The Changing Environment and Population Obesity in the United States

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Abstract

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The recent unexpected increases in the prevalence of obesity in the United States are widely agreed to be the result of changes in environmental conditions. This paper reviews the available data from diverse sources on environmental factors and obesity. Coverage includes descriptive data on temporal trends in the environment, cross-sectional and longitudinal studies of the association between environmental exposures and body weight, and experimental trials that have related environmental factors thought to be potentially important in influencing energy intake and expenditure and body weight. Over the period covered by the "obesity epidemic," a variety of environmental factors have changed dramatically. Some would seem to favor increased body weight (e.g., increased availability of convenience foods and increased use of automobiles and televised entertainment), and others would seem to favor decreased body weight (e.g., a lower-fat food supply and the increased availability of some forms of physical activity). Definitive conclusions about the relative contributions of energy intake and expenditure to increasing body weight or about the contribution of specific environmental exposures to increasing body weight are far from clear. Increased sophistication in methods for making valid inferences from existing environmental data would be helpful. Even more important, given the urgency of the problem, is experimental research on the question of what environmental changes would be necessary to reverse the obesity epidemic.

Key words: population obesity, trends in diet and exercise, weight-related behavior

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Introduction

In the last 20 years, we have witnessed a remarkable change in the body composition of the average American. After 20 years of relatively stable or slightly increasing body weight and fatness, starting in ~1980 and continuing to the present, the average body weights of Americans have increased dramatically and steadily (1,2). After adjusting for age and height, mean body weights have increased by nearly 10% in two decades, and the prevalence of clinical obesity has approximately doubled. Although not all segments of our population have experienced the same degree of change, the obesity epidemic (as some have called it) is affecting the entire U.S. population, that is, children and adults in every region of the country, in all social strata, and in all ethnic groups. The speed and magnitude of the weight increases over the last 20 years are unprecedented historically and have elevated obesity to the number one nutritional issue on the national public health agenda.

In many respects, the recent obesity epidemic is a mystery. It was not predicted in advance, it was not recognized until several years after it had begun, and its causes, for the most part, are unknown. Given the short time frame in which the change has occurred, most scientists are in agreement that its causes are more likely to be found in changing environmental conditions than in biology (3). However, it has so far proven difficult to make a compelling case for any specific causal agents. At a proximal level, changes in body weight are surely caused by changes in behaviors that affect energy intake (i.e., eating) and those that affect energy expenditure (i.e., physical activity). There is little consensus among health care professionals, however, on the relative roles that energy intake and energy expenditure have played in the epidemic, and there is even less consensus on the environmental factors that may have caused intake and expenditure behaviors to shift so dramatically over a short period of time. The purpose of this paper is to systematically review the available data on the environmental factors that may be related to recent trends in population body weight. Of particular interest are the available data on the changing mix of behavioral choices available to the U.S. population (i.e., how behavioral choices related to eating and exercise

have changed over the last two decades); changes in the information regarding body weight, eating behavior, and physical activity to which the U.S. population is exposed (i.e., how recommendations about eating and activity have changed over time and the sources of that information); and changes in the economics of eating and physical activity (i.e., the monetary and behavioral costs of various eating and exercise choices).

Because efforts to identify causal associations between environment and weight-related behaviors are relatively new, the data search used for this paper was intentionally broad. In addition to conducting a systematic review of the traditional peer-reviewed scientific literature, we also explored data available from governmental, business, and industry sources. The review was also intentionally broad in respect to the types of data examined. We examined descriptive data on temporal trends in environmental factors occurring contemporaneously with the recent increases in body weight, cross-sectional and longitudinal studies of associations between specific environmental exposures and body weight or changes in body weight and also experimental studies that examine the effects of purposeful environmental changes on health behaviors and body weight. Peer-reviewed scientific papers were identified by a computerized search of Medline and Psych Info. Governmental data sources were identified through searches of Internet sites of specific governmental departments and through databases such as FirstGov. Business and industry data were identified through searches with key words in the ABI/Inform Global, Business, and Industry and the Lexis/Nexus databases and searches of the Internet sites of professional trade organizations and independent companies. Business and industry sources included corporate reports, trade journals, and market research reports.

