white women and 2.0 times per week among other ethnic/gender groups. Higher baseline consumption of fast food was associated with increased weight gain after 15 years. Increased fast food consumption was also associated with significantly increased insulin resistance in all ethnic/gender groups. Other cross-sectional studies have shown similar associations between fast food intake and increased body weight.[55,56]

The specific aspect of fast food consumption that contributes most to obesity and insulin resistance is currently the subject of much debate. One possibility is that the high caloric density of fast food is the sole culprit, but there may also be a specific component in fast food that contributes to the increased risk for obesity and diabetes. Fast food is indeed characterized by a high caloric density (energy content/food weight ratio), and the total caloric content of a typical fast food meal exceeds that of the average meal by 65%.[53] In addition to high caloric density, fast food has historically had higher amounts of industrially produced trans fatty acids (TFAs). Compared to other fats, TFAs have higher melting points, better taste, and longer shelf lives.[52,53,57,58] The lower rates of CVD in countries such as France, where use of TFAs is limited but total fat consumption remains high, has led to observational studies evaluating the link between TFAs and heart disease.[52,57] In the United States, an average daily intake of 5 g of TFAs has been estimated to increase an individual's risk of heart disease by 25%.[59-61] The Nurses Health Study found that intake of TFAs was directly related to risk of CHD, and a subsequent observational study of 21,930 Finnish men who were followed for 6 years found a positive correlation between TFA intake and risk of death from CHD.[62,63] Individuals in the top quintile of TFA intake (6.2 g/day) had a multivariate RR of 1.39 (95% CI 1.09–1.78) for death from CHD, compared to those in the lowest quintile of TFA intake (1.3 g/day).

The Expert Committee of the American Medical Association recently concluded that there is strong evidence that eating away from home, specifically consumption of fast food, is a risk factor for childhood obesity.[64,65] Fast food children's meals were first introduced in the late 1970s and have been very popular with toddlers and adolescents.[66] In terms of nutrient composition, fast food children's meals are high in total fat and TFAs, have high caloric density, and offer very little nutritional value.[66] A recent study examined the nutrient quality of fast food meals marketed to young children.[66] Criteria from the National School Lunch Program (NSLP) were used to analyze these meals in terms of their percentage of energy from fat and carbohydrates, overall energy density, and vitamin composition. Only 3% of the fast food children's meals met the NSLP criteria for healthy meals; those meals were offered with milk and fruit, and the majority were deli sandwich–based meals.[66] Children's meals are often offered with toys, which promotes brand recognition and repeated visits to the restaurant.[66,67] Given the nutritional composition of children's fast food meals, it is not surprising that obese and overweight children consume more meals away from home than normal-weight children.[68]

In addition to children's fast food meals and the early brand recognition they build, children are bombarded with television advertising from fast food companies. Branding involves developing recognition and positive associations with a product. Studies have found that children aged 3–6 years view, understand, and remember advertising when cartoon characters are used.[67,69] One study examined the content of advertising contained in children's television programs on 3 popular networks (Public Broadcasting Service, Disney, and Nickelodeon) using randomly selected 4-hour blocks from 9 AM to

1 PM.[67] In 96 half-hour blocks, there were 130 food-related advertisements (1.4 per half hour). Half of these advertisements were specifically aimed at children, with most from fast food companies. The fast food advertisements seemed to focus on building brand recognition and positive associations through the use of logos and cartoon characters.[67]

In addition to fast food advertising directed at children, some evidence suggests that a disproportionate number of fast food restaurants are located in close proximity to schools.[70] Using the California Healthy Kids Survey of over 500,000 children, data were analyzed for specific questions about high-risk behaviors such as fast food consumption and proximity of fast food restaurants to home. The primary outcome in this study was BMI.[70] Students with fast food restaurants within 0.5 miles of their home were more likely to be overweight or obese. These children also consumed more soda and ate less fruits and vegetables.[70] Other studies have shown similar findings, demonstrating a link between increased rates of obesity in urban areas with a predominately poor, African American population and a high density of fast food restaurants, versus lower rates of obesity in white neighborhoods with large chain grocery stores.[71,72]

Portion Distortion, Soft Drinks, and Fructose

The high caloric density and trans-fat content of fast food are only some of the factors contributing to the obesity epidemic. In the past 30 years, the portion sizes of many foods have increased, leading to increased energy intake.[73-76] Fast food companies have increased portion sizes 2- to 5-fold since the items were originally introduced over 50 years ago.[77] In response to the 2004 documentary *Super Size Me,* McDonald's announced plans to phase out their "Super Size" items. Despite this action, items on McDonald's current menu still dwarf the portion sizes introduced in 1955. These items include French fries (increased by 250%), soda (increased by 457%), and hamburgers (precooked weight increased by 500%).[77] Despite dropping the "Super Size" name, a large order of French fries in 2006 (6.0 oz) was only slightly smaller than the "Super Size" French fries served in 1998 (6.3 oz). Wendy's followed suit and dropped the "Biggie" label from its largest-portioned items, but this change was only in name. The "Great Biggie" French fries served in 2002 (6.7 oz) became large French fries in 2006 (6.7 oz), and the 2002 "Biggie Soda" (32 oz) increased in size to become the 2006 large soda (42 oz). The largest increase in portion sizes has come with the ever expanding size of hamburger options.[77] In 2003, Hardee's introduced the "Monster Thickburger," with 1,420 calories, and Burger King's "Angry Triple Whopper" is the highest-calorie item on the restaurant's menu, with 1,360 calories.

