

# Does social class predict diet quality?<sup>1-3</sup>

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## ABSTRACT

A large body of epidemiologic data show that diet quality follows a socioeconomic gradient. Whereas higher-quality diets are associated with greater affluence, energy-dense diets that are nutrient-poor are preferentially consumed by persons of lower socioeconomic status (SES) and of more limited economic means. As this review demonstrates, whole grains, lean meats, fish, low-fat dairy products, and fresh vegetables and fruit are more likely to be consumed by groups of higher SES. In contrast, the consumption of refined grains and added fats has been associated with lower SES. Although micronutrient intake and, hence, diet quality are affected by SES, little evidence indicates that SES affects either total energy intakes or the macronutrient composition of the diet. The observed associations between SES variables and diet-quality measures can be explained by a variety of potentially causal mechanisms. The disparity in energy costs (\$/MJ) between energy-dense and nutrient-dense foods is one such mechanism; easy physical access to low-cost energy-dense foods is another. If higher SES is a causal determinant of diet quality, then the reported associations between diet quality and better health, found in so many epidemiologic studies, may have been confounded by unobserved indexes of social class. Conversely, if limited economic resources are causally linked to low-quality diets, some current strategies for health promotion, based on recommending high-cost foods to low-income people, may prove to be wholly ineffective. Exploring the possible causal relations between SES and diet quality is the purpose of this review. *Am J Clin Nutr* 2008; 87:1107–17.

## INTRODUCTION

Morbidity and mortality rates in industrialized societies follow a socioeconomic gradient (1–3). The more disadvantaged groups suffer from higher rates of obesity (4–6), diabetes (7, 8), cardiovascular disease (9), osteoporosis (10, 11), dental caries (12), and some forms of cancer (13). All of these diseases have a direct link to nutrition and diet (14). It has been suggested, more than once, that dietary factors may help explain some of the observed social inequities in health (15, 16). The more affluent population subgroups are not only healthier and thinner, but they also consume higher-quality diets than do the poor (17).

Diet quality is affected not only by age and sex, but also by occupation, education, and income levels (18–20)—the conventional indexes of socioeconomic status (SES) or social class (21). The different socioeconomic indicators appear to have similar, although independent, effects on nutrition and diet (18–20, 22). However, a convincing causal relation between SES indicators

and diet quality still remains to be established. Given that SES variables are likely to affect all aspects of energy balance, from access to healthy foods to opportunities for physical activity, there is a pressing need to address them directly in the context of epidemiologic research. It may well turn out that the reported associations between diet quality and better health, found in so many epidemiologic studies, may have been confounded by unobserved indexes of socioeconomic status.

## EVIDENCE OF A SOCIAL GRADIENT IN DIET QUALITY

Dietary energy density is one index of the overall quality of the diet (23). Diets high in whole grains, lean meats, fish, and fresh vegetables and fruit have a low energy density (defined as the available dietary energy per unit weight) and a high content of vitamins and minerals (23, 24). In many epidemiologic studies, their consumption has been associated with better health (14). Conversely, diets high in refined grains, added sugars, and added fats tend to be energy-dense but nutrient-poor (24). Such diets have been associated with higher energy intakes and with lower intakes of several micronutrients (23, 24). In epidemiologic studies, their consumption has been associated with higher disease risk and higher mortality rates (14). In some studies, dietary energy density was an independent predictor of obesity and the metabolic syndrome (25).

Studies suggest that energy-dense foods and energy-dense diets may predispose the consumer to overeating (26). Palatability is one explanation. Energy-dense foods, especially mixtures of sugars and fat, tend to be more palatable than foods of low energy density and high water content (27). A reduced volume of energy-dense foods is said to suppress satiation and satiety (26).

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For the same amount of food, a greater quantity of energy is consumed when the food is high in energy than when its energy density is low (27). The combined effects of high-energy density and large portion size may also lead to excess energy intakes and body weight gain (28). Reducing the energy density of the diet by replacing added sugars and fats with fresh vegetables and fruit has become a standard strategy for weight management (25). However, low-energy-density diets can entail substantially higher diet costs (29).