Although our search for data related to environment and obesity was both valuable and necessary for the present purposes, it should be kept in mind that such a search has limitations. First, to the best of our knowledge, there is no comprehensive index of data sources on environmental trends. Thus, we have almost certainly overlooked some potentially interesting information. Second, the data sources that we identified almost certainly differ in accuracy and credibility because of the use of various sources and methodologies. Third, because of the huge volume of data available in some of the databases that we identified, editorial judgment had to be exercised in selecting which specific pieces of data to report in this paper.

A final introductory comment is a reminder that most of the data described below are observational rather than experimental and thus should be viewed with epidemiological principles of causal inference in mind, i.e., strength of association, consistency across measurement methods and populations, temporality, and biobehavioral plausibility.

Trends in Diet and Exercise

One of the difficulties in targeting a search for potential environmental causes of the obesity epidemic is that, although trends in body weight and the prevalence of obesity over time are well documented, secular trends in energy intake and expenditure have provided a much less clear indication of the behavioral causes. The primary source of data on trends in population energy intake comes from U.S. Department of Agriculture (USDA)[1] surveys of the dietary intake on representative population samples (4). Over the time period spanned by the obesity epidemic, estimates of total energy intake per capita have not shown much change in these surveys. For example, data from the USDA's Nationwide Food Consumption Surveys (NFCS 1965 and NFCS 1977) and Continuing Survey of Food Intake in Individuals (CSFII 1991 and NSFII 1996) indicated a significant drop in standardized per capita food energy intake between 1965 and 1980, no change between 1980 and 1990, and an increase back to 1965 levels between 1990 and 1995 (5). In short, individual-level data on diet show essentially no change in energy intake during a period when the average body weight increased by ~5 kg.

If correct, the dietary data presented above would seem to suggest that the primary cause of the obesity epidemic may be decreases in physical activity. Unfortunately, data on energy expenditure obtained from surveys of individuals do not show this. No national surveys of physical activity have been done across the entire time period of the obesity epidemic using standardized methods. The closest data that we could find for this report are from the Minnesota Heart Survey, which examined temporal trends in physical activity between 1980 and 1995 in the upper Midwest using the Minnesota Leisure Time Physical Activity Questionnaire (6). The results of the survey indicated no change in the reported amount of time (minutes per week) spent on leisure-time physical activity over this time period (7). That study, like the USDA studies, also found little or no change in reported energy intakes but dramatic increases in weight. More recent data from the Behavioral Risk Factor Surveillance System provide a basis for estimating changes in physical activity nationally between 1990 and 1998. These data indicate that the proportion of the population engaging in recommended levels of physical activity increased slightly from 24.3% to 25.4% between 1990 and 1998, whereas the proportion of those reporting no physical activity decreased (8).

Given that the data now available on diet and exercise trends in the U.S. population over the last 20 years are disappointingly ambiguous about the contribution of eating vs. that of a lack of physical activity to the obesity epidemic, much less the contribution of specific behaviors, it is un-

[1] Nonstandard abbreviations: USDA, United States Department of Agriculture.

derstandable that health care professionals are not in consensus about where efforts to address the obesity epidemic should be focused. A number of explanations have been offered for the failure of diet and exercise data to track changes in body weight appropriately (4). For food intake, explanations have included the possibility of increased underreporting of intake over time because of the social stigma associated with being overweight, technical changes in assessment methodologies, secular trends in larger typical portion sizes that are not adequately captured by dietary assessment methods, and the consumption of a higher proportion of food away from home, for which nutrient databases may not be as accurate. Secular increases in overreporting of physical activity have been offered as one explanation for why declines in physical activity are not seen over time. The other, and perhaps more popular, explanation for not seeing decreases in physical activity is that most of the available physical activity assessment methods focus on leisure-time physical activity, and thus, may be insensitive to the decreases in physical activity that may be occurring in non–leisure-time activity domains (3). The net result of all of the factors mentioned above, however, is that there is genuine uncertainty in the scientific community about how the energy imbalance leading to increased national body weight is occurring.

