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Chronic Disease, Prescription Medications, and Food Purchases

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Abstract

Purpose: Diet-related chronic diseases like diabetes can be dangerous and expensive to treat, especially for patients who do not follow a recommended diet. Meanwhile, prescription drugs can alleviate the symptoms of or control many diet-related chronic diseases, but these drugs may also weaken the resolve to follow recommended diets (moral hazard).

Design: We measure the effect of a diagnosis of chronic disease and subsequent pharmacological treatment on the dietary quality of food purchases using a large panel data set of US consumers. We estimate the effect of prescription drug utilization on food purchases for the following chronic diseases: type 2 diabetes, high cholesterol, heart disease, and obesity.

Participants: Panelists of the Information Resources, Inc consumer panel.

Measures: Dietary quality is measured as purchases of (1) food groups (ie, fruit, vegetables, and sweets) and (2) nutrients (ie, saturated fat, fiber, sodium, sugar, and total calories).

Analysis: Linear regression with mixed effects on pooled panel (household random effects, city fixed effects).

Results/Conclusion: We do not find strong effects of either diagnosis or pharmacological treatment of diet-related disease on food purchases.

Keywords
chronic disease, food purchases, drugs, diet, moral hazard

Introduction

The direct cost of diet-related chronic illness comprises a non-trivial fraction of health-care spending in the United States. By 1 estimate, in 2008, the direct cost of obesity—an "oracle condition" for other severe chronic illnesses—was $139 billion, or about 5% to 10% of total national health-care spending. According to the American Diabetes Association, the direct cost of (type 2) diabetes was $176 billion in 2012, or about 6.5% of total direct health spending. These costs are at least partly borne by the public sector through current costs to Medicaid and current and future costs to Medicare. Moreover, the high incidence of these conditions tends to increase health-care premiums, making the shared direct cost of these conditions significant. The total costs—which also account for lost productivity and consumer well-being—are far greater than the total direct costs.[1]

There have been several broad policy responses to the secular increase in the prevalence of diet-related chronic diseases. One response proposes Pigouvian taxes on foods or macronutrients in food thought to be related to disease—sugar-sweetened beverages, added sugar, and saturated fat have been the targets of choice.[2] (note 1) Another response has been to lower the cost of nutrition information, that is, by improving access to it, particularly for food away from home, which is thought to contribute to poor diets. Access to nutrition information for food away from home has been mandated in recent years only; the most significant example is the Affordable Care Act, which has mandated calorie information on the menus of restaurant chains that have more than 20 locations nationwide.[3]

Both of these strategies for reducing diet-related illness face considerable practical and theoretical problems, not the least of which is the fact that people are often reluctant to change their diets despite price incentives or additional information. Moreover, in the case of type 2 diabetes, heart disease, high blood pressure, and high cholesterol, the relative ease of getting prescription medication to treat these conditions may work against a health-care professional's advice to improve one's own diet. That is, pharmaceutical treatment may actually induce worse dietary behavior, as it reduces the full present utility costs of disease and eliminates some of the potential costs associated with having a poor diet. In the context of health technologies,

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this phenomenon is known as ex ante moral hazard, which occurs when patients fail to exercise strategies to avoid adverse events due to the presence of said technology.

In this article, we examine this possibility with respect to high cholesterol, type 2 diabetes, heart disease, and obesity. Specifically, we identify the effect of prescription medication use on the healthfulness of purchases using Information Resources, Inc (IRI) panel data. We find weak evidence of moral hazard among consumers who take diabetes drugs, in terms of their intake of various dietary components including sweets; these results are not robust to sample or specification choice.

Literature Review

The literature that addresses the moral hazard effects of medical technology is somewhat mixed. Generally, researchers have found that although patients' diets improve after a chronic disease diagnosis, the effect is not universal. For example, Blanchard et al[4] find that only 47% of patients made dietary changes after a colon cancer diagnosis, whereas Alfano et al[5] find that only 40% made dietary changes after a breast cancer diagnosis. Similarly, Patterson et al[6] find that among long-term survivors of breast cancer, 44% reported decreasing their fat intake, 42% reported increasing their fiber intake, and 43% reported increasing their consumption of fruit and vegetables. Castera et al[7] find that 48% of patients reported dietary intake changes after diagnosis with hepatitis C.

The aforementioned studies are small in scale (ranging from 185-356 participants), are cross-sectional, and rely on self-reported broad dietary changes. However, another study—a meta-analysis of postcancer dietary studies over a 40-year period by Demark-Wahnefried et al[8]—finds that only 25% to 42% of cancer survivors consume adequate amounts of fruit and vegetables. The study found that older, male, and less-educated individuals are less likely to adhere to dietary advice than their younger, female, and more highly educated counterparts. Additionally, a large study of cancer survivors by Wang et al[9] showed an increase in consumption of fruit and vegetables postdiagnosis. Hefferon et al's[10] review of qualitative studies also showed an improvement in diet after a chronic disease diagnosis.

Looking at health-related behaviors other than diet, Newsom et al[11] found that after diagnosis with any of a variety of chronic diseases (heart disease, stroke, diabetes, cancer, and lung disease), there was a moderate reduction in smoking and very small changes in alcohol consumption but almost no change in exercise. On the other hand, Schneider et al[12] found an increase in physical activity after diabetes diagnosis.

