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Chapter Author: Jay Bhattacharya, Janet Currie

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Youths at Nutrition Risk
Malnourished or Misnourished?

Jay Bhattacharya and Janet Currie

The words *youth malnutrition* conjure up images of gaunt, starving waifs. Fortunately, such extreme nutrition deprivation is rare in the United States and in other developed countries. Nevertheless, as we will show, many American youths are "misnourished." The nutrition problems prevalent in the West are generally due to the composition of the diet—many youths underconsume important nutrients while overconsuming calories and high-fat foods. This pattern is linked to the increasing prevalence of obesity, which has important long-term health consequences. Poor diet quality (e.g., overconsumption of fats and underconsumption of foods such as fruits and vegetables) has also been increasingly linked to the development of leading killers such as cancer and heart disease in later life.

Standard human-capital theory suggests that youths (or their parents) choose diets in order to maximize utility, subject to two sets of constraints. The first constraint is the information that they have available about the link between food inputs and health outcomes that they care about. The second constraint is the household budget. This formulation leads naturally to the question of whether misnourished youths lack information about the relation between nutrition and health or whether they lack re-

Jay Bhattacharya is associate economist at the Rand Corp. in Santa Monica, Calif., and visiting professor in the Department of Economics at the University of California, Los Angeles. Janet Currie is professor of economics at the University of California, Los Angeles. She is a consultant with the Labor and Population group at Rand, a research associate of the National Bureau of Economic Research and a member of the NBER's Children and Families programs, and a faculty associate at the Chicago/Northwestern Poverty Center.

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sources (which would imply that nutrition problems are heavily concentrated among the poor)?

U.S. public policies concerning nutrition are generally predicated on the notion that resource constraints are of paramount importance. In order to assess this hypothesis, we focus on an array of outcome measures, including various nutrition deficiencies, obesity and high cholesterol, measures of overall dietary quality, and food insecurity.

Food insecurity is the most commonly used measure of nutrition status. It can be thought of as uncertainty about where one's next meal is coming from. We find that, while poor youths are more likely to suffer from food insecurity, they are also more likely to be obese than are other youths. Yet they are no more likely to suffer vitamin deficiencies, and the overall quality of their diets is no worse than that of other youths.

Thus, resource constraints alone cannot explain the patterns that we see. On the other hand, proxies for information are very important. Youths in households with more-educated heads are less likely to be obese, eat healthier diets, and are less likely to suffer from food insecurity, other things being equal. We also find that school-meals programs have positive effects on the quality of the diet, which is likely due to the fact that they are mandated to follow particular meal patterns.

These findings all suggest that policies designed to alter the composition of the diet are likely to address the nutrition problems of American youths more effectively than are those policies (such as food stamps) that merely seek to increase the quantity of food consumed.

The rest of the paper is laid out as follows. In section 10.1, we discuss important background information related to the measures of nutrition status that we examine. In section 10.2, we provide an overview of the human-capital theory underlying our approach. Section 10.3 provides an overview of the data, while section 10.4 presents our main results. Section 10.5 concludes.

10.1 Background

10.1.1 Measures of Nutrition Status

As discussed above, measures of nutrition status can be grouped into four broad categories: food insecurity, dietary quality (measured using dietary intake surveys), and measures of nutrition deficiency and obesity that are based on physical examinations. This section discusses the pros and cons of the different measures.

Food Insecurity

The most commonly used measure of nutrition status in the United States is *food insecurity,* which is often defined as missing a meal because there was no food in the house or because there was no money to buy food. More simply, respondents may be asked if there is "enough food to eat, sometimes not enough to eat, or often not enough to eat," as they are in NHANES (National Health and Nutrition Examination Survey) III. A recent USDA report (Nord, Jemison, and Bickel 1999) found that one in ten U.S. children suffer from food insecurity.[1] This estimate is almost double our estimate (5.5 percent) for adolescents.

The link between food insecurity and actual nutrition deficiencies is, however, unclear. In the USDA study, only 3.5 percent of households had food insecurity severe enough that one or more household members were hungry at some point during the year. Rose and Oliveira (1997) use data from the longitudinal 1989–91 Continuing Survey of Food Intake by Individuals and find a negative relation between food insecurity and nutrient intakes among young women and the elderly but not among children. Wilde (1997) and Wilde and Ranney (1997) use data from the Consumer Expenditure Survey and find that, while adults in families using food stamps frequently eat less during the fourth week of the month (the benefits are issued monthly), children do not. These findings suggest that parents are largely successful in shielding their children from the nutritional effects of food insecurity, although such insecurity could well have negative psychosocial consequences. As we will show below, we also find little relation between food insecurity and measures of nutrition deficiencies.[2]

Dietary Recall

A second common source of information about nutrition is dietary-recall data. Respondents are typically asked to keep a food diary for lengths of time varying from one or two days to up to one week. In NHANES III, respondents were asked how many times they ate various foods in the past month. Nutrient values are then calculated on the basis of the respondent's account of the types of foods and the amounts that were eaten. Since food intakes vary a great deal from day to day, food intakes measured over longer periods are considered more accurate (see Beaton, Burema, and Ritenbaugh 1997).

Because dietary recalls are self-reported, there is a possibility of system-

1. The definition used in this study includes those who answered yes to questions ranging from "We worried whether our food would run out before we got money to buy more" to "In the last 12 months did any of the children ever not eat for a whole day because there wasn't enough money for food?"

2. Still, some would dispute this assessment. For example, Neuhauser, Disbrow, and Margen (1995) estimate that 2 million children in California alone go hungry because their parents do not have the resources to buy food. They obtain this estimate by comparing estimates of total family income less other necessities with the amount necessary to purchase an adequate diet. However, their estimates are much higher than those obtained from surveys of the poor, probably because they underestimate the total resources available to households. Frank et al. (1996) show that the fraction of emergency-room visits accounted for by children who are small for their age rises during the winter months in a Boston hospital. They attribute this to a "heat-or-eat" effect, but it could also be due to selection if small children are more susceptible to illness.

Table 10.1 Components of the HEI

Component	Criteria for Score of 10	Criteria for Score of 0
1. Grains	6–11 servings[a]	0 servings
2. Vegetables	3–5 servings	0 servings
3. Fruits	2–4 servings	0 servings
4. Milk	2–3 servings	0 servings
5. Meat	2–3 servings	0 servings
6. Total fat	< 31% calories from fat	> 46% calories from fat
7. Saturated fat (s.f.)	< 10% calories from s.f.	> 14% calories from s.f.
8. Cholesterol	< 300 mg	> 449 mg
9. Sodium	< 2,400 mg	> 4,800 mg
10. Variety	> 16 different categories	< 7 different categories

[a] These criteria refer to the number of servings consumed daily. Recommended numbers of servings vary with the energy needs of the individual.

atic bias. For example, Briefel et al. (1997) compare the self-reported energy-intake information derived from NHANES III with a measure of basal metabolic rate for sedentary individuals derived from fundamental principles of energy physiology (Goldberg, Black, and Jebb 1991). They find that 18 percent of men and 28 percent of women underreport their consumption of energy. Underreporting is greatest among overweight individuals and among those trying to lose weight.

Nevertheless, food-frequency questionnaires provide useful information for researchers. Studies generally report moderate to high correlations between the dietary information gleaned from food-frequency questionnaires and methods that rely on direct observation (see Rockett and Colditz 1997). Since extensive food diaries and direct observation place considerable burdens on researchers and subjects, and since the act of observation may by itself alter the diets of subjects, food-frequency questionnaires are an indispensable tool for nutrition researchers.

We have adopted the USDA's Healthy Eating Index (HEI) as a way of summarizing the food-diary information available in NHANES III (Kennedy et al. 1995).[3] The USDA uses the HEI to assess overall diet quality. The index has ten components, and each component is scored between 0 and 10. The components and the scoring algorithms are shown in table 10.1. Intakes that fall between the criteria for scores of 0 and 10 are scored proportionally.

Perhaps surprisingly, the index does not penalize those with a high sugar

3. We use a slightly modified version of the HEI. Kennedy et al. (1995) define the *variety* component of the HEI using a survey that asks about food intake over the past several days, whereas NHANES asks about intake over the past month. We redefined the top and bottom *variety* criteria in such a way that the same proportion of people received a score of 0 and 10 in NHANES as Kennedy et al. (1995) report for their sample. The cutoffs that we use are more than thirty-three different food items (for a score of 10) and fewer than fourteen different food items (for a score of 0).

intake, which could well contribute to the consumption of excessive numbers of calories. Hence, we will look separately at the determinants of high sweets consumption, where *high sweets* is a variable set equal to 1 if the person consumed more than thirty sweets per month.

Measures Based on Physical Examinations

Measures based on physical examinations are likely to be the most accurate of the three types of measures, although their interpretation is not without controversy. In what follows, we focus on measures based on body-mass index (BMI) (a measure of obesity)[4] and on measures of blood cholesterol and of vitamin and iron deficiencies based on blood and urine samples.