Temporal Trends in Food Exposures

Despite our inability to confidently apportion the responsibility for increased body weights to intake or expenditure, data on temporal trends in the food supply and in opportunities to engage in physical activity provide interesting information about how environmental factors that may influence eating and activity have been changing. USDA food disappearance data, which have been collected over a long period of time by very similar methodologies, provide an aggregate picture of dietary exposures in the United States. On an aggregate basis, the per capita availability of food energy in the United States tracks fairly well temporally, quantitatively, and qualitatively with body weight and other diet-related health indices (9,10). Between 1970 and 1980, per capita energy availability remained stable, which is congruent with the stability of body weight over that time period. Starting in ~1980, however, the per capita availability of food energy gradually increased; it is now ~15% higher than it was in 1970. The macronutrient compositions of the foods available in the U.S. marketplace over the time period have also changed. Between 1970 and 1995, per capita carbohydrate availability in the U.S. food supply increased by ~27%, whereas the per capita fat availability increased by only ~3%. The net result has been dramatic increases in carbohydrate availability and decreases in fat availability as a percentage of total energy. The observed changes in the macronutrient composition of the food supply, a change also seen in individual diet surveys, provides an explanation for why we have observed declining serum cholesterol levels and declining cardiovascular disease rates, despite increases in body weights. The U.S. food supply was qualitatively healthier with respect to heart disease in the year 2000 than it was in 1980.

Of course, people eat foods rather than nutrients, and an examination of temporal trends in the per capita availability of specific foods provides an additional perspective on how environmental exposures to food are changing. The complete list of foods for which longitudinal data on availability can be found is large. For our purposes here, we simply note that over the last 20 years, there have been many dramatic changes in the availability of many foods, both upward and downward. Some trends would seem to favor weight increases, and others would seem to favor weight decreases. Examples of food availability changes between 1970 and 1994 seemingly favorable to lower body weight include the following: red meat decreased by 12%, chicken increased by 85%, butter decreased by 13%, whole milk decreased by 63%, fruit increased by 29%, vegetables increased by 17%, refined sugar decreased by 34%, diet soft drinks increased by 586%, and alcohol was unchanged (10). Simultaneously, other changes in food availability seemingly favor increased weight: salad and cooking oil increased by 47%, cheese increased by 111%, corn sweetener increased by 283%, and regular soft drinks increased by 75%. There may be clues in these data to the factors contributing to population obesity. However, in the absence of a method for analytically tying time trends in food availability to time trends in body weight, food supply statistics are probably more valuable as a reminder of the complexity and volatility of the food marketplace than they are as a tool for identifying specific contributors to changes in the prevalence of obesity.

Looking at trends in the food environment from a perspective broader than simply disappearance, it is also apparent that there have been substantial changes in the way that food is made available to the U.S. population over the last quarter century as well as the mix of foods available. An especially striking trend is the increase in the emphasis on convenience in food availability. The convenience food industry has been a strong growth sector in the food distribution economy. Between 1967 and 1997, the number of food stores in the United States actually declined by ~15%. However, the number of locations where ready-to-eat foods can be purchased (e.g., restaurants, cafeterias, and snack bars) have more than doubled (11). As these data would support, Americans have dramatically increased the proportion of food dollars spent away from home in the last 20 years (12), showing a particular preference for restaurants with limited menus, quick service, and the option to take food out (13). The amount of food distributed through vending machines has also increased (14). The foods available in traditional food stores are also increasingly processed to facilitate ease of preparation. For example, sales

of prepared meals at grocery stores more than doubled between 1982 and 1992 and was projected to double again by 1997 (15). Likewise, the processed food sector of the U.S. food system grew at a high rate (41%) between 1972 and 1992, with sales in this sector increasing from $243 billion in 1972 to $342 billion in 1992 (16). Taken together, it seems possible that trends toward increased availability and convenience in food distribution may have contributed to net increases in per capita food intake relative to energy expenditure in the United States. The absence of agreed on definitions for terms like "availability" and "convenience," however, is a serious impediment to scientific study of the question.

Temporal Trends in Exercise Exposures

The available data on longitudinal trends in population exposures to opportunities to engage in physical activity are not as available as those on trends on the food supply, making the picture that one gets from examination of the data more fragmentary. The availability of recreational opportunities in some areas has increased dramatically over the last two decades. For example, the number of commercial health clubs and related recreational facilities is up significantly, as is the number of sporting goods stores (11). The number of homes with exercise equipment has also increased substantially (17). As is the case with food, the mixture of choices available for physical activity have also changed with time. Bowling alleys, bicycling (indoor and out), and rowing machines have declined recently, whereas home treadmills and gym sales have increased substantially (11,17). One area in which there has clearly been a reduction in opportunities for physical activity is in public schools, where the amount of curriculum time devoted to physical education is significantly less than it was 20 years ago. Overall, however, it is unclear whether opportunities for recreational activities in the United States have declined, increased, or remained unchanged during the period of the obesity epidemic. As with food, there is no agreed on definition of overall availability and enough examples to support either side of the argument.