Oster[13] is perhaps the article that is most similar to ours. She studies the effect of a type 2 diabetes diagnosis on consumers' purchases, using Homescan data. She finds that diagnosis results in caloric reductions, which are enough to lose 10 pounds over the first year; the amount of caloric reduction, however, is just 20% of what is suggested by physicians. The estimated effect is especially strong in the first month after diagnosis. Oster[14] and the studies[4-7,9,11,12] include the time of diagnosis of chronic diseases, which play an important role in the analysis. We extend her work to include other chronic diseases and furthermore we concentrate on the nutritional quality—in addition to the quantity (caloric content)—of food.

Data

Information Resources, Inc Food Data

Our main source of information on consumer purchases and health information is the IRI Household panel data. Information Resources, Inc, in conjunction with Nielsen, runs a large national survey of consumer food purchases with about 120 000 panelists a year. Households are sampled from 52 markets (note 2) in the 48 contiguous states. Between 46% and 52% of IRI households provided sufficient quantity and quality of data to be included in the data set's static panel; these households account for 70% to 80% of transactions.[15] We will use this static panel as the source of our estimation sample. The survey also includes detailed demographic information on the panelists, which is updated once a year. Projection weights, based on participants' demographics, are also provided by IRI so that the data are nationally representative overall and for various demographic groups.

Homescan panelists are given handheld scanners and are instructed to scan the barcodes of all food products they purchase in food stores. Panelists record the quantity purchased, the date of the shopping trip, and the store where the product was purchased. Information Resources, Inc inputs the price of each product, using information from the stores so that consumers don't have to fill in this information. That said, the prices in the data may be different than the prices paid by the consumers because, for most transactions, IRI records the average weekly price, which may be different from the actual price the consumer paid.

In order to be included in the final data set, panelists need to provide at least 9 months of consistent information. After that point, they can stay in the survey as long as they want, and some do for many years. Each shopping trip is a separate observation, with all purchases recorded at the household level. Finally, the IRI data set also provides a Universal Product Code (UPC) dictionary that both contains nutrition information and classifies food products into major categories, such as cookies or potato chips. From the contents of this UPC dictionary, we use information on calories, fat, sodium, and other nutrients.

Items with no UPC (fresh apples sold by weight) are recorded only in aggregate form (eg, vegetables, fruit, and beef). In this case, panelists are asked to record only the amount spent for each aggregate category, which means that it is not possible to use this information to determine the quantity and per-unit prices that consumers paid for nonUPC products.

Information Resources, Inc Health Data

In 2007 to 2012, IRI's National Consumer panel surveyed the panelists on the diet-related chronic diseases they have and the drugs they use to remedy their diseases. The response rate for the survey was 32% to 40% for 2010 to 2012.[15] Consumers who indicated that they are living with a particular chronic condition were asked if they use medicine to treat the condition; they were asked about both prescription drugs and over-the-counter drugs. We observe the fact that an individual treats a specific condition, such as diabetes, with prescription drugs, but unfortunately, we don't observe the specific mediation a panelists takes. For each condition, an individual can take a variety of medications. The responses to these questions were given by individuals in the household, whereas purchases are recorded for the household: for this reason, we restrict our sample to households comprised of single adults with no children.

We examine 4 common health conditions associated with poor diet: high cholesterol, type 2 diabetes, heart disease, and obesity. Although we know whether Homescan panelists had hypertension, all of the panelists who responded that they had hypertension also reported taking medication for it, making it impossible to identify the moral hazard effect of drug treatment. All conditions except for obesity were identified by asking, "Do you suffer from [condition X]?" For the present study, obesity could be identified either from a question asking respondents whether they are obese or from body mass index (BMI) calculations based on respondents' self-reported height and weight. Only 15% of respondents in single-person households self-reported as obese, whereas the rate of obesity (ie, a BMI of 30 or greater) inferred from reported height and weight is 34%. Our analysis uses the former measure of obesity (ie, the question directly asking respondents whether they are obese) rather than respondents' BMI as calculated from reported height and weight. We use this measure because what is relevant to patients' dietary behavior change (eg, food purchases) is whether they perceive that they are obese not whether they are in fact obese. Finally, any individual who is not living with the abovementioned conditions is deemed "healthy" for the purposes of this study.

Food Data

We aggregated shopping trips into monthly observations to reduce week-to-week variability in food shopping. Our 2 diet quality measures require information on food group expenditures (ie, how much was spent on fruit, vegetables, etc.) and the quantities of nutrients purchased (ie, grams of fat, fiber, etc.). We estimate diet quality by categorizing household food expenditures as healthful or unhealthful (eg, fruit and vegetables vs sweets, respectively). First, we aggregate individual food products into 52 food groups using a link provided by the Quarterly Food-at-Home Price Database.[16] Then we aggregate the 52 food groups further into broad food groups such as fruit, vegetables, and sweets.

In addition, we present nutrient-based measures such as the amount of fat, fiber, and other nutrients per 100 calories. We derive this information from the IRI nutrient dictionary, which provides nutrition information for most UPC-coded products in the IRI data. For products with missing nutrition information, we impute nutrient content by using nutrition information for the nutritionally "most similar" product or products, based on detailed product classification information provided by IRI, such as brand, product name, product groups, and other data (eg. the Webster Avenue Market sugar cookie [12 oz], for which there is nutritional information, would be matched to the private label brand flavored English toffee cookie [14 oz], for which we do not have nutritional information).