Consumption of soft drinks has been linked with metabolic syndrome and cardiovascular risk based on the Framingham study.[78] The number of calories consumed in sodas and fruit juices has increased significantly over the past 30 years.[79] The largest study to show this trend examined beverage consumption in the United States among 73,335 individuals over the age of 2 years.[79] Overall energy intake from sweetened beverages increased by 135% from 1977 until 2001, increasing average daily caloric intake by 278 calories. During the same time period, milk consumption decreased by 38%. These trends coincided with the expansion of the obesity epidemic. Prospective studies have linked increased intake of sweetened beverages directly with increased weight gain.[80,81] The first of these studies enrolled 548 ethnically diverse students (average age of 11.7 years) from public schools in 4 Massachusetts communities and followed their consumption of sugar-sweetened beverages over 19 months.[81] For each additional serving of sweetened beverage consumed on a daily basis, BMI and the incidence of obesity were significantly increased. A second prospective study examined the effect of sucrose and artificial sweeteners on weight gain in a population of overweight adults.[80] Subjects were randomized to receive sucrose supplements (152 g sucrose/day) or artificial sweeteners (0 g sucrose/day) for 10 weeks. The change in weight differed significantly between groups, with the sucrose-supplement group gaining a mean of 1.6 kg, while the artificial-sweetener group lost a mean of 1.0 kg. A recent systematic review of prospective studies reached similar conclusions, finding that increased sugar-sweetened beverage consumption was associated with weight gain and obesity and proposing that strategies to reduce consumption of these beverages would likely help reverse the obesity epidemic.[82]

The consumption of high fructose corn syrup (HFCS) has also been evaluated as a possible independent risk factor for the development of obesity.[83] Fructose typically comes from 3 main sources: sucrose, HFCS, and fruit.[84] The amount of fructose in fruit, which is relatively small compared to that in soft drinks, seems to serve the function of enticing individuals to consume other nutrients. In contrast, the HFCS added to soft drinks contains much higher concentrations of fructose and has no other nutritional benefits. Beyond adding excess calories to an individual's diet, fructose has also been linked to central adiposity, gout, and hyperlipidemia.[85,86] In 1 study, high fructose intake for 6 weeks was found to increase postprandial serum triglycerides by 32% compared to a similar diet of isocaloric high glucose intake.[87] These findings have been confirmed by other studies.[85,88,89]

The amount of fructose consumed in the United States has increased over the past 30 years. An analysis of the NHANES database showed that in 1977 the average estimated daily intake of fructose was 37 g/day

(8% of total daily calories).[90] Approximately 15 years later, the average daily intake of fructose had increased to 54.7 g/day (10.4% of total daily calories). Not surprisingly, adolescents have the highest daily consumption of fructose (72.8 g/day; 12.1% of total daily calories), and 25% of adolescents receive more than 15% of their total daily calories from fructose.[90] The correlation between obesity and soft drink consumption alone warrants limiting the amount of HFCS in an individual's diet.

Physical Inactivity

Physical activity (PA) has been suggested as an essential requirement for decreasing the incidence of obesity and reducing the number of overweight individuals.[91] Certainly, PA in any form helps to tip the balance of energy consumption versus energy expenditure in a favorable direction. A study using the NHANES database found that adults who reported low levels of PA were more likely to have gained significant weight over the previous 10-year period. Self-reported levels of PA (low, medium, or high) were compared to change in weight after 10 years. Individuals who reported low PA at the follow-up visit were more likely to have experienced major weight gain (greater than 13 kg). The study found no significant correlation between baseline PA and subsequent weight gain.[91] Looking at this relationship prospectively, another study measured 24-hour energy expenditure and future weight gain in 95 people.[92] Individuals with low 24-hour energy expenditure (200 kcal below predicted values) were 4 times more likely to gain at least 7.5 kg over a 2-year period compared to individuals with high 24-hour energy expenditure (200 kcal above predicted values).[92]

The role that PA has played in the rise in adolescent obesity over the past 20 years has been the subject of considerable debate. A recent analysis of PA showed no clear decline in PA among adolescents over the past 20 years.[93] This analysis examined 7 large studies from the Youth Risk Behavior Surveillance Surveys from 1991 to 2007. Vigorous PA was defined as any activity that caused increased sweating and a sensation of breathing hard for more than 20 minutes during 3 of the previous 7 days. The amount of vigorous PA reported by adolescents did not differ significantly between 1993 (65.8%) and 2005 (64.1%). Furthermore, the adolescent attendance rate for physical education class and the amount of exercising for over 20 minutes during class has significantly increased in recent years, and the amount of television viewing has significantly decreased.[93] These data call into question the role that PA has played in the increase in obesity among adolescents.

One of the factors thought to be responsible for decreased PA is the increase in time spent watching television. A recent study examined the role of increased television viewing on all-cause and cardiovascular mortality.[94] A total of 8,800 adults followed for a median of 6.6 years were evaluated for numerous cardiovascular risk factors. This study found a significant positive linear relationship with both BMI and WC as hours of television increased, when adjusted for age and sex.[94] Even after adjusting for age, sex, WC, and exercise, an increase in television viewing was still associated with a significant increase in all-cause and cardiovascular mortality.[94]

Probably the most important role for exercise and increased PA in individuals with obesity is the prevention of recidivism after successful weight loss from dieting and the maintenance of lean body mass as body fat mass is reduced. A meta-analysis examined the effect of exercise, exercise plus diet, and diet alone on weight gain.[95] Over the course of 15 weeks, weight loss in the exercise-only group was 2.9±0.4 kg, compared to 10.7±0.5 kg in the diet-only group. The weight loss that occurred by combining diet with exercise was not significantly different from that seen with diet alone. At the 1-year follow-up visit, however, the diet-plus-exercise group had maintained the weight loss better than the diet-only group (mean 8.6±0.8 kg total weight lost compared to 6.6±0.5 kg, respectively). Other studies have confirmed that exercise alone usually incurs only a small amount of weight loss and that the more important role of exercise is maintaining weight loss after a successful diet program.[96,97]

Health Initiatives to Prevent Obesity

Obesity is the next major epidemiologic battle for physicians, public health experts, government officials, and the general population. By many estimates, obesity has already surpassed smoking as the most pressing public health threat. In much the same way that antismoking campaigns were developed, health initiatives must now be developed to effectively prevent obesity and its associated diseases. While smoking and obesity share many similarities from a public health perspective, obesity is potentially more problematic since adequate nutrition is essential to survival; therefore, abstinence from food is not an option. Also, what constitutes good nutrition as opposed to harmful food choices is often not clearly understood by the general public. As changes to the healthcare system in the United States are discussed, plans should be offered that directly and aggressively target obesity through health initiatives and prevention programs.