Alternative indexes of dietary quality have been based on compliance with dietary recommendations and guidelines. Higher values of the Healthy Eating Index (30), Diet Quality Index (31), dietary variety (32) and diversity (33) scores, and other diet-quality measures (22, 34–38) have all been associated with higher SES. The same positive relation with SES was observed for dietary patterns (16, 39). Similarly, studies of household food purchases, a proxy for food consumption, found a positive relation between household SES and the quality (20, 40) and variety (41) of purchased diets.

### Index foods and food groups

Several cross-sectional dietary surveys have noted that the consumption of different types of foods by adults was unevenly distributed by SES variables. Data from such studies are summarized in **Table 1**. In some cases, particulars were given about

the food type (eg, fresh vegetables and fruit), but in other cases they were not.

Most studies noted that the consumption of whole grains was associated with higher SES, whereas the consumption of refined cereals (white bread), pasta, and rice was associated with lower SES (18, 42, 49, 51, 52, 72). In the 1986–1987 dietary survey of British adults, a 4-fold difference was found between nonmanual and manual social classes in the consumption of whole grains (50). Lower SES groups also consumed significantly more potatoes (18, 43–46, 48, 72).

Higher SES groups were more likely to consume vegetables and fruit, particularly fresh, not only in higher quantities but also in greater variety (59). A recent meta-analysis of studies from 7 European countries showed that fruit and vegetable consumption was consistently higher in the highest than in the lowest SES group, defined by educational level. The estimated differences in fruit consumption were 24 g/d for men and 34 g/d for women, whereas the differences in vegetable consumption were 17 g/d for both men and women (56). In Australia, a 3-fold difference was found between bottom and top quintiles of income for not consuming fruit on the previous day (59). In the Netherlands, women with a basic education level were almost 3 times as likely to be low consumers of fruit than were the most educated groups (73). In a recent Canadian analysis

**TABLE 1**

Socioeconomic status (SES; education, income, and/or occupation) and food intakes: summary of findings from individual food consumption surveys in adults

High intakes among low-SES individuals	High intakes among high-SES individuals
Grains and starchy vegetables	
Bread, white, or unspecified (37, 42–46)	Whole bread (37, 44, 45, 47–50)
Pasta/rice/cereals, refined or unspecified (18, 42, 49, 51, 52)	
Potatoes (18, 43–46, 48)	
Legumes (32, 42)	
Vegetables and fruit	
	Fruit and vegetables, unspecified (44, 45, 53–61)
	Fruit and vegetables, fresh (62)
	Vegetables, unspecified (18, 19, 33, 37, 43, 47, 63, 64)
	Vegetables, fresh/frozen (15, 42, 65)
	Fruit, unspecified (15, 19, 33, 37, 45, 46, 48, 63, 66)
	Fruit, fresh (42, 43, 52)
	Fruit juices (19, 43, 46)
	Nuts (65)
Meat, fish, eggs	
Meat, unspecified (18, 44, 46, 48, 67)	Meat, unspecified (42, 47, 49)
Organ meats (51)	
Fatty/fried/canned/deli meats, sausage, stews (32, 37, 42, 43, 45, 48, 49, 51, 63, 65)	Lean meat (37, 45, 48)
Fish, fried/canned (32, 51)	Fish/seafood, unspecified (18, 19, 37, 46, 52, 63)
Eggs (32, 37, 68)	
Dairy products	
Milk, unspecified (43, 44)	Milk, low-fat (15, 37, 45, 47–49, 63, 69)
Milk, whole (49, 63, 64, 69)	Cheese (19, 37, 43, 44, 46–49, 70)
Fats and sweets	
Added fats, unspecified (19, 44, 45, 48, 71)	Added fats, unspecified (47)
Animal fats (42, 43, 70)	
Vegetable fats (46)	Vegetable fats (19)
Sugar (18, 42, 46, 49)	Candy (42)
Sweets/cakes (46, 48, 65)	Pastries/desserts (42, 47)
Beverages	
Sweetened beverages (37, 46)	
Beer (18, 45, 46)	Wine, alcohol (45, 46, 65)

of food budget surveys, the strongest positive relation between income and the quantities of food purchased was found for fruit and vegetables (74).

