United States
Department
of Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 833

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Electronic
Report

United States Department of Agriculture

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May 2004

Electronic Report from the Economic Research Service

www.ers.usda.gov

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Abstract

This report analyzes fruit and vegetable expenditures by low-income households and higher income households, and compares the sensitivity of both groups' purchases to changes in income. On average, low-income households spent $3.59 per capita per week on fruits and vegetables in 2000 while higher income households spent $5.02—a statistically significant difference. In addition, a statistical demand model indicates that marginal increases in income received by low-income households are not spent on additional fruits and vegetables. In contrast, increases in income received by higher income households do increase their fruit and vegetable expenditures. One interpretation of this finding is that low-income households will allocate an additional dollar of income to other food or nonfood items deemed more essential to the household such as meats, clothing, or housing.

Keywords: Low-income, food expenditures, fruits and vegetables, stochastic dominance.

Acknowledgments

The authors thank Nicole Ballenger for suggesting this topic of research and for final editing of the manuscript, Dana West and Tom McDonald for editorial support, and Julie Caswell, Kuo Huang, and Gary Lucier for their gracious and encouraging reviews.

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National Agricultural Library Cataloging Record

Blisard, William Noel
Low-income households' expenditures on fruits and vegetables.
(Agricultural economic report ; no. 833)
1. Low-income consumers--United States--Nutrition.
2. Food consumption--United States. 3. Food preferences--United States.
4. Fruit--Health aspects--United States. 5. Vegetables--Health
aspects--United States.
I. Stewart, Hayden. II. Jolliffe, Dean, 1963-
III. United States. Dept. of Agriculture. Economic Research Service. IV.
Title.
TX360.P66

Summary

This analysis finds that low-income households spend significantly less per person for fruits and vegetables than other households. This result holds true for all fruits and vegetables, fresh fruits and vegetables, and processed fruits and vegetables. Furthermore, a demand analysis finds that an additional dollar of income in a low-income household (less than 130 percent of the poverty line) will probably be allocated to food groups other than fruits and vegetables or to other needs deemed more important to the household.

Variables that positively influence fruit and vegetable expenditures by low-income households include having a household head with a college education and having household members who are at least 75 years old. Variables that positively influence fruit and vegetable expenditures by higher income households include household heads with a high school degree, some college, or a college education, and household members between the ages of 65 and 74.

The analysis is based on data from the Consumer Expenditure Survey (CE) of the Bureau of Labor Statistics, U.S. Department of Labor.

Introduction

Americans' consumption of fruits and vegetables falls short of the recommended dietary intake as outlined in the Federal Food Guide Pyramid. Putnam, Allshouse, and Kantor (2002) show that American households consume about 5.2 servings of fruits and vegetables per day, which is below the 7 daily servings recommended in the Food Guide Pyramid. Echoing these findings, the Produce for Better Health Foundation (2002) finds that only 38 percent of all individuals consume the recommended number of servings of vegetables, while only 23 percent consume the recommended number of servings of fruit.

Lower income households consume smaller amounts of fruits and vegetables than higher income households (e.g., Krebs-Smith, 1995), and there are likely differences in the mix of the foods that each group purchases. Evidence in support of this latter assertion includes a study showing that low-income households use a number of economizing practices in their grocery shopping (Leibtag and Kaufman, 2003). In the context of fruit and vegetable buying, low-income households may, for example, purchase lower quality fruits and vegetables or more processed fruits and vegetables, if they were less expensive. In any case, the end result could be that differences in expenditures between low-income and other households exceed differences in consumption as measured by nutritional intake.

Furthermore, the existing literature is unclear about how low-income households might adjust their purchases of fruits and vegetables in response to an increase in their buying power. Several researchers have examined the income elasticity of demand (simply the percent change in quantity demanded divided by the percent change in income) for these foods among households of different income levels. Park et al. (1996) and Raper et al. (2002) find that low-income and higher income households would likely increase their expenditures on fruits and vegetables with a marginal increase in income. However, these findings contrast with implications drawn from empirical research on the Food Stamp Program. Studies by Wilde et al. (1999 and 2000) found that food stamps are not associated with higher levels of fruit and vegetable consumption; rather these two studies found that recipient households tended to consume more meats, added sugars, and total fats.

This report asks two questions about how income constraints affect fruit and vegetable purchases by low-income households. The first question is a seemingly straightforward one of whether or not low-income households spend less money for fruits and vegetables than other households. As we will show, however, statistically analyzing the spending difference is more complex than merely comparing averages across the two groups. The second question goes another step to ask if low-income households are likely to increase spending on fruits and vegetables following a marginal increase in their buying power. Answering the two questions together gives us a more robust assessment of the role of income constraints in low-income households' purchases of fruits and vegetables.

The report also compares the buying habits of higher and low-income households. Households in this study are classified as "low-income" if their income equals 130 percent of the poverty line or less. All other households are considered to be higher income households. This point of delineation was selected since households with higher income levels are ineligible for benefits under the Food Stamp Program.

In the first section of this study, we look at weekly per capita produce expenditures by American households in several different ways. The first of these steps is to explore trends in inflation-adjusted income in relation to trends in the prices of selected fruits and vegetables. We then analyze trends in expenditures and budget shares by both low-income and higher income households, as well as by income quintile and educational attainment. The main purpose of this descriptive exercise is to determine what has happened to fruit and vegetable expenditures and prices over time, as well as how two important economic and demographic variables affect above- or below-average expenditures. In other words, this first section of the study places past fruit and vegetable expenditures by American households in perspective. Key variables discussed in this section along with other demographic variables will be analyzed later in the study.

The second and third sections of this study focus on the role of income constraints in affecting fruit and vegetable consumption by low-income households. To do this we use two approaches.

In the first approach, we hypothesize that if low-income households actually consume less fruits and vegetables than higher income households, then they must also have significantly lower expenditures on these items. Not only would average expenditures be significantly different between low-income households and higher income households, but expenditures by most or all households in our sample of higher income households would also be larger than most or all households in the low-income sample. Hence, our approach in this section is to look at the expenditure distributions of both groups, and to determine by a statistical test if low-income households actually spent significantly less than higher income households over the entire expenditure distribution. These distributions are merely the ranking of expenditures, from lowest to highest, for each group of households. We then test to see if there is a statistically significant difference between the expenditures of both groups. This is known as a test of dominance.

The second approach to answering the question of how income constraints affect consumption of fruits and vegetables is to determine how sensitive fruit and vegetable expenditures by low-income and higher income households are to changes in income. We do this by estimating a demand equation for each type of household. This equation determines the net effect—that is, the independent marginal effect—of each variable in the model on fruit and vegetable expenditures. In the demand analysis, we primarily focus on the effect of income on purchases of fruits and vegetables. If we find dominance from answering our first question above, but we find that expenditures by both low-income and higher income households are sensitive to changes in income, then this would suggest that while low-income households are at an economic disadvantage, they might nonetheless be induced

to make further purchases of fruits and vegetables with modest economic incentives.

However, if we find dominance when answering the first question, but we also find that expenditures by low-income households are not sensitive to marginal changes in income and the higher income group is, then modest economic incentives may have little effect on fruit and vegetable spending and consumption. In this sense, income constraints could be thought of as more important in limiting fruit and vegetable spending than in the first scenario. What is our reasoning? If we do not observe a positive income effect, it is likely that an extra dollar is being allocated to other food groups, such as meats, or to non-food items deemed to be more important to meeting the household's needs and wants. We know that even these lowest income households do spend money for some low level of fruit and vegetable consumption, but spending is not influenced by marginal changes in economic variables such as income because other goods are needed more or are otherwise higher priorities.

