

Obesity and Economic Environments

Roland Sturm, PhD¹; Ruopeng An, PhD²

This review summarizes current understanding of economic factors during the obesity epidemic and dispels some widely held, but incorrect, beliefs. Rising obesity rates coincided with increases in leisure time (rather than increased work hours), increased fruit and vegetable availability (rather than a decline in healthier foods), and increased exercise uptake. As a share of disposable income, Americans now have the cheapest food available in history, which fueled the obesity epidemic. Weight gain was surprisingly similar across sociodemographic groups or geographic areas, rather than specific to some groups (at every point in time; however, there are clear disparities). It suggests that if one wants to understand the role of the environment in the obesity epidemic, one needs to understand changes over time affecting all groups, not differences between subgroups at a given time. Although economic and technological changes in the environment drove the obesity epidemic, the evidence for effective economic policies to prevent obesity remains limited. Taxes on foods with low nutritional value could nudge behavior toward healthier diets, as could subsidies/discounts for healthier foods. However, even a large price change for healthy foods could close only part of the gap between dietary guidelines and actual food consumption. Political support has been lacking for even moderate price interventions in the United States and this may continue until the role of environmental factors is accepted more widely. As opinion leaders, clinicians play an important role in shaping the understanding of the causes of obesity. *CA Cancer J Clin* 2014;000:000-000. © 2014 American Cancer Society.

Keywords: economic environment, food, diet, physical activity, obesity, body weight, price, policy

Introduction

Obesity, a condition of an excessively high proportion of body fat, is associated with elevated risks of cancers of the breast, colon and rectum, endometrium, esophagus, gallbladder, kidney, pancreas, thyroid, and possibly other cancer types.¹ Obesity is also a risk factor for coronary heart disease, type 2 diabetes, hypertension, stroke, and other chronic illnesses. In the United States, an estimated 34,000 new cases of cancer among men (4%) and 50,500 among women (7%) in 2007 were attributable to obesity, although there is great uncertainty in those estimates.²

Researchers have long recognized that the changes in dietary and physical activity patterns underlying the obesity epidemic were caused by changes in the economic, social, and physical environments that individuals face.^{3,4} Reflecting this view, the American Cancer Society has added recommendations for community action to its guidelines.⁵ Recommended community actions to prevent cancer include increasing access to healthy foods, decreasing the availability of foods of low nutritional value, and developing environments conducive to physically active recreation and transportation.⁵

Although there is no disagreement about the broad goals of preventing obesity, improving diet quality, and reducing sedentary lifestyles, finding effective policy levers remains a challenging task. This includes consideration of political acceptability or such policies will either not be adopted or will be undermined quickly. Denmark imposed a tax on foods high in saturated fats in 2011, only to repeal it in 2012; a planned tax on foods with added sugars was cancelled at the same time.⁶ In the United States, there have been numerous legislative proposals to tax soft drinks or junk food, but to date none has passed.

Various types of environments possibly play a role in the obesity epidemic, and we may classify them into 3 general categories: economic and policy environment (eg, tax, subsidy, direct pricing, serving size regulation, nutrition labeling, etc), social environment (eg, family, school, community, workplace, social norms, mass media, food marketing, nutrition education, etc), and physical environment (eg, urban design, sidewalk, parks, food outlets, exercise facilities, transportation, etc). We focus on the relationship between economic/policy environment and obesity in this review, with brief discussions of

¹Senior Economist, RAND Corporation, Santa Monica, CA; ²Assistant Professor, Department of Kinesiology and Community Health, College of Applied Health Sciences, University of Illinois at Urbana-Champaign, Champaign, IL.

Corresponding author: Roland Sturm, PhD, RAND Corporation, 1776 Main St, PO Box 2138, Santa Monica, CA 90407-2138; sturm@rand.org

DISCLOSURES: Funding provided by the National Institutes of Health and RAND internal funds. The authors report no conflicts of interest.

doi: 10.3322/caac.21237. Available online at cancerjournal.com

other factors. This is only due to the scope of a review article; addressing all areas and their interaction would require a book-length monograph.

Many factors have been suggested as causes: snack food, automobiles, television, fast food, computer use, vending machines, suburban housing developments, portion size, female labor force participation, poverty, affluence, supermarkets, and even the absence of supermarkets (“food desert”). Organizing a multitude of isolated research results and data points into a coherent picture is necessary to assess whether proposed solutions are promising or are likely to lead down a blind alley. As it turns out, some widely held beliefs about societal trends are unambiguously false; others require some qualifications.

This review uses the traditional narrative format, rather than a systematic review or meta-analysis. A systematic review or meta-analysis works best to compile information comprehensively and without bias when there is a well-defined research question addressed by a substantial number of comparable studies. A systematic review becomes less useful for summarizing studies across very different fields of investigation and if the heterogeneity of the studies requires judgment about their contribution.

A general theme throughout this review is that the obesity epidemic was driven by changes in the environment, not by differences in the environment across population groups. However, comparable data across several years, let alone several decades, are rare and therefore research has primarily analyzed environmental differences existing at a point in time. Although this identifies differences between sociodemographic groups, cross-sectional comparisons are not necessarily informative about the causes of an obesity epidemic that occurred over time, nor will they suggest effective policies to change factors behind common trends.

What Can We Learn From Data on Social Trends?

The prevalence of obesity has increased rapidly over the last decades. This increase in prevalence became widely known in the medical literature by the late 1990s.^{7,8} Although it is often thought that the obesity epidemic started in the 1980s or 1990s, increases in body mass index (BMI) have been going on for a much longer time. American children have been gaining excess weight slowly and persistently at least since the 1950s, but possibly earlier.⁹ Data prior to the 1950s are sparse, but regionally limited and socially selective samples of military cadets before nationally representative surveys became available suggest an increasing BMI among young men from the 1920s onward.⁹ For men aged 40 to 49 years, BMI may have increased since about 1900, without evidence of an acceleration in recent decades.¹⁰

It is often believed that the obesity epidemic reflects increasing social disparities or that the largest weight gains are concentrated in groups identifiable by race/ethnicity, income, education, or geography. If true, focusing on cross-sectional environmental differences between subpopulations could reveal environmental factors behind the obesity epidemic and suggest policy levers. This belief, however, is incorrect. Changes in BMI appear to be very similar across all population subgroups, even though the average BMI (and the prevalence of obesity) at any point is highest among groups with lower income and education and among some ethnic minorities. Figure 1 shows BMI trends in the United States by educational level and by race/ethnicity (results are similar when stratifying by other variables). The striking finding is the similarity of increases in BMI across groups. This makes it very unlikely that the obesity epidemic is caused by environmental changes that affect certain sociodemographic subgroups disproportionately. Instead, we interpret those trends as similar environmental changes for all sociodemographic groups.

The trends of BMI gain by sociodemographic characteristics are never perfectly parallel of course. For example, the gap between individuals without a high school education and those with some college closes a bit over time whereas the gap between individuals with some college education and those with a college degree widens. The gap between black and white men has recently narrowed, whereas the gap for women has widened. Women and non-Hispanic black individuals gained weight faster than other groups.¹¹

Nevertheless, temporal changes in the gaps between groups are secondary to the increase that all groups experience over time. It suggests that if we want to understand the role of the environment in the obesity epidemic, we need to understand a bit more of the changes over time affecting all groups rather than differences between subgroups at a given time. Similarly, fighting obesity nationwide needs universal interventions. Targeting selected sociodemographic groups might help to reduce disparities, a laudable goal itself, but it would seem very unlikely to address the much bigger effects that have occurred over time.