In some European countries, lower SES groups consumed more vegetables and fruit, as reported in food budget surveys in Greece, Spain, and Portugal (72, 75) and in the Eastern European countries Poland and Hungary (75). These countries also have the highest consumption rate of domestically produced foods (75). However, the gap in fruit and vegetables consumption between North and South Europe is narrowing (76), as class disparities are replacing geographic ones. Studies from the United Kingdom and the United States suggest that SES disparities in fruit and vegetables consumption have increased over time (77, 78). In contrast, in Finland, SES differences in vegetable consumption have slightly narrowed since 1979 (22).

Although there was no reported SES difference in total milk consumption (69), in most studies, skim or low-fat milk was the preferential choice for those in the highest SES categories, as was the consumption of cheese (70). A meta-analysis of dairy consumption in Europe showed that the consumption of cheese by the higher SES group exceeded consumption by the lower SES group by 7 g/d for men and by 9 g/d for women (69).

The consumption of lean meats, fish, and other seafood was associated with higher SES in a large number of studies (19, 37, 46, 63). Lower SES groups tended to consume larger quantities of fatty meats instead of the recommended lean meat items. Fried, breaded, and canned fish were all consumed in greater quantities by lower SES groups, who also consumed more stews (63) and fried foods (55).

Diets of lower SES groups were also characterized by more added fats (19, 44, 45, 48, 71), although only a few studies distinguished between animal fats and vegetable fats. There was less evidence that SES was related to sweets consumption. However, within the sweets category, higher SES groups consumed more candy and pastries (42, 47), whereas lower SES groups consumed more sugar and cake (18, 42, 46, 48, 49, 65).

A direct link between SES and the nutritional quality of diets was also reported among children and adolescents. A study in France showed that children of semiskilled and unskilled workers consumed significantly more sweets, bread, potatoes, cereals, and deli meats than did children from the upper SES group (79). In the United States, children and adolescents from low SES households consumed less fruit and vegetables (80, 81) and a more limited variety of produce (82). Children from families with lower education levels had the lowest fruit intakes and the highest consumption of sweetened beverages (83). Several European studies have also reported low fruit and vegetable intakes and a high frequency of soft drink consumption among low-SES children and adolescents (84–87).

In summary, the available evidence suggests that the consumption of whole grains, lean meats, fish, low-fat dairy products, and fresh vegetables and fruit was consistently associated with higher SES groups, whereas the consumption of fatty meats, refined grains, and added fats was associated with lower SES groups.

### Fiber and micronutrient intakes

Intakes of some essential vitamins and minerals follow a socioeconomic gradient consistent with the food consumption patterns described above. As summarized in **Table 2**, higher SES groups had consistently higher intakes of most vitamins and

minerals and fiber than did lower SES groups (15, 18, 37, 42, 43, 46, 48, 68, 78, 88–92). This was true regardless of whether the intakes were expressed in absolute amounts or were corrected for energy.

Consistent with a low consumption of fruit and vegetable by lower SES groups, intakes of dietary fiber were also consistently lowest in that group (18, 19, 37, 44, 45, 48, 49, 54, 55, 68, 88, 90–93). Low-SES groups also had the lowest consumption of vitamin C,  $\beta$ -carotene, and folate (15, 37, 42, 43, 48, 68, 78, 88–92), vitamin E (37), and plant-based polyphenols (98).

Low iron intakes among low-SES populations were found in most studies (37, 46, 48, 90, 91) and so were lower intakes of calcium and potassium (18, 37, 46, 48, 90, 91, 96, 97). Some studies showed significantly higher sodium intakes (90) or higher ratios of sodium to potassium (96) among lower SES respondents. Lower intakes of vitamin D were also observed (18), consistent with the low consumption of fish by lower SES groups.