In addition to income, this latter section of the analysis will also present the net effect of other significant demographic variables on fruit and vegetable expenditures by both types of households. Hence, we will also be able to check the influence of other variables, considered in previous studies, such as race and educational attainment. This is important since variables such as education may be associated with higher levels of produce expenditures for both income groups. In any case, the test of dominance and the estimation of the statistical demand model, taken together, will allow us to investigate the importance of income constraints to fruit and vegetable expenditures.

Data Used in the Analysis

An ideal data set would contain fruit and vegetable expenditures, prices, income, and household characteristics. The ideal data set would also be representative of the U.S. population. The reality is that some data sets contain some, but not all, of the variables of interest. As a compromise, we have utilized a nationally representative expenditure survey which contains data on household food expenditures in addition to income and demographic variables.

The Consumer Expenditure Survey (CE) of the Bureau of Labor Statistics (BLS) for calendar years 1991 and 2000 is the basic source of data used in this analysis. The CE contains the most recent and comprehensive data available on food spending in U.S. households at the time of this study.

The CE comprises two components, each with its own questionnaire and sample: (1) an interview panel survey in which each of approximately 5,000 households is surveyed every 3 months over a 1-year period and (2) a diary survey of approximately the same sample size in which households keep an expenditure diary for two consecutive 1-week periods.

The diary survey obtains data on small, frequently purchased items that are normally difficult to recall, including foods and beverages, tobacco, housekeeping supplies, nonprescription drugs, personal care products, services, and fuels. The diary survey excludes expenditures incurred while away from home for one night or longer. The diary survey is the exact source of data for this report, and it contains information on each participating household such as income, race, region of residence, household size, age, educational attainment, and month of participation among other variables.

For the purpose of this study, we analyze several aggregate categories of fruits and vegetables in various combinations: 1) all fruits and vegetables, 2) fresh fruits, 3) fresh vegetables, 4) processed fruits, and 5) processed vegetables. The individual commodities that make up the fruit and vegetable aggregates are contained in table 1.

The data set used in this analysis is a subset of all observations from the 1991 and 2000 CE diary surveys. The criterion for inclusion is completeness of reporting and consistency. Households that did not report complete income or did not participate in both weeks of the diary survey were excluded from the analysis. After eliminating these households, the sample for each year consisted of approximately 5,000 households for each 1-year period. For the descriptive analysis that follows, we compare data from both 1991 and 2000. We use data from the year 2000 for comparing expenditures between low-income households and higher income households, as well as for estimating a demand model. Data from the year 2000 were the latest data available when this study was begun. In addition, we felt that 10 years between data points would be more than adequate for comparing trends in expenditures, thereby suggesting a starting date of 1991.

Table 1—Individual commodities that comprise fruits and vegetables

Category	Composition
Fruits and vegetables	Fresh and processed fruits and vegetables.
Fresh fruits	Apples, bananas, oranges, other citrus fruits, and all other fresh fruits.
Fresh vegetables	Potatoes, lettuce, tomatoes, and other fresh vegetables.
Processed fruits	Frozen orange juice, frozen fruits, frozen fruit juices, fresh fruit juice, canned and bottled fruit juice, canned fruits, and dried fruits.
Processed vegetables	Frozen vegetables, canned beans, canned corn, canned miscellaneous vegetables, other processed vegetables, other peas, other beans, other miscellaneous vegetables, frozen vegetable juice, and fresh and canned vegetable juice.

Profile of Fruit and Vegetable Expenditures

The following statistics should give the reader an idea of not only what has occurred in the fruit and vegetable market over the last decade, but also how a household's economic and educational characteristics influence its expenditures on fruits and vegetables. Variables presented in this section will also be incorporated into our demand analysis of fruit and vegetable expenditures later in this analysis.

Trends in Income and Prices

Engel's law states that, as income rises, the share of a household's budget spent on necessities, such as food, will fall. However, it also suggests that the actual amount spent on necessities such as food may increase. This can happen in two ways. First, lower income households may alter the composition of their food bundle as their income rises. This can happen through substitution between broad groups of food, as when meats are substituted for grains and/or cereals. Second, as income increases, households may purchase a larger variety, higher quality, or more convenient bundle of foods that are higher priced (Deaton).

Changes in incomes and selected prices of fruits and vegetables between 1991 and 2000 are contained in table 2. Both income and all prices, except the total CPI for all items, have been adjusted for inflation. The unadjusted CPI for all items is shown in order to demonstrate the general increase in prices that has occurred between 1991 and 2000. The other CPI prices have been divided by the CPI for all items and thus are inflation adjusted. Income

Table 2—Inflation-adjusted income and selected produce prices, 1991-2000

Category	1991	2000
Average household income[1]	$42,851	$44,649
Average household size	2.6	2.5
Average income, poor households	$3,267	$3,376
Average household size	1.8	1.7
CPI[2]	100.0	126.4
Fruits and vegetables	100.0	103.9
Fresh fruits	100.0	105.4
Apples	100.0	97.3
Bananas	100.0	88.7
Fresh vegetables	100.0	112.4
Potatoes	100.0	107.4
Lettuce	100.0	112.9
Tomatoes	100.0	121.3
Other fresh vegetables	100.0	112.1
Processed fruits	100.0	94.3
Processed vegetables	100.0	95.6

[1]Income in constant 2000 dollars.
[2] The CPI is the Consumer Price Index for all urban consumers. The base year has been set to 1991. Subcategories are based on the CPI for the individual food group divided by the total CPI, and are "real" or inflation-adjusted prices.
Source: Economic Research Service.

in 1991 was adjusted to reflect buying power in the year 2000. The selected inflation-adjusted prices, based on their corresponding CPI indexes, were indexed so 1991=100.

The greater increase in income occurred among higher income households, and prices increased most for fresh fruits and vegetables. Average inflation-adjusted household income for the total population increased by approximately $1,800 or about 4.2 percent between 1991 and 2000. Household income for the low-income group increased by $109 or 3.3 percent. During the same time period, prices (not inflation-adjusted), as represented by the CPI for all items, rose by 26.4 percent. Prices for all fruits and vegetables increased by an inflation-adjusted 3.9 percent. In other words, they rose 3.9 percent more than the general CPI. (The unadjusted CPI for fruits and vegetables was 131.3, and dividing this figure by the CPI for all items, 126.4 gives the inflation-adjusted increase of 3.9 percent). This increase in all fruit and vegetable prices was driven by a 12.4-percent increase in fresh vegetables and a 5.4-percent increase in fresh fruit. At the same time, the inflation-adjusted prices of processed fruits and processed vegetables declined by 5.7 and 4.4 percent, respectively.

Trend in Average Expenditures and Budget Shares—Total Population and Low-Income

The average American modestly increased weekly per capita fruit and vegetable expenditures between 1991 and 2000 by an inflation-adjusted 7 cents (table 3). This increase occurred because per capita expenditures on fresh fruits and fresh vegetables rose by 10 and 5 cents, respectively, while expenditures on processed fruits and processed vegetables fell by 4 and 3 cents, respectively.