BMI is defined as weight in grams/(height in meters)^2. Adults with a BMI over 30 are considered to be obese. Gauging obesity among adolescents is complicated by the fact that adolescents undergo growth spurts that change their weights and heights disproportionately. One commonly used measure (see Himes and Dietz 1994) is BMI over the eighty-fifth percentile for sex and half-year of age. This measure results in fewer false positives than alternatives based on measures such as skin-fold fat or waist-hip ratios. However, a conceptual difficulty that arises with this definition is that, in any given data set, 15 percent of adolescents would always be found to be obese. A second problem is that the NHANES surveys used to calculate the cutoffs yield relatively small sample sizes and cutoffs that bounce around from one age to the next. For example, rather than being smooth, the National Center for Health Statistics (NCHS) growth curves, which are based on NHANES I and two earlier surveys, show ninetieth percentile cutoffs that rise from 21.9 to 23 between the ages of 13.75 and 14.25 and then fall again to 22.4 by age 14.75 (U.S. DHEW 1977). These cutoffs are old and are due to be updated by the NCHS in the very near future.

In this paper, we use a fixed cutoff for obesity, which is BMI over 27.3 for females and BMI over 27.8 for males. These cutoffs are the eighty-fifth percentiles of BMI for young adults between twenty and twenty-nine, calculated from NHANES II, which was fielded between 1976 and 1980. While one would expect young adults to be heavier than teens (i.e., that these are conservative cutoffs to use for a sample of teens), we will see below that, in NHANES III 10 percent of teens still exceed these cutoffs.

Blood or urine tests are used to assess the existence and extent of specific micronutrient deficiencies, such as essential vitamins and minerals.

4. In an earlier version of this paper, we also considered determinants of anorexia. We defined a person as anorexic using a BMI cutoff of the fifteenth percentile for the person's age and gender in addition to indicators of negative body image (the individual considered herself to be overweight or was trying to lose weight). However, in samples of this size, few people are anorexic, and we had little success in modeling the prevalence of this condition.

The relation between micronutrient intake and blood levels of these nutrients is complicated. Because the body can store some vitamins and minerals for a long time, it is not anomalous to find a respondent who has not recently consumed the recommended amount of some vitamin yet does not have a deficiency in that vitamin according to blood tests. For example, it can take between three and six years for a deficiency in vitamin B_{12} to become clinically evident (Middleman, Emans, and Cox 1996). Nevertheless, blood tests can provide solid, objective evidence of micronutrient malnutrition when properly interpreted.

The appendix presents the cutoff values that we use to determine vitamin and mineral deficiencies in this paper. These cutoffs, which are taken from a pediatrics textbook (DeAngelis et al. 1999), typically represent blood levels below which the nutrient deficiencies manifest themselves clinically. When possible, the cutoffs used are specific to adolescents.

In addition to providing the information necessary to assess the extent of anemia, NHANES III allows us to assess the determinants of shortages of essential vitamins A, C, and E.[5] We will focus on a measure that is equal to 1 if the person is short any of these vitamins and 0 otherwise. Finally, we can examine the level of cholesterol in the blood (serum-cholesterol levels). This measure is linked to obesity and provides an alternative to measuring this important threat to health using BMI.

10.1.2 Long-Term Effects of Poor Nutrition in Adolescents

The nutrition habits of adolescents are important for at least two reasons. First, poor nutrition habits are hard to unlearn as an adult (as the model of O'Donoghue and Rabin [chap. 1 in this volume] would predict). Second, poor nutrition can immediately damage a young person's health, and the effects can persist into adulthood. The literature on the long-term effects of poor nutrition is large, and a comprehensive review is beyond the scope of this paper. Hence, we will focus on some of the most important health consequences of adolescent obesity, high cholesterol, and micronutrient deficiencies below. It is not known whether food insecurity has any negative long-term effects, other things being equal.

The long-term effects of obesity among children are relatively well documented. While the majority of obese adults were not obese children, obese children are much more likely to become obese adults. For example, Charney et al. (1976) followed children born between 1945 and 1955 and found that, of the children who were at the ninetieth percentile of the weight distribution for their sex and age, 36 percent became obese adults, compared to only 14 percent of average or lighter-weight children. Obese adults are known to be at increased risk of many diseases, such as diabetes and heart

5. We found little evidence of any shortages of vitamin B_{12} or of calcium, so we do not examine these outcomes.

disease. Moreover, the negative effects of childhood obesity may persist even in adults who are no longer obese. Lauer, Lee, and Clark (1989) found in a sample of Iowan children that childhood obesity was linked to an increased risk of high cholesterol as an adult.[6]

The long-term effects of micronutrient deficiencies vary considerably, depending on the vitamin or mineral in question. Interested readers can find a good review from a clinical perspective in any standard pediatrics text, such as DeAngelis et al. (1999). Iron-deficiency anemia is a particularly pernicious condition since it can have devastating effects on the school outcomes of children and youths. Even mild iron deficiency is associated with fatigue, shortened attention span, decreased work capacity, reduced resistance to infection, and impaired intellectual performance (CDC 1996). About 8 percent of black Americans carry the sickle-cell trait, which places them at much higher risk of anemia than they would face otherwise (Wilson et al. 1991).

Recently, attention has been focused on the possibly beneficial effects of diets rich in the micronutrients found in fruits and vegetables rather than on the harmful effects of deficiencies. Epidemiological evidence links diets rich in fruits and vegetables to reductions in the risk of stroke, cardiovascular disease, asthma, osteoporosis, and many specific types of cancer (see Joshipura et al. 1999; Lampe 1999; Butland, Strachan, and Anderson 1999; Palace et al. 1999). While the mechanisms for these effects are not well understood, there are many plausible biological reasons that eating fruits and vegetables has positive effects. These include stimulation of the immune system, reduction of platelet aggregation, modulation of cholesterol synthesis and hormone metabolism, reduction of blood pressure, and antioxidant, antibacterial, and antiviral effects (Lampe 1999).

10.1.3 Trends over Time in the United States

A number of authors have documented an increase in the proportion of U.S. children and adolescents who are obese, although the exact trends depend on the definition of *obesity* used.[7] Figure 10.1 shows our analysis of trends in obesity using data from NHANES I, II, and III. NHANES I covers the period 1971–74, NHANES II the period 1976–80, and

6. Anorexia can also have severe long-term consequences on the health of patients, even if they receive appropriate care. The most severe consequence is death (usually due to starvation or suicide), which occurs in 6 percent of patients. Long-term follow-up studies of surviving anorexics find that about half the patients reach normal weight, 20 percent remain underweight, 20 percent continue to be anorexic, and about 5 percent become obese (Foster 1991).

7. Gortmaker et al. (1987) compare measurements of skin-fold thicknesses (a standard measure of the amount of body fat) in NHANES I and NHANES II. They report a 39 percent increase in the proportion of obese children over the interval of time spanned by these two data sets (from 1971 to 1980). Ogden et al. (1997) compare data from NHANES I and NHANES III and find that the proportion of obese preschoolers grew from 5 to 10 percent. The NCHS reports a similar finding for older children (CDC 1999).

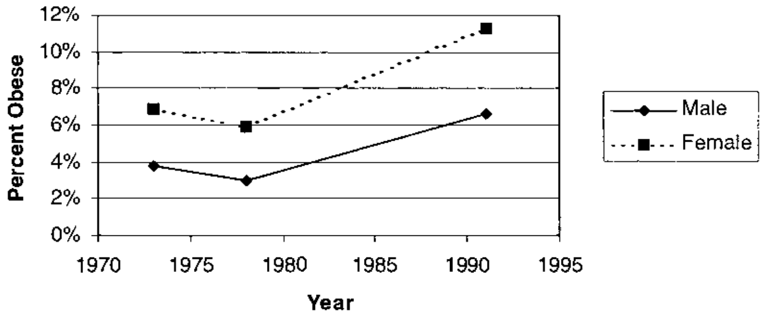

Fig. 10.1 Trends in obesity by sex
Note: Data are plotted at midpoint of year range.

NHANES III the period 1988–94. For both boys and girls (aged twelve to sixteen), the proportion obese decreased slightly between NHANES I and NHANES II but increased greatly between NHANES II and NHANES III. Figures 10.2 and 10.3 show changes in obesity by race for boys and girls, respectively. The time trends are similar for all six race and gender groups, but the much higher incidence of obesity among Hispanic men is striking, as is the increasing divergence between whites and either blacks or Hispanics.

One interesting hypothesis is that an increase in television watching is behind the increase in obesity among young people (Gortmaker et al. 1996).[8] More generally, Philipson and Posner (1999) conjecture that technological change is responsible for the increase in obesity. They argue that the number of calories consumed has been relatively constant over time but that technology has led to a reduction in the number of calories expended. Philipson and Posner dismiss the role of information in combating obesity, arguing that everyone knows how to lose weight. Thus, it will be interesting to ask whether such proxies for information as the education and age of the household head have an effect independent of income in the models of obesity estimated below.

Relatively few studies attempt to examine trends in vitamin deficiencies, primarily because relatively few American adolescents suffer from them (see Devaney, Gordon, and Burghardt 1995). For example, one recent study (Middleman, Emans, and Cox 1996) found only one reported case of vitamin B_{12} deficiency due to inadequate dietary intakes among adolescents (that of a fourteen-year-old female on a strict vegetarian diet). On average, U.S. adolescents consume more than the U.S. recommended daily allowances of all vitamins. Nevertheless, as we will show below, there are

8. The prevalence of anorexia has also been increasing over time (CDC 1996) but remains low, at 0.5–1 percent of adolescent girls.