This is not a novel insight empirically or conceptually. Empirically, analyses using the National Health and Nutrition Examination Survey from over 30 years found no increase in socioeconomic differentials in self-reported dietary attributes and biomarkers (including objective measures of BMI), but rather that differentials in most outcomes persisted over 3 decades.¹² No changes in the socioeconomic differences of BMI were observed in Finland between 1978 and 2002.¹³ Conceptually, the etiology of conditions needs to address 2 distinct issues: the determinants of individual cases and the determinants of incidence

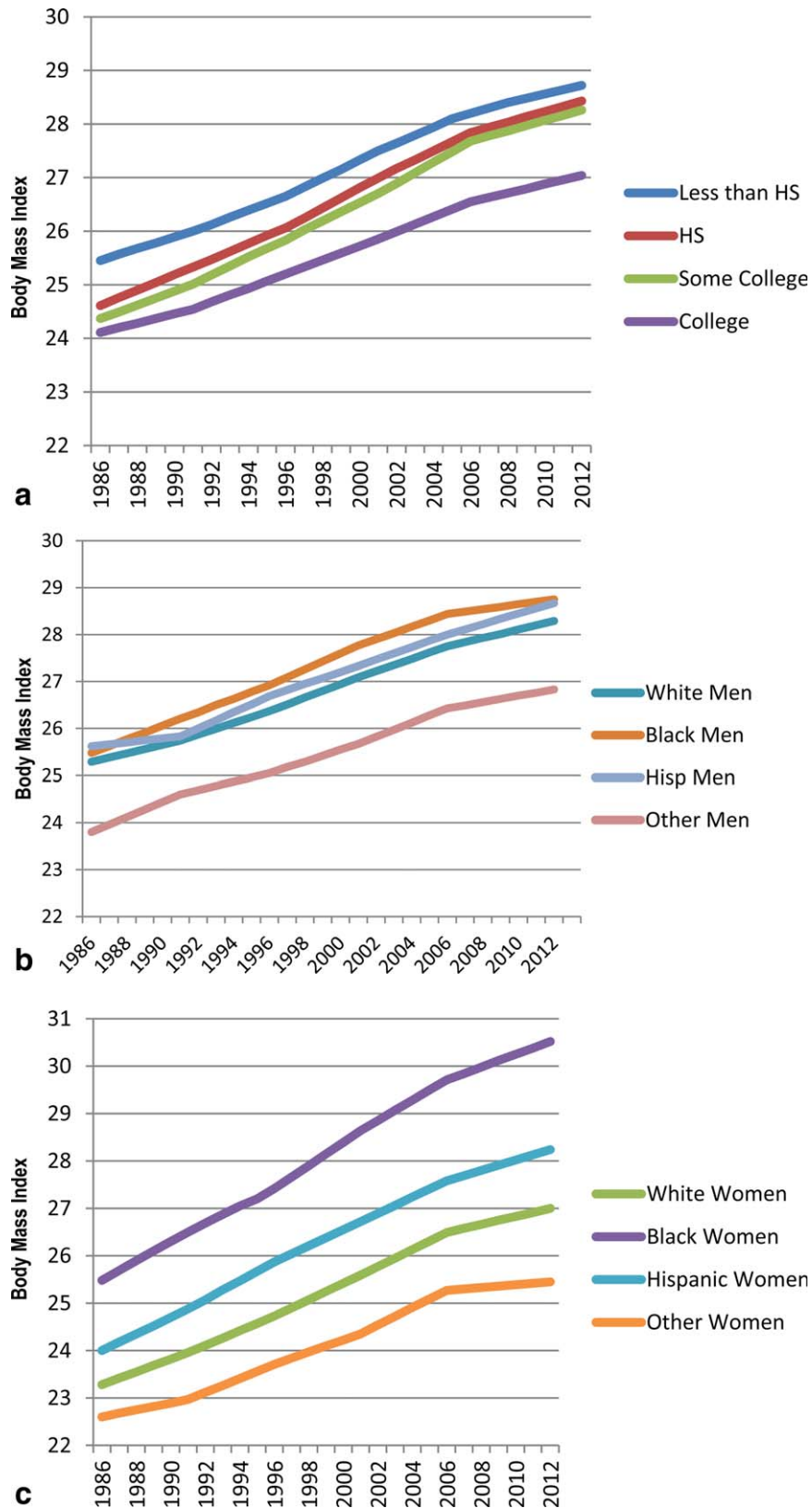


FIGURE 1. Increase in Body Mass Index Over Time Shown by (a) Educational Level, (b) Racial/Ethnic Groups Among Men, and (c) Racial/Ethnic Groups Among Women. HS indicates high school; Hisp, Hispanic. The calculations were based on the Behavioral Risk Factor Surveillance System, with smoothed trends adjusted for 2010 demographics.

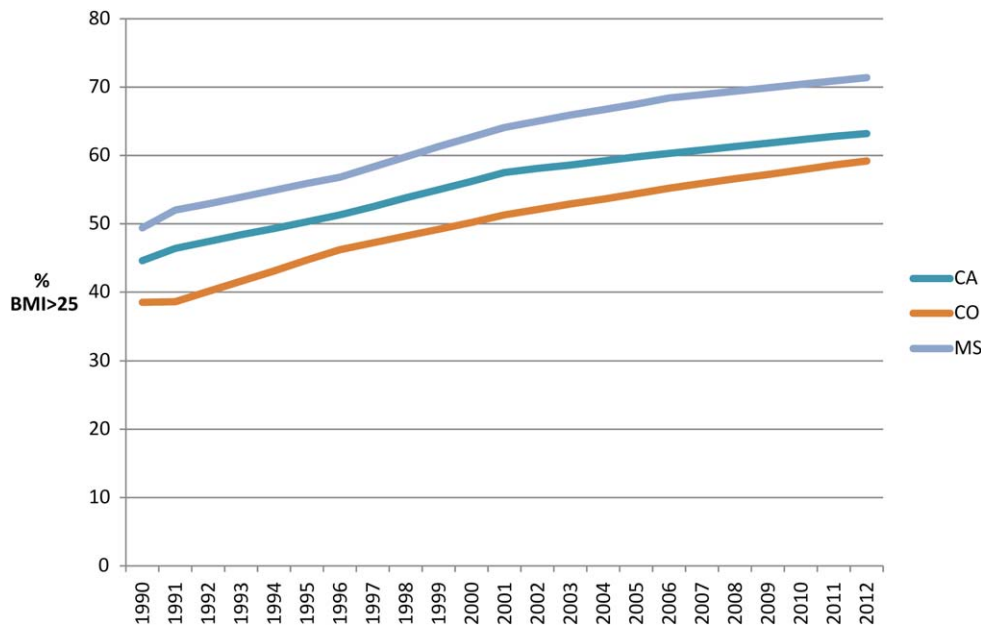


FIGURE 2. Prevalence of Overweight Over Time. BMI indicates body mass index. The calculations were based on the Behavioral Risk Factor Surveillance System, with smoothed trends adjusted for 2010 demographics. CA indicates California; CO, Colorado; MS, Mississippi.

rate, as explained in a now-famous article by Rose.¹⁴ Clinicians are concerned with the causes for individual cases, but the number of cases is driven by the cause of the incidence rate. If the cause of the obesity epidemic is an increasingly obesogenic environment to which all groups are exposed, then a cross-sectional comparison will fail to capture the major driver behind increasing obesity rates. Instead, they identify markers of susceptibility, which in this case are sociodemographic differences in obesity rates at a point in time. Focusing on more vulnerable populations and reducing disparities are important goals in their own right, but they alone are not likely to be sufficient in reversing the obesity trends in the whole population.

What about geographic differences? There is a famous set of maps by the Centers for Disease Control and Prevention that illustrate the changing obesity prevalence by stage since 1985.¹⁵ However, some interpretations of these maps seem to confuse cross-sectional differences with changes over time. A new diet book about the “Colorado diet” includes the following description by the publisher: “Americans are getting fatter. A third of them are now obese—not just a few pounds overweight, but heavy enough to put their health in jeopardy. But, one state bucks the trend. Colorado is the leanest state in the nation, but not because of something in the air or the water.”¹⁶

Figure 2 shows the prevalence of BMIs of over 25 kg/m² (ie, overweight or obese) over time for Colorado (the state with the lowest average BMI or overweight or obesity rates), California, and Mississippi (the state with usually the highest rates). The overweight/obesity rates in Colorado do lag behind those in Mississippi, but we see no evidence of any

“bucking the trend.” Instead, we interpret the data as an indication that Colorado has exactly the same experiences as Mississippi, just delayed by slightly more than a decade.