The increase in expenditures for fresh fruits and vegetables and the decrease in expenditures for processed fruits and vegetables are consistent with the notion that spending for food is "price inelastic." This means that the percent change in quantities consumed of fruits and vegetables will be less than the percent change in their prices. When prices increase, the percentage reduction in quantity purchased will be less than the percentage increase in price; therefore expenditures increase. The reverse is true when prices fall.

Table 3—Per capita inflation-adjusted fruit and vegetable mean weekly expenditures for the total population, 1991-2000

Category	1991	2000
	Deflated dollars per person	
Fruits and vegetables[1]	4.66	4.73
Fresh fruit	1.41	1.50
Other fresh fruit	.71	.65
Fresh vegetables	1.40	1.45
Other fresh vegetables	.75	.74
Processed fruit	1.07	1.03
Processed vegetables	.77	.74
Frozen vegetables	.27	.23

[1]Prices are in 2000 dollars.

Source: Economic Research Service, based on the Consumer Expenditure Survey.

Given the overall increases in fruit and vegetable prices and expenditures, we might expect fruit and vegetable budget shares to have also increased. In fact, the overall price of fruits and vegetables rose between 1991 and 2000, and the budget share also increased from 16.4 to 17.3 percent (table 4). Likewise, the budget shares of both fresh fruits and fresh vegetables increased for the average American household over this period to 5.5 and 5.1 percent, respectively.

Surprisingly, given that the inflation-adjusted price of processed fruits and processed vegetables fell between 1991 and 2000, the budget share of processed fruit also increased from 3.8 percent to 4.1 percent, and the budget share of processed vegetables remained flat at 2.7 percent. These trends indicate that the average household probably decreased food expenditures on other food items to a greater extent than on these two food groups. Americans are not eating any less. Rather, the inflation-adjusted cost of other food items has declined more than that of either processed fruit or processed vegetables. Indeed, the overall decrease in inflation-adjusted expenditures for all food at home between 1991 and 2000 was about 10 percent.

Low-income households appear to have food spending patterns unlike those of the average U.S. household. The low-income segment represents about 20 percent of the total American population, and includes a mixture of demographic groups that are not represented in the same proportion of the total population.

Average weekly per capita expenditures on fruits and vegetables declined from $4.02 in 1991 to $3.59 in 2000 among households with an income at or below 130 percent of the poverty line (table 5). This decline of about 11 percent contrasts with the earlier noted increase in expenditures for the total population. (Expenditures by higher income households were $4.86 and $5.02 for 1991 and 2000, respectively—not shown in table 5.) Spending declined in all four major subcategories: for example, expenditures on fresh vegetables fell by 14 cents (11 percent); and expenditures on processed vegetables fell by 12 cents (12 percent). At the same time, the budget share of fruits and vegetables increased from 16.1 percent to 16.5 percent between 1991 and 2000 (table 6). This implies that low-income households have reduced expenditures in other food areas even more than in the fruit and vegetable category.

Table 4—Household budget shares of fruit and vegetables for the total population, 1991-2000

Category	1991	2000
	Budget share (percent)	
Fruits and vegetables	16.4	17.3
Fresh fruit	5.0	5.5
Other fresh fruit	2.5	2.3
Fresh vegetables	4.8	5.1
Other fresh vegetables	2.6	2.6
Processed fruit	3.8	4.1
Processed vegetables	2.7	2.7
Frozen vegetables	1.0	1.0

Source: Economic Research Service, based on the Consumer Expenditure Survey.

Table 5—Per capita inflation-adjusted fruit and vegetable mean weekly expenditures for the population with income below 130 percent of the poverty line, 1991-2000

Category	1991	2000
	Per capita expenditure	
Fruits and vegetables	4.02	3.59
Fresh fruit	1.20	1.09
Other fresh fruit*	.56	.45
Fresh vegetables	1.23	1.09
Other fresh vegetables*	.60	.55
Processed fruit	.89	.83
Processed vegetables	.70	.58
Frozen vegetables	.19	.16

Prices are 2000 dollars.
*See table 1
Source: Economic Research Service, based on the Consumer Expenditure Survey.

Table 6—Household budget shares of fruit and vegetables for the population with income below 130 percent of the poverty line, 1991-2000

Category	1991	2000
	Budget share (percent)	
Fruits and vegetables	16.1	16.5
Fresh fruit	4.7	5.1
Other fresh fruit	2.1	1.9
Fresh vegetables	4.8	4.6
Other fresh vegetables	2.3	2.3
Processed fruit	3.6	4.2
Processed vegetables	3.0	2.6
Frozen vegetables	1.0	1.0

*See table 1
Source: Economic Research Service, based on the Consumer Expenditure Survey.

One explanation is that, as we noted, the inflation-adjusted price of all foods fell between 1991 and 2000, while that of fruits and vegetables increased.

However, a significant shift in the demographic composition of low-income households may explain why expenditures on fruits and vegetables fell even as budget shares went up. In checking how various demographic variables had changed over the 10-year period, we discovered single males increased from 12.3 percent of low income households to 16.3 percent. Males are typically associated with higher food expenditures. However, a check of mean expenditures showed that the average single male had fruit and vegetable expenditures of $3.40 per capita per week, compared with $4.47 for single females in 2000. The average expenditure for all other households that make up lower income households, including those with children, was found to be $3.20 per capita per week. Not all of the change in average expenditures can be attributed to this demographic shift, but it surely exerted a large downward influence.

Influence of Income and Educational Attainment on Average Expenditures and Budget Shares

We now look at two key demographic characteristics in tables 7-10 that influence fruit and vegetable expenditures for the total U.S. population: income and educational attainment. Previous research (Blisard et al.) has shown that these two demographic characteristics often have a large impact on food expenditures. While we introduce these variables in the descriptive section of this report, we will return to them when we estimate our statistical demand model for fruit and vegetable expenditures and in the conclusions.

Income Quintile

Above we discussed income in terms of low-income and higher income households. In this section, we look at expenditures by income quintile. A quintile is 20 percent of a surveyed group. Hence, quintile 1 is the lowest 20 percent of the income distribution while quintile 5 is the highest 20 percent of the income distribution. At least two things can be gained from this exercise. First, we can see if fruit and vegetable expenditures appear to respond positively to increases in income. Second, we can compare expenditures by the different income levels to see if one group, like the highest income quintile, might have overly influenced mean expenditures for the entire population. Note that the lowest income quintile approximates our group of low-income households, while quintiles 2-5 approximate our category of higher income households.