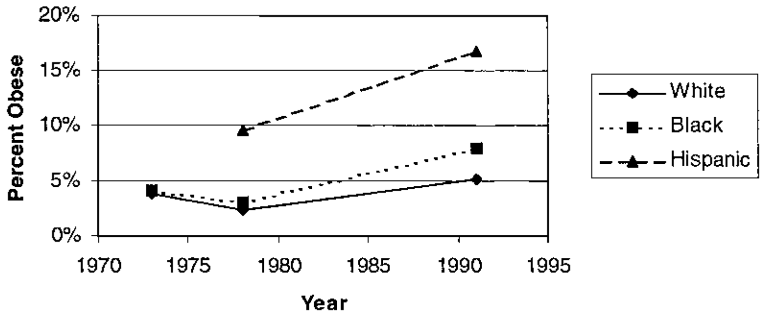

Fig. 10.2 Male trends in obesity by race
Note: Data are plotted at midpoint of year range.

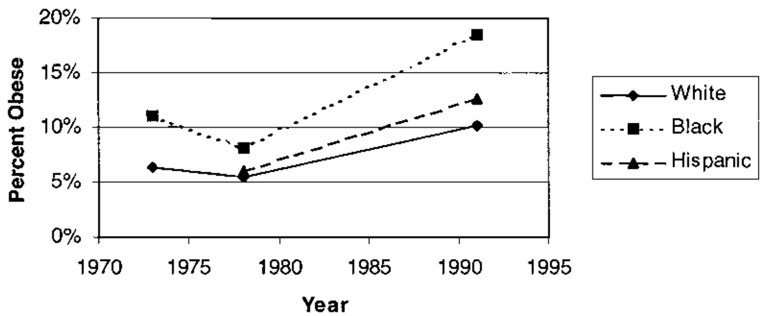

Fig. 10.3 Female trends in obesity by race
Note: Data are plotted at midpoint of year range.

significant numbers of U.S. adolescents who suffer from deficiencies of vitamins A, C, and/or E.[9]

A second reason for the paucity of information about trends in nutrition deficiencies is that the NHANES surveys, which are the main U.S. source of information about nutrition status, have changed the laboratory methods used to track deficiencies. For example, the methods used to evaluate white- and red-cell counts, serum folate, and serum vitamin C levels were updated in NHANES III, so it is difficult to infer time trends from these surveys (see Raiten and Fisher 1995; and Wright et al. 1998).

Data from other sources suggest that iron-deficiency anemia has declined significantly since the late 1960s, when several studies found that a

9. Researchers have also noted declines in calcium intakes among adolescents, which are associated with decreases in the consumption of milk (see Albertson, Tobelmann, and Marquart [1997], which examines changes between 1980 and 1992). These declines are of concern given that most adolescent girls consume less than 100 percent of the USDA-recommended daily allowance of calcium. However, we found little evidence of inadequate blood-calcium levels in our NHANES III sample.

large number of Americans (especially infants and young females) were iron deficient (see Committee on Iron Deficiency 1968; and Stockman 1987). However, Looker et al. (1997) conduct a careful assessment of trends in anemia using data from NHANES II (1976–80) and NHANES III (1988–94), adjusting for differences in the way anemia was measured in these two surveys, and find no change in the incidence of anemia. This study suggests that even trained observers may have difficulty using the NHANES surveys to detect trends in many outcomes.

Data on nutrient intakes and food insecurity have not been collected consistently either.[10] In view of these data problems, we will confine our own analysis of trends to an examination of obesity since that can be measured in the same way using data from NHANES I, II, and III.

10.1.4 U.S. Public Policy and Nutrition

Food and Nutrition Programs

The U.S. government operates a wide variety of food and nutrition programs (FANPs), including the Food Stamp Program (FSP), the National School Lunch Program (NSLP), and the School Breakfast Program (SBP), among others.[11] Most FANPs were developed with the goal of increasing food consumption among populations deemed likely to lack food. For example, the NSLP was established in 1946 in response to nutrition-deficiency-related health problems identified among young men being drafted during World War II.

The FSP provides coupons that can be redeemed for food to households with incomes less than 130 percent of the federal poverty line. There are few restrictions on the types of foods that can be purchased. The NLSP and SBP programs provide free or reduced-price meals to children with incomes less than 130 percent or 185 percent of poverty, respectively. Meals are designed to offer one-third of the USDA recommended daily allowances of specified nutrients.

However, as we have discussed, the nature of nutrition risk has changed in the United States from a situation in which significant numbers of people suffered food shortages to one in which obesity is prevalent even among the homeless—Luder et al. (1990) examined a sample of homeless-shelter users in New York City and found that 39 percent were obese.

10. In NHANES III, youths were asked about how many times they had consumed a particular type of food (e.g., broccoli) in the past month. In NHANES II, youths were asked about more general categories of food intakes (e.g., fruits and vegetables) and could report consumption in the last day, week, or month (however the person chose to respond). One might expect that asking about detailed categories of foods would lead to higher reported consumption while asking about foods consumed over the past month would lead to lower reported consumption. Hence, it is not clear a priori how the reported food intakes would be expected to differ between the two surveys.

11. For an overview of U.S. FANPs, see Currie (2000).

This observation raises the question of whether supplying meals (or food coupons) is the most effective way to address the nutrition risks facing the majority of FANP recipients.

In particular, school nutrition programs were roundly criticized in the early 1990s for providing meals that were high in fat and sodium and low in carbohydrates relative to the recommendations included in the *Dietary Guidelines for Americans* (USDA/U.S. DHHS 1995) (see Gordon, Devaney, and Burghardt 1995). These criticisms led to the Healthy Meals for Healthy Americans Act in November 1994, which mandated implementation of the dietary guidelines in school nutrition programs. Unfortunately, the data available do not allow us to assess the effects of these changes, although NHANES IV (which is currently in the field) will allow such analyses.

Whether or not FANPs improve the quality of the diet, one would expect the availability of these programs to reduce the probability of suffering from food insecurity. Yet, to our knowledge, no studies have been conducted of this issue. We will attempt to fill this gap in the literature in our analyses below.

Educational Interventions

Several studies have looked directly at the question of whether the provision of information through education programs can affect eating patterns. The existing evidence suggests that a wide variety of interventions can successfully improve young children's eating patterns. For example, Harrell et al. (1996) find that both classroom and individual nutrition education had positive effects on third- and fourth-grade children in terms of reducing blood cholesterol levels. Glenny et al. (1997) report similar results for family therapy and other interventions aimed at lifestyle modification.

Evaluations of the federal Nutrition Education and Training Program (NET), which provides grants to states that implement nutrition-education programs in their schools, have found that it is much easier to improve nutrition knowledge than it is to affect behavior. However, some evaluations of school-based programs have shown that children's willingness to try new foods offered in school lunches and the quality of snacks chosen away from home improved and that children were more likely to consume fruits, vegetables, protein foods, and foods with vitamin A. Poor children have been shown to be more likely to consume dairy products and foods with vitamin C as a result of school nutrition-education programs. Longer programs (e.g., fifty classroom hours or more) have been found to have greater effects on behavior (Contento, Manning, and Shannon 1992).

The Personal Responsibility and Work Opportunity Reconciliation Act of 1996 beefed up the nutrition-education component of the FSP considerably. Nutrition-education spending increased from \$32.7 million in fiscal year 1997 to a projected \$75 million in fiscal year 1999. In response to the

Healthy Meals for Healthy Americans Act, the USDA has also implemented the School Meals Initiative for Healthy Children to provide nutrition education to both children and food-service staff (Hamilton and Fox 2000).

Thus, public investments in nutrition education have grown considerably in the past few years, and it would be useful to know whether these investments can be expected to "pay off" in the form of improved eating habits. These investments can be contrasted with alternative approaches designed to promote the provision of nutrition information by the private sector.

A number of studies by Pauline Ippolito and Alan Mathios (1990, 1995, 1996) have examined the effects of attempts by both the government and advertisers to inform the public about the health benefits of diets low in fat and high in fiber. They argue that government efforts to get this message out during the 1970s were relatively unsuccessful (perhaps because they were underfunded?). But, in the mid-1980s, the Federal Trade Commission and the Food and Drug Administration relaxed rules that had prevented food manufacturers from making health claims for their products. Ippolito and Mathios show that, after declining very slowly between 1977 and 1985, the consumption of fats and cholesterol fell dramatically between 1985 and 1990 while the consumption of cereals rich in fiber increased. The Nutrition Labeling and Education Act of 1990 is apparently also influencing consumer choices (Ippolito and Mathios 1993).

10.1.5 International Comparisons

The evidence on the negative long-term effects of obesity is international in scope. For example, Mossberg (1989) reports the results of a forty-year follow-up of a sample of Swedes who were obese as children. Forty-seven percent of this sample remained obese. Power, Lake, and Cole (1997) provide an overview of similar evidence for the United Kingdom. Both studies also find an elevated mortality risk among adults who were obese as children, even among those who later slimmed down. Similarly, Post et al. (1997) report that Dutch children with a high fat diet were more likely to develop high cholesterol as adults, regardless of whether they remained obese. Gonzalez-Requejo et al. (1995) report that, in a sample of Spanish children, those with high-fat diets had higher blood cholesterol and lipid levels, which themselves can cause heart damage over time.