Nutritional Quality. The federal standard for measuring dietary nutritional quality is the Healthy Eating Index (HEI). Designed by United States Department of Agriculture (USDA)'s Center for Nutrition Policy and Promotion, the HEI is based on US dietary recommendations contained in the Dietary Guidelines for Americans (DG).[17] Unfortunately, it is currently impossible to match UPCs from scanner data to cup equivalents of the USDA food groups, which form the basis of the HEI. As a result, we use proxies for diet quality. We use 2 proxies in this study: select food group expenditures and macronutrients. Food group expenditures can be a reasonable proxy for quantity of food purchased or at least for the consumer's preferences over these foods. Using expenditures also allows us to use items that have no UPC code, such as produce sold by weight. Macronutrients are a standard way of measuring diet healthfulness.

In terms of food groups, we need to find foods that can be characterized as healthy or unhealthy in a relatively unambiguous way. For this, we use household monthly expenditures on fruit, vegetables, and sweets, such as candy, cakes, sugary drinks, and ice cream. We picked these 3 categories because dietary studies invariably recommend increased fruit and vegetable consumption for the United States. Sweets contain large quantities of added sugars, which the DG recommends be limited, and refined carbohydrates, which have relatively little nutritional value. Many other food groups, such as lean meats, are not considered here because it is recommended that they be consumed in moderation, which is difficult to define, even if the definition of "lean" were easily operationalized.

The second of 2 measures we employ is the amount of nutrients per 100 calories purchased. We examine 4 main nutrients: fiber, sugar, saturated fat, and sodium. These measures can pick up differences in healthfulness between the food products that make up a large and heterogeneous food group—for example, the difference between triple cheese pizza with pepperoni and a ready-to-eat meal of fish with brown rice, which may both belong to a large processed food category. However, nutrient information on fiber and saturated fat would mark a clear difference between the 2 products.

Out of these 4 nutrients examined, fiber is strongly recommended, and saturated fat is strongly discouraged. Foods rich in fiber are fruit, vegetables, and whole grains, whereas foods rich in saturated fat are fatty meats and whole milk products, which the DG recommend against. The DG also suggest that consumers lower their sodium intake; excessive sodium consumption can lead to an elevated systolic blood pressure, with some

Table 1. Means of Health Status and Prescription Drugs Use.[a]

	Healthy	Obese	Cholesterol	Diabetes	Hypertension	Heart Disease	All
Healthy	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.34 (0.46)
Obese	0.00 (0.00)	1.00 (0.00)	0.23 (0.42)	0.36 (0.48)	0.23 (0.42)	0.24 (0.42)	0.17 (0.38)
Cholesterol	0.00 (0.00)	0.46 (0.50)	1.00 (0.00)	0.70 (0.46)	0.59 (0.49)	0.65 (0.47)	0.34 (0.48)
Diabetes	0.00 (0.00)	0.25 (0.44)	0.23 (0.42)	1.00 (0.00)	0.23 (0.42)	0.26 (0.44)	0.11 (0.33)
Hypertension	0.00 (0.00)	0.49 (0.50)	0.62 (0.49)	0.72 (0.44)	1.00 (0.00)	0.68 (0.45)	0.36 (0.49)
Heart disease	0.00 (0.00)	0.16 (0.36)	0.22 (0.41)	0.26 (0.43)	0.22 (0.41)	1.00 (0.00)	0.11 (0.32)
Uses drugs to lower cholesterol	0.00 (0.00)	0.40 (0.50)	0.89 (0.30)	0.67 (0.47)	0.55 (0.50)	0.62 (0.48)	0.30 (0.47)
Uses drugs for type 2 diabetes	0.00 (0.00)	0.22 (0.42)	0.22 (0.41)	0.92 (0.28)	0.22 (0.41)	0.23 (0.42)	0.10 (0.32)
Uses drugs for hypertension	0.00 (0.00)	0.49 (0.50)	0.62 (0.49)	0.72 (0.44)	1.00 (0.00)	0.68 (0.45)	0.36 (0.49)
Uses drugs for obesity	0.00 (0.00)	0.23 (0.42)	0.05 (0.21)	0.09 (0.27)	0.05 (0.21)	0.07 (0.24)	0.04 (0.19)
Uses drugs for heart disease	0.00 (0.00)	0.14 (0.35)	0.21 (0.40)	0.24 (0.42)	0.21 (0.40)	0.92 (0.25)	0.10 (0.31)

Abbreviation: IRI, Information Resources, Inc.
[a]IRI consumer panel data restricted to single-adult households who answered health survey, 2010 to 2012. The numbers in the brackets are standard deviations.

consumers being more sensitive to this consequence of sodium consumption than other consumers.[18] In addition, DG recommend consumers to limit their intake of added sugars, which are abundant in many processed foods. Unfortunately, the Nutrition Facts label (the source of our nutrition information) does not distinguish between added and naturally occurring sugars, and the latter can be found in many recommended foods, such as oranges. As we cannot observe the amount of added sugars in foods, we use the total sugar in the analysis with the caution that this measure may imperfectly identify unhealthful added sugars.

Data Quality. Information Resources, Inc's sample of consumers is deliberately constructed to mimic the demographic composition of the US population in terms of gender, race, ethnicity, income, and other characteristics. However, after accounting for response rates to various questions, the demographics of our final sample deviate from that of the US population. Our final sample is older, whiter, more female, and higher income than the overall US population. This problem is partially solved via population weights, which we use in our estimation.

Missing data in the household food purchase sample affect only about 0.2% of observations, primarily households that reported zero food purchased in a given month. We drop these observations, as we don't think we have a good model to predict missing food purchases. However, about half of the food products lack nutrition information, which we use in our analysis. As discussed earlier in the "Food Data" section, we impute this missing nutrition information.