Similar patterns of micronutrient intake were reported among lower SES children and adolescents (84–86). Dietary intakes of vitamin C, folate, and iron were insufficient to meet dietary recommendations (80, 99–101). These nutrient deficiencies may be exacerbated by low rates of breastfeeding among lower SES families (102–104), with potential consequences on iron nutrition status (105, 106) and future obesity risk (107).

### Energy and macronutrient intakes

On the other hand, the association found between SES and energy intakes or the macronutrient composition of the diet intakes was either not statistically significant or inconsistent. As shown in Table 2, the associations observed between SES and protein consumption were positive (37, 45, 90), negative (88, 92), or not significant (18). No consistent SES gradient was obtained for carbohydrate intakes. Differences between SES categories were either not significant (18, 45, 46) or were variable depending on the study (36, 43, 68, 88–91). Some studies found higher intakes of sucrose in adults of lower SES (37, 88).

No consistent SES gradient was observed for total fat intakes. Some studies showed evidence of a higher fat intake among low-SES groups (48, 49, 54, 92); however, an equally large number of studies found no significant differences (18, 43, 46, 68, 78, 89, 94, 108). Other studies obtained results that differed according to country, ethnic origin, or type of SES indicator (19, 45, 55, 66, 88, 91, 95). In the recent analysis of the Canadian food budget surveys, fat was the only nutrient not related to income, whereas a positive income gradient was found for all of the micronutrients studied (74).

There may be some differences by SES in the types of fat consumed, although the data were inconsistent. Some studies reported higher energy contributions from saturated fats and/or cholesterol among lower SES groups (19, 37, 45, 91, 92); however, other studies did not (18, 33, 43, 46, 89, 94). Studies that analyzed ratios of polyunsaturated to saturated fatty acids produced inconsistent results, variously reporting lower ratios (45, 88), higher ratios (48), or no significant differences (63, 94) between low-SES groups and the rest of the population. A recent meta-analysis of European studies reported significantly higher total fat and saturated fat intakes in adults with a low SES (with occupation level as the indicator) than in those with a higher SES in the majority of countries, except Spain and Estonia (109). However, the differences were small, in the order of 1% and 0.2%

**TABLE 2**

Variation in energy and nutrient intakes by socioeconomic status (SES; education, income, and/or occupation): summary of findings from individual food consumption surveys in adults<sup>1</sup>

	High intakes among low-SES individuals	High intakes among high-SES individuals	Not statistically significant (or inconsistent)
Energy intakes			
Men	(19, 42, 43, 45, 46, 48, 68, 88)	(33, 90)	(18, 37, 91–93)
Women	(44, 45, 88)	(33, 90)	(18, 19, 37, 42, 43, 46, 48, 91, 92)
Carbohydrates			
Men	(88)		(18, 36, 43, 45, 46, 89, 91)
Women	(43, 89)	(36)	(18, 45, 46, 88, 91)
Proteins			
Men	(88, 92)	(37, 45, 90)	(18)
Women	(88, 92)	(37, 45, 90)	(18)
Fats			
Men	(48, 49, 55, 92)	(88)	(18, 19, 37, 43, 45, 46, 89, 91, 94, 95)
Women	(36, 37, 45, 48, 49, 54, 55, 88, 92)		(18, 19, 43, 44, 46, 89, 91, 94, 95)
Fiber			
Men		(18, 19, 37, 45, 48, 49, 55, 88, 90–93)	(43, 89)
Women		(18, 19, 37, 44, 45, 49, 54, 55, 88, 90–92)	(43, 48, 89)
Vitamin C			
Men		(15, 37, 42, 43, 68, 88–92)	(46, 48)
Women		(15, 37, 42, 43, 48, 88–92)	(46)
Folates			
Men		(37, 90–92)	
Women		(37, 90–92)	
$\beta$ -Carotene			
Men		(15, 42, 43, 68, 88, 90)	(48, 89)
Women		(15, 42, 43, 48, 88, 90)	
Calcium			
Men		(18, 37, 46, 48, 90, 91, 96)	(89)
Women		(18, 37, 46, 48, 90, 91, 96, 97)	(89)
Iron			
Men		(18, 37, 46, 90, 91)	(48)
Women		(18, 37, 46, 48, 90, 91)	