Similarly, the available evidence suggests that the increase in the prevalence of obesity over time is not an exclusively U.S. phenomena. Similar findings have been reported in England, particularly in the twenty-seven-year-old National Study of Health and Growth (Rona 1995). For example, Hughes et al. (1997) report that triceps skin-fold measurements from samples of five- to eleven-year-old English and Scottish children increased by 7–8 percent between 1972 and 1994. This problem is especially acute for minority populations within England, except for Caribbean blacks (Chinn, Hughes, and Rona 1998). As in the United States, there is concern that adolescents eat too much junk food: "The average 11–12 year old consumes three portions of crisps, six cans of soft drink, seven bars of chocolate or other biscuits and seven puddings every week" (Shepard and Dennison 1996, 347).

Other countries have similar problems with increasing trends in child obesity. Barth et al. (1997) report that, between 1985 and 1995, the ninetieth percentile of BMI for children taken from a sample of German pediatric hospitals increased by 5 kilograms per meter squared for males and 2.5 kilograms per meter squared for females, a dramatic rise. Seidell (1995) reports that increasing obesity is a problem throughout Europe, but especially in the Southern and Eastern European countries. Even in China, where the trend has been toward improving the nutrition status of children, there have been recent increases in obesity prevalence among adolescents (Wang, Popkin, and Zhai 1998).[12]

As in the United States, it is rare to find vitamin deficiencies in most European countries. For example, de Bree et al. (1997) review studies of vitamin B_{12} and folate deficiency in Europe and find that mean intake levels of these nutrients meet or exceed recommended levels in most European countries. However, just as in the United States, there is concern that some pregnant women may not be getting enough extra folate (found in green leafy vegetables) to prevent neural-tube defects in their babies.

In Europe, as in the United States, there is evidence that a substantial number of women may be iron deficient. Hallberg (1995) reviews the literature on the iron-deficiency status of Europeans. He reports that, in Europe, estimates of the prevalence of iron deficiency among menstruating females range between 11 and 45 percent, depending on the country and also on the particular measure of iron-deficiency status used in the study. In general, studies that focus on younger age groups tend to find higher prevalence rates. If these studies are accurate, they indicate that iron deficiency is a much greater problem in Europe than it is in the United States.[13]

12. Anorexia nervosa is apparently less prevalent in Europe than it is in the United States. For example, using the British General Practice Research Database, Turnbull et al. (1996) estimate that the prevalence of anorexia in England is 4.2 cases per 100,000 population. In a study of nearly twenty-five hundred Austrian, German, and Hungarian college students, Szabo and Tury (1995) report that not one person met the DSM-III-R (APA 1987) criteria for a diagnosis of anorexia nervosa (DSM-III-R is the predecessor to DSM-IV [APA 1994]). Not surprisingly, then, anorexia nervosa has not enjoyed the scholarly interest in Europe that it has in the United States.

13. However, Hallberg (1995) points out that some of the prevalence studies are methodologically flawed because they do not account for the fact that measurements of iron deficiency spuriously rise if subjects have a cold (or other insults to the immune system). Accounting for this, he reduces the prevalence estimate of one of the studies that he reviews by half.

10.2 Nutrition as an Investment in Human-Capital Formation

Grossman (1972) offers a model of health as a form of human capital that is "produced" by investing in certain activities. Health is treated as a durable-stock variable that depreciates with age and that can be improved by investing in health-producing activities, such as adopting a healthy diet. In his model, a consumer's utility depends on the stock of health rather than on the consumption of any of the investment goods per se. However, this restriction can easily be relaxed to allow consumers to obtain utility from the consumption of "investment" goods (e.g., hamburgers) as well as from health outcomes.

Consumers choose a stream of health investments with the aim of maximizing lifetime utility. In making these choices, they are constrained both by what they know about the production of health capital (the human-capital production function) and by their budget constraints. The key equilibrium condition in Grossman's model is that consumers choose their stream of investments to equate the marginal cost of the investment (which includes the lost utility from choosing carrots over cookies) with the present value of the marginal benefit of that investment.

Grossman's model generates an important prediction about patterns of health stocks and investments over the life cycle. If the rate of depreciation of health stocks increases with age, then health investments will increase with age, as long as the elasticity of the marginal efficiency of health investment is less than 1.[14] Since children and adolescents have the highest stock of health capital and the lowest rates of depreciation, the model predicts that, conditional on the resources and information available to them, they will be less likely than adults to choose a healthy diet. As a practical matter, the food choices of young children may be determined largely by what their parents provide for them to eat. Thus, one might well expect adolescents, who enjoy increasing autonomy from their parents, to make the worst food choices.

Of course, poor food choices in adolescents are a matter of concern largely because they may forecast a lifetime of poor eating habits. An explanation for the persistence of poor eating habits that is consistent with the Grossman model is that food choices are determined largely by information and resource constraints rather than by health depreciation rates and that these constraints show persistence over the life cycle (i.e., the children of the poor and uneducated are more likely to be poor and uneducated). A second possible explanation (see O'Donahue and Rabin, chap. 1 in this volume) is that teenagers rationally decide that they can afford to subsist on hamburgers and french fries for the moment but underestimate how difficult it will be to lose their taste for these foods later on.

14. That is, a 10 percent increase in health investment improves health by less than 10 percent.

These considerations suggest estimation of an input demand function, or health outcome function, of the following form:

$$(1)\quad \text{OUTCOME} = a_0 + a_1\text{INFO} + a_2\text{RESOURCE} + a_3 X + e,$$

where INFO represents variables that affect the information available to the decision maker, RESOURCE is a vector of variables affecting resource constraints, X is a variable of other variables that may affect the outcome in question (such as gender), and e is an error term that is assumed to be uncorrelated with the other right-hand-side variables in the model.

10.3 Data

Our main source of data is NHANES III. This nationally representative survey was conducted between October 1988 and October 1994 and oversampled blacks and Mexican Americans. NHANES is unique in that it combines demographic information, data from a standard clinical exam conducted by doctors (including blood and urine tests), questions about dietary intakes, information about participation in the FSP, the NLSP, and the SBP, and questions on food insecurity. Our sample includes all those who were aged twelve to sixteen at the time of the survey and who had nonmissing explanatory variables.[15] These restrictions yield a sample of 1,358 youths.

Means of the outcome variables that we consider are given in table 10.2, for everyone and by gender, race, and ethnicity. Precise definitions of these variables are given in the appendix. These means indicate that, as discussed above, anemia is rare and is found primarily among black girls. However, vitamin deficiencies are surprisingly common, affecting 9 percent of the sample. It is interesting that Hispanics are less likely than blacks or whites to suffer from these deficiencies. Obesity is also common, especially among blacks and Hispanics. In the table, we show 100 minus the HEI (so that high numbers for any of our outcomes are always "bad"). This measure of the composition of the diet indicates that blacks have worse diets than whites or Hispanics on average but that the differences are not large. Blacks are also more likely than are whites to have high sweets consumption, while Hispanics are less likely. Finally, blacks and Hispanics are much more likely than are whites to report that they suffer from food insecurity: the fractions are 4, 12, and 9 percent for whites, blacks, and Hispanics, respectively.

The second half of table 10.2 examines the relations between these variables. If, for example, it was true that those with vitamin deficiencies also

15. Unfortunately, older adolescents were asked somewhat different questions (they completed the adult questionnaire rather than the youth questionnaire), and it proved impossible to integrate them into the sample. For example, questions about food frequencies were asked only of the twelve- to sixteen-year-old sample.

Table 10.2 Means of Outcome Variables and Fraction with One Problem Who Also Have Another

A. Means

	All	Male	Female	White	Black	Hispanic
Anemia	.035	.005	.069	.019	.122	.019
Short any vitamin (A, C, E)	.089	.100	.078	.093	.107	.063
High blood cholesterol	.048	.032	.065	.032	.075	.099
Obese	.089	.066	.113	.075	.134	.146
100—Healthy Eating Index	40.3	44.5	35.7	39.9	43.8	38.8
	(.420)	(.563)	(.563)	(.780)	(.670)	(.864)
High sweets	.243	.239	.248	.232	.324	.147
Food insecure	.055	.062	.048	.038	.115	.092
No. of observations	1,358	622	736	371	527	402

B. Fraction with One Problem Who Also Have Another

	Anemic	Short Vitamins	High Cholesterol	Obese	100 HEI	High Sweets	Food Insecure
Anemic	1	.096	.053	.104	39.4	.241	.089
Short vitamins	.038	1	.016	.102	43.5	.283	.062
High blood cholesterol	.039	.030	1	.183	39.3	.168	.121
High BMI	.041	.103	.098	1	41.5	.111	.110
HEI ≤ 25th percentile	.032	.110	.032	.103	60.9	.235	.083
High sweets	.035	.104	.033	.040	38.1	1	.069
Food insecure	.057	.100	.105	.176	43.8	.302	1
No. of observations	100	150	81	172	341	353	133

Note: Standard errors are given in parentheses. Means are calculated using sampling weights.

usually suffered from food insecurity, then it would not be necessary to examine the two measures separately. Instead, table 10.2 shows that, while there are nutrition problems that tend to be found together, our measures of nutrition quality do seem to measure different dimensions of "misnutrition." Moreover, measures of deficiencies and food insecurity are often related to overconsumption of calories and sweets. For example, among those who are short vitamins, 4 percent are anemic, and 6 percent are food insecure, but 10 percent are obese, and a surprising 28 percent consume too many sweets. Thus, for many youths, being vitamin deficient is less a matter of consuming too little food than a matter of consuming the wrong types of food. The results for food insecurity are also striking. Of youths suffering from food insecurity, 10 percent have high blood-cholesterol levels, 18 percent are obese, and 30 percent consume too many sweets. Thus, although these youths do not always know where their next meal is coming from, on average they are consuming too much sugar and fat and too many calories overall.