In areas of life that involve nonrecreational physical activity, recent trends for the most part seem to be consistent with the idea that declining levels of physical activity may contribute to the obesity epidemic. There has been a consistent trend over the last 20 years toward the use of private automobiles for transportation to and from work and a commensurate decline in the use of public transportation, walking, or biking (18).

Much attention has been given to the hypothesis that inactive forms of entertainment, such as television viewing and home computer use, are contributing to the obesity epidemic, and temporal trends in the availability of these inactive entertainment choices are clearly upward. Most homes had television sets before 1980 (19). However, videocassette recorders, cable television, and home computers are all technologies that have become widely available to the general population only in the last two decades. There have also been increases in the percentage of homes with more than one of television (i.e., the proportion of households with multiple television sets increased from 35% in 1970 to 75% in 2000). During the same time period, the percentage of households with cable television increased from 7% to 76% (19).

We did not attempt to locate for this review specific longitudinal data on the availability of a myriad of other laborsaving devices that have become increasingly available to Americans over the last two decades (e.g., lawn mowers, garage door openers, television remote controls, keyless entry devices, automatic sprinkler systems, electric pencil sharpeners, and microwave ovens). Nevertheless, it is undoubtedly true that such devices have proliferated. To the best of our knowledge, no studies of the effects of these devices on energy expenditure have been done. Nevertheless, it is certainly plausible that the cumulative effects of laborsaving devices like these may have contributed in part to the steadily declining number of hours that U.S. adults report that they spend on housework (a reduction of ~20% since 1965) (20). Between 1970 and 1997, there was also a significant increase in the total amount of time that married couples reported that they spent at work. This has been driven in large part by the fact that a larger proportion of households have two full-time working adults (21).

In summary, during the last 20 to 30 years, data on temporal trends in the availability of physical activity choices in the United States indicate that trends in access to recreational physical activity choices are mixed. However, changes in activity choices outside the recreational activity area have probably favored more sedentary lifestyles because of a proliferation of labor-saving technologies.

Temporal Trends in Information

People's behaviors, of course, are guided not only by what options are available but also by social communications conveyed by individuals, media, and institutions regarding the most appropriate forms of behavior. In the case of eating, the primary source of public information about what people should eat is arguably the food industry. The food industry spends in the neighborhood of $50 per person per year to publicize food products. In contrast, the USDA spends about $1.50 per person per year for all types of nutritional education (22). The effects of general food advertising on population consumption trends are seen most clearly in connection with targeted ad campaigns and products (3). Advertising conducted under the Dairy and Fluid Milk Acts, for example, was estimated to have increased the level of at-home fluid milk consumption by 6% and the level of at-home cheese consumption by 2.3% (23). Trend data also suggest that changes in regulations regarding

advertising content may have affected both product availability and food consumption patterns. For example, until ~1985, the Food and Drug Administration placed fairly tight limits on the health claims that could be made about foods. When these restrictions were relaxed in the mid-1980s, the food industry began to more heavily market foods on the basis of their health-enhancing qualities and introduced a substantial number of nutritionally improved foods (24). Special emphasis was placed on new products lower in fat and calories (25), but the new products introduced also included foods with reduced levels of cholesterol, salt, and sugar as well as increased amounts of fiber and calcium. At least two positive population benefits have been accelerated by increased health marketing. These are increased consumption both of high-fiber foods and of lower-fat foods, both of which have been central themes of USDA's dietary recommendations for Americans for the last 20 years (26). Although food industry efforts to promote lower-calorie foods have not translated into positive trends in population body weight, it is arguable that ambiguity in the federal government's public health messages is partly to blame. Over the years the Dietary Guidelines for Americans have consistently encouraged the selection of foods with higher nutritional value and discouraged the selection of foods high in fat, cholesterol, sugar, and sodium. They have never recommended eating less (27).