As mentioned earlier, the 2010 to 2012 response rate for IRI's health survey was 32% to 40%. There is no evidence of any demographic difference between respondents and nonrespondents to this health survey. The data quality study found that the distribution of chronic conditions reported in the health survey is similar to the distribution of these conditions from reputable health surveys, such as NHANES.[15] We dropped from our sample those households that did not complete the health survey, as we did not have a reliable model to predict chronic conditions from food purchases and available demographics.

Data Presentation

Tables 1 and 2 present means and standard errors for individuals grouped by health condition. Means are calculated using the population weights provided by IRI. Health conditions tend to correlate with each other; for example, among obese individuals 36% have diabetes, whereas among all panelists only 8.7% have diabetes. Individuals with heart disease were particularly likely to have a host of other health conditions. Among them, 39% were obese, 65% had high cholesterol, and 68% had hypertension. However, heart disease was comparatively less common (only 11% of the panelists reported having it).

There is little difference between the different groups of consumers in terms of: monthly expenditures on fruit and vegetables. Consumers with heart disease spend the least on vegetables ($6.96/month), whereas consumers with hypertension spend the most ($7.43/month). The difference in fruit expenditures is even smaller, as consumers with type 2 diabetes spend the most ($3.94/month) and healthy consumers spend the least ($3.66/month). There is larger variation in spending on sweets, with healthy consumers spending $8.91/month, much less than consumers with chronic conditions, whose spending on sweets varies from $11.68 to $12.07 per month. Healthy consumers also purchase the smallest amount of calories (33 057 kcal/month), while consumers with chronic conditions purchase 38 706 to 40 405 kcal per month.

Healthy consumers tend to purchase less saturated fat and sodium and more carbohydrates, fiber, and sugar. People with high cholesterol, who are particularly sensitive to saturated fat, consume saturated fat at a rate similar to other individuals. People with diabetes, who are recommended to limit their sugar consumption, purchase the least amount of sugar per 100 kcal. However, people with diabetes also spend the most on sweets, possibly due to purchases of sweets with sugar substitutes. People with hypertension, who have high blood pressure and

Table 2. Means of Food Purchases, Demographics and Health Status.[a]

	Healthy	Obese	Cholesterol	Diabetes	Hypertension	Heart Disease	All
Vegetables expenditure ($/month)	13.6 (15.7)	13.8 (15.5)	13.5 (14.9)	13.6 (15.6)	13.5 (15.0)	13.0 (14.8)	13.5 (15.3)
Fruits expenditures ($/month)	6.9 (10.0)	7.3 (9.3)	6.9 (9.2)	7.2 (9.2)	6.8 (9.1)	7.0 (10.4)	6.9 (9.6)
Sweets expenditures ($/month)	16.9 (20.7)	21.1 (22.4)	20.3 (21.5)	21.0 (21.7)	20.0 (20.7)	20.9 (23.7)	19.0 (21.4)
Calories per month	33 057 (24 679)	40 049 (26 996)	38 706 (25 357)	40 405 (27 005)	39 156 (25 662)	38 715 (25 275)	36 566 (25 602)
Saturated fat per 100 calories (g)	1.75 (7.80)	1.79 (1.38)	1.76 (1.45)	1.82 (5.64)	1.76 (1.86)	1.73 (2.50)	1.76 (5.00)
Carbohydrates per 100 calories (grams)	12.7 (4.6)	12.3 (11.4)	12.3 (8.0)	11.9 (13.2)	12.1 (7.8)	12.4 (3.3)	12.5 (5.9)
Fiber per 100 calories (grams)	0.93 (0.78)	0.87 (9.16)	0.87 (6.15)	0.90 (13.45)	0.86 (5.99)	0.86 (0.66)	0.90 (4.78)
Sodium per 100 calories (milligrams)	151 (107)	159 (116)	156 (118)	165 (142)	158 (128)	157 (130)	155 (111)
Sugar per 100 calories (grams)	0.87 (1.06)	0.82 (0.91)	0.81 (0.80)	0.78 (0.83)	0.79 (0.79)	0.81 (0.71)	0.84 (0.92)
Hispanic	0.05 (0.17)	0.04 (0.14)	0.04 (0.13)	0.04 (0.14)	0.03 (0.12)	0.03 (0.12)	0.04 (0.15)
Male	0.34 (0.45)	0.27 (0.42)	0.33 (0.46)	0.38 (0.47)	0.32 (0.46)	0.39 (0.48)	0.32 (0.45)
Age	47.1 (12.9)	52.9 (11.4)	60.3 (10.7)	59.3 (10.6)	60.9 (11.0)	61.5 (11.7)	53.4 (12.6)
Employed	0.49 (0.50)	0.39 (0.49)	0.27 (0.45)	0.23 (0.43)	0.27 (0.45)	0.20 (0.40)	0.40 (0.49)
Black	0.11 (0.30)	0.13 (0.32)	0.12 (0.30)	0.16 (0.34)	0.16 (0.34)	0.11 (0.29)	0.13 (0.32)
Asian	0.04 (0.17)	0.01 (0.07)	0.01 (0.10)	0.01 (0.11)	0.01 (0.09)	0.01 (0.08)	0.02 (0.12)
White	0.80 (0.37)	0.83 (0.35)	0.84 (0.34)	0.79 (0.38)	0.80 (0.37)	0.86 (0.33)	0.81 (0.36)
Income ($1000)	45.8 (34.0)	36.6 (29.9)	37.2 (31.0)	34.4 (29.2)	36.2 (29.6)	31.0 (28.5)	41.0 (32.0)
Education (years)	15.4 (1.9)	15.0 (1.9)	14.7 (2.0)	14.7 (1.9)	14.7 (2.0)	14.6 (2.0)	15.1 (2.0)

Abbreviation: IRI, Information Resources, Inc.
[a]IRI consumer panel data restricted to single-adult households who answered health survey, 2010 to 2012. The numbers in the brackets are standard deviations.

are likely to be sensitive to sodium consumption, consume slightly higher-than-average amounts of sodium. Overall, though, we don't observe large differences in the amounts of nutrients purchased. The differences between healthy individuals and individuals with various health conditions are within 10% of the healthy individuals' amount.