Means of the explanatory variables that we consider are shown in table 10.3, arranged by whether respondents had one of four types of nutrition problem. Of the potential explanatory variables that we observe, education of the head is the most obvious indicator of the extent of nutrition information that is likely to be available to the household. The age of the head may also be important if there are cohort effects in the ability of household heads to assimilate new information and pass it on to their children. Immigrant parents may also bring with them different information about foods than native-born parents do. Urban residents may have greater exposure to new information as well as to a wider array of products.[16]

An additional measure that we consider is the youth's exposure to television, measured by the number of hours of television that he or she watched on the previous day. While the decision to watch television is clearly an endogenous choice, it also affects the youth's store of nutrition information via passive exposure to advertising messages. These messages generally promote the consumption of sweet, high-fat food and drink. And, evidently, television watching will reduce the number of calories expended if it takes the place of less sedentary activities.

The most natural measure of resources is household income, and an

16. On the other hand, a large literature on urban food prices argues that people in poor inner-city neighborhoods pay more for food than do those in more affluent neighborhoods. This literature suggests that people in poor urban neighborhoods may find things like fresh fruits and vegetables prohibitively expensive. Hayes (1999) reviews this literature and argues that most of it is flawed by the use of "samples of convenience" rather than random samples. Using data from a stratified random sample of stores in New York City, he finds no differences in food prices between the inner city and other areas. The USDA recently reported that 90 percent of the poverty population lives in an area with at least one supermarket and that supermarkets in poor areas do not charge more than those in other areas (Mantovani et al. 1997).

Table 10.3 **Means of Explanatory Variables**

	Short Vitamins		Obese		100 HEI		Food Insecure	
	No	Yes	No	Yes	< 25	> 75	No	Yes
Education head	12.6	11.95	12.6	11.1	12.0	12.8	12.6	10.1
	(.086)	(.217)	(.086)	(.195)	(.144)	(.178)	(.083)	(.282)
Age head	40.4	39.0	40.4	39.3	39.6	40.9	40.4	37.9
	(.205)	(.619)	(.203)	(.666)	(.406)	(.363)	(.207)	(.457)
Urban	.486	.347	.470	.515	.394	.554	.473	.484
	(.014)	(.039)	(.014)	(.038)	(.027)	(.027)	(.014)	(.043)
Immigrant	.149	.127	.148	.137	.148	.170	.147	.142
	(.102)	(.027)	(.010)	(.026)	(.019)	(.020)	(.010)	(.030)
Income less than 1.3	.288	.382	.276	.498	.333	.241	.266	.811
times poverty line	(.013)	(.040)	(.013)	(.038)	(.026)	(.023)	(.0126)	(.034)
Female head	.210	.287	.202	.367	.250	.178	.190	.671
	(.012)	(.037)	(.012)	(.037)	(.023)	(.021)	(.011)	(.041)
Household size	4.68	4.46	4.68	4.44	4.60	4.80	4.64	4.98
	(.044)	(.125)	(.044)	(.118)	(.094)	(.077)	(.043)	(.150)
Mother's BMI	25.7	26.9	25.6	28.1	26.3	24.6	25.7	26.5
	(.160)	(.502)	(.158)	(.522)	(.298)	(.288)	(.160)	(.520)
Hours television	2.91	3.32	2.87	3.71	3.06	2.55	2.94	3.01
viewing	(.052)	(.154)	(.053)	(.143)	(.103)	(.098)	(.052)	(.162)
Food stamps	.158	.209	.148	.312	.163	.121	.152	.341
	(.010)	(.033)	(.010)	(.035)	(.020)	(.018)	(.010)	(.041)
No. of times school	3.14	3.56	3.16	3.39	3.56	2.92	3.17	3.42
lunch/week	(.063)	(.167)	(.063)	(.161)	(.114)	(.119)	(.062)	(.177)
No. of times school	.484	.508	.451	.840	.533	.419	.462	.895
breakfast/week	(.040)	(.113)	(.039)	(.134)	(.077)	(.069)	(.039)	(.156)
No. of observations	1,208	150	−1,186	172	341	340	1,225	133

Note: Standard errors are given in parentheses. Means are computed using sample weights.

indicator equal to 1 if the household's income is below 1.3 times the poverty line is included in table 10.3. This is the cutoff for free school meals and for participation in the FSP. Additional indicators of household resources include whether the family is female headed and indicators for household size. Participation in food and nutrition programs can also be expected to increase the resources available to the household. However, because the families who select into these programs are likely to differ from families who do not, one may well find that participation is associated with poorer nutrition outcomes, even if the programs have positive effects. Finally, we have included mother's BMI as an indicator of the parent's health status (and thus of the child's endowment).[17]

Table 10.3 provides an initial look at whether these explanatory variables appear to be related to nutrition outcomes. Youths with poorer nutrition outcomes come, on average, from households with poorer, younger, less-educated, and often female heads. These differences are particularly large when we compare youths who suffer from food insecurity with other youths. Misnourished youths also tend to watch more television than others. For example, obese youths typically watched almost one hour more of television in the previous evening than did other youths. Compared to youths from other households, youths from households that use food stamps are more likely to be short vitamins, to be obese, and to suffer food insecurity. However, they do score better on the HEI. The (unconditional) differences in the use of school nutrition programs show similar patterns. Thus, although participation in food and nutrition programs may narrow gaps in nutrition outcomes between participants and nonparticipants, it does not appear to close them.

10.4 Results

10.4.1 Baseline Estimates

Estimates from baseline models of the form (1) appear in table 10.4. Increased education of the head is associated with a reduced incidence of obesity, better overall diet quality, and lower sweets consumption as well as with a reduced probability of food insecurity. The estimates indicate, for example, that youths in households with college-educated heads would be 4 percentage points less likely to be obese than are those in households with high-school–educated heads. There is little evidence of cohort effects, although older heads are somewhat less likely to be food insecure. Being urban reduces the probability of being short vitamins but also increases

17. In earlier work, we also included father's BMI as well as indicators equal to 1 if either parent had high blood pressure, stroke, or diabetes. We found that it was difficult to sort out the separate effects of these variables as they were all positively correlated. An additional problem was that father's BMI is often missing. Hence, we focus only on mother's BMI.

Table 10.4 Baseline Estimates

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
Education head	−.0003	−.004	.002	−.010	−.518	−.013	−.007
	(.144)	(1.496)	(.761)	(3.48)	(3.39)	(2.801)	(2.93)
Age head	.001	−.002	−.0002	−.001	−.089	−.0006	−.002
	(1.395)	(1.536)	(.256)	(1.28)	(1.56)	(.385)	(1.85)
Urban	.004	−.033	−.002	.036	−2.02	−.024	.006
	(.418)	(1.994)	(.201)	(2.29)	(2.40)	(.965)	(.486)
Immigrant	−.004	.026	.038	−.031	−2.95	.048	−.029
	(.203)	(.903)	(1.748)	(1.08)	(1.98)	(1.01)	(1.29)
Income less than 1.3 times poverty line	−.003	.020	.059	.034	1.60	−.047	.071
	(.214)	(.939)	(3.804)	(1.65)	(1.49)	(1.49)	(4.45)
Female head	.004	.013	−.014	.022	.120	−.011	.113
	(.278)	(.556)	(.848)	(.976)	(.103)	(.337)	(6.50)
Household size	.002	−.005	−.007	−.011	−.294	.009	.014
	(.618)	(.942)	(1.619)	(2.14)	(1.05)	(1.07)	(3.24)
Mother's BMI	.001	.025	.005	.055	2.43	−.064	−.007
	(.101)	(1.75)	(.434)	(4.01)	(3.37)	(3.02)	(.681)
Male	−.061	.019	−.031	−.046	8.93	−.012	.002
	(6.22)	(1.20)	(2.726)	(3.02)	(11.24)	(.516)	(1.85)
Black	.098	−.005	.026	.007	2.99	.109	.002
	(6.46)	(.198)	(1.445)	(.313)	(2.45)	(3.04)	(.090)
Hispanic	−.005	−.055	.033	.032	−.420	−.113	.011
	(.279)	(1.85)	(1.526)	(1.09)	(.278)	(2.57)	(.504)
Other	.018	−.047	−.002	−.032	3.98	.097	−.001
	(.710)	(1.16)	(.073)	(.808)	(1.95)	(1.61)	(.038)
Constant	.003	.176	.044	.175	41.09	.567	.099
	(.058)	(2.32)	(.781)	(2.36)	(10.57)	(4.98)	(1.72)
R^2	.069	.021	.033	.058	.130	.032	.121

Note: *t*-statistics are given in parentheses. There were 1,358 observations in all regressions.

the probability of being obese. Children of immigrants are more likely to have high blood cholesterol but also have healthier diets overall, as measured by the HEI.[18]

It is striking that, while poverty is associated both with higher blood-cholesterol levels and obesity, it is not a significant determinant of either of our deficiency measures (short vitamins or anemia). Poverty is associated with food insecurity, however, as is female headship and a larger household size. Mother's obesity is associated with adolescent obesity, a higher probability of being short vitamins, and poorer overall diet quality, as one might expect. However, it may be surprising to see that youths with obese mothers consume fewer sweets, perhaps in an attempt to avoid obesity themselves.