Conventional wisdom is an unreliable guide, and therefore we need to take a careful look at the (relatively limited) data about social trends. The American Cancer Society’s guidelines echo common beliefs by claiming, for example, that “longer workdays. . . reduce the amount of time available for the preparation of meals” or “reduced leisure time contribute[s] to reduced levels of physical activity.”⁵

However, one of the most consistent trends over the past half century has been a reduction in work hours, and an increase in leisure or free time and time spent in transportation.^{17,18} Leisure time has seen a large increase since 1965 (Fig. 3).¹⁹ Occupation and productive activities at home (cooking, cleaning, repairing things, and childcare) have diminished to make room for this. Thus, increasing weight has been accompanied by increased rather than decreased leisure/free time. Women spend more time in the labor force than before, but that is more than offset by declines in home production (eg, cooking, cleaning, childcare). The increase in free time and in transportation time also occurs in all population groups, even if there are differences at any point in time (in particular, men have always had more free time than women when household activities are factored in). This trend is brought about by the changes in the economic and technological environment that reduces the need for work (which includes unpaid work at home).

Figure 3 shows trends by linking different surveys that were conducted prior to 2000. In 2003, the Bureau of Labor Statistics started an annual time use survey and

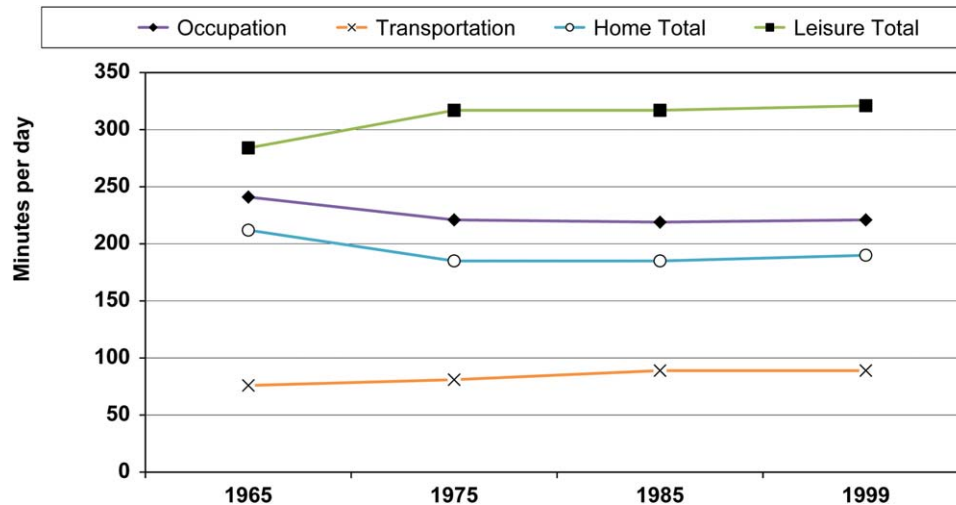


FIGURE 3. Trends in Time Use Among US Adults. Source for 1965 through 1985: Robinson JP, Godbey GG. *Time for Life: The Surprising Ways Americans Use Their Time*. 2nd ed. University Park, PA: Pennsylvania State University Press; 1999¹⁷ as well as the authors' calculations using Family Interaction, Social Capital, and Trends in Time Use (FISCT) 1999.

Bureau of Labor Statistics publications confirm that the trends shown in Figure 3 have continued. In 2012, people spent 10 minutes less on (paid) work and related activities and 24 minutes less on (nonpaid) household activities and caring for children than in 2003. In contrast, people watched 15 minutes more of TV, participated 4 more minutes in active sports/exercise, and slept or napped 10 minutes more in 2012 than in 2003.¹⁹

Another persistent myth is that Americans are exercising less. In reality, there has been a consistent increase in active sports or walking/hiking, reflected both in time use data, expenditures on active sports activities (gyms, sports clubs, and equipment), and the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance system (BRFSS) surveys. The BRFSS has demonstrated a consistent decline in sedentary behavior. The percentage of people reporting at least 30 minutes of moderate activity on 5 or more days or 20 minutes of vigorous activity on 3 or more days per week increased from 46% in 2001 to 51% in 2009 (the median state rate in the BRFSS). Self-report is known to exaggerate actual levels of activity (just as self-reported height and weight understates actual BMI), but it nevertheless indicates an increase in activity levels. The American Time Use Survey showed an increase of 4 minutes between the first year it was conducted (2003) and the latest year for which data are available (2012).¹⁹ Obviously, only a rather small part of the increased free time went into active leisure. Leisure-time physical activity is only one component of total physical activity and how total physical activity has changed depends also on labor force and home production as well as transportation patterns.

Transportation is part of everyday life, not only to get to work but also to run (or drive) errands, go out for dinner, or see friends. It could also be a key factor of changes in physical

activity because small shifts in travel modes noticeably alter energy expenditure. Adults spend over 10 hours per week traveling, more than ever before, split about equally into transportation related to occupation (work commute), home activities (child care/shopping/personal care), and leisure-time activities. Transportation time, together with leisure time, has increased at the expense of occupation and household activities.

These social trends themselves do not identify the linkage between the environment and obesity, but they indicate that several popular ideas about causes of the obesity epidemic are misleading. Weight gain has not been concentrated among specific sociodemographic groups nor in particular geographic areas, and therefore we have to look for environmental changes that are similar for all groups rather than search for existing environmental differences. The obesity epidemic occurred as leisure time increased, and therefore it is not a result of reduced leisure time. In addition, even though many and possibly most Americans fall short of physical activity recommendations, leisure-time physical activity has increased rather than fallen during the obesity epidemic. To understand the obesity epidemic, rather than asking a question such as "Why are people in Colorado thinner than people in Mississippi?" we need to ask why are people in Colorado gaining weight at the same rates as people in Mississippi?

Economic Environment

It has been argued that the obesity epidemic is primarily a story of economics and technology and we largely agree with this view.^{20,21} Food systems in developed countries have been extraordinarily successful in ensuring a plentiful food supply. The major issue in developed and medium-income countries (such as Brazil) is obesity, rather than a shortage of food (except for those at the lowest income

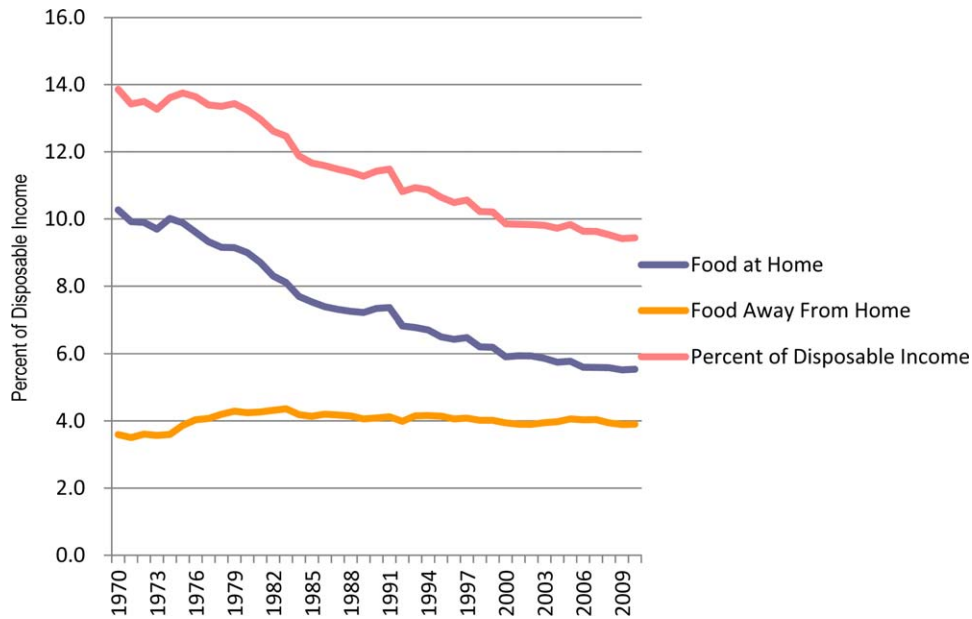


FIGURE 4. Food Expenditure as Percentage of Disposable Income. Source: Economic Research Service of the United States Department of Agriculture, Prices and Expenditures.

level), which was experienced even in countries like the United States or in Western Europe less than a century ago. The problem of food shortage has shaped agricultural policies. Worldwide, hunger and malnutrition remain very real and affect around 870 million people, primarily in sub-Saharan Africa and South Asia.²²

Americans now have the cheapest food in history when measured as a fraction of disposable income. In the 1930s, Americans spent one-quarter of their disposable income on food, dropping to one-fifth in the 1950s. Figure 4 shows the trend since 1970 and the share is now under one-tenth of disposable income (Fig. 4). In contrast, approximately one-quarter of income is spent on food in medium-income countries such as Mexico and Turkey (comparable to the share of food expenditure in the 1930s in the United States). In places such as Kenya or Pakistan, food expenditures consume on average almost one-half of the disposable income.

