Estimating the Impact of Medication on Diabetics' Diet and Lifestyle Choices

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Introduction

Often repeated diet and health recommendations from the public health community are to increase consumption of fruits and dark green leafy vegetables, reduce intake of added sugars, trans-fats, saturated fats, cholesterol, salt, and alcohol while maintaining bodyweight by aligning caloric intake with one's level of physical activity. The impetus for such advice is that scientific evidence suggests obesity leads to an increased risk of premature death, type II diabetes, heart disease, stroke, hypertension, gallbladder disease, osteoarthritis, and many other maladies (U.S. Department of Health and Human Services, 2001). Regardless, recent statistics on obesity and dietary intake show that the majority of Americans are far from complying with this advice: the majority of Americans are overweight; approximately one third are obese; and the average diet is too high in calories, added sugars and saturated fat. To meet the 2005 *Dietary Guidelines*, the typical American would need to more than double their current intake of vegetables and whole-grain foods while halving their intake of solid fats and added sugars (Hedley, et al., 2004; United States Department of Health and Human Services and United States Department of Agriculture, 2005).

This increasing prevalence of obesity and diet-related illnesses begs the question why so many people are putting themselves at risk of such serious illnesses. There must be something that compensates for accepting such risks—a tradeoff that makes the risks worth accepting. Clearly, many Americans still eat too much food and choose those that are too high in fat, salt refined grains and added sugar. Given these strong preferences, the task the public health community has set for itself—changing American's diets—is extremely difficult. Here, we offer a quantitative perspective on just how difficult it will be to realize a substantial improvement. We focus attention on the subset of consumers who have strong incentives to choose a healthful diet, those who have been diagnosed with diabetes, and show that they embrace opportunities to resist any change.

In this paper, we first provide some background on diabetes in the United States, indicating how diet and risk preferences could lead to a variety of behavioral adjustments and concomitant health (or health risk) outcomes. We offer a theoretical model that shows that if consumers treat diet and medication as substitutes in producing good health, consumers are unlikely to realize all the health benefits possible from diet and medication. In fact, consumers may choose diets that pose health risks even larger than those incurred in undiagnosed states: diet quality for those on medication may be worse than those who do not have diet-related chronic diseases. This study uses the most recent data sets from the National Health and Nutrition Examination Survey 1999-2000 and 2001-2002 (for simplicity NHANES 1999-2002), which contain detailed information on dietary intake, medical conditions and whether an individual takes medication for such conditions. We estimate how differences in dietary quality correlate with whether or not an individual has been diagnosed with diabetes, and whether or not an individual uses medication to manage his or her health condition. By examining diet quality for those having a diet-related disease, we show that the threat of severe adverse health consequences (premature death, blindness, loss of limbs, kidney failure) can induce major improvements in diet quality (improvements from the perspective of the public health community, not consumers). But the availability of medications that can also forestall the adverse health consequences of chronic diet-related disease means that most consumers will compromise diet quality. We examine the overshooting that occurs as people with diabetes rely on medication, compromising diet quality. We conclude with suggestions for new guidance for information policy.

Background

Over the past twenty-five years, the percent of Americans diagnosed with diabetes has nearly doubled. According to 2005 estimates from the Centers for Disease Control and Prevention, seven percent of the American population now has diabetes (United States Department of Health and Human Services, Centers for Disease Control and Prevention, 2005). Complications from diabetes include heart disease, stroke, high blood pressure, blindness, kidney disease, amputations and premature death. It is estimated that the risk of death among people with diabetes is about twice that of similar aged people without diabetes. In 2002, the estimated total direct and indirect costs of diabetes were calculated to be 132 billion dollars (American Diabetes Association, 2003). As diabetes is more likely to affect ethnic minorities and older adults, these statistics are likely to worsen as our population ages and becomes more diverse.

Although these statistics are discouraging, individuals can reduce the negative effects of diabetes through fairly straightforward behavioral changes such as eating a healthful diet and increasing physical activity. The same changes can prevent onset of the disease (American Diabetes Association, no date). Economic theory predicts that individuals will choose to alter current behavior when the benefits of doing so outweigh the costs. Thus, depending on the alignment of prices, income, beliefs about how current lifestyle influences future health, and preferences, an individual may choose to remain sedentary, slightly overweight and eat too much of the wrong foods, knowing that such choices compromise health and longevity.