There are also some significant differences by race, gender, and ethnicity that are generally consistent with the differences shown in table 10.2 above. Males have worse overall diet quality than do females and are more likely to report food insecurity. However, females are more likely to suffer from anemia, high blood cholesterol, and obesity. Blacks have poorer-quality diets and consume more sweets. Hispanics have better diet quality and are less likely to be short vitamins. They also consume fewer sweets. There are many potential explanations for these differences, including differences in teenage metabolism between boys and girls and differences in socioeconomic status. These racial and ethnic differences are explored in further detail in table 10.7 below.

In summary, if we group our dependent variables into those representing deprivation, obesity, and overall diet quality, table 10.4 supports the following generalizations. First, both education and income have important effects on our outcome measures. The effects of education are always positive (where they are significant), while effects of poverty are always negative. Second, education affects some outcomes that do not seem to be sensitive to income, and vice versa. To be more specific, measures of household resources are important determinants of food insecurity but have little effect on actual nutrition deficiencies, such as anemia and vitamin deficiencies. Information, as proxied by the education of the household head, plays an important role in the determination of overall diet quality, the prevention of obesity, and the reduction of food insecurity. Other variables, such as urbanicity, immigrant status, and mother's BMI, also play significant roles in the determination of some nutrition outcomes, but it is difficult to determine whether this reflects information or resource effects, or both.

18. The finding on immigrant status complements the conclusions of a recent National Research Council/Institute of Medicine (1998) report on the health status of immigrant children, which concluded that, despite poorer economic status, the health of immigrant children tends to be better than that of native-born children and to decline with assimilation.

10.4.2 Effects of Television and of Food and Nutrition Programs

The estimated effects of two sets of potentially endogenous explanatory variables are shown in table 10.5. Panels A and B report estimates from two separate sets of regression. In the first panel, the variables representing hours of television watched were added to models identical to those shown in table 10.4 above, while, in the second panel, variables indicating participation in food and nutrition programs were added to these models. For the sake of brevity, only the coefficients on the added variables are shown.

Effects of Television

Excessive television watching is associated with some very negative effects on diet quality. While we found no statistically significant effects among youths who reported watching two to four hours of television the previous evening, those who had watched five or more hours were more likely to be short vitamins, had poorer overall diet quality, and had a higher BMI than other youths. On the other hand, these youths consumed fewer sweets (although this effect is only marginally statistically significant) and were less likely to report food insecurity.

These observations are consistent with those of Gortmaker et al. (1996). There are many ways in which television watching can affect obesity. It is possible that the information content of the programming and especially of the advertising plays a role, by enticing people to eat junk food. Alternatively, one can view advances in television technology as something that makes this sedentary form of recreation more attractive than other, more active ways in which people could spend their leisure hours.

Of course, the correlations that we find do not prove that television watching causes poor dietary habits or obesity. It is possible that both are caused by some third, unobserved factor, such as a low value attached to health or a lack of information about healthy lifestyles. Without an exogenous source of variation in the data, it will be difficult to demonstrate a causal linkage.

Effects of Food and Nutrition Programs

The second panel of table 10.5 contains initial estimates of the effects of participation in food and nutrition programs on nutrition outcomes. These estimates may also be biased by unobserved variables. For example, if youths in observationally similar nonparticipating households are actually less needy, then these estimates may be biased toward finding negative or nil effects of participation. On the other hand, if youths in observationally similar households do not participate because they lack information about the programs or because their parents place less value on good nutrition, then these estimates will overstate the positive effects of the programs.

Table 10.5 Effects of Television and Nutrition Programs

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
			A. Television Watching				
2–4 hours yesterday	.008	.007	−.007	.015	.489	−.001	−.018
	(.752)	(.427)	(.549)	(.919)	(.568)	(.043)	(1.38)
Over 5 hours	−.014	.077	.001	.086	3.92	−.071	−.051
yesterday	(.838)	(2.93)	(.026)	(3.36)	(2.92)	(1.79)	(2.58)
R^2	.070	.027	.034	.066	.135	.034	.125
			B. Food and Nutrition Programs				
Food stamps	.001	−.009	.018	.034	−1.04	−.069	−.064
	(.059)	(.327)	(.942)	(1.32)	(.770)	(1.73)	(3.18)
School breakfast	−.021	.036	−.003	.036	−2.98	.025	.033
1–4 times/week	(.928)	(.984)	(.109)	(1.03)	(1.62)	(.456)	(1.21)
School breakfast 5	.015	−.027	.057	.051	−3.48	.044	−.0002
times/week	(.739)	(.843)	(2.39)	(1.61)	(2.10)	(.905)	(.010)
School lunch 1–4	−.045	.007	.039	−.011	−1.42	.015	.007
times/week	(3.08)	(.303)	(2.27)	(.464)	(1.20)	(.443)	(.403)
School lunch 5	−.020	.013	−.020	−.003	−.581	.007	−.019
times/week	(1.62)	(.669)	(1.34)	(.160)	(.569)	(.236)	(1.29)
R^2	.077	.023	.047	.051	.136	.034	.131

Note: t-statistics are given in parentheses. All models include all the variables listed in table 10.4 above and 1,358 observations.

In any case, the estimates suggest that the FSP has little effect on measures of deficiencies, obesity, or dietary quality, although it is associated with reductions in food insecurity. School lunch is associated with a lower prevalence of anemia, which is encouraging given that these meals aim to provide iron. School breakfast and lunch are, however, both associated with higher cholesterol levels, although school breakfast is also associated with slightly better overall diet quality.

Table 10.6 lays out the results of an attempt to address the endogeneity of school nutrition program participation using difference-in-difference methods. The identification in panels A and B comes from the fact that, while children may be income eligible for school meals year-round, the meals are provided only while school is in session.[19] Thus, after controlling for the main effects of eligibility and of school being in session, the interaction term can be interpreted as measuring "exposure" to school meals. Panel A measures exposure to free school meals by defining the eligible as those with incomes less than or equal to 1.3 times the federal poverty line. Panel B measures exposure to free or reduced-price meals by using 1.85 times the federal poverty line as the income eligibility cutoff.

Panel A suggests that exposure to free school meals improves the overall quality of the diet, although it has no significant effect on our measures of deficiencies (anemia and being short vitamins), obesity, or food insecurity. The magnitude of the improvement is enough to offset the negative effect of simple eligibility (i.e., poverty) on diet quality. Panel B indicates that, in addition to improving overall diet quality, exposure to free or reduced-price school meals reduces blood cholesterol (which is increased by poverty) and sweets consumption. Since the difference between panel A and panel B is that the latter includes children with incomes between 1.3 and 1.85 times the federal poverty line in the eligible group, these results suggest that the reduction in cholesterol and sweets intake is concentrated in this group. These generally positive results of exposure to school meals suggest that, despite the fact that these meals have been found to be high in cholesterol and sodium, they are healthier than the meals that youths would eat in the absence of school meal programs.

10.4.3 Differences by Race and Ethnicity

As noted above, we estimated all our models separately by race and ethnicity. These estimates are shown in table 10.7. Note that, since blacks and Hispanics were oversampled in NHANES III, we actually have larger

19. Some youths may participate in the Summer Food Service Program, which provides meals similar to those of the NLSP or the SBP during the summer months and is often run through the schools. However, the caseload is small relative to the NLSP or the SBP. In the summer of 1998, the program served 2.3 million children per day, compared to the 14.7 million children per day who participated in the NLSP and the 6.8 million who participated in the SBP during the 1997–98 school year.

Table 10.6 Difference-in-Differences Evaluations of the Effects of School Nutrition Programs

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
			A. Eligible for Free School Meals				
Eligible	−.019	−.004	.090	.050	5.82	.019	.086
	(.847)	(.099)	(.027)	(1.39)	(3.12)	(3.51)	(3.11)
School in session	−.033	.010	−.022	−.021	1.83	.086	.006
	(2.39)	(.477)	(1.39)	(.972)	(1.64)	(2.64)	(.352)
Eligible × in session	.025	.026	−.038	−.020	−5.94	−.090	−.023
	(.988)	(.627)	(1.25)	(.496)	(2.86)	(1.47)	(.728)
R^2	.073	.020	.038	.061	.133	.037	.122
			B. Eligible for Reduced-Price School Meals				
Eligible	−.010	−.008	.096	.028	2.83	.068	.078
	(.465)	(.237)	(3.99)	(.857)	(1.70)	(1.40)	(3.16)
School in session	−.050	.011	−.010	−.024	1.46	.128	.006
	(1.99)	(.458)	(.535)	(1.03)	(1.18)	(3.54)	(.332)
Eligible × in session	.011	.015	−.054	−.004	−3.09	−.159	−.014
	(.472)	(.407)	(1.99)	(.124)	(1.64)	(2.90)	(.515)
R^2	.073	.020	.040	.059	.128	.042	.122

Note: See table 10.5 above. These models did not include the indicator for income < 1.3 and poverty since this is the same as eligibility.