Somewhat surprisingly, quintiles 1, 4, and 5 reduced their real fruit and vegetable expenditures while quintiles 2 and 3 increased theirs between 1991 and 2000 (table 7). However, in either year, each succeeding quintile spent more per capita on fruits and vegetables except for quintile 2 which spent more than quintile 3 in both years. In 2000, quintile 1 spent about $4.23 per capita whereas quintile 5 spent $5.38 per capita. In addition, budget shares increased for each quintile (table 8). In fact, the budget share for the aggregate of fruits and vegetables increased by 1.3 percentage points

Table 7—Per capita inflation-adjusted fruit and vegetable mean weekly expenditures by income quintile, 1991-2000

	1991					2000				
	Income quintile									
Category	1	2	3	4	5	1	2	3	4	5
	Per capita expenditure									
Fruits and vegetables	4.27	4.65	4.49	4.67	5.43	4.23	4.89	4.57	4.56	5.38
Fresh fruit	1.26	1.43	1.28	1.45	1.74	1.34	1.67	1.39	1.40	1.71
Other fresh fruit	.58	.74	.67	.71	.95	.55	.72	.54	.64	.80
Fresh vegetables	1.36	1.39	1.36	1.41	1.63	1.28	1.48	1.35	1.41	1.73
Other fresh vegetables*	.67	.73	.74	.78	.90	.65	.74	.66	.70	.97
Processed fruit	.95	1.07	1.11	1.03	1.23	.98	.99	1.06	.99	1.15
Processed vegetable	.71	.76	.74	.78	.83	.63	.76	.78	.76	.78
Frozen vegetables	.19	.23	.28	.29	.36	.18	.22	.24	.25	.27

Prices are in 2000 dollars.
A quintile is 20 preccent of a surveyed group. The first quintile is the lowest, the fifth is the highest.
*See table 1.
Source: Economic Research Service, based on the Consumer Expenditure Survey.

for the second quintile, 1 percentage point for the fifth quintile, and 0.8 percentage point for the first quintile.

Educational Attainment

We hypothesized that a more educated consumer eats a more healthful diet than a less educated consumer. However, we have to be careful when we look at descriptive statistics, since we cannot control for other variables. For example, we know that educational attainment and income are both positively correlated, so when we look at educational attainment, we are also seeing the influence of income as well as other factors. However, later in this report we will present results from our statistical demand model that allows us to determine the net effect of our variables of interest.

Interestingly, inflation-adjusted per capita expenditures on fruits and vegetables increased from $5.55 in 1991 to $5.99 in 2000 for households headed by someone with 4 or more years of college (table 9). Contrasted to this, per

Table 8—Household budget shares of fruit and vegetables by income quintile, 1991-2000

	1991					2000				
	Income quintile									
Category	1	2	3	4	5	1	2	3	4	5
	Budget share (percent)									
Fruits and vegetables	16.6	16.1	16.3	16.4	17.1	17.4	17.4	16.7	17.0	18.1
Fresh fruit	4.8	5.1	4.8	5.1	5.5	5.5	5.8	5.1	5.3	5.7
Other fresh fruit	2.1	2.5	2.4	2.4	3.1	2.1	2.4	2.0	2.3	2.6
Fresh vegetables	5.1	4.6	4.7	5.2	5.0	4.8	5.2	4.9	5.1	5.6
Other fresh vegetables*	2.5	2.4	2.5	3.0	2.8	2.4	2.6	2.4	2.5	3.1
Processed fruit	3.6	3.8	4.1	3.5	4.0	4.5	3.7	4.0	3.8	4.2
Processed vegetable	3.1	2.6	2.6	2.6	2.5	2.5	2.8	2.7	2.8	2.5
Frozen vegetables	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0

A quintile is 20 preccent of a surveyed group. The first quintile is the lowest, the fifth is the highest.
*See table 1.
Source: Economic Research Service, based on the Consumer Expenditure Survey.

Table 9—Per capita inflation-adjusted fruit and vegetable mean weekly expenditures by educational attainment of household head, 1991-2000

	1991				2000			
Category	No high school	High school	Some college	College grad	No high school	High school	Some college	College grad
	Per capita expenditure							
Fruits and vegetables	4.35	4.32	4.46	5.55	4.26	4.25	4.30	5.99
Fresh fruit	1.32	1.27	1.34	1.76	1.41	1.26	1.35	1.99
Other fresh fruit*	.64	.64	.71	.89	.51	.50	.61	.94
Fresh vegetables	1.31	1.33	1.32	1.66	1.38	1.29	1.31	1.81
Other fresh vegetables*	.68	.68	.72	.93	.67	.62	.65	1.01
Processed fruit	.96	.96	1.08	1.29	.86	.96	.93	1.33
Processed vegetables	.77	.76	.73	.83	.62	.74	.71	.86
Frozen vegetables	.21	.26	.26	.34	.15	.23	.22	.29

Prices are in 2000 dollars.
*See table 1.
Source: Economic Research Service, based on the Consumer Expenditure Survey.

capita expenditures on fruits and vegetables fell between the same years for household heads without a high school diploma, with a high school diploma, and with less than 4 years of college. For college-educated households, per capita expenditures on fruits and vegetables were about 27 percent higher than the total U.S. average. In fact, expenditures for this group increased for all four major subcategories with per capita expenditures increasing the most for fresh fruit ($0.23), and increasing the least for processed vegetables ($0.03). And while each demographic group increased the budget share of fruits and vegetables between 1991 and 2000, households whose head have a college education increased their budget share by 1.6 percentage points (table 10). This compares to a 0.4-percentage point increase for heads without a high school diploma and an increase of 0.2-percentage points for households whose head has some college. Clearly, household heads who are college educated have been a driving force in the increase in fruit and vegetable expenditures between 1991 and 2000.

In summary, our descriptive profile suggests the following story. Overall, the inflation-adjusted price of fruits and vegetables rose between 1991 and 2000, and as expected the budget share of this food commodity also grew. While the average expenditure on fruits and vegetables rose between 1991 and 2000 for the general population (and higher income households), average expenditures fell for low-income households. Some of this decline in average expenditures by low-income households may be attributed to an increase in the proportion of single males in this income group. However, the increase in average fruit and vegetable expenditures for the total population was not totally driven by all higher income households. We know this since only income quintiles 2 and 3 had increases in their expenditures between 1991 and 2000. Conversely, households in the lowest and the two highest income quintiles, which represent 60 percent of American households, actually reduced their inflation-adjusted expenditures. Hence, one main driving force in increased average expenditures for fruits and vegetables appears to derive from college-educated households who increased their expenditures by almost 8 percent between 1991 and 2000. The validity of this claim will be further checked when we estimate the demand model for fruits and vegetables.

Table 10—Household budget shares of fruit and vegetables by educational attainment of household head, 1991-2000

	1991				2000			
Category	No high school	High school	Some college	College grad	No high school	High school	Some college	College grad
	Budget share (percent)							
Fruits and vegetables	16.7	15.2	15.9	18.0	17.1	16.6	16.1	19.6
Fresh fruit	5.2	4.5	4.8	5.8	5.8	5.0	5.0	6.5
Other fresh fruit*	2.5	2.2	2.4	2.9	1.9	2.0	2.1	3.9
Fresh vegetables	4.9	4.6	4.7	5.3	5.3	4.9	4.6	5.8
Other fresh vegetables*	2.5	2.3	2.4	2.9	2.7	2.3	2.3	3.3
Processed fruit	3.6	3.5	3.8	4.3	3.4	4.0	3.9	4.7
Processed vegetables	3.0	2.7	2.6	2.6	2.6	2.8	2.6	2.6
Frozen vegetables	1.0	1.0	1.0	1.1	.7	.8	.8	.9

*See table 1.

Source: Economic Research Service, based on the Consumer Expenditure Survey.

Do Low-Income Households Spend Significantly Less on Fruits and Vegetables than Higher Income Households?

We compare per capita weekly spending on fruits and vegetables by low-income households and higher income households using a standard statistical test. How to statistically test for a difference in spending between the two groups is problematic. One approach would be to test for a difference between the average expenditures of low income and higher income households. From table 4 we know that the low income households had an average per capita expenditure of $3.59 per capita per week in 2000. This compares with an average expenditure of $5.02 on fruits and vegetables by the higher income households in the same year. We could test to see if this difference of $1.43 was significantly different from no difference in a statistical sense.