The various theories about the benefits of risk regulation provide a framework for evaluating behavioral responses to a diabetes finding. Dickie and Gerking (1997) identified four hypotheses about how people respond to changes in risk policies. Technologists might extrapolate from laboratory experiments to forecast that the benefits of a new and imposed technology would be fully realized. Namely, no one would change behavior and everyone would thus exact all possible health benefits of the new technology. Alternatively, people adapt to risk reducing innovations by becoming less vigilant about safety. They listed three variations of this notion. Peltzman (1975) argued that a risk reducing technology lowers the cost of risky behavior and induces an increase in risky behavior. The outcome of more risk taking could at least partially offset the benefits of the regulation. Wilde (1982) postulated a target risk level so that behavioral change would exactly offset benefits of regulation, leaving no net change in health outcomes. Viscusi (1992) suggested that people may overestimate the risk-reducing capability of required technologies. This lulling effect could lead people to take more risks than before the risk-reducing technology was required. Health outcomes could be worse.

If a person were surprised by being told he is diabetic, then clearly he was overestimating his health status. Usually such information is not given in isolation. Doctors would likely issue a stern lecture about the importance of managing diet (making big changes) and taking more exercise. The importance of medication would also be part of the lecture. In effect, the newlyrevealed diabetic is given an arsenal of tools for mitigating the adverse health effects of diabetes, all of which diminish utility.

One response to this package of information could be to strictly follow doctor's orders: changing diet and lifestyle, and taking medication. From the perspective of the public health community, such a strategy is the only rational response. Anything else is more risky and more likely to compromise health. That is, failing to make diet and lifestyle changes or failing to take medication would be considered costly from a health perspective.

However, in an individual's attempts to maximize overall well-being, desires for his familiar diet and lifestyle may compete against his desires to mitigate health risks from diabetes. Diet and lifestyle choices reflect preferences conditioned by a lifetime of habit as well as by family and community traditions. Undoing the force of habit and tradition is unlikely to be easy. He may consider the prescribed diet and lifestyle changes to be somewhat substitutable for medication in reducing the probability of adverse health outcomes. He might think that medication lowers the health cost (increased probability of an adverse outcome) of failing to make diet and lifestyle changes. In this case, offsetting behavior is certain; the important question for forecasting a health outcome is how much offsetting behavior will occur? If the protective effect of medication is assumed large while the pull of the familiar diet and lifestyle is strong, major diet and lifestyle changes are unlikely. Some individuals might enjoy a large protective effect from medication. But others might simply overestimate the protective effect and be lulled into believing that medication eliminates the health risks of diet and lifestyle choices.

Theoretical Model

We begin with a standard model influenced by Becker (1965), Lancaster (1966) and Grossman (1972) of consumer demand that assumes individuals gain utility from behaviors (B), health (H) and all other goods (C). For our purposes, behaviors over which utility is defined are selecting a nutritionally poor diet and having a sedentary lifestyle. These are exactly opposite to the dietary and lifestyle choices that diabetics are typically encouraged to make: limit consumption of sugar, fat, and cholesterol and maintain at least a moderate level of physical activity (American Diabetes Association, no date; U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2005). Such recommendations may be difficult to follow because, though they offer long-term health benefits, they may also entail an immediate cost, such as foregoing dessert or spending 30 minutes on a tread-mill instead of watching TV.

However, as long as good health enters the utility function, the health-compromising (undesirable) attributes of behaviors also influence the utility maximization. Define H as a perceived health production function. For simplicity, we assume that individuals manage health through behaviors and medication (M). Also, we assume that how highly an individual assesses his or her current level of health is driven by η, a parameter that represents medical evidence of a current health condition. For example, someone who was told that he or she had type II diabetes would assess his or her health at a lower level than before learning this news. Thus, there is an inverse relationship between H and η. Other goods (C) are assumed to have no direct impact on health.

Maximizing utility subject to the income constraint and to the health production function can be written in standard form as

$$\max \quad U(B, H(B, M; \eta), C\ )$$

$$s.t. \quad P_B B + P_M M + C \le I\ .$$

Thus the Lagrangian for this optimization problem can be written as follows:

$$L = U(B, H(B, M; \eta), C) + \lambda(I - P_B B - P_M M - C).$$

Where I is income, P_B and P_M are the prices for behaviors and medication, and for simplicity, the price of all other goods, C, is defined as the numeraire. The first order conditions are

$$1a) \quad L_B = U_B + U_H H_B - \lambda P_B = 0$$
$$1b) \quad L_M = U_H H_M - \lambda P_M = 0$$
$$1c) \quad L_C = U_C - \lambda = 0$$
$$1d) \quad L_\lambda = I - P_B B - P_M M - C = 0.$$

Solving 1a and 1b for λ and equating (or for U_C through 1c) exhausts the budget constraint 1d and yields:

$$2) \quad \frac{U_B + U_H H_B}{U_H H_M} = \frac{P_B}{P_M}.$$

That is, the marginal rate of substitution between behaviors and pharmaceuticals that offset the health cost of behaviors is equal to the price ratio. The marginal utility of behaviors is a net concept as it includes the direct benefits as well as the health cost.