Food Labeling

Labeling the nutritional content of food products and fast food has been proposed as a way to allow consumers to make informed choices about the types of foods they con-

sume. Beginning in the 1960s, the government required tobacco products to have labels from the US Surgeon General stating that smoking may be hazardous to one's health. These labeling requirements have since progressed to more specific statements, ie, that smoking causes lung cancer and emphysema and that quitting smoking may reduce the risk for serious health concerns.[98] The problem with these labels is that they appear in small print and people often do not read them. Indeed, there are little data to suggest that this labeling has been effective in preventing smoking. Ironically, these labels have been used by tobacco manufacturers in litigation against patients with smoking-related diseases to claim that patients were properly warned about the dangers of smoking.[99-101]

In a similar fashion, little data exist to show that labeling food products has improved eating habits. In a recent RCT from Germany, a variety of food labeling strategies were compared, including no labeling, food labels with daily recommended levels for specific nutrients, labels with healthy choice designations, and traffic light labels indicating the level of healthiness.[102] No significant differences were found in consumption habits between the different labeling strategies.[102] In a study evaluating a similar "stop light" labeling technique, adolescents at 3 different high school cafeterias were found to purchase more items deemed to be high calorie (red) compared to lower calorie options (green and yellow), despite being given a higher percentage of healthier options.[103]

One of the main problems with the current strategy for labeling nutritional content is that this information is very difficult for consumers to comprehend. Most consumers are unaware of the dietary content of restaurant foods. A recent RCT was conducted to evaluate whether providing calorie information influenced the types of foods purchased at fast food restaurants.[104] After randomization, half of the 594 participants were provided with menus containing calorie information, while the other half were given menus without this information.[104] The number of calories consumed was not statistically different between the 2 groups.[104] However, some data suggest that providing calorie information does influence consumption patterns, at least for females.[105]

The Nutrition and Education Labeling Act of 1994 specifically exempted restaurants from providing nutritional labeling of their products.[106] Recently, however, New York City mandated that fast food companies provide nutritional labeling for all of their products.[107] Initial data suggested that 1,156 customers had perceived a change in consumption because of the labeling, but comparison to a similar population in New Jersey (where labeling is not mandated) showed that there was no difference in actual calories consumed.[107] Nonetheless, having nutritional labeling on restaurant food should lead to more informed decisions about consumption. Overall, there may be a role for nutritional labeling, but use of this technique without other strategies or regulation of nutritional content should not be expected to significantly alter eating habits or prevent obesity-related consequences.

Eliminating Trans Fat in New York City, Denmark, and Beyond

The average daily per capita intake of TFAs in the United States has been shown to increase heart disease risk by 25%, and most leading health organizations have advocated the complete removal of TFAs from foods.[108-110] To achieve this objective, however, consumers would need to read labels and become educated about the TFA content of food, and healthcare providers would need to provide counsel on TFA-free options. In 2003, the US Food and Drug Administration required all packaged goods to reveal the amount of TFA if it exceeded 0.5 g.[108,111] However, the food industry has circumvented these labeling requirements. For example, fast food companies have reduced serving sizes to keep the amount of TFA below 0.5 g, allowing them to continue using TFA without having to report it on labels.[109] Furthermore, restaurants are not required to report the amount of TFA in the food they serve. In addition to such roadblocks, educating patients about healthy food options is often frustrating and time-consuming for healthcare providers. Therefore, the best option is to eliminate the use of industrially produced TFAs and shift toward the use of safer fats in both packaged goods and restaurant food.

In 2006, the New York City Department of Health and Mental Hygiene put forth a bold proposal to eliminate all artificial TFAs from restaurant food. The response from the restaurant and food industry was not surprising, with critics calling the ban a threat to the flavor of food and saying that the increased cost of converting to TFA-free food would be an economic burden.[108] The first phase of the ban involved restricting TFAs in cooking oils and spreads only, as this goal was more easily obtainable than the complete elimination of TFAs. By the summer of 2008, 99% of restaurants had successfully changed to oils and spreads low in TFAs.[108] The second phase of the ban involved the complete elimination of artificial TFAs from other foods and ingredients. Approximately 6 months after the second phase was initiated, the use of artificial TFAs had been reduced from 50% to 1.6%.[108] By using healthier replacement oils, the amount of saturated fats was also reduced. Outcome data regarding the impact of this measure will not be available for several years, but previous studies suggest that the elimination of TFAs should reduce the risk of heart disease and hyperlipidemia among residents of New York City.

Denmark has been monitoring artificial TFAs in the diets of its residents for over 30 years.[112-114] Authorities there determined that labeling was not an effective way

to reduce the consumption of foods high in TFAs, such as fast food (especially children's meals), and in March 2003, Denmark became the first country to restrict the use of TFAs in food products.[112] The consumption of food potentially high in TFAs was analyzed before and after this ban, and researchers found that the amount of TFA in the same representative food (such as a large order of French fries and chicken nuggets) was reduced from 30 g to less than 1 g. Over the same period, the same meal in countries without a ban (such as Hungary, Poland, and the United States) still contained 36–42 g of TFAs.

As a result of the successful efforts in New York City and Denmark, legislation to ban artificial TFAs from restaurants has been passed by 1 state legislature, 10 local city governments, and Puerto Rico, and 17 more states are considering similar legislation.[109,115] While these programs are encouraging, a complete ban on TFAs in all states may be necessary to optimize the health of the US population.

Taxation of High Calorie Beverages

Large portion sizes and increased consumption of soft drinks and fruit juices are partially responsible for the obesity epidemic. These beverages are prevalent in schools, which may place children at an increased risk of diabetes. The current debate is how to limit the consumption of these beverages in the US school system. Two ideas that have been proposed are to increase taxation on high calorie beverages and to restrict their availability in vending machines in schools.[116,117] While the volume of soft drinks consumed by adolescents that comes from vending machines in schools is much smaller than the volume purchased in commercial stores or restaurants, much of the legislative effort has focused only on restricting vending machine sales.[118]

The current level of taxation on high calorie beverages is probably insufficient to decrease consumption.[119] A recent study used multivariate linear regression analysis to determine how state taxes on soft drinks affect adolescent obesity.[119] Self-reported BMI data were obtained from students in the 8th, 10th, and 12th grades between 1996 and 2007. The BMI data were compared to differences in taxation for vending machine products from various states. No significant correlation was found between the rate of adolescent obesity and the level of taxation in the various states involved in the study.[119] The most obvious explanation for this finding was that these taxes were all very small and thus were unlikely to have an effect on consumption or long-term consequences such as weight gain. The average state tax on a $1.00 bottle of soda sold in a store is approximately $0.04.[119]