<sup>1</sup> Macronutrient intakes were always expressed as a percentage of total energy or in daily quantities adjusted for total energy. Fiber and micronutrient intakes were analyzed after energy adjustment or expressed as nutrient densities except in references 42, 49, and 93. Nutrient intakes of men and women were analyzed separately in all studies, with few exceptions (15, 33). Only men were analyzed in references 68, 93, and 97. Only women were analyzed in references 44 and 54.

of energy intakes for total lipids and saturated fats, respectively, between extreme levels of SES (109). In fact, high- and low-SES groups seem to have different sources of saturated fats; the former use more cheese, whereas the latter use more butter and fatty meats (62).

The data on total energy intakes by SES were equally inconsistent. Several studies have reported higher energy intakes among populations of low SES (19, 42–46, 48, 68, 88). However, in most of those studies, this inverse relation between SES and energy intakes was observed primarily among men (19, 42, 43, 46, 48, 68). Other studies found that energy intakes did not vary with SES (18, 89, 92, 93) or found variations depending on country, ethnic origin, or type of SES indicator (37, 91). One problem is that underreporting of energy intakes is a major source of bias in dietary surveys, and its prevalence shows a marked inverse association with SES (89, 108). In contrast, in food budget surveys, the amount of energy purchased was higher among high-SES households because of a higher amount of food wasted in these households (74). As a result, there is no agreement as to the influence, if any, of social class on total energy intakes.

Dietary energy density has been used as another proxy measure of diet quality (23, 24). Because water contributes to energy density more than any macronutrient, dietary energy density

measures are primarily influenced by the proportion of vegetables and fruit (27). A recent analysis of the National Health and Nutrition Examination Survey (NHANES) 1999–2002 observed a negative relation between SES and dietary energy density. Higher education and the highest income level were associated with lower dietary energy density (33). A negative relation was also found between income level and the energy density of food purchases among Canadian households (74). Recent data from the consumer panel on food expenditures in France similarly showed that higher incomes were associated with lower energy density and higher nutrient density of food purchases (110).

### Vitamin and mineral status

Studies of plasma biomarkers of dietary exposure provide additional evidence that SES affects diet quality. However, it must be noted that these studies have typically focused on nutritionally at-risk groups, namely, elderly persons and pregnant and breastfeeding women.

In the recent European Prospective Investigation of Cancer–Norfolk study, low-SES individuals had significantly lower plasma vitamin C concentrations than did high-SES individuals. This SES gradient was found to be independent of cigarette and vitamin supplement use and was observed among both men and



women (111). In a study of persons aged >65 y, conducted in the United Kingdom, plasma concentrations of vitamins C and B-12, riboflavin, and  $\beta$ -carotene (and other carotenoids) were lower in the low-SES group than in the high-SES group (90, 112). In this study, a 2-fold difference was observed in vitamin C intakes, and this was associated with a 4-fold difference in plasma vitamin C (90). Urinary measures of sodium and potassium indicated an imbalance in the ratio of sodium to potassium, with less favorable potassium concentrations found in the low-SES group (90). The French EVA study (113), conducted in persons aged 57–71 y, showed a positive association between participant SES and their selenium and carotenoid status, even after adjustment for a large number of potential confounding factors, such as age, sex, body mass index, alcohol, tobacco, and lipid variables. Other studies suggested that pregnant or breastfeeding women of low SES were at greater risk of insufficient vitamin and mineral intakes (114, 115), inducing iron (116) and vitamin A (117) deficiencies. In other studies, deficiencies in plasma vitamin A, iron, and selenium were more common among children in lower SES households (106, 118–123).

### SEARCH FOR CAUSAL MECHANISMS

Associations found in cross-sectional studies are not, by themselves, evidence of causality. A plausible biological or behavioral mechanism is required to draw causal links between SES indicators and diet-quality measures. This can be a challenge, because the determinants of food choice are both complex and multifactorial. Rather than focus on individual nutrition knowledge (124) or on motivation or behavior (125, 126), the current trend is to emphasize structural factors such as access to grocery stores, transportation, and neighborhood safety as well as inequities in access to healthy foods (127–130). There is also an increasing awareness that healthier foods are associated with increased monetary and time costs (17).