The problem with a statistical comparison of means is that it ignores variation in expenditures by each group. For example, in the group of low-income households, some households will have per capita expenditures below $3.59, while others will be above this average. In fact, some low-income households will have per capita expenditures that are above the average expenditure of the higher income households. This problem in comparing expenditure averages suggests that we need a more rigorous test that can ascertain if expenditures are different between low-income and higher income households.

A better approach analyzes the expenditure distributions of low-income and higher income households. This distribution is merely a ranking of expenditures from lowest to highest for each income group separately. If the low incomes constrain fruit and vegetable expenditures by low-income households, then it should be the case that expenditures of the higher income group will always be greater—from the lowest expenditure to the highest—than the expenditures of the low income group, again ranked from the lowest expenditure to the highest. This technique is known as a test of stochastic dominance. As a test, it is much stricter than just testing for a difference between the mean expenditures of the two groups.

The stochastic dominance technique ascertains whether the expenditure distribution of each group is statistically different for the entire expenditure distribution. If there is no overlap between the two distributions, then we may be able to ascertain a statistical difference between the low-income and higher income groups. Even if we find no overlap, the difference between expenditure distributions might be so small that it would not be statistically different from a zero difference. If there is overlap between the two groups, then there will be no statistical difference between the two expenditure distributions. If the expenditure distributions are not statistically different, we could reject the hypothesis that low-income households are more constrained in their fruit and vegetable purchases by either high prices or low income.

The stochastic dominance test was conducted for expenditures in 2000 ranging from zero to $20 per person per week, which contains 98.3 percent

of all observations in our sample of low- and higher income households. This approach is similar to a study by Raper et al. (2002), who removed the upper 1 percent of each expenditure category "to circumvent problems associated with data outliers." Outliers can create problems both in hypothesis testing and in interpreting results. For instance, in our data, one higher income household spent an average of $119.52 per capita each week over the survey period, which is the maximum of all observations. However, this spending more likely reflects a special event, such as purchasing fruits and vegetables for a home wedding reception, rather than being representative of this household's normal pattern of expenditures.

Figure 1 presents the cumulative distribution function (cdf) for both the low-income and higher income samples. This graph plots the cumulative per capita expenditures of each income group against the cumulative proportion of each group. Hence, zero expenditures are plotted against the proportion of each population that had no fruit and vegetables expenditures. The lowest observed level of expenditures is then plotted against the proportion of the sample that spent this amount. This process is continued until all expenditures for each population have been plotted. In our analysis, it is easy to see that the cdf for low-income households lies everywhere above the cdf of higher income households. For example, about 19 percent of the low-income households spend zero dollars on produce versus only about 9 percent of higher income households. Importantly, this gap holds at all positive levels of spending under study. For instance, the graph indicates that about 55 percent of the low-income households spend $3 or less per capita compared with only 40 percent of the higher income households.

The test for a statistical difference between the two distributions indicates that the per capita expenditures of the higher income households are always greater than those of the lower income households, and that this difference is statistically significant from a zero difference.[1] Thus, we find that expenditures by higher income households "dominate" those of lower income households.

It is possible that low-income households purchase lower quality fruits and vegetables and that the prices they pay are lower. If this were the case, then these households may actually be purchasing a quantity of fruits and vegetables that may compare favorably with the nutritional content of the fruit and vegetables purchased by higher income households. Arguing against this hypothesis is the Krebs-Smith study, which found that low-income households consume smaller quantities than individuals in higher income households.

However, it may be possible that lower income households concentrate their expenditures on either mostly fresh fruit and vegetables or mostly processed fruits and vegetables. For example, one might find that selected processed fruits and vegetables are, on average, priced lower throughout a given year than their corresponding fresh counterparts. Hence, it might be possible that the lower income households would buy mostly processed fruits and vegetables. Or it might be possible that certain fresh fruits and vegetables are actually the least expensive, given imports during the winter months. In any case, for thoroughness, we decided to test if dominance holds for only fresh fruits and vegetables or only processed fruits and vegetables.

[1]The test along with the software program is available from the authors upon request.

Spending on fresh fruits and vegetables by higher income households clearly dominates that of lower income households (figure 2). For instance, 24 percent of low-income households spend zero dollars on fresh fruits and vegetables versus only 13 percent of higher income households. This gap continues to hold at higher levels of expenditure. Among lower income households, 73 percent spend $3 or less on fresh fruits and vegetables compared with 62 percent of higher income households. Furthermore, we found that the distance between the two cdf's is statistically significant from zero over the range of $0 to $19, which contains over 99 percent of all households in the data.

Figure 1

Distribution of fruit and vegetable expenditures by income level

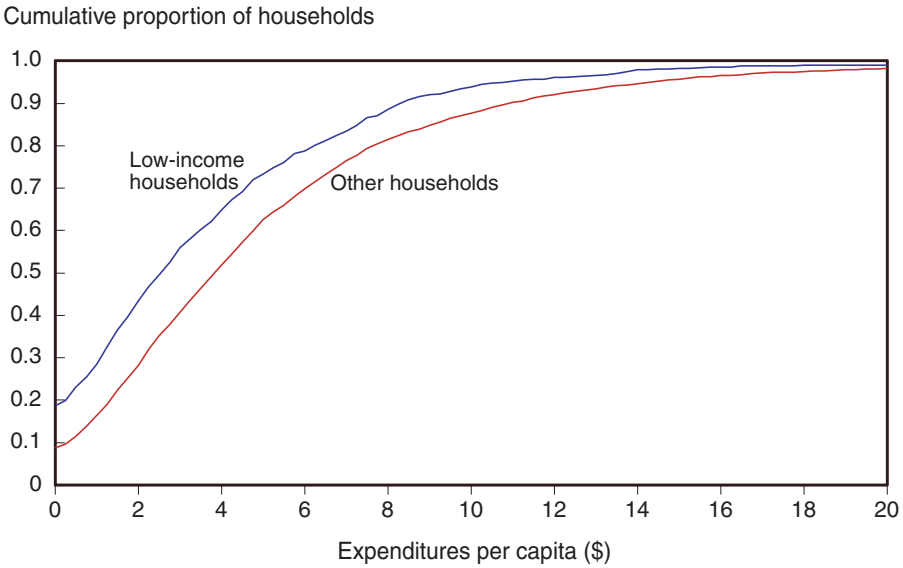
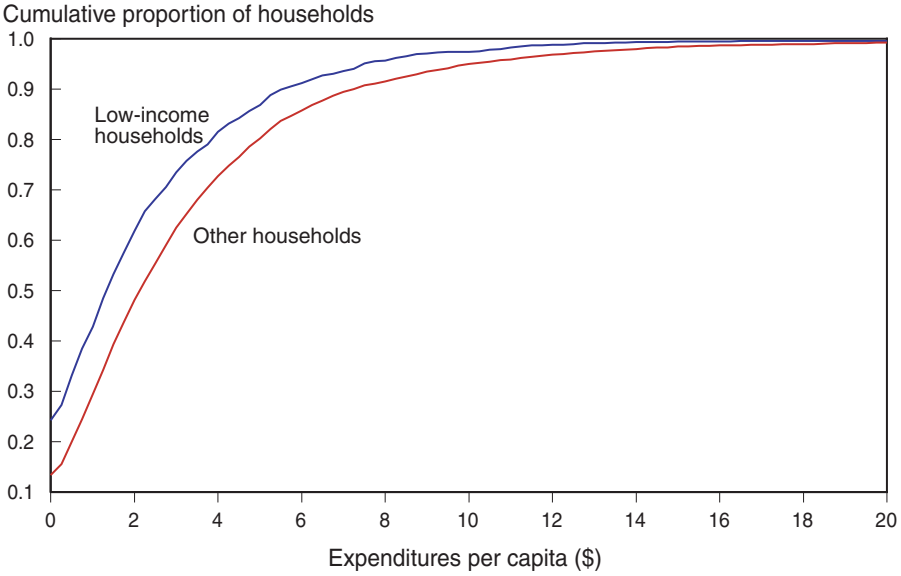