The share varies across income groups of course, and is higher than the average for lower-income groups in every country. For the bottom-income quintile in the United States, food expenditures account for about one-third of disposable income.

Along with the real decrease in food cost, per capita food availability has increased. Consequently, this smaller share of disposable income now buys many more calories (Fig. 5).

The decline of food expenditures relative to income becomes even more dramatic when one factors in “quality” improvements,²¹ including greater convenience, reduced time costs for preparation, variety, and ubiquitous availability of food. These changes have value to consumers. Married women outside the labor force spent more than 2 hours per day preparing meals and cleaning up in the 1960s; 30 years later, they spent one-half that amount of time. Greater convenience, reduced time costs of obtaining

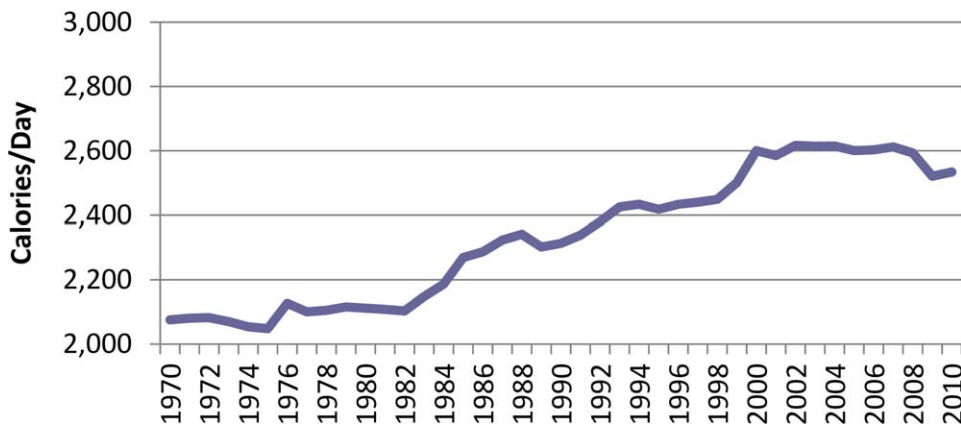


FIGURE 5. Average Daily Per Capita Calories Adjusted for Waste. Source: Economic Research Service of the United States Department of Agriculture Food Availability (Per Capita) Data System.

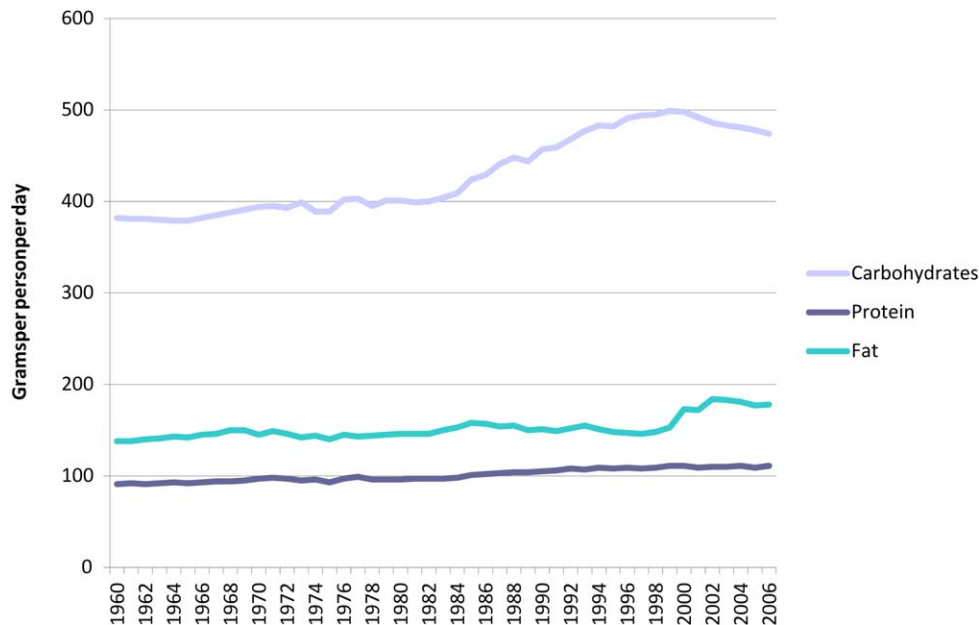


FIGURE 6. Change in Macronutrients During the Obesity Epidemic. Source: United States Department of Agriculture Center for Nutrition Policy and Promotion [data update February 1, 2012].

meals, and increased accessibility lead to increased food consumption and possibly have been the major causes behind weight gain since the 1980s.²⁰

Regarding macronutrients, the most noticeable change was an increase in carbohydrates, especially during the 1980s (Fig. 6). Although high-fructose corn syrup became popular as a low-cost sweetener, it accounts only for a small part of the carbohydrate increase, and therefore there is no obvious economic/technological reason that drove this development. There could be reasons in the social environment, possibly the combination of widespread interest in a low-fat diet and the food industry's response of reduced fat products. After 2000, carbohydrates declined while fat availability increased. Again, this might be a reflection of changes in the social environment driving demand, possibly the popularity of Atkins-like diets, rather than changes in the economic or policy environment affecting food supply. The demand effects of fad diets can be very large even though there is no reliable way of tracking them. The most commonly quoted numbers come from a consulting firm and suggest that at the peak of the Atkins diet boom (late 2003 to early 2004), about 9% of all adults were following the diet and 17% had tried it. By the end of 2004, the number of people following the diet dropped to 2% (which still would be approximately 5 million American adults) and Atkins Nutritionals Inc filed for bankruptcy one year later.^{23,24}

The general tenor in public debates is that diet quality has deteriorated through a shift toward "junk food," that cross-sectional disparities in obesity rates are caused by a lack of access to "healthy food," or that "healthy food" has become too expensive. Americans eat fewer fruits and vegetables than recommended by dietary guidelines, current

production would be insufficient to achieve guideline consumption, and individuals who eat more fruits and vegetables tend to be thinner, all of which are true. However, preventing obesity is not about eating more food, regardless of how many nutrients it provides, but consuming less energy or expending more. Regardless of the coming and going of nutritional fads, fruit and vegetable consumption has increased, not fallen, while obesity rates increased. Figure 7 shows the increase in the availability for fresh produce over the last 40 years (a 27% increase in fresh fruit and a 21% increase in fresh vegetables per capita from 1970 to 2010). Total produce (which includes frozen and canned products) has increased similarly, by approximately 80 pounds per capita. Foods that increased above average include broccoli, cauliflower, tomatoes, onions, apples, bananas, and grapes. In contrast, there was a net decline in per capita potato consumption. Admittedly, analysis of aggregate data has limitations on potential confounding issues (a classic example of the Simpson paradox). However, individual-level food consumption surveillance data are much narrower with regard to time coverage. Nevertheless, data from the BRFSS have suggested the frequency of fruit and vegetable consumption remained relatively stable between 1994 and 2005 whereas small increases were found for men aged 18 to 24 years and for women who were aged 25 to 34 years, non-Hispanic African American individuals, and nonsmokers.²⁵

Because most Americans still fall short of the recommended intake of fruits and vegetables, additional increases could be desirable to improve diet quality, but it is much more questionable that this would reduce obesity. In experimental settings and weight loss programs, low