Predictably, demographic characteristics are correlated with health. Healthy individuals are much younger (eg, an average age of 47 years vs 61.5 years for individuals with heart disease) and they earn more ($45 800/year vs $31 000/year for individuals with heart disease). Healthy individuals are also better educated (15.4 years of education vs 14.6 years for individuals with heart disease). None of these statistics should be interpreted as causal. For example, healthy individuals may make more money because they are healthy, or they may be healthier because they have more money. In addition, healthy individuals and obese people are younger. With an average age of 47 and 53, respectively, they are closer to the age of peak earnings, which occurs in early 50s.[19]

When looking at the use of prescription drugs, it is important to remember that only consumers who reported having a particular health condition were asked if they use a pharmaceutical treatment for it. Hence, for the purposes of this study, healthy individuals take no prescription drugs. Obese individuals are not likely to take prescription drugs for obesity (just 8% do so), as there are few well-established pharmacological treatments for it. Approximately, 15% of obese individuals treated their condition with over-the-counter drugs.

Other medical conditions have multiple well-established prescription drug options and most patients do take advantage of them. In particular, 89% of individuals with high cholesterol treat their condition with medication, while the corresponding numbers for diabetes, hypertension, and heart disease are 92%, 100%, and 92% , respectively. As mentioned above, this means that identifying the moral hazard effect of hypertension medication is not possible. It also points to the fact that identification of moral hazard effects of other treatments is made off of about 10% of our sample.

Estimation

There are several estimation issues with which we must contend. The most pressing is that unobserved confounders might bias our parameter estimates of the effect of disease or drug adherence on our chosen outcomes. Additionally, there might be geographic effects in people's buying habits and responses

Table 3. Estimated Associations Between Food Expenditures and Chronic Disease.[a,b]

	Log Vegetable Expenditures	Log Fruits Expenditures	Log Sweets Expenditures	Log kcal per Person
Obesity (95% CI)	−0.009 (−0.039 to 0.021)	0.017 (−0.01 to 0.045)	0.029[c] (−0.001 to 0.059)	0.050[d] (0.026 to 0.074)
High cholesterol (95% CI)	−0.008 (−0.037 to 0.02)	0.003 (−0.021 to 0.027)	0.015 (−0.009 to 0.038)	0.002 (−0.019 to 0.024)
Diabetes type 2 (95% CI)	−0.019 (−0.065 to 0.027)	0.021 (−0.02 to 0.061)	−0.006 (−0.047 to 0.035)	−0.024 (−0.062 to 0.014)
Hypertension (95% CI)	0.038[e] (0.008 to 0.068)	−0.017 (−0.045 to 0.011)	0.020 (−0.01 to 0.051)	0.019 (−0.012 to 0.049)
Heart disease (95% CI)	0.029 (−0.009 to 0.067)	0.017 (−0.018 to 0.053)	0.040[e] (0.008 to 0.072)	0.012 (−0.016 to 0.04)
Hispanic (95% CI)	−0.093 (−0.223 to 0.037)	−0.043 (−0.144 to 0.058)	−0.149[d] (−0.261 to −0.037)	−0.130[e] (−0.24 to −0.021)
Male (95% CI)	−0.232[d] (−0.283 to −0.182)	−0.001 (−0.046 to 0.045)	−0.084[d] (−0.132 to −0.035)	0.089[d] (0.047 to 0.131)
Age (95% CI)	0.006[d] (0.005 to 0.008)	0.000 (−0.001 to 0.001)	0.004[d] (0.002 to 0.005)	0.007[d] (0.006 to 0.009)
Female part-time work (95% CI)	0.034 (−0.016 to 0.085)	−0.017 (−0.062 to 0.028)	−0.040[c] (−0.087 to 0.006)	−0.021 (−0.063 to 0.022)
Black (95% CI)	−0.181[d] (−0.308 to −0.054)	−0.130[e] (−0.232 to −0.029)	−0.058 (−0.171 to 0.055)	−0.045 (−0.16 to 0.069)
Asian (95% CI)	−0.310[d] (−0.49 to −0.131)	−0.286[d] (−0.424 to −0.147)	−0.597[d] (−0.767 to −0.427)	−0.405[d] (−0.59 to −0.219)
White (95% CI)	0.053 (−0.066 to 0.173)	−0.022 (−0.116 to 0.072)	−0.057 (−0.161 to 0.047)	0.056 (−0.049 to 0.161)
Income (95% CI)	0.003[d] (0.002 to 0.004)	0.000 (0 to 0.001)	−0.001[e] (−0.001 to 0)	−0.001[d] (−0.002 to −0.001)
Years of education (95% CI)	0.035[d] (0.024 to 0.047)	−0.000 (−0.009 to 0.009)	−0.043[d] (−0.053 to −0.033)	−0.027[d] (−0.037 to −0.017)
Constant (95% CI)	0.969[d] (0.73 to 1.208)	1.340[d] (1.147 to 1.533)	2.869[d] (2.653 to 3.085)	10.125[d] (9.916 to 10.334)
Number of observations	307 284	307 284	307 284	306 798
χ^2	472.486	51.371	345.840	445.650

Abbreviations: CI, confidence interval; IRI, Information Resources, Inc.