Equation (2) can be rewritten as

$$F \equiv U_H H_M - \frac{P_M}{P_B}(U_B + U_H H_B) = 0.$$

As the function F is identically zero, the implicit function rule can be used to explore relations among variables in the perceived health production function and in the utility function.

$$\frac{\partial B}{\partial \eta} = -\frac{F_\eta}{F_B} = -\frac{U_H H_{M\eta} + H_M U_{HH} H_\eta - \frac{P_M}{P_B}(U_{BH} H_\eta + U_H H_{B\eta} + H_B U_{HH} H_\eta)}{U_H H_{MB} + H_M U_{HB} - \frac{P_M}{P_B}(U_{BB} + 2U_{BH} H_B + U_H H_{BB} + U_{HH}(H_B)^2)}$$

Our goal is to sign the derivative $\frac{\partial B}{\partial \eta}$ for a typical individual, not all mathematically possible utility and production functions. We make conventional assumptions that

$U_i > 0$ and
$U_{ii}, H_{ii} < 0$ for $i = B, H, C.$

That is, the marginal utilities are positive, and utility and production functions are concave. The marginal product of medicine is positive, but behaviors that bring enjoyment are assumed unhealthful and information about health is assumed to be bad news, reducing perceived health status.

$H_j > 0$ for $j = M$ and
$H_j < 0$ for $j = B, \eta.$

Conventional utility and production function assumptions, however, are not sufficient to sign the derivative. In addition, cross partials must meet a test of reasonableness or plausibility. We assume that $U_{BH} = U_{HB} \geq 0.$ That is, bad behavior is more rewarding when in better health. The equality allows for the possibility that the rewards from bad behavior are independent of health status. We assume $H_{M\eta} \geq 0, \quad H_{B\eta} \leq 0, \quad H_{MB} = H_{BM} = 0.$ Medicine becomes more important (or of unchanged importance) to health when health news is bad, behaviors compromise health more (or compromise health equally) when health news is bad, and the efficacy of medicine is independent of poor diet and lifestyle choices. The latter condition is equivalent to insulin's marginal impact on health being unaffected by one's level of physical activity. Under these conditions, $\frac{\partial B}{\partial \eta}$ is negative, indicating that the net effect of bad health news is to reduce behaviors that compromise health. Individuals will adjust to bad health news by making healthier diet and lifestyle choices.

To sign the derivative $\frac{\partial B}{\partial M}$ for a typical individual, we again rely on the implicit function theorem,

$$\frac{\partial B}{\partial M} = -\frac{F_M}{F_B} = -\frac{U_H H_{MM} + U_{HH}(H_M)^2 - \frac{P_M}{P_B}(U_{BH}H_M + U_H H_{BM} + H_B U_{HH} H_M)}{U_H H_{MB} + H_M U_{HB} - \frac{P_M}{P_B}(U_{BB} + 2U_{BH}H_B + U_H H_{BB} + U_{HH}(H_B)^2)}.$$

Under the same conditions imposed on partial derivatives and cross partials, $\frac{\partial B}{\partial M}$ is positive. In effect, medicine makes it easier to return to behaviors that compromise health. The impact of making health benefits possible from pharmaceuticals means that many will forego some, or all, of the possible health benefits. They will make themselves better off by returning to less healthy diet and lifestyles. This means that some individuals will find they improve their overall well-being by taking medication while also choosing diets and lifestyles that are less healthful than they would choose if they had to rely on diet and lifestyle alone to manage a diet-related disease.

Showing that $\frac{\partial B}{\partial M} > 0$ also reveals how unlikely are health impacts predicted from pharmaceutical trials alone. A pharmaceutical company would be tempted to promote new medications (point to large health benefits), making epidemiological predictions by extrapolating from such trials. Large benefits are more likely if the company assumes that all the health benefits possible from pharmaceuticals would be realized. Such a prediction would not allow for the possibility that individuals might adjust to the possibility of using medicine. The prediction would assume that individuals do not make themselves better off by modifying their diet and lifestyle choices along with taking medicine, in effect $\frac{\partial B}{\partial M} = 0$.

To achieve the company's forecasts requires F_M to be identically zero. One could make assumptions that make F_M identically zero. For example, if utility were linear in health and health were linear in medicine, $U_H = k \Rightarrow U_{HH} = 0$ and $H_M = l \Rightarrow H_{MM} = 0$. Adding the requirement that medicine is universally free, $P_M = 0$, implies $F_M = 0$ and thus $\frac{\partial B}{\partial M} = 0$. But giving up concavity and the notion that medicine might command a positive price are extreme and unsupportable assumptions.