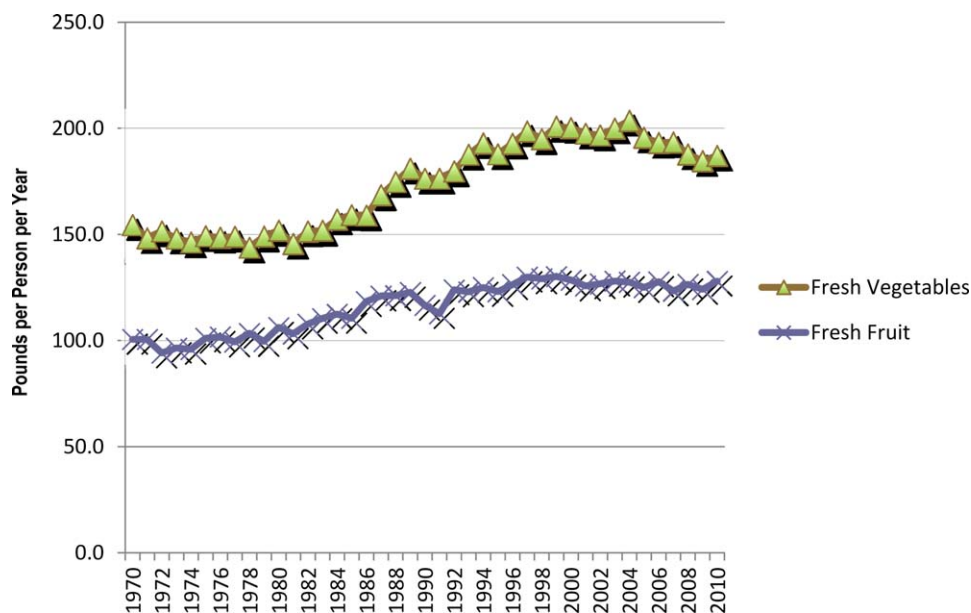


FIGURE 7. Availability of Fresh Fruit and Vegetables Has Increased (Pounds per Capita). Source: Economic Research Service of the United States Department of Agriculture [data last updated February 1, 2012].

energy-dense foods are promising, and therefore fruits and vegetables can be effective because they substitute for more energy-dense foods.^{26,27} However, it is questionable that the substitution has taken place at the population level because the widening of waistlines coincided with increased fruit and vegetable consumption. In fact, coinciding with the increase in fruit and vegetable intake over time, the percentage of adult sugar-sweetened beverage (SSB) drinkers increased from 58% to 63%, per capita consumption of SSB increased by 46 kilocalories per day, and daily SSB consumption among drinkers increased by 6 ounces from 1988 to 2004.²⁸ Thus, the idea that the increasing availability of fruits and vegetables in isolation leads to less energy intake is most likely just wishful thinking.²⁹

There are many theories about obesity and even contradictory hypotheses can be correct if they apply to different situations, just as public health and clinical perspectives differ. Eventually, it is an empirical question what the primary effects are and whether there are special situations in which other considerations apply. We want to contrast the 2 most prominent hypotheses and their empirical evidence.

The first hypothesis is the basic economic argument that individuals consume more when their income increases or prices fall.^{20,21,30} Moreover, the “full” price is not just money, but also the time and effort it takes to obtain it. The full price of a home-prepared meal includes not just ingredients but travel to the store, time preparing the food, and time cleaning up. As food becomes relatively cheaper, there is constant access, and individuals become wealthier (all of which occurred in the past 50 years), the simple economic theory predicts that obesity rates should increase.²¹ The basic economic effect is strengthened by natural bio-

logical and psychological factors (ie, that increased portion size, food visibility, and salience of food can stimulate the desire to eat more).³¹ Moreover, individuals are often unaware of the amount of food they have eaten or of the environmental influences on their eating, and therefore the reduced economic constraints on consumption can have a larger effect than just a price effect for intentional purchases. This seems very consistent with the longitudinal data and the public health concept that the causes of the changing prevalence of obesity are environmental changes that affect all groups.

There is a set of related alternative hypotheses that recently received much media attention as a possible cause of the obesity epidemic and that make essentially the opposite argument, in particular that low income or high food prices or limited access to food outlets (“food deserts”) cause obesity. Drewnowski and Specter proposed what arguably is the most compelling hypothesis among that set.^{32,33} They argued that the lowest-cost options to obtain a given amount of energy from food is through an energy-dense diet composed of refined grains, added sugars, and fats. The high energy density and palatability of sweets and fats increase energy intake. Lower-income individuals tend to spend less on food overall and specifically less on lower energy-dense (but more costly) foods such as fruits and vegetables. The high energy density and palatability of sweets and fat drive up caloric intake. A related argument was made in a clinical case report of an obese 7-year old girl by Dietz.³⁴ Dietz argued that the increased fat content of food eaten during times when the family had insufficient income to buy a healthy diet was the primary reason, but offered as an alternative hypothesis that obesity is an adaptive response to

episodic food insufficiency. Using the terminology introduced to public health by Rose,¹⁴ these ideas seem to be more consistent with the concept of “causes of cases,” (ie, they may identify individual risk factors in cross-sectional data) than with “causes of incidence.” According to a recent review of different variants of the “scarcity” hypothesis, its major shortcomings lie in the inconsistency with time trends in United States as well as international data.³⁵ More disconcertingly, even its relevance for cross-sectional differences is limited because it only appears to apply to women (obesity rates vary more than 2-fold by income level) but not men (there is no income gradient, only an education gradient).³⁶

The economic and technological environment also affects physical activity. Digging trenches by hand or cutting wood without power tools may expend much energy, but are not a desirable use of time. Increased mechanization and a resulting shift of jobs from agriculture to industry and eventually to services meant that instead of being paid for expending energy as part of a job, individuals now have to budget time for leisure-time exercise.

Although the economic environment historically has had a large impact on utilitarian physical activity (eg, activity for work or transportation rather than leisure), there are 2 reasons why it is a less plausible explanation for the obesity epidemic. First, the largest changes due to motorization precede the obesity epidemic by decades and are primarily a phenomenon of the first one-half of the 20th century. US macronutrients data even demonstrate a decline primarily in carbohydrate consumption from 1910 to approximately 1960, indicating that people actually consumed fewer calories, presumably because energy needs for daily activities declined. Second, occupation-related changes in physical activity should have affected mainly individuals in the labor force, but weight changes have been similar across groups regardless of employment status and the obesity epidemic affected children as well. Increased mechanization/motorization is not limited to changes in the labor market, but also affects household tasks such as gardening, cleaning, or washing. However, the timing of the diffusion of those labor-saving devices for household production also seems to precede the obesity epidemic. Electric service was almost universal by 1950 and the diffusion of household washing machines peaked in 1980 (and has dropped since).

A more recent change in technology that appears to fit the timing better has been electronics, which led to an explosion in the supply and variety of passive entertainment and communication options, and sedentary behavior and screen time have been well documented to contribute to very low energy expenditure, obesity, and many other illnesses.³⁷⁻³⁹ Video cassette recorders, already an obsolete entertainment technology by now, diffused rapidly during the 1980s. Video cassette recorders had been adopted by the majority of households within a decade after the first VHS format player was intro-

duced in 1976. A rapid flow of new entertainment options competes with more active recreation activities. Electronic communication may even make jobs more sedentary than before as the personal computer (in the 1980s) and later the Internet (in the 1990s) became available. The consequences of these changes on physical activity are too subtle to be measurable, even if they could contribute to energy imbalance.

Built Environment

The economic and built environment are inextricably linked. Some general trends for built environments are well known and could have led to higher obesity rates. This includes urbanization; increased personalized transportation; and some features of “urban sprawl,” characterized by developments with lower population density than traditional cities and the separation of residential, shopping, and business areas. This type of development increases dependence on automobiles for transportation and increases commuting distances, a trend observed in Europe just as much as in the United States.

Plausible pathways exist through which built environments can affect health.⁴⁰ However, the evidence is almost exclusively cross-sectional, which may or may not be relevant to explaining changes over time, and the results are much more ambiguous and fragile than typically presented in the media. The research literature tends to fall into 2 different areas with surprising little overlap.