One of the most talked about food promotion practices over the last two decades has been that based on portion size. Products ranging from soft drinks to bagels are now available in sizes much larger than they were in previous decades (28). Among products available in multiple sizes, the unit price for larger servings is less (3,29). Some portion sizes that at one time were considered standard (e.g., 6- and 8-ounce bottles of Coca Cola) are no longer sold at all. Although the overall density of exposure to food advertising and its impact on consumption are difficult to quantify, some evidence suggests that the competition for market share among food providers has become more intense over time, in that the proportion of the purchase price of food attributable to advertising expenditures has systematically increased over the last decade (30).

Messages about adequate and appropriate physical activity have been clear and consistent since 1965, i.e., that people should engage in 30 minutes of physical activity three to five times per week (31). That recommendations about physical activity have not changed parallels our previous discussion that leisure-time physical activity has apparently not decreased over the past two decades.

A final form of information about obesity and related behaviors available to the public is the portrayal of personal behavior and body weight in the media. It has been cogently argued that the use of extremely lean models, particularly for women, in the promotion of commercial products as well as in entertainment media may contribute to undesirable eating and exercise behaviors (32,33). Researchers have been tracking "ideal" body shapes for women for several decades by studying fashion models. Similar studies of "ideal" body shapes for men are also available, although for a much shorter period of time. For women, fashionable body shapes were relatively full in the 1950s, became quite thin in the 1960s (i.e., BMIs of 18 to 19 kg/m^2), and have not changed much since then (34). Because women's actual body weights are increasing, on average, the discrepancy between "real" and "ideal" body weights has been widening, which has engendered increasing concern about the media's possible contribution to excessive dieting behaviors. Interestingly, male models tend not to be as lean as female models (BMIs of ~25 kg/m^2), and over the last decade, they have been getting heavier. A recent study of how the media have portrayed eating and exercise behaviors over the last decade or so suggest a mixed picture with respect to influences on weight. Depiction of physically active lifestyles has increased, as have depiction of eating foods high in energy density (35). In summary, although there clearly are some obese celebrities in the U.S., based on scientific analyses of media depiction of body weight and lifestyle, there seems to be little reason to think that major shifts in social attitudes favoring larger body sizes have taken place over the last 20 years, at least for women.

Cross-Sectional and Longitudinal Associations between Environment and Weight or Weight-Related Behaviors

The discussion presented above primarily considered temporal trends in environmental factors, eating and exercise behaviors, and body weight. The purpose was to identify candidate environmental changes that might be contributing to increasing rates of obesity. A second level of questioning related to environmental factors is whether there are data that indicate whether people who are exposed to different levels of specific environmental factors have different body weights. A fairly substantial body of data shows that people who eat differently and who have different physical activity patterns tend to have different body weights (36). Cross-sectional and longitudinal analyses of the relationships between diet, physical activity, and body weight show that total energy intake and fat intake tend to be associated with higher body weight and that changes in energy and fat intake over time are associated with changes in weight in the same direction (36). Similarly, higher habitual levels of physical activity are associated with lower body weight, and increases and decreases in physical activity over time are associated with weight loss and weight regain, respectively. Fewer studies of specific food exposures have been conducted but those that have suggest that the consumption of specific high-fat foods (e.g., hamburgers and french fries) and of large quantities of sugar (e.g.,

from soft drinks) tends to be associated with higher body weights in both children and adults (37–40). The frequency of reported eating at fast-food restaurants has also been positively associated with higher body weight (41–43). Reported rates of "dieting" to lose weight and consumption of specific commercially available "diet" foods tend to be higher among more obese persons, and if anything, these behaviors are predictive of weight gain rather than weight loss over time (44–47). One study, however, has shown that if the duration of "dieting" is assessed, individuals reporting that they spend more time intentionally dieting and intentionally exercising for the purpose of controlling weight achieved better weight control over time (47).

In summary, cross-sectional and longitudinal data on the relationship between food selections-exposures and body weight provide additional support for the idea that the increased availability and convenience of calorie-dense foods may contribute to obesity. However, research on the consumption of specific foods and body weight is very limited. Thus, conclusions about the unique contribution of any specific food item to obesity are highly speculative as are the relationships between consumption and environmental exposures.

Data on exposures to individual environmental factors and physical activity are also quite modest. A substantial literature on urban design, primarily developed by transportation planners, shows that different structural features in communities are associated with higher or lower levels of use of automobiles (48). Communities laid out in rectangular grid patterns tend to be associated with more travel by foot and less travel by automobile. Several longitudinal studies of traffic-calming measures (e.g., speed bumps and other devices introduced to discourage high-speed automobile traffic) have shown increased use of street by pedestrians after the introduction of such changes (48).