Newly proposed legislative strategies have suggested raising the tax on nondiet soda, fruit drinks, and flavored milk.[119-121] The governor of New York recently included an 18% tax on nondiet sodas in his proposed budget.[120] Others have suggested placing a per-ounce excise tax of $0.01 on non-diet sodas.[120] Such a strategy would add a tax of $0.20 to a 20-oz bottle of soda (normally sold for approximately $1.00), thus increasing the total cost by 20%. When offered options of diet sodas or other healthier beverages costing 20% less than the nondiet beverages, consumers may be more likely to choose the lower calorie alternatives. Such behavior has been seen when tobacco products have been taxed at higher rates.[122-124] Adolescents aged 12–18 years in states with a cigarette tax in the highest quartile ($0.60–$1.00 per pack) were less likely to experiment with tobacco and become established smokers than adolescents in states with a tax in the lowest quartile.[123]

Implications for Gastroenterologists

In addition to the many consequences already mentioned, the growing obesity epidemic is also expected to impact the morbidity and mortality associated with certain gastroenterologic disease processes, the performance of endoscopic procedures, and the complexity of patient management. When evaluating patients in a clinic setting, therefore, gastroenterologists should calculate BMIs and determine whether patients are overweight or obese, as well as determine their WCs and make a determination regarding central versus peripheral adiposity. Determining the degree of obesity (normal weight, overweight, obese, and so on) and the distribution of adiposity will help to identify patients at increased risk for complications from certain gastrointestinal disorders.

The incidence of cholecystitis and choledocholithiasis will likely increase as the obesity epidemic continues to affect more individuals. A recent prospective observational study found that obese patients with acute cholecystitis were more likely to be admitted to the hospital and spent more days in the hospital than nonobese patients.[125] The incidence of gastroesophageal reflux disease (GERD) is also increased in overweight and obese individuals.[126,127] Increased WC (>80 cm), but not greater BMI, has been shown to correlate with an increased incidence of Barrett esophagus.[126,128] Obesity alone is associated with increased severity in acute pancreatitis.[129] Similar to the data for GERD, umbilical WC was shown to be better than BMI for predicting the development of severe acute pancreatitis in obese patients.[130] Additionally, central adiposity is a driving factor in nonalcoholic steatohepatitis (NASH).[131,132] Increases in the incidence of NASH and cirrhosis will likely occur as a result of this obesity epidemic. Eventually, NASH cirrhosis may become the most common indication for liver transplantation.[131]

Obesity increases morbidity for critically ill patients compared to their lean counterparts.[133,134] In trauma

patients in a surgical intensive care unit, obesity may also increase mortality.[135,136] Potentially, the observed increase in mortality among obese trauma patients could be explained by obesity-associated decreases in hepatic blood flow.[137] In these critically ill obese patients, gastroenterologists may increasingly be called upon to achieve enteral access and manage enteral feeding. Optimal nutritional therapy in this situation is controversial and involves high protein, hypocaloric "permissive" underfeeding.[138-141] In the near future, nutritional formulas may involve pharmaconutrition with specific formulas for obese patients that are designed to reduce oxidative stress, remove fat from the liver, and promote microvascular perfusion.[142-145]

Gastroenterologists will also increasingly be called upon to manage complications in patients who have undergone bariatric surgery. The anatomic alterations from these surgical procedures can result in myriad micronutrient deficiencies that require the skills of a clinical nutritionist for long-term management.[146-148] Severe nutritional deficits can be avoided with aggressive supplementation following bariatric surgery.[147] Endoscopy is often required in the evaluation of such patients when nausea, vomiting, gastrointestinal bleeding, or anastomotic ulceration complicates the postoperative course. Obesity may increase the complexity of such endoscopic procedures. Obese patients are also at risk for restrictive lung disease as well as central or obstructive sleep apnea.[149] Thus, clinicians may have greater difficulty when performing conscious sedation, as obese patients may have a greater likelihood for oxygen desaturation. As a result, a larger number of endoscopic procedures may need to be performed under medical anesthesia care.

Finally, endoscopic therapies to promote weight loss in obese patients are already on the horizon. Gastric inflatable balloons, one of the earliest endoluminal concepts to treat obesity by promoting early satiety, are being reevaluated as a weight loss technique and potential bridge to later bariatric surgery.[150,151] Two new strategies to achieve gastric restriction using endoscopic suturing or stapling devices are also being investigated. Endoluminal vertical gastroplasty utilizes the EndoCinch Suturing System (C. R. Bard), which was previously used for the treatment of GERD, to apply a running suture line from the fundus to the antrum, effectively reducing gastric luminal capacity.[152] Similarly, transoral gastroplasty utilizes an endoluminal stapling device to achieve a full-thickness tissue plication and pleating of the gastric folds from opposing stomach walls to create a similar restriction of the gastric lumen.[153] Finally, the duodenojejunal bypass sleeve is a temporary, removable stenting device that is anchored in the duodenal bulb and extends beyond the ligament of Treitz; this sleeve is designed to promote a variable degree of malabsorption.[154]

Conclusion

Obesity is the next major public health challenge facing the United States. Currently, over 60% of the US population is overweight or obese. The health consequences of obesity include increased rates of diabetes, hyperlipidemia, heart disease, and cancer. BMI is a useful epidemiologic tool that can approximate body adiposity for large groups of people, but clinicians may need to combine BMI with WC in the office setting in order to more accurately identify patients at risk for CVD. Currently, health initiatives to address obesity need to be developed and promoted. Based on previous experience with the smoking epidemic, allowing the food industry to control the rate and direction of such measures will result in inadequate or suboptimal programs. Instead, artificial TFAs should be completely banned, as was done in Denmark and New York City, and the number of high calorie beverages consumed on a daily basis should be limited; increased taxation and restricted access to vending machines in schools may help decrease the number of calories consumed from soda and other high calorie beverages. Finally, a renewed emphasis on PA in the school curriculum may help to prevent children from becoming overweight or obese. The obesity epidemic will undoubtedly affect gastroenterologists, whether through obesity-related gastrointestinal disorders, the emerging need for endoscopic therapies to treat obesity, or the greater complexity of patient management in this population. The obesity epidemic must be fought using a wide range of strategies, as initiatives that address only certain portions of the problem at any given time have been shown to be ineffective.