The first area focuses on urban design and initial studies found correlations between built environments and obesity and chronic conditions related to lack of physical activity.^{41,42} Since then, much more research has been conducted and several systematic reviews have examined the empirical evidence of the influence of the built or physical environment on the risk of obesity.⁴³⁻⁴⁷ However, study results are rather mixed and at times contradictory, leading reviewers to conclude that “few consistent findings emerged,” that “findings were inconsistent and mixed across studies,”⁴⁶ and that “the great heterogeneity across studies limits what can be learned from this body of evidence.”⁴⁵

Although evidence of a causal relationship between characteristics of the built environment and obesity is weak, findings for an association between the built environment and physical activity seem more consistent.^{48,49} Access to a mix of local recreational and nonrecreational destinations (eg, cafes, grocery stores, food stores, other retail services, and schools) is positively associated with transportation and leisure walking.^{48,50} For children, the most supported correlates of physical activity were walkability, traffic speed/volume, access/proximity to recreation facilities, land-use mix, and residential density; for adolescents, the most supported correlates were land-use mix and residential density⁵¹; and for adults, there is consistent evidence that better access to

relevant neighborhood destinations (eg, local stores, services, and transit stops) can be conducive to utilitarian walking.⁵² There is some, although weaker, evidence suggesting that the availability of sidewalks and well-connected streets can facilitate utilitarian walking.⁵² Built environments that incorporate diverse housing types, mixed-land use, housing density, compact development patterns, and accessible open space were associated with increased levels of physical activity, primarily walking.⁴⁷ Associations with other forms of physical activity were less common and there was no apparent impact on body weight.⁴⁷

The second area of research centers focused on food availability, in particular the concept of a “food desert.” The US Department of Agriculture originally defined an urban “food desert” as a census tract in which a significant number of residents live more than one-half mile or 1 mile away from a supermarket. Conventional wisdom holds that obesity rates are higher in such “food deserts” because people shop for groceries at small stores with limited or no selection of attractive healthy foods. Indeed, densely populated low-income neighborhoods tend to have fewer large supermarkets. This argument was cited in the American Cancer Society’s guidelines on nutrition and physical activity for cancer prevention.⁵

The evidence may be weaker than commonly thought. Recent research could not confirm the claims that distance to supermarkets predicts obesity or even diet quality.⁵³⁻⁵⁶ Across numerous studies, distance to various types of food stores demonstrated no relationship to dietary outcomes.⁵⁶ The only study that evaluated the impact of opening a new supermarket in a “food desert” found that this did not lead to changes in reported fruit and vegetable intake or BMI.⁵⁷ Proximity to the nearest supermarket had no impact on obesity rates in the Seattle Obesity Study, which also examined shopping patterns and found that only one in 7 respondents reported shopping at the nearest supermarket and the other 6 instead did their grocery shopping further away.⁵³

Equating the absence of a supermarket with an unhealthy food environment or a “food desert” is a unique US concept. Elsewhere, the growth of supermarkets has been deplored as reducing access to fruits and vegetables and even increasing prices for fresh produce.⁵⁸ Supermarkets are very efficient at supplying a wide range of brands (think about cereal or soft drink aisles). In the United Kingdom and Australia, “fruiterers and greengrocers” have been the traditional source for fresh produce, not supermarkets.

Policy Approaches

Obesity is a consequence of long-term changes in the environment that cannot easily be reversed, although policies can certainly be used to “nudge” people toward healthier (and maybe even smaller) diets and more active lifestyles, including suggestions for taxes on soft drinks or fast food

or subsidies for healthier foods or sports activities. There are also structural policies that do not influence health-related behaviors directly but are more upstream in that they alter characteristics of the food and built environment over the long run. An example would be production-linked payments to farms that led to the overproduction of staples in many countries, mortgage tax deductions in the United States that have contributed to urban sprawl, or transportation policies favoring individualized motorized transport almost everywhere.

Taxes and subsidies are obvious policy instruments to incentivize consumers to improve their food and beverage consumption patterns and related health outcomes. There has been a long history of price manipulation in food markets, but not with the goal of preventing obesity or improving diet quality. Traditional goals of agricultural and food policy have been self-sufficiency, national security, viability of rural communities, reducing hunger and food insecurity, and occasionally preservation and heritage (an important theme in France, for example). In more recent years, biodiversity, sustainability, environmental protection, food safety, and balanced diets have received some consideration, but policy change is slow. Every food system is multifunctional, which means it also creates outputs that are not traded on markets, whether they are positive (cultural heritage, food security) or negative (antibiotic resistance, water pollution), and this multifunctionality has shaped food policy.⁵⁹

Health groups worldwide have started to call for agricultural policies to adopt dietary goals, such as intake of saturated fats, sugar, or salt or the underconsumption of vitamins or minerals. The argument is that primary food production and processing stages can influence nutritional quality and the structural determinants of food choices, including availability and price. The US is not unusual in that the policies in traditional farm bills have become dysfunctional given today’s challenges, nor in the slow change to adapt to new challenges. In Europe, production-based payments to farmers led to the overproduction of staples as well, which then were dumped on the world market or occasionally even on the home market. Germany held annual holiday surplus sales of “Christmas butter” until the 1980s. Even though the European Commission in 2010 expressed an intention to include dietary goals in the common agricultural policy, the only nontraditional goal in the 2013 political agreement on new directions for the common agricultural policy has been to promote sustainability and combat climate change.⁶⁰

In the United States, the traditional policy approach was to spur production of commodity crops and the production-led agricultural policy was very successful in producing cheap calories.⁶¹ Since 1974, the US Department of Agriculture implemented a federal policy that incentivized commodity farmers to produce as much as possible, which resulted in a

massive overproduction of corn and soybeans. Not surprisingly, their relative price plunged and the government intervened by heavily subsidizing large-scale farmers to compensate for their loss, thus creating another round of overproduction and forming a vicious cycle. Consumers at the end of the food supply chain responded to the price drop for corn flour, corn syrup, soybean oil, etc and increased their consumption noticeably. From 1970 to 2007, among Americans' grain intake, calories from corn led the way with a 191% increase, and added sugar intake from corn sweetener rose by 359%. Due to the extreme complexity of the US agricultural system, which evolved over decades and promoted obesity, simply limiting or eliminating farm subsidies to commodity farmers is unlikely to be a quick fix.⁶¹ The 2014 Farm Bill made several steps in that direction, such as ending more than 15 years of crop programs that made payments to producers based on historical production.⁶² Although the farm bill represents approximately \$1 trillion over the next decade, 80% of the funds are for nutrition programs, primarily supplemental nutrition assistance (previously known as food stamps).

Whether altering the costs of nutritionally less desirable foods versus "healthier" choices through pricing policies closer to the consumer end could change food consumption patterns and overall diet enough to significantly reduce population weight outcomes remains unclear. For some subgroups, price changes are more likely to have a measurable effect on weight outcomes, including youth, members of low socioeconomic populations, and those at risk of becoming obese.⁶³ In areas with lower fruit and vegetable prices, children consume more fruits and vegetables and gain less excess weight over time.⁶⁴⁻⁶⁶ Generally, however, the demand for most types of food is inelastic, which means that even large price changes only result in a moderate demand response.⁶⁷ The exception might be SSB, in which demand may change proportional to price changes, but even in this case, large taxes would be needed to have noticeable effects on body weight.^{63,68}

Attempts to raise taxes on nutritionally less desirable foods, such as SSB, have been unsuccessful in the United States to date. The most recent law was passed in Mexico in 2013. Although primarily a measure to reduce the budget deficit, curbing unhealthy consumption habits was an explicit goal and the soft drink and food industries lobbied heavily in an attempt to defeat the plan. Since January 2014, soft drinks are taxed one peso per liter (approximately 8 cents) and there is an 8% tax on high-calorie snack foods, including chocolates, sweets, ice cream, chips, puddings, and processed foods based on cereals.

Denmark imposed a tax on saturated fat in 2011, but that tax was rescinded the following year and a planned sugar tax was shelved at the same time.⁶ In 2011, Hungary introduced a tax on foods with high fat, sugar, and salt con-

tents, whereas France introduced a "soda tax" on SSB in 2012.⁶⁹ No data are yet available on the effects of any of these policies.