One community survey reported a positive cross-sectional association between the proximity of commercial physical activity facilities and the levels of physical activity reported by the survey respondents. The proximity of publicly available recreational facilities (such as parks and school athletic fields) was not associated with physical activity, however (49). Additional studies of the effects of proximity on physical activity opportunities have shown positive relationships between the presence of physical activity equipment in people's homes and their reported levels of physical activity (50).

In recent years, television viewing has attracted singular attention as a potential obesity promoter. Several studies have now shown that the number of hours of television viewing per week is associated with higher body weights in both children and adults (51–56). Longitudinal relationships between television viewing and body weight change have been less strong, however, and one study of obese children's physical activity preferences before and after successful weight loss has suggested that preference for passive over active forms of entertainment may be a consequence rather than a cause of obesity (57). Interesting as well are studies that show a stronger relationship between television viewing and eating than between television viewing and recreational physical activity (58,59). If true, it suggests that the mechanism connecting television viewing to higher body weights may be through increased eating rather than decreased physical activity. The observation that television advertising represents about three-fourths of food industry advertising expenses is consistent with this idea (60).

Overall, the most extensively studied environmental exposures associated with obesity are those involving television viewing and convenience foods. The associations for both exposures are consistent with the idea of that there is a causal connection, but the associations for both exposures are also subject to question because of inconsistent and sometimes weak associations, especially those trying to establish temporal sequencing. Both exposures also have a strong associations with social class that may be difficult to control for statistically. In addition, both television viewing and the consumption of convenience foods are high-frequency behaviors that are almost certainly embedded in larger diet and physical activity patterns. Thus, they may be symbols identifying obesity-promoting lifestyles rather than unique, independent causal agents.

Experimental Studies on the Influence of Environmental Factors in Body Weight and Weight-Related Behaviors

The final section of this review is on experimental studies that have investigated the ways in which the environment might be changed to facilitate behavioral change and body weight. Because education-based studies in this area have been reviewed extensively elsewhere (61), a detailed review of the literature on this topic is not presented here. We note, however, that to date, the results of studies that have relied on education about diet and exercise to reduce population body weight or to prevent population weight gain over time have not been very successful. School-based studies that have attempted to change the eating and exercise behaviors of children through classroom curricula have been effective in changing attitudes, beliefs, knowledge, and some self-reported behaviors. They have not been shown to have a positive effect on body weight (62). Studies at work sites targeting the same behaviors in adults have had similar results (63), as have studies targeting entire communities with multiple educational approaches (64). Education has been successful in making people aware of obesity as a health concern, and it has been effective in teaching them the principles of energy balance and the behaviors needed to modify weight. Education has not been successful in changing population body weight.

Experimental studies on the effects of environmental changes on eating, physical activity, and weight are relatively new. The most extensive have been a series of studies by French et al., who examined the effects that changes in the availability and price of food might have on food choice in real-world settings. In the first of these studies, salad and fruit purchases were targeted at a work site cafeteria (66). After 3 weeks of observation of food purchases, the prices of salad and fruit were reduced by 50%, and the numbers of fruit and salad choices were doubled. After 3 more weeks of observation, the original prices and the original choices were reinstated. The effects of this intervention on both salad and fruit purchases were dramatic. Purchases of fruit and salad more than doubled during the intervention period and then returned to levels very similar to those at the baseline after the baseline environmental conditions were reinstated. Studies of the sensitivity of fruit and vegetable purchases to price changes was demonstrated in two high schools (66) and of low-fat snacks through vending machines at adult work sites (67) produced similar findings.

These small studies of food price and availability eventually led to the first, and to date, only, large randomized trial examining the feasibility and effectiveness of environmental interventions in modifying food choices (68). The study targeted low-fat snacks sold through vending machines at 12 work sites and 12 high schools. Vending machine configurations were changed periodically so that for 1 month, purchases of low-fat snacks were examined under each of 12 experimental conditions at each site. The 12 conditions were constructed by crossing three levels of education about low-fat snacks with four levels of pricing for low-fat snacks compared with the prices for higher fat items. The three education conditions were 1) none, 2) labeling of low-fat products with distinctive color codes, and 3) color coding of products and the inclusion of posters inside the vending machines encouraging the selection of low-fat foods. The four price conditions were 1) equal price for high- and low-fat items and price reductions of 2) 10%, 3) 25%, and 4) 50% for low-fat items. The results of this study were quite striking. The health promotion effects were statistically significant but modest in magnitude. An 8% increase in sales of low-fat items was seen with the maximal educational intervention. By contrast, pricing effects were dramatic. Ten percent, 25%, and 50% reductions in the price of low-fat items resulted in 10%, 39%, and 93% increases in the purchases of low-fat items, respectively.