Figure 2

Distribution of fresh fruit and vegetable expenditures by income level

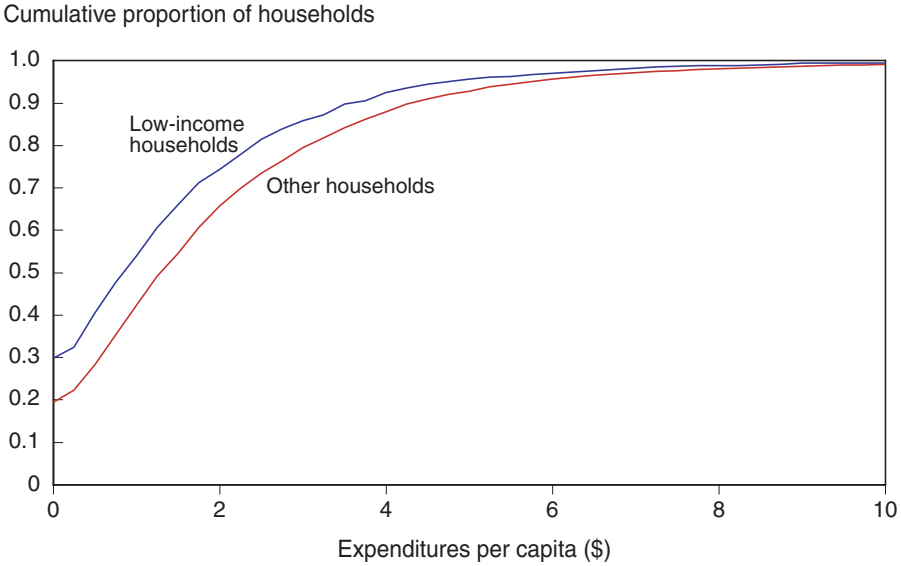


Further analysis shows that expenditures by higher income households on processed fruits and vegetables also stochastically dominate those of lower income households, although the results are weaker than for fresh fruits and vegetables (figure 3). In this situation, we found that stochastic dominance held for over 97.4 percent of the expenditure distribution. The cdf associated with spending by low-income households again lies everywhere above the same cdf for higher income households. For instance, 30 percent of low-income households spend zero dollars on processed fruits and vegetables versus only 19 percent of higher income households. Similarly, the gap remains significant at $7 per capita. We found that 98 percent of low-income households spend this much or less on processed fruits and vegetables compared with 97 percent of the higher income group. However, the distance between the two cdf's is not statistically different from a zero difference at levels of expenditure greater than $7 per capita.

Clearly, higher income households spent more per person per week than low-income households over the majority of the expenditure distribution. It also appears that this result holds for both fresh and processed items, although the results are not as strong for processed items. The second phase in our analysis is to assess whether or not purchases of fruits and vegetables by low-income households are influenced by changes in their income, and, if so, to what extent.

Figure 3

Distribution of processed fruit and vegetable expenditures by income level



Are Expenditures by Low-Income and Higher Income Households Sensitive to Changes in Income?

We now assess whether or not fruit and vegetable expenditures are sensitive to small changes in the income received by both low-income and higher income groups. We attempt to answer this question by estimating a statistical demand model that allows us to take into account most of the variables that may affect food expenditures by both the low- and higher income households. This technique allows us to determine the net effect of income on expenditures, given the other variables in the statistical model. This is in contrast to the descriptive section of this report, where fruit and vegetable expenditures were shown by various demographic characteristics, but no effort was made to control for race, household size, income, or region while looking at expenditures by, say, educational attainment.

Again, let us state that our hypothesis is that if low-income households are income constrained in their purchases of fruits and vegetables, then two things are likely to occur. First, as demonstrated above, low-income households are likely to be outspent by higher income households. And second, if we look at the influence of income on both low-income and higher income households, we would expect a positive and significant effect for higher income households but not for low-income households. One might be tempted to argue that perhaps low-income households simply do not like fruits and vegetables. The counter argument to this is that about 81 percent of all low-income households do have some fruit and vegetable purchases.

The statistical model that we estimate and analyze in this section is a special type of demand curve called an "Engel curve." Since our survey data are collected within a span of 2 weeks for each household, we can assume that prices fluctuate little, and that observed price differences reflect variation in product content and quality rather than variation in relative prices. This assumption about prices simplifies the process involved in estimating Engel relationships. Demand equations are functions of income and relevant household characteristics only, such as region, race, educational attainment, and the age structure of the households. Thus, food expenditures and budgeting patterns observed in our cross-sectional survey data are snapshots of a wide variety of households in different circumstances. Analysts usually assume that the different circumstances reflect what would occur if the circumstances changed for any particular household. If this assumption is valid, one can then use statistical models to measure the implied behavioral response parameters. Hence, the fact that one does not usually observe a particular household under changing circumstances does not prevent the measurement of these response parameters.

Household food surveys measure consumption in terms of quantity (physical weight) or money value. The quantity measure is related to the physical satisfaction of demand and the need to fulfill certain nutritional requirements (Wold and Jureen). The money value is a measure of consumer satisfaction and economic well-being obtained through the marketplace, in the sense that the prices consumers pay reflects the unit value of the goods. The money value of a purchased product group, such as fruits and vegetables, is

a price or value-weighted sum of the physical quantities used. Viewing expenditures as a value-weighted quantity provides a link between household budget analysis and the traditional theory of consumer demand, which utilizes prices, income and household characteristics. Using prices as weight to aggregate items into groups has been shown to be consistent with economic theory when relative item prices are constant (Green). The use of expenditures, or money value, provides a consistent method for aggregating many detailed and heterogeneous items into a manageable number of product groups when using cross-sectional data, such as the CE.

We analyze the impact of a change in income on fruit and vegetable expenditures while taking into account a household's level of educational attainment, age profile, race, household size, as well as the region the household resides in, and the season the survey was conducted. In this part of the analysis, our choice of statistical model is in part dictated by the fact that many households in our data set do not spend any money on fruits and vegetables. Such data are said to be "censored" at the value of zero. In such cases, ordinary least squares (OLS) can result in biased parameter estimates, because assumptions about the model do not generally hold when censored data are utilized. A standard way to correct for censoring is to use the Tobit estimator. However, this model relies on the assumptions that the error terms are normally distributed and homoscedastic (Hurd). These assumptions are not usually met with cross-sectional survey data (Deaton).

In the presence of non-normal errors and censored expenditure variables, Powell's (1984) censored least absolute deviations (CLAD) or "quantile" estimator yields acceptable parameter estimates. An additional advantage of the CLAD, or quantile estimator, is that it is more robust in its response to data outliers (values of variables that far exceed the norm) than least-squares estimators because the quantile regression is affected by whether predicted residuals fall above or below the quantile and not by the square of their distance from the average like OLS parameter estimates.