### Food prices and diet costs

The observed SES gradient in diet quality may be mediated by food prices and diet costs (17, 29, 131–133). It follows from economic theory that food price is an important determinant of food choice (134–137). Not surprisingly, the lowest-cost diets are also the least healthy (138–140). In general, high-energy-density diets are associated with lower costs (29), whereas nutrient-dense diets are associated with higher costs per megajoule (24, 141). As shown in **Figure 1**, on the basis of a large

sample of self-selected diets in the French population, participants in the lowest quartile of energy cost had the highest energy intakes, the most energy-dense diets, and the lowest daily intakes of key vitamins and micronutrients (24); this has been attributed to the high water content and very low energy density of vegetables and fruit, which makes them expensive sources of energy (142). Lean meats, fish, or fresh fruit and vegetables are far more costly per calorie than are added sugars and added fats (17, 143). Diets composed of low-energy-density nutrient-rich foods are more expensive than are diets composed of refined grains, added sugars, and added fats (133).

Food costs are a barrier to the adoption of nutrient-dense diets, especially by the lower income groups (144, 145). One recent study, based on the US Department of Agriculture Thrifty Food Plan, reported that the cost of substituting healthier foods can cost up to 35–40% of an American low-income family's food budget (146). Other studies have shown that food costs are an obstacle to reducing fat intakes (147) or to increasing the consumption of fish (148), whole-grain products (149), or vegetables and fruit (59, 125). In a recent US study, women who considered food price very important were likely to live in low-income households and to have energy-dense diets (150). Several studies have emphasized that food budgets of the poor are insufficient to obtain a balanced diet (151–154). Even when low-income groups develop efficient purchasing strategies (155–158), the food budget may not be adequate to procure the recommended diet.

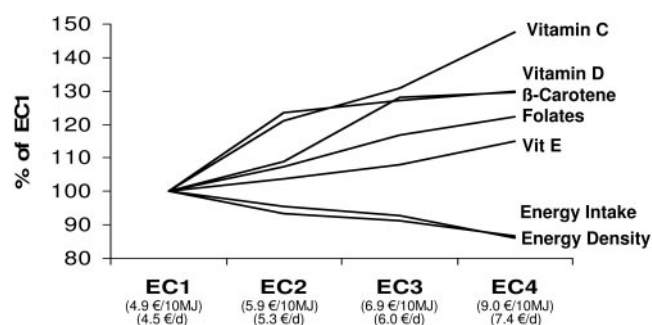
Poverty may lead to the selection of low-cost diets that are both energy rich and shelf stable. Foods with the longest shelf life are dry packaged foods (159) likely to contain refined grains, added sugars, and added fats. The emphasis on maximum calories and least waste and spoilage is another characteristic of poverty. Because trying a new food represents a risk of waste (160), diets of low-income households are often monotonous. Poverty is often accompanied by isolation, boredom, and depression—behaviors that may encourage snacking, simplifying or skipping meals, and sedentary behavior.

### Food access and the food environment

Access to foods can also be a function of the physical environment (161, 162). Whereas supermarkets and grocery stores may cluster in the more affluent neighborhoods (129, 130, 163), some lower-income neighborhoods have been characterized as “food deserts” (164).

Some studies have viewed physical proximity to healthy food choices as the chief influence on diet quality. Easy access to supermarkets was shown to be associated with a higher intake of fruit and vegetables (162), even within a low-income population in the United States (163, 165). Living in lower-income neighborhoods has been associated with lower consumption of fruit, vegetables, and fish (161). The quality of food choices was directly influenced by the ease of access to a supermarket as well as to the availability and variety of healthy foods in neighborhood stores (162, 166). For example, foods recommended for the self management of diabetes are less likely to be stocked in East Harlem than on the Upper East Side (167).