Another line of research on environment and food relates to the provision of food products designed specifically to facilitate weight control among people enrolled in weight loss programs. Four randomized trials have shown that providing or strongly encouraging the use of commercially available meal and snack substitutes facilitates weight loss over periods for as long as 2 years compared with the effects of encouraging reduced energy consumption without specific reference to these products (69–72). A particularly interesting study was recently conducted by Weststrate et al. (73) in The Netherlands. In that study, nonobese individuals who had no desire to lose weight were randomized to one of two treatment conditions for a period of 6 months. Individuals assigned to one condition were given cost-free access to 44 food products, primarily meat and dairy products, that were "fat reduced," whereas those assigned to the other condition were given cost-free access to full-fat versions of the same products. Over 6 months, weight gain was observed in both groups; the provision of cost-free food seemed to encourage overconsumption (i.e., more weight gain was observed over 6 months than would be expected in a population sample). However, the provision of low-fat food was associated with 0.74 kg less weight gain than provision of high-fat food. A similar study by Poppitt et al. (74) randomly assigned 46 obese persons to one of three diets for 6 months: a control diet, a low-fat complex carbohydrate diet, or a low-fat simple carbohydrate diet. Approximately 60% of dietary intake was provided free of charge through a grocery store. Over 6 months, the control group gained 1.03 kg, the group consuming the low-fat simple carbohydrate diet lost 0.28 kg, and the group consuming the low-fat complex carbohydrate diet lost 4.25 kg.

All of the studies mentioned above show that changing conditions under which food is available to individuals in the general population and/or those with specific weight control objectives can have beneficial effects on food consumption patterns and body weight and that these effects occur independent of nutrition education.

Experimental studies on environment and physical activity are also beginning to emerge. The largest number of studies in this area is probably on the use of environmental changes to encourage the use of stairs instead of escalators and elevators in public buildings (75–78). A consistent finding across most of these studies is that the placement of signage near stairways to encourage stairway use tends to increase rates of stairway use. One recent study also demonstrated that making the stair environment more pleasant through a music and art program further increased the rate of stairway use (75).

Two experimental studies examining television usage and body weight have now been completed (79,80). Both were done through schools, focused on children, and provided both education about the desirability of reducing television viewing time and technological support for parents in the form of devices that could be programmed to automatically limit television usage. Although the studies were somewhat limited methodologically, both of these studies reported decreases in the children's television viewing times over the course of the study and reductions in the prevalence of overweight.

Jakicic et al. (81) recently reported on another study of environmental change, physical activity, and body weight.

In that study, individuals who wanted to lose weight were given the standard exercise recommendations. One-half of the individuals were then randomly assigned to a group in which home treadmills and treadmill servicing were supplied. The other half did not receive home exercise equipment. The results showed higher levels of physical activity and more weight loss among those given home treadmills.

Three studies of which we are aware have examined the effects of incentives on participation in physical activity. In two of these, study volunteers were given free access to high-quality exercise facilities for periods ranging from 1 to 3 months to assess the effect that removing cost as a barrier to participation in physical activity might have on the use of community exercise facilities (82,83). Both studies failed to show significant ongoing increases in the rates of use of exercise facilities. In the third study, Raynor et al. (84) demonstrated in a controlled experimental setting that the minor barrier of having to walk 5 minutes to reach an exercise facility reduced the rate of participation in this activity by more than 50% compared with the rate among those for whom the same opportunity was immediately available.

In summary, environmental interventions to increase physical activity, like those involving diet, have shown that it is possible to change physical activity through environmental change alone, and in some cases, these changes can occur to such a degree that they influence body weight.

Summary and Conclusions

The cause of the obesity epidemic that has affected the United States and many other countries in the world over the last 20 years remains unknown. Although changes in body weight and fatness are surely the result of changes in energy intake and energy expenditure that are mediated by changes in food and activity choices, clear data identifying the specific contribution of energy intake vs. energy expenditure or the specific contributions of specific behavioral choices are not available. Indeed, the inability of population data on energy intake and energy expenditure to elucidate this issue is a cause for concern.