References

1. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295:1549-1555.
2. Flegal KM, Ogden CL, Carroll MD. Prevalence and trends in overweight in Mexican-american adults and children. *Nutr Rev.* 2004;62:S144-S148.
3. Ogden CL, Troiano RP, Briefel RR, Kuczmarski RJ, Flegal KM, Johnson CL. Prevalence of overweight among preschool children in the United States, 1971 through 1994. *Pediatrics*. 1997;99:E1.
4. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The epidemiology of obesity. *Gastroenterology.* 2007;132:2087-2102.
5. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer- and service-specific estimates. *Health Aff (Millwood).* 2009;28:w822-831.
6. Ogden CL, Carroll MD, Flegal KM. Epidemiologic trends in overweight and obesity. *Endocrinol Metab Clin North Am.* 2003;32:741-760, vii.
7. Ogden CL, Carroll MD, McDowell MA, Flegal KM. Obesity among adults in the United States—no statistically significant chance since 2003-2004. *NCHS Data Brief.* 2007(1):1-8.
8. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA.* 2002; 288:1728-1732.
9. Rosenbloom AL, Joe JR, Young RS, Winter WE. Emerging epidemic of type 2 diabetes in youth. *Diabetes Care*. 1999;22:345-354.

10. Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003-2006. *JAMA*. 2008;299:2401-2405.
11. Obesity prevalence among low-income, preschool-aged children—United States, 1998-2008. *MMWR Morb Mortal Wkly Rep*. 2009;58:769-773.
12. Flegal KM, Ogden CL, Wei R, Kuczmarski RL, Johnson CL. Prevalence of overweight in US children: comparison of US growth charts from the Centers for Disease Control and Prevention with other reference values for body mass index. *Am J Clin Nutr.* 2001;73:1086-1093.
13. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet*. 2006;367:1747-1757.
14. James PT. Obesity: the worldwide epidemic. *Clin Dermatol.* 2004;22: 276-280.
15. Goh VH, Tain CF, Tong TY, Mok HP, Wong MT. Are BMI and other anthropometric measures appropriate as indices for obesity? A study in an Asian population. *J Lipid Res*. 2004;45:1892-1898.
16. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363:157-163.
17. Stevens J, Nowicki EM. Body mass index and mortality in Asian populations: implications for obesity cut-points. *Nutr Rev*. 2003;61:104-107.
18. Huang KC. Obesity and its related diseases in Taiwan. *Obes Rev*. 2008;9: 32-34.
19. Deurenberg-Yap M, Chew SK, Lin VF, Tan BY, van Staveren WA, Deurenberg P. Relationships between indices of obesity and its co-morbidities in multi-ethnic Singapore. *Int J Obes Relat Metab Disord*. 2001;25:1554-1562.
20. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *J Am Diet Assoc*. 2001;101:28-34; quiz 35-36.
21. Kovalchik S. Validity of adult lifetime self-reported body weight. *Public Health Nutr*. 2009;12:1072-1077.
22. Niedhammer I, Bugel I, Bonenfant S, Goldberg M, Leclerc A. Validity of self-reported weight and height in the French GAZEL cohort. *Int J Obes Relat Metab Disord*. 2000;24:1111-1118.
23. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW, Jr. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med*. 1999;341:1097-1105.
24. Adams KF, Schatzkin A, Harris TB, et al. Overweight, obesity, and mortality in a large prospective cohort of persons 50 to 71 years old. *N Engl J Med*. 2006;355:763-778.
25. Lee S, Bacha F, Gungor N, Arslanian SA. Waist circumference is an independent predictor of insulin resistance in black and white youths. *J Pediatr*. 2006;148:188-194.
26. Rankinen T, Kim SY, Perusse L, Despres JP, Bouchard C. The prediction of abdominal visceral fat level from body composition and anthropometry: ROC analysis. *Int J Obes Relat Metab Disord*. 1999;23:801-809.
27. Yusuf S, Hawken S, Ounpuu S, et al. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. *Lancet*. 2005;366:1640-1649.
28. Stevens J, Keil JE, Rust PF, Tyroler HA, Davis CE, Gazes PC. Body mass index and body girths as predictors of mortality in black and white women. *Arch Intern Med*. 1992;152:1257-1262.
29. Stevens J, Keil JE, Rust PF, et al. Body mass index and body girths as predictors of mortality in black and white men. *Am J Epidemiol*. 1992;135:1137-1146.
30. Larsson B, Seidell J, Svardsudd K, et al. Obesity, adipose tissue distribution and health in men—the study of men born in 1913. *Appetite*. 1989;13:37-44.
31. Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *Br Med J (Clin Res Ed)*. 1984;288:1401-1404.
32. Despres JP, Arsenault BJ, Cote M, Cartier A, Lemieux I. Abdominal obesity: the cholesterol of the 21st century? *Can J Cardiol*. 2008;24:7D-12D.
33. Welborn TA, Dhaliwal SS. Preferred clinical measures of central obesity for predicting mortality. *Eur J Clin Nutr*. 2007;61:1373-1379.