Powell's CLAD estimator is the β parameter that minimizes:

$$\sum_i \left| y_i - max(0, x_i' \beta) \right| \qquad (1)$$

where y_i is the dependent variable (expenditure on fruits and vegetables) and x_i are the independent variables noted above such as region of residence, season, income, and household size (for a technical explanation of our model see the appendix).

The CLAD estimator allows us to examine the impact of income and other variables at any point in the expenditure distribution (actually at any point in the distribution of the error terms of the model, known as the "conditional" distribution) of low-income or higher income households. For these points, we chose the 25th, 50th, and 75th percentiles. The use of these three points is an important asset. For example, we can examine how income and other variables influence expenditures by low-income households who fall into the lowest half of the conditional expenditure distribution, i.e., at the 25th and 50th percentile. We believe that these low-income and underspending households may be at the most risk of underconsuming fruits and

vegetables relative to higher income households. Therefore, as noted, we estimate the demand model for fruit and vegetable expenditures at the three different points along the conditional expenditure distribution. In this way we can determine if our selected variables, such as income, impact all levels of expenditure in the same way, or if income impacts households differently depending upon the level of their expenditures. If income is insignificant at our selected points, then one possible interpretation is that low-income households are more likely to allocate an additional dollar of income to other goods, such as meats or cereal and bakery goods or even to non-food items, than to fruits and vegetables. In addition, these estimates for the low-income households can then be compared to the corresponding estimated equations for higher income households at the same levels of conditional expenditure.

Our estimated parameters for low-income households are contained in table 11. Our model contains 21 variables plus a constant term. We have three variables for region of residence, the North Central, South, and West, to control for regional price variations as well as regional differences in tastes and preferences. We entered one variable for race of the household head, Black. All other household heads were classified as non-Black. We elected not to control for Hispanic heritage since about half of the CE participants do not know if they are Hispanic. We entered three variables for the seasons winter, spring,

Table 11—Estimated statistical models for all households versus low-income households

Independent variables	All households	Low-income households		
	50th quantile	25th quantile	50th quantile	75th quantile
Constant	4.173*	1.857*	3.439*	4.876*
North Central States	-.841*	-.041	-.832	-.403
South	-.864*	-.451	-1.390*	-.943
West	-.438*	-.457	-1.060*	-.494
Black	-.095	-.212	-.339	-.401
Winter	.103	.061	.614	-.042
Spring	.212	-.251	.202	-.230
Summer	.212	.138	.307	-.335
Income	.192*	.210	.845	.173
Income squared	-.003*	.035	-.286	.080
Household size (inverse)	-.599*	-1.005	-.623	.894
High school	.398*	.034	.175	-.353
Some college	.457*	.130	-.177	-.260
College	1.192*	.452	1.444*	1.466
Proportion age 0-4	-2.139*	.154	.056	1.310
Proportion age 5-9	-2.266*	-.569	-.989	-1.073
Proportion age 10-14	-2.019*	.109	-.865	-.783
Proportion age 15-19	-3.138*	-1.053	-1.965*	-2.456*
Proportion age 20-29	-2.817*	-.806	-2.093*	-1.837*
Proportion age 30-44	-1.279*	-.533	-.696	.604
Proportion age 65-74	1.134*	.537	1.716	2.588*
Proportion 75 and older	.415	.901	1.547*	2.275*

*= estimated coefficient lies within a 95-percent confidence interval.

and summer. These variables also control for seasonal price variations. Per capita income was entered along with the square of income. This particular form of income allows expenditures to increase at a decreasing rate as income increases (if the squared term has a negative sign on its coefficient). This means that each succeeding positive response in expenditure will decline slightly for each succeeding dollar increase in income. The inverse of household size was also entered into the model. This specification allows for economies of size as the number of household members increases. In other words, per capita expenditures are less for a two-person household than for a one-person household.

To account for the education attainment of the household head, we have variables for those with a high school education, those with some college, and those with college or graduate degrees. Finally, we have also entered the proportion of each household whose members range in age from 0-5, 5-9, 10-14, 15-19, 20-29, 30-44, 45-64, 65-74, and 75+ years old.

We have included parameter estimates for the 50th expenditure quantile for all households in the sample to provide a contrast to the estimated parameters of low-income households (table 11). In the equation for all households, most variables are statistically significant at acceptable levels with the exception of race, the seasons, and the proportion of households age 75 years or older. In focusing on the two income terms, they are statistically significant; and normally these estimated parameters would be statistically tested for joint significance. Unfortunately, our chosen technique of estimation does not allow us to do this test of joint significance. However, we believe that the two income estimates would be jointly significant since they are each individually significant. Hence, for the total sample of low-income and higher income households, income provides a positive effect on fruit and vegetable expenditures, but this effect increases at a declining rate (due to the negative, but statistically significant, effect of the squared income term).

Interestingly, households in the North Central States, South, and West all spent less per capita than those in the Northeast. This may be a function of higher prices in the Northeast, a preference for fruits and vegetables, or a combination of both.

Larger households spend more per capita than smaller households do. (The negative sign on the inverse of household size indicates a positive effect.) Larger households have higher food-at-home food expenditures than smaller households do. Hence, larger households spent more time preparing meals from scratch, and, thereby, use more raw ingredients. Following this logic, it is not surprising that expenditures on fruits and vegetables are higher for larger households.

Also, it is interesting that household members between the ages of 0 and 44 exerted a negative influence on fruit and vegetable expenditures. Often children and adolescents do not care for fruits and (especially) vegetables, but households with members age 20-44 also spend an amount that is significantly less than households with members age 45-64.

Most noteworthy is that the largest positive effect comes from households whose head has a college education or higher. This confirms our finding in the profile section, and contrasts to the positive but smaller estimated parameters for those heads with some college or a high school education.

When we turn our attention to the estimated parameters of the income variables for low-income households, we do not find any evidence for the statistical significance of this variable. This holds true for the 25th, 50th, and 75th quantiles of expenditures (we also estimated an equation for the 90th quantile with the same insignificant results). What this implies is that an additional dollar of income for low-income households will not be spent on fruits and vegetables. This finding suggests that increased income to these households will be spent on other foods such as meats and/or cereal and bakery products (Wilde et al., 1999 and 2000), or on non-food items.

In looking at the estimated coefficients of other variables in our statistical model, we find that few have any impact on fruit and vegetable expenditures. In focusing on the 50th expenditure quantile, we find that having a college education was associated with a large, positive, and statistically significant effect. It is quite interesting that the positive "college" effect holds even for the educated that reside in low-income households (about 10 percent of the low-income sample). This result also confirms the strong education effect that we found in the estimated equation for the total sample. Contrasted to this, we found that both the South and West had a negative influence on expenditures, as did having household members between the ages of 15-19 and 20-29.

We re-specified our model by dividing income into cash income, plus any food stamp allotment. We could do this because income in our data is composed of wages, interest, food stamps, and other income sources. By entering food stamps as a variable in our model we can test the hypothesis that an extra allotment of food stamps might be spent on fruits and vegetables. However, the relationship between fruit and vegetable expenditures and food stamps was statistically insignificant. We need to note that food stamps and money income are not perfect substitutes, but the above offers some evidence that food stamps by themselves do not induce poor households to buy fruits and vegetables.