Table 10.7 Differences in the Effects of Information and Resources by Race and Ethnicity

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
White							
Education head	.002	−.002	.002	−.016	−.950	−.011	−.004
	(.554)	(.257)	(.431)	(2.97)	(3.14)	(1.22)	(.969)
Age head	.001	−.004	−.001	−.003	−.137	−.002	−.001
	(1.08)	(1.46)	(.926)	(1.20)	(1.19)	(.640)	(.810)
Urban	−.012	−.045	−.020	.042	−2.52	−.033	.006
	(.820)	(1.38)	(1.03)	(1.50)	(1.63)	(.703)	(.319)
Immigrant	.033	.145	.009	−.088	−2.70	.014	−.034
	(.904)	(1.86)	(.189)	(1.31)	(.729)	(.127)	(.733)
Income less than 1.3 times poverty line	.0002	.048	.045	.119	.372	−.038	.027
	(.013)	(1.07)	(1.64)	(3.08)	(1.75)	(.576)	(1.01)
Female head	.001	−.020	−.010	−.056	−1.22	.019	.209
	(.041)	(.394)	(.326)	(1.27)	(.507)	(.253)	(6.86)
Household size	.004	−.012	.005	−.022	−.651	.024	−.020
	(.685)	(1.02)	(.629)	(2.09)	(1.12)	(1.37)	(2.77)
Mother's BMI	−.001	.002	.000	.006	.268	−.007	−.001
	(.914)	(.742)	(.086)	(2.26)	(1.90)	(1.63)	(.329)
Male	−.040	.023	−.018	−.057	8.73	−.039	.015
	(2.79)	(.762)	(.955)	(2.15)	(5.98)	(.864)	(.818)
Constant	−.012	.250	.048	.344	49.72	.577	.010
	(.165)	(1.61)	(.508)	(2.55)	(6.72)	(2.54)	(.107)
R^2	.033	.035	.020	.105	.178	.021	.186

Black							
Education head	−.006	−.002	−.0004	.002	−.150	−.015	.001
	(1.01)	(.369)	(.076)	(.352)	(.490)	(1.61)	(.200)
Age head	.0004	.002	.0004	.001	−.037	.002	−.001
	(.252)	(1.27)	(.278)	(.663)	(.480)	(.643)	(−.775)
Urban	.072	.045	.005	.042	.317	−.008	−.016
	(2.52)	(1.63)	(.198)	(1.41)	(.231)	(.186)	(.574)
Immigrant	−.050	−.027	−.026	−.045	−6.04	−.060	.089
	(.944)	(.515)	(.576)	(.800)	(2.34)	(.752)	(1.69)
Income less than 1.3	.015	.019	.010	−.042	−.229	−.025	.150
times poverty line	(.489)	(.625)	(.394)	(1.27)	(.152)	(.535)	(4.87)
Female head	.023	.070	−.032	.065	−2.37	−.002	−.033
	(.742)	(2.34)	(1.26)	(2.03)	(1.60)	(.037)	(1.09)
Household size	−.001	−.001	−.005	.007	.066	.001	−.005
	(.095)	(.129)	(.788)	(.861)	(.166)	(.050)	(.616)
Mother's BMI	.001	−.000	.004	.010	.016	−.003	.001
	(.364)	(.016)	(2.51)	(4.57)	(.164)	(.925)	(.570)
Male	−.166	.022	−.061	−.102	4.58	.055	.003
	(5.98)	(.800)	(2.66)	(3.53)	(3.42)	(1.33)	(.116)
Constant	.188	−.020	.010	−.226	45.72	.511	.073
	(1.30)	(.142)	(.086)	(1.50)	(6.56)	(2.38)	(.511)
R^2	.084	.026	.031	.077	.036	.014	.060

(*continued*)

Table 10.7 (continued)

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
Hispanic							
Education head	−.003	−.008	.009	−.005	−.025	−.006	−.020
	(1.61)	(2.03)	(2.00)	(.971)	(.106)	(1.19)	(4.86)
Age head	−.001	−.002	.006	−.002	−.052	.006	−.004
	(1.19)	(1.06)	(3.33)	(.772)	(.507)	(2.66)	(2.54)
Urban	−.006	.048	.039	.051	−3.08	−.050	.015
	(.391)	(1.83)	(1.26)	(1.35)	(1.85)	(1.33)	(.508)
Immigrant	−.019	−.028	.092	.066	−3.92	−.007	−.140
	(1.22)	(1.04)	(2.84)	(1.69)	(2.27)	(.186)	(.473)
Income less than 1.3	−.017	−.004	.089	−.115	2.09	−.039	.090
times poverty line	(1.08)	(.147)	(2.65)	(2.83)	(1.17)	(.952)	(2.94)
Female head	−.013	−.011	.089	.172	7.01	−.060	.054
	(.677)	(.334)	(2.30)	(3.65)	(3.38)	(1.28)	(1.51)
Household size	.007	.014	−.026	−.005	−1.15	.029	.019
	(1.35)	(1.64)	(2.53)	(.367)	(2.09)	(2.35)	(2.04)
Mother's BMI	.000	.003	−.002	−.002	.650	−.007	−.005
	(.004)	(1.54)	(.645)	(.512)	(4.73)	(2.28)	(2.27)
Male	−.031	−.007	−.030	.017	12.30	.080	.137
	(2.21)	(.265)	(1.03)	(.473)	(7.77)	(2.22)	(5.06)
Constant	.105	.104	−.206	.135	25.06	.045	.467
	(1.48)	(.827)	(1.38)	(.745)	(3.16)	(.249)	(3.43)
R^2	.039	.050	.117	.067	.252	.073	.215

Note: t-statistics are given in parentheses. There are 371 whites, 527 blacks, and 402 Hispanics.

samples of these groups than we do of whites. The effects of information and resources differ substantially between the three groups. For example, among whites, education reduces the incidence of obesity and improves the overall quality of the diet. Among Hispanics, education reduces the probability of being short vitamins and of being food insecure but has a small positive effect on the incidence of high blood cholesterol. Among blacks, education of the head has no statistically significant effects. Similarly, we find evidence of cohort effects only for Hispanics—for them, increases in the age of the household head are associated with higher cholesterol and sweets intake but also with a lower probability of food insecurity. Urban residence is associated with a higher probability of anemia among blacks but with lower probabilities of being short vitamins and higher overall diet quality among Hispanics. Being an immigrant is associated with higher-quality diets among blacks and Hispanics (although Hispanic immigrants are also more likely to have high cholesterol and to be obese) but with vitamin deficiencies among whites.

Turning to the effects of resource constraints, poverty increases the probability of high cholesterol and obesity among whites and is associated with worse overall diet quality. Among Hispanics, poverty is also associated with high cholesterol as well as with food insecurity. However, poverty is actually associated with a lower probability of obesity among Hispanics. Remarkably, among blacks, poverty has no effect on any outcome except food insecurity.

The contrast between the effects of income on BMI among whites and Hispanics is suggestive of the Jeffrey et al. (1991) result that obesity tends to rise with income in poor countries and to fall with income in rich countries. A possible explanation is that, in rich countries, where most jobs are sedentary, it takes money and leisure to exercise, so thinness becomes a status symbol. In poor countries, where many people engage in manual labor, fatness is the status symbol. Many Hispanics may have brought this attitude with them from their countries of origin.

Among both blacks and Hispanics, female headedness is an important predictor of problem diets—black youths in these households are more likely to be short vitamins and also to be obese. Hispanics in these households are more likely to be obese, to have high cholesterol, and to have diets of worse overall quality. Among whites, female headedness predicts food insecurity but is not related to the other outcome measures. Finally, it is interesting that larger white households are less likely to experience food insecurity while larger Hispanic households are more likely to be food insecure.

To summarize, the main conclusion to be drawn from table 10.7 is that most of our explanatory variables have quite different effects on whites, blacks, and Hispanics. Differences between whites and Hispanics in the effects of education and income are particularly striking. Essentially, education of the head appears to improve diet quality and to lower BMI only among whites. Among Hispanics, education is associated with less deprivation but also with less healthy diets. Similarly, poverty increases BMI among whites but decreases it among Hispanics. Education and income have no significant effect on deficiencies or quality of diet among blacks, although poverty does affect food security.

10.4.4 Differences by Gender

Table 10.8 shows the results of regressions similar to those of table 10.4 above except that they are estimated separately for boys and girls. There is some evidence that both information and resources are needed to explain the pattern of outcomes. Increased education of the household head improves diet quality for both boys and girls but reduces the proportion obese among girls only. For boys, increased education of the household head reduces sweets consumption and food insecurity. Girls from poor families have higher blood cholesterol, worse diet quality, and a higher probability of food insecurity than girls from richer families. Among boys, poverty is associated with a higher incidence of vitamin deficiencies and obesity but not with worse diet quality. Overall, this pattern of results suggests that, while there are some differences in the effect of these covariates for boys and girls, education generally improves nutrition status and poverty decreases it. Since the covariates do not differ markedly among boys and girls and the effects of these covariates on nutrition outcomes also do not differ markedly, the most plausible explanation for differences in outcomes across gender are biological and metabolic differences in the rate of maturation in adolescence for boys and girls.

10.4.5 Determinants of Trends in Obesity over Time

Using NHANES I, II, and III, separately, table 10.9 compares coefficients from a regression of obesity status (high BMI) on a limited set of covariates that are available in all three data sets. For all three data sets, increasing education of the household head is correlated with lower obesity prevalence, but the effect is largest in NHANES III, the most recent data set. Urban children are 3 percentage points more likely to be obese in NHANES III but not in the other data sets. Immigrant children are less likely to be obese in NHANES II and III but not in NHANES I. These patterns on the effect of urbanity and immigration status are likely due to demographic shifts in these populations over time. Larger households tend to have lower obesity prevalence in all three data sets, with the largest absolute effect in NHANES III. Children from poor households are more likely to be obese than are children from other household in NHANES III but not in NHANES I and II. Females are 3–4 percentage points more likely to be obese than are males in all three data sets, with a 1 percentage point increase in the gap in NHANES III over the other two time points.