[a]The table presents coefficients estimated in the mixed effects model with metropolitan area fixed effects and household random effects. The numbers in brackets show 95% CI of the estimated coefficients.

[b]IRI consumer panel data restricted to single-adult households who answered health survey aggregated by month, 2010 to 2012.

[c,d,e]10%, 5%, and 1% statistical significance, respectively. The head of each column is the dependent variable. χ^2 statistics is the outcome of the test that all coefficients are equal to zero, and the test is rejected for all outcomes.

to illness that need to be accounted for. Given these, we estimate a number of specifications in order to check the robustness of our results to different assumptions about unobserved heterogeneity. Our primary specification uses fixed effects for geographic market groups identified by IRI, and household random effects—for our purposes, we call this the mixed effects model; additionally, we separate out models by race, gender, and educational status. Although there are reasonable objections to a random effects specification—for example, it assumes that unobservables are uncorrelated with the observed characteristics—we decided against the use of the household fixed effects model as very few households changed their health status in 3-year panel, and it is not clear in what month the change of the health status has happened.

Results

Diets and Disease

Table 3 shows results for a regression of log expenditure for vegetables, fruit, sweets, and total kilocalories on chronic health conditions and demographics of a single-person household. Table 4 presents estimation of the effect of chronic health conditions on the purchase of nutrients per 100 kcal. Generally, household follow the most crucial recommendations for specific diseases. The diabetics purchase less sugar per 100 kcal, individual with high cholesterol reduce purchases of saturated fat, and consumers with heart diseases purchase less saturated fats and more vegetables. The only exception are individuals with hypertension who, against recommendation, purchase more sodium. Finally, obese individual have the worst diet they purchase more sweets, calories saturated fat, and sodium than healthy nonobese individuals.

Drugs, Diets, and Disease

In Tables 5 and 6, we add pharmacological treatments to the food purchase model. It is important to reiterate that most consumers use prescription drugs, so the effect of the nonusers is identified from a small share of the sample (about 10%). We don't find clear evidence of moral hazard effects on diet from prescription drugs with the exception of high cholesterol. The diagnosis is associated with a 2.4% decrease in purchases of saturated fat per 100 kcal, while taking the prescription drugs against high cholesterol is associated with an increase in saturated fat purchases by 1.7%. Generally, the use of prescription drugs was associated with dietary improvements for the disease-specific nutrients and foods. The effect of drugs on diet

Table 4. Estimated Associations Between Nutrients and Chronic Disease.[a,b]

	Log Saturated Fat per 100 kcal	Log Fiber per 100 kcal	Log Sodium per 100 kcal	Log Sugar per 100 kcal
Obesity (95% CI)	0.009[c] (−0.001 to 0.019)	−0.004 (−0.016 to 0.007)	0.010[d] (0.001 to 0.02)	−0.005 (−0.019 to 0.009)
High cholesterol (95% CI)	−0.010[d] (−0.021 to 0)	0.004 (−0.007 to 0.015)	0.001 (−0.008 to 0.009)	0.016[d] (0.003 to 0.03)
Diabetes type 2 (95% CI)	0.024[e] (0.01 to 0.038)	0.007 (−0.011 to 0.024)	0.037[e] (0.024 to 0.05)	−0.028[d] (−0.05 to −0.006)
Hypertension (95% CI)	0.016[e] (0.006 to 0.026)	−0.015[d] (−0.026 to −0.003)	0.029[e] (0.02 to 0.038)	−0.018[d] (−0.033 to −0.004)
Heart Disease (95% CI)	−0.012[d] (−0.023 to 0)	0.003 (−0.012 to 0.017)	0.001 (−0.01 to 0.011)	−0.008 (−0.025 to 0.008)
Hispanic (95% CI)	−0.061[e] (−0.103 to −0.02)	0.033 (−0.01 to 0.077)	−0.072[e] (−0.125 to −0.02)	−0.049[c] (−0.107 to 0.009)
Male (95% CI)	−0.017[c] (−0.035 to 0.001)	−0.053[e] (−0.072 to −0.034)	0.046[e] (0.03 to 0.061)	−0.051[e] (−0.075 to −0.027)
Age (95% CI)	0.001[e] (0.001 to 0.002)	0.000 (0 to 0.001)	−0.001[d] (−0.001 to 0)	−0.003[e] (−0.004 to −0.003)
Female part-time work (95% CI)	0.002 (−0.016 to 0.019)	−0.002 (−0.019 to 0.015)	0.007 (−0.008 to 0.022)	0.008 (−0.015 to 0.031)
Black (95% CI)	−0.100[e] (−0.148 to −0.052)	−0.008 (−0.061 to 0.044)	−0.028 (−0.073 to 0.017)	0.056[c] (0 to 0.112)
Asian (95% CI)	−0.099[d] (−0.188 to −0.009)	−0.023 (−0.105 to 0.06)	−0.105[e] (−0.179 to −0.03)	−0.097[c] (−0.208 to 0.015)
White (95% CI)	0.011 (−0.034 to 0.056)	−0.002 (−0.051 to 0.047)	0.034 (−0.008 to 0.075)	0.007 (−0.045 to 0.059)
Income (95% CI)	0.000(0 to 0)	0.001[e] (0.001 to 0.001)	0.000 (0 to 0)	−0.000[e] (−0.001 to 0)
Years of education (95% CI)	−0.008[e] (−0.012 to −0.004)	0.023[e] (0.019 to 0.026)	−0.002 (−0.006 to 0.001)	0.001 (−0.004 to 0.006)
Constant (95% CI)	0.490[e] (0.4 to 0.58)	−0.638[e] (−0.732 to −0.544)	4.947[e] (4.869 to 5.024)	−0.185[e] (−0.29 to −0.079)
Number of observations	306 232	306 232	306 232	306 232
χ^2	271.258	353.515	230.473	171.306