A point of general agreement is that the cause of the obesity epidemic is most likely to be found in changes in environmental conditions promoting increased levels of food consumption or decreased levels of physical activity, or both, rather than changes in biological factors (3). However, the scientific evidence available at present is so weak that it seems unlikely that a quick consensus will be reached on either what environmental factors are driving the epidemic or, for that matter, how the search for them might best be organized. This review has shown that the state of knowledge in the area is fragmented, of uneven coverage with respect to topics, and very likely of uneven quality as well. Many of the available data simply consist of descriptive information about contemporaneous trends in environmental factors, behaviors, and body weight, which are among the weakest forms of data for making causal inferences.

Cross-sectional and longitudinal studies on the relationship between specific environmental exposures and body weight have provided better insights into the possible importance of a few high-profile environmental factors and body weight (e.g., television viewing and convenience foods). The available data are quite limited in scope, however, and causal interpretations are plagued by potential confounders such as social class, by the fact that temporality has at best been weakly demonstrated, and in many cases, by the absence of data establishing plausible underlying mechanisms.

Experimental studies on environmental factors and weight and weight-related behaviors provide the strongest evidence for causal interpretation and also provide ideas about what aspects of the environment might be changed in an effort to positively influence weight-related behaviors and obesity. The largest body of research on population interventions for obesity has approached the problem by changing the information available to people about diet, exercise, and weight through education. These studies have shown that reaching people with educational messages is feasible but that achieving beneficial effects on population weight trends has so far proved elusive. We believe that a likely explanation for the weakness of health education in this regard is that health education efforts have been overwhelmed by information on the same topics coming from other sources. The best-funded public educational programs that we are aware of have had less than one-tenth of the resources of the food industry to devote to encouraging behavioral change. Interestingly, the most successful nutrition education effort in the United States over the last 20 years may have been that devoted to reducing dietary fat intake. This particular effort appears to have been enhanced dramatically by the food industry through both the development of low-fat food products and their promotion. In our view, future public health education efforts related to obesity in the United States would clearly be most successful if they were consistent with education messages about nutrition coming from the private sector, including those in food advertising. How to achieve this consensus of purpose, however, is far from clear.

Environmental intervention studies on obesity in areas other than health education have so far been fairly small, but nevertheless, they are thought provoking. Cost, convenience, and attractiveness have been shown to influence both eating and exercise choices in various real-world settings. Several small studies have also shown that in both clinical and nonclinical samples reduced access to specific food products or reduced access to sedentary physical activities (e.g., television viewing and exercise equipment) can have positive influences on body weight over time.

Although we believe that some of the ideas tested so far may not be either politically feasible or acceptable to wide audiences, a variety of possibilities might very well meet these criteria and merit consideration for wider study.

What further research is needed to improve our understanding of the environment and the obesity epidemic? More research is needed in almost every area. We need better ways to conceptualize and measure the environmental factors that might be related to health behavior, as well as better and more accurate means of surveillance of the eating and exercise habits of the population and environmental changes. We also need more experimental and observational studies that specifically examine environment, behavior, and weight interactions. It is an exciting area and one in need of more research to make progress in halting and reversing the obesity epidemic. It should also be noted that the focus of this review of environmental factors is not meant to discourage investigations into the possibility that societal attitudes toward obesity, personal gratification, consumerism, and other factors are not also worthy of further exploration.

Are there other policy implications that derive from current knowledge about environment and obesity? It would be difficult to look at the existing body of knowledge on environment and obesity and make specific recommendations about actions, in either the public sector or the private sector, that would have a high likelihood of making a substantive impact on the prevalence of obesity in the population and that would at the same time be politically feasible and consistent with the values held by most members of society. The most important policy message that comes from an examination of the current state of affairs with respect to obesity and environment is probably the fact that it is time to open up a candid dialogue among organizations and individuals who are influential in setting environmental factor-related policies for the country with the objective of reaching consensus that 1) obesity is an important society-wide problem that needs to be addressed, 2) that solution of the obesity epidemic will require society-wide and environmental efforts, and 3) that we need to work together to develop concrete steps that may be taken to develop a solution.

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