34. Dhaliwal SS, Welborn TA. Central obesity and multivariable cardiovascular risk as assessed by the Framingham prediction scores. *Am J Cardiol*. 2009;103:1403-1407.
35. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. *J Clin Epidemiol*. 2008;61:646-653.
36. de Koning L, Merchant AT, Pogue J, Anand SS. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *Eur Heart J*. 2007;28:850-856.
37. Snijder MB, Visser M, Dekker JM, et al. The prediction of visceral fat by dual-energy X-ray absorptiometry in the elderly: a comparison with computed tomography and anthropometry. *Int J Obes Relat Metab Disord*. 2002;26:984-993.
38. Field AE, Coakley EH, Must A, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Arch Intern Med*. 2001;161:1581-1586.
39. Gregg EW, Cheng YJ, Cadwell BL, et al. Secular trends in cardiovascular disease risk factors according to body mass index in US adults. *JAMA*. 2005; 293:1868-1874.
40. Renehan AG, Tyson M, Egger M, Heller RF, Zwahlen M. Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. *Lancet*. 2008;371:569-578.
41. Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Al Mamun A, Bonneux L. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Ann Intern Med*. 2003;138:24-32.
42. Burke V. Obesity in childhood and cardiovascular risk. *Clin Exp Pharmacol Physiol*. 2006;33:831-837.
43. Flegal KM, Graubard BI, Williamson DF, Gail MH. Cause-specific excess deaths associated with underweight, overweight, and obesity. *JAMA*. 2007; 298:2028-2037.
44. Bamgbade OA, Rutter TW, Nafiu OO, Dorje P. Postoperative complications in obese and nonobese patients. *World J Surg*. 2007;31:556-560.
45. Alley DE, Chang VW. The changing relationship of obesity and disability, 1988-2004. *JAMA*. 2007;298:2020-2027.
46. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002;346:393-403.
47. Neter JE, Stam BE, Kok FJ, Grobbee DE, Geleijnse JM. Influence of weight reduction on blood pressure: a meta-analysis of randomized controlled trials. *Hypertension*. 2003;42:878-884.
48. Anderson JW, Konz EC. Obesity and disease management: effects of weight loss on comorbid conditions. *Obes Res*. 2001;9:326S-334S.
49. Guthrie JF, Lin BH, Frazao E. Role of food prepared away from home in the American diet, 1977-78 versus 1994-96: changes and consequences. *J Nutr Educ Behav*. 2002;34:140-150.
50. Pereira MA, Kartashov AI, Ebbeling CB, et al. Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *Lancet*. 2005;365:36-42.
51. Rydell SA, Harnack LJ, Oakes JM, Story M, Jeffery RW, French SA. Why eat at fast-food restaurants: reported reasons among frequent consumers. *J Am Diet Assoc*. 2008;108:2066-2070.
52. Stender S, Dyerberg J, Astrup A. High levels of industrially produced trans fat in popular fast foods. *N Engl J Med*. 2006;354:1650-1652.
53. Stender S, Dyerberg J, Astrup A. Fast food: unfriendly and unhealthy. *Int J Obes (Lond)*. 2007;31:887-890.
54. Stender S, Dyerberg J, Astrup AV. Fast food promotes weight gain. *Ugeskr Laeger*. 2007;169:1804-1806.
55. French SA, Jeffery RW, Forster JL, McGovern PG, Kelder SH, Baxter JE. Predictors of weight change over two years among a population of working adults: the Healthy Worker Project. *Int J Obes Relat Metab Disord*. 1994;18:145-154.
56. French SA, Harnack L, Jeffery RW. Fast food restaurant use among women in the Pound of Prevention study: dietary, behavioral and demographic correlates. *Int J Obes Relat Metab Disord*. 2000;24:1353-1359.
57. Stender S, Astrup A, Dyerberg J. Ruminant and industrially produced trans fatty acids: health aspects. *Food Nutr Res*. 2008;52.
58. Stender S, Dyerberg J. Influence of trans fatty acids on health. *Ann Nutr Metab*. 2004;48:61-66.
59. Dansinger M. Ban trans fats in 2007. *MedGenMed*. 2006;8:58.
60. Mozaffarian D, Abdollahi M, Campos H, Houshiarrad A, Willett WC. Consumption of trans fats and estimated effects on coronary heart disease in Iran. *Eur J Clin Nutr*. 2007;61:1004-1010.
61. Mozaffarian D, Willett WC. Trans fatty acids and cardiovascular risk: a unique cardiometabolic imprint? *Curr Atheroscler Rep*. 2007;9:486-493.
62. Willett WC, Stampfer MJ, Manson JE, et al. Intake of trans fatty acids and risk of coronary heart disease among women. *Lancet*. 1993;341:581-585.
63. Pietinen P, Ascherio A, Korhonen P, et al. Intake of fatty acids and risk of coronary heart disease in a cohort of Finnish men. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study. *Am J Epidemiol*. 1997;145:876-887.
64. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics*. 2007;120:S164-S192.
65. Spear BA, Barlow SE, Ervin C, et al. Recommendations for treatment of child and adolescent overweight and obesity. *Pediatrics*. 2007;120:S254-S288.