Table 10.8 Differences in the Effects of Information and Resources by Sex

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
Females							
Education head	.0004	−.003	.003	−.016	−.57	−.0010	−.001
	(.105)	(.836)	(.840)	(3.85)	(2.78)	(1.65)	(.368)
Age head	.002	−.000	.001	−.002	−.072	.002	−.003
	(1.68)	(.227)	(.503)	(1.31)	(.937)	(1.05)	(2.44)
Urban	.008	−.008	−.014	.037	−1.06	.028	−.008
	(.417)	(.395)	(.738)	(1.52)	(.914)	(.834)	(.474)
Immigrant	−.0002	−.016	.081	−.089	−4.55	.027	.008
	(.004)	(.403)	(2.31)	(1.99)	(2.11)	(.437)	(.268)
Income less than 1.3 times poverty line	−.004	−.032	.061	−.013	2.93	−.043	.079
	(.158)	(1.21)	(2.53)	(.422)	(1.99)	(1.03)	(3.45)
Female head	.009	.032	−.053	.041	−1.93	−.012	.056
	(.339)	(1.14)	(2.05)	(1.24)	(1.21)	(.266)	(2.53)
Household size	.007	.005	−.016	−.015	−.851	.012	.010
	(1.08)	(.710)	(2.40)	(1.80)	(2.14)	(1.07)	(1.87)
Mother's BMI	.0001	.007	.004	.005	.527	−.011	−.001
	(.056)	(3.99)	(2.08)	(2.54)	(5.05)	(3.71)	(.409)
Constant	−.090	−.075	−.038	.317	36.24	.507	.099
	(1.01)	(.781)	(.426)	(2.84)	(6.72)	(3.30)	(1.32)
R^2	.062	.028	.047	.065	.107	.048	.082

(*continued*)

Table 10.8 (continued)

	Anemia (1)	Short Vitamins (2)	High Cholesterol (3)	Obese (4)	100 HEI (5)	High Sweets (6)	Food Insecure (7)
Males							
Education head	−.0001	−.005	.001	−.004	−.465	−.014	−.013
	(.096)	(.979)	(.520)	(.985)	(2.01)	(2.02)	(3.63)
Age head	−.0001	−.002	−.001	−.001	−.080	−.003	.000
	(.339)	(1.40)	(.561)	(.625)	(.963)	(1.32)	(.037)
Urban	.002	−.061	.003	.023	−3.39	−.070	.012
	(.368)	(2.27)	(1.65)	(1.06)	(2.69)	(1.83)	(.603)
Immigrant	−.007	.085	.008	.010	−1.57	.052	−.071
	(.645)	(1.92)	(.309)	(.284)	(.752)	(.814)	(2.14)
Income less than 1.3	.002	.069	.046	.089	−.164	−.024	.058
times poverty line	(.265)	(2.07)	(2.34)	(3.24)	(.104)	(.512)	(2.34)
Female head	.0002	−.007	.027	−.004	2.08	−.005	.170
	(.019)	(.182)	(1.27)	(.148)	(1.20)	(.096)	(6.21)
Household size	−.0002	−.015	.003	−.009	.269	.005	.016
	(.087)	(1.73)	(.543)	(1.24)	(.669)	(.402)	(2.50)
Mother's BMI	−.0000	−.001	−.002	.006	−.029	−.002	−.001
	(.093)	(.647)	(1.47)	(3.17)	(.284)	(.628)	(.427)
Constant	.0080	.378	.049	.010	53.95	.587	.124
	(3.84)	(3.13)	(.690)	(.098)	(9.52)	(3.41)	(1.39)
R^2	.032	.045	.040	.068	.038	.044	.186

Note: *t*-statistics are given in parentheses. Regressions also include race dummies.

Table 10.9 **Trends in BMI Regression Results—NHANES, I, II, and III**

	NHANES I (1)	NHANES II (2)	NHANES III (3)
Education head	−.0036	−.0028	−.012
	(3.6)	(1.5)	(4.0)
Age head	.00024	.0016	−.0012
	(.33)	(2.2)	(1.1)
Urban	−.012	−.0037	.030
	(.99)	(.28)	(1.9)
Immigrant	.0053	−.053	−.039
	(.26)	(2.4)	(1.4)
Income less than 1.3 times poverty line	−.014	.013	.043
	(.92)	(.86)	(2.1)
Female head	.0073	.0021	.018
	(.42)	(.13)	(.81)
Household size	−.0066	−.003	−.011
	(2.2)	(.90)	(2.1)
Male	−.030	−.032	−.044
	(2.7)	(3.0)	(2.9)
Black	.028	.0062	.017
	(1.6)	(.36)	(.73)
Hispanic	—	.056	.018
		(2.2)	(.67)
Constant	.22	.040	.33
	(4.1)	(.85)	(5.0)
R^2	.0194	.0191	.0445
N	1,697	1,509	1,358

Note: t-statistics are given in parentheses. Non-English language spoken at home is used as a proxy for immigration status in the NHANES I sample.

Finally, despite the racial differences present in figures 10.2 and 10.3 above in obesity prevalence, the regressions reveal no significant differences by race, except for Hispanics in NHANES II.

Overall, these results suggest that a structural break in the relation between the covariates and obesity prevalence occurred between NHANES II and NHANES III. In particular, the importance of both information (education of household head) and resources (poverty) in predicting obesity increased in NHANES III over the other two data points.

10.5 Conclusions

We find that, although many youths suffer from nutrient deficiencies (either anemia or vitamin deficiencies), these conditions are not generally sensitive to measures of resource constraints and hence are unlikely to be due solely to a lack of food. The only exception is in black female-headed households, where youths are more likely to be vitamin deficient. Hence, as discussed in the introduction, most U.S. youths who suffer nutrition deficiencies are "misnourished" rather than malnourished and in fact often consume too many rather than too few calories.

These results suggest that such programs as the FSP that provide additional access to food but do not attempt to alter the composition of the diet may have smaller effects on important nutrition outcomes such as overall diet quality than do school meal programs, which offer specific types of food. Our difference-in-difference estimates do in fact suggest that school nutrition programs lead to healthier diets than would otherwise be consumed. The recent reforms to the program are likely to enhance this effect.

A second noteworthy finding is that the determinants of food insecurity appear to be quite different than the determinants of nutrition deficiencies, obesity, or diet quality. In particular, resource constraints are more strongly linked to food insecurity than to the other nutrition outcomes that we examine. It is also remarkable that we find little evidence that access to school nutrition programs relieves food insecurity, at least in our difference-in-difference models. These findings suggest that it is somewhat simplistic to equate food insecurity with hunger, as is often done. Food insecurity appears to be a more complex problem, with strong relations to such social phenomena as female headedness. More generally, our results suggest that it is worthwhile to examine a range of indicators that capture different aspects of nutrition status.

Although it is difficult directly to test the hypothesis that information or technology matters, we find several pieces of evidence consistent with this idea. First, education of the head has a consistently beneficial effect in models of obesity, diet quality, and food insecurity. It is worth noting, however, that we find these effects predominantly among whites. Second, the age of the head matters in Hispanic families, with families with older heads having poorer-quality diets. This type of cohort effect is consistent with a slow diffusion of new information about nutrition through the population over time, with younger heads being more receptive to new ideas than older heads. Indeed, we find that the effect of the household head's education level on obesity prevalence increases in size in the most recent data set that we examine. Third, we find that television viewing has consistently negative effects on all our outcome measures. This could be due either to the content of the programming and advertising (i.e., advertisements for soft drinks and potato chips) or to the fact that television technology encourages people to spend their leisure hours in sedentary activity.

While the preceding summary emphasizes instances in which our explanatory variables have statistically significant effects, it is striking that, in many cases, our models have relatively little explanatory power. This finding suggests that poor nutrition is a problem for American youths regardless of family background. The very pervasiveness of the problem suggests that it is unlikely to be entirely due to a lack of household resources and that broadly based policies designed to alter the composition of the diet, either through the provision of information (e.g., through nutrition labeling) or through the direct provision of healthy food (as in the revised school lunch program), should be encouraged.

Appendix

Definitions of Outcome Variables

Sufficient Food

When asked whether they had "enough food to eat, sometimes not enough to eat, or often not enough to eat," respondents answered that they had enough food to eat.

Dietary Intakes

Healthy Eating Index. Described in text.

High sweets. Reported consuming more than thirty sweets per month.

Measures Based on Physical Examination and Laboratory Measures

Anemia. For age twelve, cutoffs were hemoglobin 11.5 g/dL and hematocrit lt 35 percent. For over twelve years, cutoffs were hemoglobin 12 g/dL and hematocrit lt 37 percent.

High blood cholesterol. Serum cholesterol gt 5.44 nmol/L.

Short vitamin C. 11.4 mmol/L.

Short vitamin A. 1.05 umol/L.

Short vitamin E. 11.6 umol/L.

Obese. 27.3 for females and 27.8 for males.

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