Subsidizing healthier foods can increase the purchase and consumption of subsidized products, but inelastic demand means that changes in consumption will be smaller than price changes. A typical magnitude is observed in an intervention in South Africa, in which a 25% rebate on healthy foods led to an 8.5% increase in the share of purchases of fruits and vegetables and a drop of 7.2% in the share of nutritionally less desirable foods.⁷⁰

Based on empirical evidence and expert opinion, 3 recommendations have been supported by a broad group of health economists in the obesity area⁷¹: 1) incorporate health impact assessments to review agricultural policies so that they do not have a deleterious impact on population rates of obesity; 2) implement a tax on SSB; and 3) examine how to implement fruit and vegetable subsidies targeted at children and low-income households. It is unrealistic to expect those measures to be a quick and easy fix for the obesity epidemic, but at least they appear to be a step in the right direction.

From a policy perspective, it is less obvious what economic instruments can do to promote physical activity directly and clear policy recommendations cannot be made at this time.⁷¹ Most physical activity takes place in natural environments, not gyms, and does not need to be a purposeful exercise session. Walking for leisure is the most common activity people engage in and transportation walking also accounts for a substantial share of physical activity.⁷¹ Policy levers to affect physical activity are therefore more likely to be found in the built environment, rather than by providing subsidies for gyms. This is different from the food policies in which taxes and subsidies can more directly influence consumption.

The design of built environments provides an opportunity, but also a challenge. Once in place, built environments can provide a sustainable strategy for physical activity. Neighborhoods are especially important as the majority of physical activity, including walking, occurs there. However, if they are poorly designed and discourage physical activity, remodeling or rebuilding is extremely costly and time-consuming.

Discussion

Changes in dietary and physical activity patterns are driven by changes in the environment and by the incentives that individuals face. Many factors have been suggested as causes of the "obesity epidemic." Forming a multitude of isolated data points into a coherent picture is a challenging task, but is necessary to assess whether proposed solutions are promising or likely to lead down a blind alley. Conventional wisdom tends to be a very unreliable guide and as the

data in this review show, some widely held beliefs about obesity and environments have little evidence in their favor, and some are contradicted by the data.

The obesity epidemic is a phenomenon over time. BMI has increased similarly in different sociodemographic groups, suggesting that the same environmental changes impact all social groups. There are disparities in obesity prevalence across groups at every point in time, but reducing health disparities is different from addressing the obesity epidemic.

The obesity epidemic has been fueled by historically low food prices relative to income. Americans are spending a smaller share of their income (or corresponding amount of effort) on food than any other society in history or anywhere else in the world, yet get more for it. Although the prices for prepared foods (which are more commonly high in refined carbohydrates or fat) have become particularly cheap, fruits and vegetables are now more widely available than ever, and consumption has increased rather than declined during the obesity epidemic. There appears to be reasonable evidence that weight outcomes are responsive to food and beverage prices, although (politically feasible) food taxes and subsidies may not do much more than “nudge” individuals toward healthier (and maybe even smaller) diets.

The built environment has received much attention, but strong evidence only emerges for physical activity. The association with obesity or even just diet behavior is tenuous, most likely because the link between neighborhood stores and shopping has been weakened in a mobile society. A limitation is that the evidence regarding the effects of built environments on obesity, diet, and physical activity comes primarily from cross-sectional data. The contribution of long-term changes in built environments, including the increased dependence on cars, on obesity may very well be different than the current (minor or nonexistent) association in cross-sectional data.

Examining time trends for which there are data, what jumps out are changes in food availability, in particular the

increase in caloric sweeteners and carbohydrates. Average daily discretionary calories from salty snacks, cookies, candy, and soft drinks now exceed the discretionary calories recommended in the Dietary Guidelines for energy balance and essential nutrients and the ratio of consumed to recommended discretionary calories is a significant predictor of BMI in the population.¹⁸

It is true that individuals still do not eat as many fruits and vegetables as dietary guidelines recommend. But if people had access to more produce or cheaper produce, or just ate more of it, would they eat less candy and be thinner? Probably not. More variety means more eating, not less; outside clinical settings, there is limited evidence that people substitute; and as far as obesity is concerned, juice is not that different from soda in terms of energy content. Separately, some research also indicates that fruit juice has a less beneficial effect on health compared with whole fruit and might even increase the risk of obesity and type 2 diabetes.⁷²⁻⁷⁴ The 2009 report by the Institute of Medicine on food deserts also points to total consumption: “greater fruit and vegetable consumption alone will not reduce weight without the qualification to moderate energy intake.”⁷⁵ The unaffordability of healthy food may not be the problem as far as obesity is concerned; it is the excess availability and affordability of all types of food. Effective policy interventions must address the need to reduce calories in the diet and replace calorie-dense foods with fruits and vegetables, rather than just add fruits and vegetables to the diet.

Many policy interventions are focusing on “positive” approaches or messages, such as increasing fruit and vegetable consumption and increasing physical activity. However, an emphasis on reducing discretionary calorie consumption, particularly SSBs and salted snacks, may be a promising lever to reduce overweight and obesity. The majority of adults exceed the amount of recommended discretionary calories for energy balance. Although increasing fruit and vegetable consumption may be a laudable goal for other health reasons, it is unlikely to be an effective tool for obesity prevention. ■

References

- Giovannucci E, Harlan DM, Archer MC, et al. Diabetes and cancer: a consensus report. *CA Cancer J Clin.* 2010;60:207-221.
- National Cancer Institute. Obesity and Cancer Risk. cancer.gov/cancertopics/factsheet/Risk/obesity. Accessed December 10, 2013.
- Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science.* 2003;299:853-855.
- Institute of Medicine. Preventing Childhood Obesity: Health in the Balance. Washington, DC: Institute of Medicine; 2004.
- Kushi LH, Doyle C, McCullough M, et al; American Cancer Society 2010 Nutrition and Physical Activity Guidelines Advisory Committee. American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA Cancer J Clin.* 2012;62:30-67.
- Stafford N. Denmark cancels “fat tax” and shelves “sugar tax” because of threat of job losses. *BMJ.* 2012;345:e7889.
- Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960-1994. *Int J Obes Relat Metab Disord.* 1998; 22:39-47.
- Mokdad AH, Serdula MK, Dietz WH, Bowman BA, Marks JS, Koplan JP. The spread of the obesity epidemic in the United States, 1991-1998. *JAMA.* 1999;282:1519-1522.
- Komlos J, Breitfelder A, Sunder M. The transition to post-industrial BMI values among US children. *Am J Hum Biol.* 2009;21:151-160.
- Costa D, Steckel R. Long-Term Trends in Health, Welfare, and Economic Growth in the United States. Chicago: University of Chicago Press for National Bureau of Economic Research; 1997.
- Truong KD, Sturm R. Weight gain trends across sociodemographic groups in the United States. *Am J Public Health.* 2005;95:1602-1606.
- Kant AK, Graubard BI. Secular trends in the association of socio-economic position with