Abbreviations: CI, confidence interval; IRI, Information Resources, Inc.
[a]The table presents coefficients estimated in the mixed effects model with metropolitan area fixed effects and household random effects. The numbers in brackets show 95% CI of the estimated coefficients.
[b]IRI consumer panel data restricted to single-adult households who answered health survey aggregated by month, 2010 to 2012.
[c,d,e]10%, 5%, and 1% statistical significance, respectively. The head of each column is the dependent variable. χ^2 statistics is the outcome of the test that all coefficients are equal to 0, and the test is rejected for all outcomes.

Table 5. Estimated Associations Between Chronic Disease, Drugs, and Food Expenditures.[a,b]

	Log Vegetable Expenditure	Log Fruits Expenditure	Log Sweets Expenditure	Log kcal per Person
Obesity (95% CI)	−0.017 (−0.048 to 0.014)	0.010 (−0.02 to 0.04)	0.023 (−0.009 to 0.055)	0.056[c] (0.03 to 0.082)
High cholesterol (95% CI)	0.001 (−0.047 to 0.05)	−0.011 (−0.055 to 0.034)	−0.021 (−0.061 to 0.019)	−0.012 (−0.045 to 0.021)
Diabetes type 2 (95% CI)	−0.065[d] (−0.139 to 0.009)	−0.011 (−0.096 to 0.074)	−0.003 (−0.086 to 0.08)	−0.045 (−0.103 to 0.014)
Hypertension (95% CI)	0.037[e] (0.007 to 0.067)	−0.023 (−0.051 to 0.005)	0.014 (−0.016 to 0.045)	0.017 (−0.013 to 0.048)
Heart disease (95% CI)	0.075 (−0.037 to 0.187)	−0.043 (−0.166 to 0.08)	0.002 (−0.095 to 0.099)	0.020 (−0.064 to 0.104)
Cholesterol drugs (95% CI)	−0.012 (−0.063 to 0.039)	0.020 (−0.027 to 0.067)	0.048[e] (0.006 to 0.091)	0.018 (−0.017 to 0.054)
Diabetes type 2 drugs (95% CI)	0.054 (−0.025 to 0.134)	0.034 (−0.056 to 0.124)	−0.007 (−0.094 to 0.08)	0.024 (−0.041 to 0.089)
Obesity drugs (95% CI)	0.033 (−0.023 to 0.09)	0.044 (−0.014 to 0.102)	0.034 (−0.014 to 0.082)	−0.032 (−0.097 to 0.034)
Heart disease drugs (95% CI)	−0.053 (−0.169 to 0.063)	0.073 (−0.053 to 0.198)	0.045 (−0.054 to 0.144)	−0.008 (−0.092 to 0.076)
Number of observations	306 437	306 437	306 437	305 953
χ^2	475.153	58.775	359.445	448.954

Abbreviations: CI, confidence interval; IRI, Information Resources, Inc.
[a]The table presents coefficients estimated in the mixed effects model with metropolitan area fixed effects and household random effects.
[b]IRI consumer panel data restricted to single-adult households who answered health survey aggregated by month, 2010 to 2012.
[c,d,e]10%, 5%, and 1% statistical significance, respectively. The head of each column is the dependent variable. Chi-squared statistics is the outcome of the test that all coefficients are equal to zero, and the test is rejected for all outcomes.

has been mixed. Drugs against high cholesterol were associated with a 4.8% increase in sweets purchases and 1.7% increase in the saturated fat per 100 kcal and a 2% decline in the amount of sugar per 100 calories. In addition, the use of drugs against diabetes is associated with a 4.2% increase in the sodium per 100 calories, whereas the drugs against heart disease decrease the sodium by 3.9%. The effect of drugs against obesity is insignificant and very few consumers report taking them. We were not able to estimate the effect of hypertension drugs as all consumers who have hypertension take it.

Table 6. Estimated Associations Between Chronic Disease, Drugs and Nutrients.[a,b]