Low-income families are less likely to own a car and may find it more difficult to reach out-of-town supermarkets, in urban (128) as well as in rural (168) areas. Deprived neighborhoods may limit not only food access but also opportunities for physical activity, because of the lack of facilities (169–173) or because of security issues (174). Physical activity levels are lower among



**FIGURE 1.** Evolution of daily energy intakes, dietary energy density, and daily intakes of selected vitamins per quartile of energy cost (EC) of diets of adults living in France. Adapted from reference 24.

low-SES groups (5, 175), and living and growing up in a high-poverty area represents in itself a risk factor for obesity (176, 177).

### Education and culture

Studies of dietary habits of lower SES groups have emphasized lack of nutrition knowledge (124), lack of cooking skills, lack of motivation (125, 126), and a general disinterest in cooking (126). It is not clear that such reports are correct. One UK study found that cooking skills showed little differentiation by SES and that lower income groups are more likely to cook than are higher income groups (178). Similar observations were made in Canada (179) and in France (63, 180), where the middle and upper classes cook less and consume more convenience and ready-to-eat foods. Other studies found that low-income groups have adequate cooking skills (155, 181). In very poor families, the lack of cooking equipment will in itself discourage cooking.

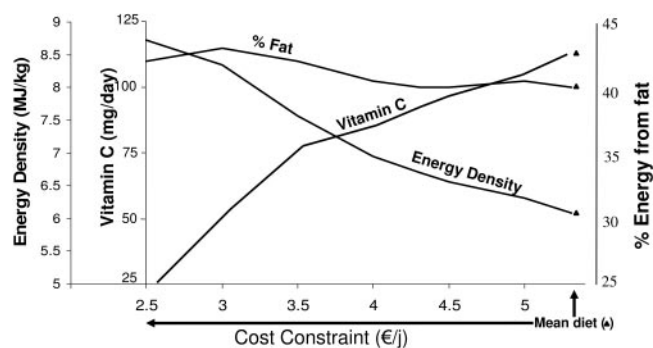
A lack of nutrition knowledge (182), apathy toward nutrition prevention messages (183), and an erroneous perception of body weight (184–186) have all been cited as potential explanations for unhealthy dietary habits and high obesity rates among disadvantaged groups. However, nutrition knowledge alone may not necessarily be sufficient to initiate behavioral application of healthy diets (187, 188). Limited time for food shopping and cooking is an important factor influencing food intake among low-income mothers (189).

Residence, country of origin, and social integration are also determining factors of diet quality. Studies conducted in the US among poor families showed that establishment of a strong social network (190) and among migrants, the maintenance cultural traditions (191), were associated with a lower risk of food insecurity, independent of income level. In France, some studies suggest that immigrants of southern Europe (192) and elderly people living in rural areas in southern France (193) have maintained healthy Mediterranean food practices despite a lower SES than the general population.

### MEDIATING FACTORS

The monetary and time cost of healthy foods may be the looked-for intermediate variable. Economic access is a factor, given that healthier foods and the more nutrient-dense diets cost more (142, 143) and seem to be preferentially selected by higher SES groups. Low-cost foods satisfy hunger and are more affordable and more accessible in low-income areas. Plausible biological mechanisms may also include the higher palatability and lower satiety value of energy-dense foods.

Such relations are difficult to explore in the course of intervention studies. Mathematical diet modeling studies were therefore conducted to simulate the impact of a decrease in the budget for food on the food choices made to select a diet that is socially acceptable while keeping energy intake constant. The most rational food choices were to decrease fruit, vegetables, meat, and fish intakes and to increase the intake of refined cereals, which resembled the food intake patterns observed among low socioeconomic groups (131). As shown in **Figure 2** (131), the cost constraint increased energy density and decreased nutrient densities, which suggests that economic considerations are likely to contribute to the high prevalence of obesity and nutrient deficiencies in these groups. In contrast, the constraint induced only a moderate increase in total lipid content. This is consistent with



**FIGURE 2.** Impact of a cost constraint on the energy density, the vitamin C content, and the lipid content of diets modeled by linear programming. Adapted from reference 131.

the epidemiologic observations that micronutrient intakes are more affected than are macronutrients intakes by socioeconomic status and with the increasing contribution of refined cereals when income decreases.