- self-reported dietary attributes and biomarkers in the US population: National Health and Nutrition Examination Survey (NHANES) 1971-1975 to NHANES 1999-2002. *Public Health Nutr.* 2007;10:158-167.
13. Prattala R, Sippola R, Lahti-Koski M, Laaksonen MT, Mäkinen T, Roos E. Twenty-five year trends in body mass index by education and income in Finland. *BMC Public Health.* 2012;12:936.
 14. Rose G. Sick individuals and sick populations. *Int J Epidemiol.* 1985;14:32-38.
 15. Center for Disease Control and Prevention. Overweight and Obesity. cdc.gov/obesity/index.html. Accessed March 10, 2014.
 16. Hill JO, Wyatt H, Aschwanden C. State of Slim: Fix Your Metabolism and Drop 20 Pounds in 8 Weeks on the Colorado Diet. Emmaus, PA: Rodale; 2013.
 17. Robinson JP, Godbey GG. Time for Life: The Surprising Ways Americans Use Their Time. 2nd ed. University Park, PA: Pennsylvania State University Press; 1999.
 18. Sturm R. Stemming the global obesity epidemic: what can we learn from data about social and economic trends? *Public Health.* 2008;122:739-746.
 19. Bureau of Labor Statistics. American Time Use Survey: Time Spent in Detailed Primary Activities, and Percent of the Civilian Population Engaging in Each Detailed Activity Category, Averages Per Day By Sex [Table A1]. Washington, DC: Bureau of Labor Statistics; 2013.
 20. Cutler DM, Glaeser DL, Shapiro JM. Why have Americans become more obese? *J Econ Perspect.* 2003;17:93-118.
 21. Variyam JN. The price is right: economics and the rise in obesity. *Amber Waves.* 2005; 3:20-27.
 22. Food and Agriculture Organization of the United Nations. The State of Food Insecurity in the World. Rome: Food and Agriculture Organization of the United Nations; 2012.
 23. NPD Group. NPD's New Dieting Monitor Tracks America's Dieting Habits [press release]. May 3, 2004.
 24. Kaufman W. Atkins Bankruptcy a Boon for Pasta Makers. npr.org/templates/story/story.php?storyId=4783324. Accessed March 10, 2014.
 25. Blanck HM, Gillespie C, Kimmons JE, Seymour JD, Serdula MK. Trends in fruit and vegetable consumption among U.S. men and women, 1994-2005. *Prev Chronic Dis.* 2008;5:A35.
 26. Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. *J Am Diet Assoc.* 2005;105(5 suppl 1):S98-S103.
 27. Williams RA, Roe LS, Rolls BJ. Assessment of satiety depends on the energy density and portion size of the test meal. *Obesity.* 2014;22:318-324.
 28. Bleich SN, Wang YC, Wang Y, Gortmaker SL. Increasing consumption of sugar-sweetened beverages among US adults: 1988-1994 to 1999-2004. *Am J Clin Nutr.* 2009;89:372-381.
 29. Cohen DA, Sturm R, Scott M, Farley TA, Bluthenthal R. Not enough fruit and vegetables or too many cookies, candies, salty snacks, and soft drinks? *Public Health Rep.* 2010;125:88-95.
 30. Lakdawalla D, Philipson T. The growth of obesity and technological change. *Econ Hum Biol.* 2009;7:283-293.
 31. Cohen D, Farley TA. Eating as an automatic behavior. *Prev Chronic Dis.* 2008;5:A23.
 32. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr.* 2004;79:6-16.
 33. Drewnowski A. Obesity and the food environment: dietary energy density and diet costs. *Am J Prev Med.* 2004;27(suppl 3): 154-162.
 34. Dietz WH. Does hunger cause obesity? *Pediatrics.* 1995;95:766-767.
 35. Hruschka DJ. Do economic constraints on food choice make people fat? A critical review of two hypotheses for the poverty-obesity paradox. *Am J Hum Biol.* 2012;24: 277-285.
 36. Sturm R, Bao Y. Socioeconomics of obesity. In: Kushner R, Bessesen DH, eds. *Contemporary Endocrinology: Treatment of the Obese Patient*. Totowa, NJ: The Humana Press Inc; 2007:444.
 37. Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2011;8:98.
 38. Thorp A, Owen N, Neuhaus M, Dunton D. Sedentary behaviors and subsequent health outcomes in adults: a systemic review of longitudinal studies, 1996-2011. *Am J Prev Med.* 2011;41:207-215.
 39. Lynch B. Sedentary behavior and cancer: a systematic review of the literature and proposed biological mechanisms. *Cancer Epidemiol Biomarkers Prev.* 2010;19:2691-2709.
 40. Frumkin H. Urban sprawl and public health. *Public Health Rep.* 2002;117:201-217.
 41. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med.* 2004;27:87-96.
 42. Sturm R, Cohen DA. Suburban sprawl and physical and mental health. *Public Health.* 2004;118:488-496.
 43. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev.* 2007;29: 129-143.
 44. Dunton GF, Kaplan J, Wolch J, Jerrett M, Reynolds KD. Physical environmental correlates of childhood obesity: a systematic review. *Obes Rev.* 2009;10:393-402.
 45. Feng J, Glass TA, Curriero FC, Stewart WF, Schwartz BS. The built environment and obesity: a systematic review of the epidemiologic evidence. *Health Place.* 2010;16:175-190.
 46. Lachowycz K, Jones AP. Greenspace and obesity: a systematic review of the evidence. *Obes Rev.* 2011;12:e183-e189.
 47. Durand CP, Andalib M, Dunton GF, Wolch J, Pentz MA. A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. *Obes Rev.* 2011;12:e173-e182.
 48. Saelens BE, Handy SL. Built environment correlates of walking: a review. *Med Sci Sport Exerc.* 2008;40(suppl 7):S550-S566.
 49. McCormack GR, Shiell A. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act.* 2011;8:125.
 50. Krieger J, Saelens BE. Impact of Menu Labeling on Consumer Behavior: A 2008-2012 Update. Princeton, NJ: Robert Wood Johnson Foundation; 2013.
 51. Ding D, Sallis J, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a review. *Am J Prev Med.* 2011;41:442-455.
 52. Sugiyama T, Neuhaus M, Cole R, Giles-Corti B, Owen N. Destination and route attributes associated with adults' walking: a review. *Med Sci Sports Exerc.* 2012;44: 1275-1286.
 53. Drewnowski A, Aggarwal A, Hurvitz PM, Monsivais P, Moudon AV. Obesity and supermarket access: proximity or price? *Am J Public Health.* 2012;102:e74-e80.
 54. An R, Sturm R. School and residential neighborhood food environment and diet among California youth. *Am J Prev Med.* 2012;42:129-135.
 55. Hattori A, An R, Sturm R. Neighborhood food outlets, diet, and obesity among California adults, 2007 and 2009. *Prev Chronic Dis.* 2013;10:E35.
 56. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. *Health Place.* 2012;18:1172-1187.
 57. Cummins S, Flint E, Matthews SA. New neighborhood grocery store increased awareness of food access but did not alter dietary habits or obesity. *Health Aff (Millwood).* 2014;33:283-291.
 58. Wallop H, Spencer P. 3,000 greengrocers lost in last decade. *The Telegraph.* June 8, 2008. telegraph.co.uk/news/uknews/2094507/3000-greengrocers-lost-in-last-decade.html. Accessed May 5, 2014.
 59. Sturm R. Affordability and obesity: issues in the multifunctionality of agricultural/food systems. *J Hunger Environ Nutr.* 2009;4:454-465.
 60. European Commission. Political Agreement on New Direction for Common Agricultural Policy [press release]. europa.eu/rapid/press-release_IP-13-613_en.htm. Accessed March 10, 2014.
 61. Wallinga D. Agricultural policy and childhood obesity: a food systems and public health commentary. *Health Aff (Millwood).* 2010;29:405-410.
 62. Economic Research Service, United States Department of Agriculture. Farm Bill Resources. Washington, DC: US Department of Agriculture; 2014.
 63. Powell LM, Chriqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes. *Obes Rev.* 2013;14: 110-128.
 64. Sturm R, Datar A. Body mass index in elementary school children, metropolitan area food prices and food outlet density. *Public Health.* 2005;119:1059-1068.
 65. Sturm R, Datar A. Food prices and weight gain during elementary school: 5-year update. *Public Health.* 2008;122:1140-1143.
 66. Sturm R, Datar A. Regional price differences and food consumption frequency

- among elementary school children. *Public Health*. 2011;125:136-141.
67. Andreyeva T, Long MW, Brownell KD. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health*. 2010;100:216-222.
68. Powell LM, Chaloupka FJ. Food prices and obesity: evidence and policy implications for taxes and subsidies. *Milbank Q*. 2009; 87:229-257.
69. Holt E. Hungary to introduce broad range of fat taxes. *Lancet*. 2011;378:755.
70. Sturm R, An R, Segal D, Patel D. A cash-back rebate program for healthy food purchases in South Africa: results from scanner data. *Am J Prev Med*. 2013;44: 567-572.
71. Faulkner GE, Grootendorst P, Nguyen VH, et al. Economic instruments for obesity prevention: results of a scoping review and modified Delphi survey. *Int J Behav Nutr Phys Act*. 2011;8:109.
72. Monsivais P, Rehm CD. Potential nutritional and economic effects of replacing juice with fruit in the diets of children in the United States. *Arch Pediatr Adolesc Med*. 2012;166:459-464.
73. Lindstrom J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care*. 2003;26:725-731.
74. Wojcicki JM, Heyman MB. Reducing childhood obesity by eliminating 100% fruit juice. *Am J Public Health*. 2012;102:1630-1633.
75. Institute of Medicine. *The Public Health Effects of Food Deserts*. Washington, DC: National Academies Press; 2009.