66. O'Donnell SI, Hoerr SL, Mendoza JA, Tsuei Goh E. Nutrient quality of fast food kids meals. *Am J Clin Nutr*. 2008;88:1388-1395.
67. Connor SM. Food-related advertising on preschool television: building brand recognition in young viewers. *Pediatrics*. 2006;118:1478-1485.
68. Gillis LJ, Bar-Or O. Food away from home, sugar-sweetened drink consumption and juvenile obesity. *J Am Coll Nutr*. 2003;22:539-545.
69. Fischer PM, Schwartz MP, Richards JW Jr, Goldstein AO, Rojas TH. Brand logo recognition by children aged 3 to 6 years. Mickey Mouse and Old Joe the Camel. *JAMA*. 1991;266:3145-3148.
70. Davis B, Carpenter C. Proximity of fast-food restaurants to schools and adolescent obesity. *Am J Public Health*. 2009;99:505-510.
71. Powell LM, Chaloupka FJ, Bao Y. The availability of fast-food and full-service restaurants in the United States: associations with neighborhood characteristics. *Am J Prev Med*. 2007;33:S240-S245.
72. Powell LM, Auld MC, Chaloupka FJ, O'Malley PM, Johnston LD. Associations between access to food stores and adolescent body mass index. *Am J Prev Med*. 2007;33:S301-S307.
73. Burger KS, Kern M, Coleman KJ. Characteristics of self-selected portion size in young adults. *J Am Diet Assoc*. 2007;107:611-618.
74. Fisher JO, Kral TV. Super-size me: portion size effects on young children's eating. *Physiol Behav*. 2008;94:39-47.
75. Fisher JO, Liu Y, Birch LL, Rolls BJ. Effects of portion size and energy density on young children's intake at a meal. *Am J Clin Nutr*. 2007;86:174-179.
76. Ledikwe JH, Ello-Martin JA, Rolls BJ. Portion sizes and the obesity epidemic. *J Nutr*. 2005;135:905-909.
77. Young LR, Nestle M. Portion sizes and obesity: responses of fast-food companies. *J Public Health Policy*. 2007;28:238-248.
78. Dhingra R, Sullivan L, Jacques PF, et al. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. *Circulation*. 2007;116:480-488.
79. Nielsen SJ, Popkin BM. Changes in beverage intake between 1977 and 2001. *Am J Prev Med*. 2004;27:205-210.
80. Raben A, Vasilaras TH, Moller AC, Astrup A. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. *Am J Clin Nutr*. 2002;76:721-729.
81. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet*. 2001;357:505-508.
82. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr*. 2006;84:274-288.
83. Bray GA, Nielsen SJ, Popkin BM. Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *Am J Clin Nutr*. 2004;79:537-543.
84. Bray GA. Fructose—how worried should we be? *Medscape J Med*. 2008;10:159.
85. Bantle JP. Dietary fructose and metabolic syndrome and diabetes. *J Nutr*. 2009;139:1263S-1268S.
86. Choi HK, Curhan G. Soft drinks, fructose consumption, and the risk of gout in men: prospective cohort study. *BMJ*. 2008;336:309-312.
87. Bantle JP, Raatz SK, Thomas W, Georgopoulos A. Effects of dietary fructose on plasma lipids in healthy subjects. *Am J Clin Nutr*. 2000;72:1128-1134.
88. Couchepin C, Le KA, Bortolotti M, et al. Markedly blunted metabolic effects of fructose in healthy young female subjects compared with male subjects. *Diabetes Care*. 2008;31:1254-1256.
89. Abdel-Sayed A, Binnert C, Le KA, Bortolotti M, Schneiter P, Tappy L. A high-fructose diet impairs basal and stress-mediated lipid metabolism in healthy male subjects. *Br J Nutr*. 2008;100:393-399.
90. Vos MB, Kimmons JE, Gillespie C, Welsh J, Blanck HM. Dietary fructose consumption among US children and adults: the Third National Health and Nutrition Examination Survey. *Medscape J Med*. 2008;10:160.
91. Williamson DF, Madans J, Anda RF, Kleinman JC, Kahn HS, Byers T. Recreational physical activity and ten-year weight change in a US national cohort. *Int J Obes Relat Metab Disord*. 1993;17:279-286.
92. Ravussin E, Lillioja S, Knowler WC, et al. Reduced rate of energy expenditure as a risk factor for body-weight gain. *N Engl J Med*. 1988;318:467-472.
93. Li S, Treuth MS, Wang Y. How active are American adolescents and have they become less active? *Obes Rev*. 2010;11:847-862.
94. Dunstan DW, Barr EL, Healy GN, et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*. 2010;121:384-391.
95. Miller WC, Koceja DM, Hamilton EJ. A meta-analysis of the past 25 years of weight loss research using diet, exercise or diet plus exercise intervention. *Int J Obes Relat Metab Disord*. 1997;21:941-947.
96. Slentz CA, Duscha BD, Johnson JL, et al. Effects of the amount of exercise on body weight, body composition, and measures of central obesity: STRRIDE—a randomized controlled study. *Arch Intern Med*. 2004;164:31-39.
97. Curioni CC, Lourenco PM. Long-term weight loss after diet and exercise: a systematic review. *Int J Obes (Lond)*. 2005;29:1168-1174.
98. Robinson TN, Killen JD. Do cigarette warning labels reduce smoking? Paradoxical effects among adolescents. *Arch Pediatr Adolesc Med*. 1997;151:267-272.
99. White V, Webster B, Wakefield M. Do graphic health warning labels have an impact on adolescents' smoking-related beliefs and behaviours? *Addiction*. 2008;103:1562-1571.
100. O'Hegarty M, Pederson LL, Yenokyan G, Nelson D, Wortley P. Young adults' perceptions of cigarette warning labels in the United States and Canada. *Prev Chronic Dis*. 2007;4:A27.
101. RA CR, Kok G. Saying is not (always) doing: cigarette warning labels are useless. *Eur J Public Health*. 2005;15:329.
102. Borgmeier I, Westenhoefer J. Impact of different food label formats on healthiness evaluation and food choice of consumers: a randomized-controlled study. *BMC Public Health*. 2009;9:184.
103. Snelling AM, Korba C, Burkey A. The national school lunch and competitive food offerings and purchasing behaviors of high school students. *J Sch Health*. 2007;77:701-705.
104. Harnack LJ, French SA, Oakes JM, Story MT, Jeffery RW, Rydell SA. Effects of calorie labeling and value size pricing on fast food meal choices: Results from an experimental trial. *Int J Behav Nutr Phys Act*. 2008;5:63.
105. Gerend MA. Does calorie information promote lower calorie fast food choices among college students? *J Adolesc Health*. 2009;44:84-86.
106. Wootan MG, Osborn M. Availability of nutrition information from chain restaurants in the United States. *Am J Prev Med*. 2006;30:266-268.
107. Elbel B, Kersh R, Brescoll VL, Dixon LB. Calorie labeling and food choices: A first look at the effects on low-income people in New York City. *Health Aff (Millwood)*. 2009;28:w1110-w1121.
108. Angell SY, Silver LD, Goldstein GP, et al. Cholesterol control beyond the clinic: New York City's trans fat restriction. *Ann Intern Med*. 2009;151:129-134.
109. Mello MM. New York City's war on fat. *N Engl J Med*. 2009;360:2015-2020.
110. Rivkees SA. No trans fat for you! New York City's bold step. *J Pediatr Endocrinol Metab*. 2007;20:1-3.
111. Food labeling: trans fatty acids in nutrition labeling, nutrient content claims, and health claims. Final rule. *Fed Regist*. 2003;68:41433-41506.
112. Leth T, Jensen HG, Mikkelsen AA, Bysted A. The effect of the regulation on trans fatty acid content in Danish food. *Atheroscler Suppl*. 2006;7:53-56.
113. Stender S, Dyerberg J, Bysted A, Leth T, Astrup A. A trans world journey. *Atheroscler Suppl*. 2006;7:47-52.
114. Stender S, Dyerberg J, Holmer G, Ovesen L, Sandstrom B. The influence of trans fatty acids on health: a report from the Danish Nutrition Council. *Clin Sci (Lond)*. 1995;88:375-392.
115. Tan AS. A case study of the New York City trans-fat story for international application. *J Public Health Policy*. 2009;30:3-16.
116. Cawley J. Markets and childhood obesity policy. *Future Child*. 2006;16:69-88.
117. Roehr B. "Soda tax" could help tackle obesity, says US director of public health. *BMJ*. 2009;339:b3176.
118. Wang YC, Bleich SN, Gortmaker SL. Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988-2004. *Pediatrics*. 2008;121:e1604-e1614.
119. Powell LM, Chriqui J, Chaloupka FJ. Associations between state-level soda taxes and adolescent body mass index. *J Adolesc Health*. 2009;45:S57-S63.
120. Brownell KD, Farley T, Willett WC, et al. The public health and economic benefits of taxing sugar-sweetened beverages. *N Engl J Med*. 2009;361:1599-1605.
121. Brownell KD, Frieden TR. Ounces of prevention—the public policy case for taxes on sugared beverages. *N Engl J Med*. 2009;360:1805-1808.
122. Frieden TR, Mostashari F, Kerker BD, Miller N, Hajat A, Frankel M. Adult tobacco use levels after intensive tobacco control measures: New York City, 2002-2003. *Am J Public Health*. 2005;95:1016-1023.
123. Thomson CC, Fisher LB, Winickoff JP, et al. State tobacco excise taxes and adolescent smoking behaviors in the United States. *J Public Health Manag Pract*. 2004;10:490-496.
124. Sung HY, Hu TW, Ong M, Keeler TE, Sheu ML. A major state tobacco tax increase, the master settlement agreement, and cigarette consumption: the California experience. *Am J Public Health*. 2005;95:1030-1035.
125. Liu B, Balkwill A, Spencer E, Beral V. Relationship between body mass index and length of hospital stay for gallbladder disease. *J Public Health (Oxf)*. 2008;30:161-166.