Computer modeling studies also showed that forcing energy density to increase only moderately decreased diet cost, while forcing diet cost to decrease induced a dramatic increase in energy density (132). Therefore, it is possible to purchase an energy-dense diet for a relatively high cost, while economic constraints will necessarily increase energy density. In other words, the more affluent groups have a choice of high-energy-density or low-energy-density diets, whereas for low-SES groups, the ability to adopt a healthier diet may have less to do with motivation than with economic means. Recent studies from both the United Kingdom (194) and the United States (195) have shown that providing vouchers for purchasing fruit and vegetables was a simple and effective way of increasing fruit and vegetables intakes in low-income women, whereas dietary advice alone had no great effect (194).

### CONCLUSIONS

The cross-sectional studies reviewed above permit the conclusion that higher-quality diets are, in general, consumed by better educated and more affluent people. Conversely, lower quality diets tended to be consumed by groups of lower SES and more limited economic means. This conclusion is based on a review of empirical data and some computer modeling of dietary habits subjected to cost and other constraints. The remaining question is whether the observed relation between SES and diet-quality measures can be characterized as causal.

The observed relation between SES indicators and diet-quality measures was consistent. The relation was observed in different groups by age and sex, with multiple measures of SES—occupation, education, and income (18–20, 22)—and with multiple measures of diet quality. It was observed with food purchase data at the aggregate household level (20, 41, 72, 75, 179) and with individual food consumption data (37, 89, 91, 92). It held for fiber and nutrient intakes and for selected plasma biomarkers. The data sets that the analyses were based on came from multiple European countries, Canada, Australia, and the United States.

The observed relation between SES variables and diet quality was graded rather than threshold dependent (16, 34, 35, 59, 74, 89, 91, 111). Diet quality showed a continued improvement

across a wide range of economic strata, continuing to improve well above the poverty threshold.

The relation between SES indicators and diet-quality measures was strong. In the Whitehall II survey, employment grade was directly associated with sharply higher intakes of vitamin C (89). Whereas women in the lowest grade ( $n = 6$ ) consumed 91 mg/d, those in the highest grade consumed 133 mg/d. Similar trends were observed for fiber and for other nutrients found in vegetables and fruit (89, 90). From 1971–1975 to 1999–2002, the mean energy density of the diet of US adults with  $>12$  y of education was 1.59 kcal/g, a level equal to that of the mean energy density of the US diet in 1971–1975. In contrast, in those with  $<12$  y of education, it was 1.71 kcal/g, a level equal to the mean energy density of the US diet in 1999–2002 (33). In other words, the education-dependent differences in dietary energy density in the United States were as strong as those induced by 30 y of secular trends. Recent data from Canada suggest that the relation between SES and the nutrient density of diets is growing stronger (74). Other data suggest that the price of vegetables and fruit has increased disproportionately over the past 20 y relative to sweets and fats (17). Increases in food availability and ongoing marketing incentives to consume large quantities of low-cost energy-dense foods may be particularly damaging to the health of lower SES groups, for whom such foods represent a source of affordable calories.

The present associations appear to meet some of the standard tests for causality. SES variables may have a causal influence on diet quality and on diet cost. The observed epidemiologic relations between diet quality and health outcomes may have been confounded by unmeasured SES factors. Persons with a certain type of dietary pattern may differ, in several unobserved ways, from persons with another type of dietary pattern. For the most part, indexes of SES are unobserved variables in many studies of diet and chronic disease risk. Thus, high vitamin C consumption may have been associated with better health outcomes, but persons in the top quintile of vitamin C consumption not only paid more for their diets but their financial resources may have been very different from those of persons in the bottom quintile of vitamin C consumption. In other words, it is difficult to tell whether improved health outcomes are attributable to vitamin C or to diet costs, poverty, or wealth.

British researchers have already issued the plea that nutrition research should not lose touch with reality (196). The promotion of high-cost foods to low-income people without taking food costs into account is not likely to be successful. Future studies of diet quality and SES need to use planned dietary interventions, many of which should be targeted at minorities and low-income and other vulnerable groups.

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