	Saturated Fat per 100 kcal	Fiber per 100 kcal	Sodium per 100 kcal	Sugar per 100 kcal
Obesity (95% CI)	0.010[c] (−0.001 to 0.021)	−0.005 (−0.017 to 0.007)	0.012[d] (0.002 to 0.023)	−0.009 (−0.025 to 0.007)
High cholesterol (95% CI)	−0.024[e] (−0.041 to −0.006)	−0.000 (−0.02 to 0.019)	−0.004 (−0.018 to 0.01)	0.031[e] (0.009 to 0.054)
Diabetes type 2 (95% CI)	0.008 (−0.033 to 0.049)	−0.009 (−0.045 to 0.028)	−0.000 (−0.032 to 0.032)	−0.031 (−0.069 to 0.007)
Hypertension (95% CI)	0.015[e] (0.005 to 0.025)	−0.016[e] (−0.02 to −0.005)	0.028[e] (0.019 to 0.037)	−0.018[d] (−0.033 to −0.004)
Heart disease (95% CI)	0.008 (−0.023 to 0.04)	−0.023 (−0.059 to 0.013)	0.035[e] (0.012 to 0.059)	−0.008 (−0.045 to 0.029)
Cholesterol drugs (95% CI)	0.017[c] (−0.002 to 0.036)	0.006 (−0.015 to 0.027)	0.006 (−0.008 to 0.021)	−0.020[c] (−0.044 to 0.003)
Diabetes type 2 drugs (95% CI)	0.019 (−0.023 to 0.06)	0.019 (−0.019 to 0.057)	0.042[d] (0.009 to 0.076)	0.002 (−0.038 to 0.042)
Obesity drugs	−0.006 (−0.029 to 0.017)	0.005 (−0.018 to 0.028)	−0.006 (−0.03 to 0.018)	0.018 (−0.018 to 0.053)
Heart disease drugs (95% CI)	−0.023 (−0.057 to 0.01)	0.030 (−0.008 to 0.067)	−0.039[e] (−0.063 to −0.014)	0.001 (−0.039 to 0.04)
Number of observations	305 390	305 390	305 390	305 390
χ^2	277.117	370.421	253.264	181.406

Abbreviations: CI, confidence interval; IRI, Information Resources, Inc.
[a]The table presents coefficients estimated in the mixed effects model with metropolitan area fixed effects and household random effects.
[b]IRI consumer panel data restricted to single-adult households who answered health survey aggregated by month, 2010 to 2012.
[c,d,e]10%, 5%, and 1% statistical significance, respectively. The head of each column is the dependent variable. χ^2 statistics is the outcome of the test that all coefficients are equal to zero, and the test is rejected for all outcomes.

Discussion

We find that most consumer follow dietary recommendations for the most critical nutrients/foods, that is, reducing sugar with diabetes, saturated fat with high cholesterol, and so on. Obese consumers are least likely to follow dietary recommendations. We don't find evidence of moral hazard with the exception of consumers diagnosed with high cholesterol. In a separate analysis not presented due to space limitation, we studied consumers with low income and consumers without college degree. We find that these consumers less likely to follow the dietary recommendations for the chronic conditions they have, however, among these subpopulations we, also, do not find evidence of moral hazard, again with the exception of consumers diagnosed with high cholesterol. These results are available from the authors.

The magnitude of estimated coefficients is relatively small, so we don't find large differences in the diets between diets of healthy consumer and consumer with chronic disease, the differences are mostly within 10% of the prediagnosis baseline for the nutritional measures we examine. For example, we find that diagnosis with type 2 diabetes is associated with a statistically insignificant reduction in purchases of 877 calories per month, which is a small fraction of the 36 566 calories reported to be purchased by consumers on an average month.[13] Oster Using Nielsen Homescan data from 2004 to 2013 finds a similar reduction in 600 to 1300 calories per month for single-person households newly diagnosed with type 2 diabetes.

Furthermore, Oster[14] finds that in the short term, consumers diagnosed with diabetes increase purchases of recommended foods and decrease purchases of less healthful foods. In the long run, only the second effect persisted; as we did not observe the exact month of diabetes diagnosis in the present study, we could only try to replicate the long-run effect. Similar to Oster's finding, we find that diabetes diagnosis is associated with decreased purchases of a less healthful nutrient (sugar). But we did not find that diabetes diagnosis was associated with decreased purchases of saturated fat; in fact, there was a slight positive association between diabetes diagnosis and purchases of saturated fat.

We find some evidence of moral hazard associated with the use of prescription drugs against high cholesterol, but the magnitude of these effect is small. The results for other drugs are mixed, weak, and confined to the purchases of sodium, which is not the primary health concern for conditions other than hypertension. A limitation of the drug results is that we don't observe a specific drug an individual takes.

The study has several limitations. The most obvious one is the restriction of analysis to single-adult households, which represent just 27% of all households and even smaller share of populations. Hence the findings of this study may not be generalizable beyond households composed of 1 adult with no children. Social support and interpersonal relationship dynamics[20,21] are major factors in dietary intake patterns, so people who live with others may be subject to other important influences on their diet that the people in our sample were not. Second major limitation is the use of IRI data, which has biases such as oversampling of white, female, higher income consumers. We reduce these biases by using population weights, but these biases need to be acknowledged nevertheless. Finally, just 30% of IRI panelists answered the health survey. Although researchers did not find any obvious correlation between nonresponse rates and demographics or health status, such high nonresponse rate is a reason for concern.

We suggest that, in the future, researchers continue investigating these research questions and that the analysis be extended to included physical activity as an outcome instead of just food expenditures and nutrients per 100 kcal. For example, if patients are indeed more motivated or more educated about taking care of their health after they are prescribed medication, does this lead to higher levels of physical activity as well? Finding answers to questions like these will contribute to our understanding of the importance of access to health care and prescription medication for the health of people living with diet-related chronic disease.

SO WHAT?

We find that diagnosis with chronic disease have little effect on diet. The pharmacological treatments of these disease, have also little effect on diet.

Authors' Note

The views expressed in the study are those of the authors and cannot be attributed to the US Department of Agriculture or the US Department of Health and Human Services. Any opinions, findings, recommendations, or conclusions are those of the authors and do not necessarily reflect the views of the Economic Research Service, US Department of Agriculture. The analysis, findings, and conclusions expressed in this article also should not be attributed to Information Resources, Inc. (IRI).

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Notes

1. A Pigouvian tax is a tax levied against any market activity that generates negative externalities.
2. The 52 Nielsen market areas mostly correspond to metropolitan areas. Some market areas are rural and can span several States.

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