126. Anand G, Katz PO. Gastroesophageal reflux disease and obesity. *Gastroenterol Clin North Am*. 2010;39:39-46.
127. Jacobson BC, Somers SC, Fuchs CS, Kelly CP, Camargo CA Jr. Body-mass index and symptoms of gastroesophageal reflux in women. *N Engl J Med*. 2006;354:2340-2348.
128. Corley DA, Kubo A, Levin TR, et al. Abdominal obesity and body mass index as risk factors for Barrett's esophagus. *Gastroenterology*. 2007;133:34-41; quiz 311.
129. Martinez J, Johnson CD, Sanchez-Paya J, de Madaria E, Robles-Diaz G, Perez-Mateo M. Obesity is a definitive risk factor of severity and mortality in acute pancreatitis: an updated meta-analysis. *Pancreatology*. 2006;6:206-209.
130. Duarte-Rojo A, Sosa-Lozano LA, Saul A, et al. Methods for measuring abdominal obesity in the prediction of severe acute pancreatitis, and their correlation with abdominal fat areas assessed by computed tomography. *Aliment Pharmacol Ther*. 2010;32:244-253.
131. Farrell GC, Larter CZ. Nonalcoholic fatty liver disease: from steatosis to cirrhosis. *Hepatology*. 2006;43:S99-S112.
132. Farrell GC, Teoh NC, McCuskey RS. Hepatic microcirculation in fatty liver disease. *Anat Rec (Hoboken)*. 2008;291:684-692.
133. Duane TM, Dechert T, Aboutanos MB, Malhotra AK, Ivatury RR. Obesity and outcomes after blunt trauma. *J Trauma*. 2006;61:1218-1221.
134. Morris AE, Stapleton RD, Rubenfeld GD, Hudson LD, Caldwell E, Steinberg KP. The association between body mass index and clinical outcomes in acute lung injury. *Chest*. 2007;131:342-348.
135. Bochicchio GV, Joshi M, Bochicchio K, Nehman S, Tracy JK, Scalea TM. Impact of obesity in the critically ill trauma patient: a prospective study. *J Am Coll Surg*. 2006;203:533-538.
136. Brown CV, Neville AL, Rhee P, Salim A, Velmahos GC, Demetriades D. The impact of obesity on the outcomes of 1,153 critically injured blunt trauma patients. *J Trauma*. 2005;59:1048-1051; discussion 1051.
137. Matheson PJ, Hurt RT, Franklin GA, McClain CJ, Garrison RN. Obesity-induced hepatic hypoperfusion primes for hepatic dysfunction after resuscitated hemorrhagic shock. *Surgery*. 2009;146:739-747; discussion 747-738.
138. Dickerson RN. Specialized nutrition support in the hospitalized obese patient. *Nutr Clin Pract*. 2004;19:245-254.
139. Choban PS, Dickerson RN. Morbid obesity and nutrition support: is bigger different? *Nutr Clin Pract*. 2005;20:480-487.
140. Dickerson RN. Hypocaloric feeding of obese patients in the intensive care unit. *Curr Opin Clin Nutr Metab Care*. 2005;8:189-196.
141. Dickerson RN, Boschert KJ, Kudsk KA, Brown RO. Hypocaloric enteral tube feeding in critically ill obese patients. *Nutrition*. 2002;18:241-246.
142. Cave MC, Hurt RT, Frazier TH, et al. Obesity, inflammation, and the potential application of pharmaconutrition. *Nutr Clin Pract*. 2008;23:16-34.
143. Hurt RT, Frazier TH, Matheson PJ, et al. Obesity and inflammation: III. *Curr Gastroenterol Rep*. 2007;9:307-308.
144. Hurt RT, Frazier TH, Matheson PJ, et al. Obesity and inflammation: II. *Curr Gastroenterol Rep*. 2007;9:306-307.
145. Hurt RT, Frazier TH, Matheson PJ, et al. Obesity and inflammation: should the principles of immunonutrition be applied to this disease process? *Curr Gastroenterol Rep*. 2007;9:305-306.
146. Ziegler O, Sirveaux MA, Brunaud L, Reibel N, Quilliot D. Medical follow up after bariatric surgery: nutritional and drug issues. General recommendations for the prevention and treatment of nutritional deficiencies. *Diabetes Metab*. 2009;35:544-557.
147. Coupaye M, Puchaux K, Bogard C, et al. Nutritional consequences of adjustable gastric banding and gastric bypass: a 1-year prospective study. *Obes Surg*. 2009;19:56-65.
148. Poitou Bernert C, Ciangura C, Coupaye M, Czernichow S, Bouillot JL, Basdevant A. Nutritional deficiency after gastric bypass: diagnosis, prevention and treatment. *Diabetes Metab*. 2007;33:13-24.
149. Patil SP, Schneider H, Schwartz AR, Smith PL. Adult obstructive sleep apnea: pathophysiology and diagnosis. *Chest*. 2007;132:325-337.
150. Spyropoulos C, Katsakoulis E, Mead N, Vagenas K, Kalfarentzos F. Intragastric balloon for high-risk super-obese patients: a prospective analysis of efficacy. *Surg Obes Relat Dis*. 2007;3:78-83.
151. Genco A, Bruni T, Doldi SB, et al. BioEnterics intragastric balloon: the Italian experience with 2,515 patients. *Obes Surg*. 2005;15:1161-1164.
152. Fogel R, De Fogel J, Bonilla Y, De La Fuente R. Clinical experience of transoral suturing for an endoluminal vertical gastroplasty: 1-year follow-up in 64 patients. *Gastrointest Endosc*. 2008;68:51-58.
152. Moreno C, Closset J, Dugardeyn S, et al. Transoral gastroplasty is safe, feasible, and induces significant weight loss in morbidly obese patients: results of the second human pilot study. *Endoscopy*. 2008;40:406-413.
153. Tarnoff M, Rodriguez L, Escalona A, et al. Open label, prospective, randomized controlled trial of an endoscopic duodenal-jejunal bypass sleeve versus low calorie diet for pre-operative weight loss in bariatric surgery. *Surg Endosc*. 2009;23:650-656.