Our estimated parameters for per capita expenditures on fruits and vegetables for higher income households are contained in table 12. In contrast to the estimates for the low-income sub-population, the first income term is statistically significant for expenditures by higher income households at the 25th, 50th, and 75th quantiles. We assume that both this term and the square of income would be jointly significant, although this is not needed in our case to indicate that fruit and vegetable expenditures by this income group are sensitive to small changes in income. Instead of a curvilinear relationship, we found a linear relationship. In any case, our estimated income coefficient indicates that a proportion of an additional dollar of income will be allocated to fruit and vegetable expenditures. However, we also estimated our model for the 90th expenditure quantile, but interestingly neither income nor the income-squared variable was significant at that level. Hence,

Table 12—Estimated statistical models for all households versus higher income households

Independent variables	All households	Higher income households		
	50th quantile	25th quantile	50th quantile	75th quantile
Constant	4.173*	3.081*	4.101*	6.272*
North Central States	-.841*	-.716	-.805	-.1410
South	-.864*	-.733	-.782*	-.978
West	-.438*	-.245	-.378*	-.602
Black	-.095	-.112	-.076	-.010
Winter	.103	.091	.044	-.105
Spring	.212	-.157	.266	-.587
Summer	.212	.050	.110	-.230
Income	.192*	.112*	.156*	.169*
Income squared	-.003*	-.002	-.002	-.001
Household size (inverse)	-.599*	-1.811*	-.245	2.500*
High school	.398*	.263	.527*	-.501
Some college	.457*	.295	-.645*	-.660
College	1.192*	.878*	1.325*	1.633*
Proportion age 0-4	-2.139*	-1.502*	-2.352*	-3.669*
Proportion age 5-9	-2.266*	-1.817*	-2.629*	-4.480*
Proportion age 10-14	-2.019*	-1.782*	-2.101*	-3.268*
Proportion age 15-19	-3.138*	-1.906*	-3.161*	-4.218*
Proportion age 20-29	-2.817*	-1.807*	-2.864*	-3.718*
Proportion age 30-44	-1.279*	-1.267*	-1.333*	-2.280
Proportion age 65-74	1.134*	.713	.964*	.374*
Proportion 75 and older	.415	.086	.197	-.013

*= estimated coefficient lies within a 95-percent confidence interval.

higher income results in larger fruit and vegetable expenditures up to a point.

Among higher income households, variables other than income that influence fruit and vegetable expenditures included education—again with a large positive effect from college-educated household heads. Offsetting income and education are the age composition variables, which are all negative in influence, except for the proportion of the household age 65-74 (the proportion 75 years and older was statistically insignificant). Only the regional indicator for the North Central States was negative and statistically significant.

The results, especially for low-income households, should be interpreted with caution. We are using two different tests to ascertain whether income affects low-income households' consumption of fruits and vegetables. Given that low-income households are clearly outspent by higher income households, and given that a small change in income has no measurable statistical effect on fruit and vegetable expenditures, we conclude that low-income households may find it very difficult to increase purchases of fruits and vegetables. It very well may be the case that low-income households feel they are not consuming enough basic commodities such as meats, cereal and bakery goods, etc., so that an additional dollar of income is allocated to these or other food groups. In any case, our estimated demand curve does not provide evidence that a small increase in income will be translated into additional fruit and vegetable expenditures for the low-income group.

Conclusions and Implications

Both public and private organizations have argued that, on average, Americans' consumption of fruits and vegetables does not meet the recommended dietary intake, as outlined in the Federal Food Guide Pyramid. Moreover, research shows that low-income households on average consume even smaller quantities than other households. Concurrent with these arguments, there has also been much talk about ways to promote fruit and vegetable consumption. The findings of this study may suggest likely outcomes for some proposals.

Our analysis, as well as other studies, such as those by Wilde et al., indicate that it may be difficult to induce low-income households to increase their expenditures on fruits and vegetables. Clearly, low-income households spend less than higher income households. However, our statistical demand model indicates that low-income households are not likely to allocate an extra dollar in income or food stamps to increased expenditures on fruits and vegetables. These households will likely allocate an extra dollar of income or food stamps to what low-income households perceive as more basic, and thus more desirable, food groups.

One is thereby tempted to speculate that perhaps more nutrition education, coupled with food stamps, might induce the low-income households to purchase and consume more fruits and vegetables. However, we would make a distinction between the effect of formal education and that of nutrition education. This has been the subject of much debate. One argument put forward is that households with higher education are better able to process and use nutritional information. This may very well be the case. However, it is also possible that, on average, persons who invest the time and effort required to secure a college education, or higher, also value the future more highly than those who do not have a college degree (in traditional economic theory this is known as the "discount rate" of time). These college-educated households may view healthy diets as one avenue to realizing their economic and social goals in the future. This viewpoint might be contrasted to that of people who are unsure about their future. These individuals may put more value on the present, and thereby be less concerned about their current diet's effect on future health. However, the likelihood of success of a nutrition education program, coupled with food stamps targeted toward fruits and vegetables, is an empirical problem that would have to be studied with the aid of actual data.

Our analysis indicates that higher income households spend more on fruits and vegetables than do lower income households. In addition, our analysis indicates higher income households are income sensitive to fruit and vegetable expenditures and will spend a small but statistically significant amount of an additional dollar on fruits and vegetables.

Furthermore, household heads with a college education spend a significantly higher sum on fruits and vegetables than do other households regardless of income level. Again, it may be that college-educated households are more aware of the benefits that may be derived from fruit and vegetable consumption, regardless of the income situation of the household. (It would

be interesting to see if these households consume the recommended levels of fruits and vegetables.) In any case, the results presented above point out the importance that income and formal education currently play in American households' fruit and vegetable expenditures.

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Appendix: The CLAD Model

In this study, our choice of model was dictated by the fact that many households spend no money on fruits and vegetables. As a result, survey data on household expenditures will then be censored at zero. In such cases, ordinary least squares (OLS) can result in biased parameter estimates, because the zero-mean restriction placed on the residuals will not generally hold. A standard way to correct for censoring is to use either the Tobit model, Heckman's two-step estimator, or some variant of the Tobit model such as one of the double-hurdle models. However, these models rely on an assumption about the normality of the error terms, which is often not supported when using cross-sectional expenditure survey data. Hurd (1979) and Nelson (1981) show that the Tobit and Heckman estimators are biased when the assumption of homoscedastic errors is violated, and Arabmazar and Schmidt (1981) show that the potential magnitude of the bias can be quite large.

In the presence of heteroscedasticity and censored dependent variables, Powell's (1984) censored least absolute deviations (CLAD) estimator results in consistent estimates. An additional advantage of the CLAD, or any quantile estimator, is that it is more robust to outliers than least-squares estimators because the median regression is affected by whether observations fall above or below the median and not by the distance from the median.

The algorithm used in this paper for the CLAD estimator is Buchinsky's (1994) iterative linear programming algorithm (ILPA). The ILPA first produces the least absolute deviation (LAD) estimates on the full sample, then deletes observations associated with negative predicted values, and re-estimates the LAD on the trimmed sample. The ILPA converges if there are no negative predicted values on two successive iterations, and Buchinsky (1991) shows that if the process converges, then a local minimum is obtained. Standard errors for the CLAD are obtained through a design-matrix bootstrap procedure.