The overall change in behavior depends on the relative magnitudes of $\frac{\partial B}{\partial \eta}$ and $\frac{\partial B}{\partial M}$. If $\frac{\partial B}{\partial M}$ is relatively small compared to the absolute value of $\frac{\partial B}{\partial \eta}$, the overall response to bad health news would be real attention to diet and exercise—a substantial change in diet and lifestyle. As the magnitude of $\frac{\partial B}{\partial M}$ rises relative to the magnitude, in absolute value, of $\frac{\partial B}{\partial \eta}$, the sum of the two partials approaches zero, and diet and exercise concerns diminish. If the sum is zero, diet and lifestyle return to the level chosen before the bad news arrived. In this case, the increased risk taking by returning to old diet and exercise habits completely offsets the health benefits of medicine.

Even with the sign restrictions imposed here, it is possible that $\frac{\partial B}{\partial \eta}+\frac{\partial B}{\partial M}>0$. That is, bad health news and the opportunity to mitigate adverse health effects with medication could have a decidedly negative effect on diet and lifestyle choices, leaving individuals with greater health risks than if they had not been diagnosed with a diet-related illness. The shape and position of the perceived health production function allow for this possibility. Health can be compromised if $H_M > \left|H_\eta\right|$ and $\left|H_{MM}\right| > \left|H_{M\eta} - \frac{P_M}{P_B} H_{B\eta}\right|$. While there is little intuition that can be offered for the second inequality, the first is straightforward. The inequality suggests that medication is perceived to offer health benefits at the margin that are greater than the health decrement lost to bad health news. That is, if medication offers to more-than-counteract the bad news, it opens the opportunity to maximize utility by compromising on diet and exercise even more than before the news.

Empirical Approach

The theoretical model implies that dietary choices and level of physical activity will be a function of prices, health conditions and whether or not an individual takes medication to control these conditions. Analysis of the equilibrium conditions yields three hypotheses that can be tested empirically:

- There is a negative relationship between the being made aware of a health condition, such as diabetes, and specific behaviors, such as choosing to eat an unhealthful diet or being physically inactive;
- There is a positive relationship between taking medication for a health condition and these same behaviors; and
- The effect of medication on increasing behaviors may offset the reductive effect of better health awareness.

The theoretical model suggests that an individual's chosen level of behaviors (B_i) can be modeled as a function of income, prices, and health status (H_i) which, as defined in the theoretical model, is determined by one's behaviors, awareness of a health condition (η_i) and whether or not one takes prescribed medication (M_i). This specification illuminates the simultaneous nature of behavioral choices, medication and health status. For simplicity (and data availability) we use a static framework. In reality, these decisions are more dynamic; past food and behavioral choices influence our current health status, which in turn influence our future choices regarding food, behaviors and medication. The empirical model can be written as:

(3a) $B_i = \beta' X_i + \delta\eta_i + \phi M_i + e_i$

(3b) $M_i = \xi Z_i + \varepsilon_i$,

where X_i is a vector of exogenous explanatory variables that relate to individual behavioral choices, η_i indicates whether or not an individual has a specific health condition, M_i indicates whether or not an individual takes medication for this condition and Z_i is a vector of exogenous explanatory variables relating to whether or not an individual chooses to manage his or her health condition through medication, and e_i, ε_i are random disturbance terms. An estimation approach that does not explicitly address this simultaneous process will bias the estimated relationship between behaviors, such as food intake or physical activity and the explanatory variables. For that reason, we estimate these two equations simultaneously using a treatment effects estimator. In the first equation, we run a probit regression to estimate whether an individual chooses to manage health via medication. In the second equation, we estimate the magnitude of diet and activity choices recommended to control diabetes. To obtain robust variance estimates, we use STATA 9.0 to control for survey sample weights and inter strata variation.

Data and Results

Data

Since 1999, the NHANES data have been collected annually through the Centers for Disease Control and Prevention via the National Center for Health Statistics. Each year 5,000 civilian, noninstitutionalized persons in the U.S receive a thorough medical examination, provide a 24-hour dietary recall, and answer questions related to health behaviors, such as dieting, physical activity, alcohol consumption and cigarette smoking. This survey is designed to be nationally representative and over-samples African Americans, Mexican Americans and individuals with low-income (United States Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2005). Using the Pyramid servings database, this survey can also be used to calculate the number of servings for each pyramid food group consumed over the 24-hour period (United States Department of Agriculture, 2006). For this study, we limit our analysis to adults, aged twenty and older[1]. We exclude pregnant and

[1] Our analysis focuses on adults because most children do not have complete control over their food intake or level of physical activity.

lactating women since their dietary needs differ from the rest of the population. In total, our sample includes observations on 7,319 individuals.

For this study, we question if and how individuals alter behaviors with the knowledge that they have diabetes and take medication to control the disease. As such, we look at how well individuals conform to dietary recommendations set forth by the American Diabetes Association and defined in the Diabetes Food Pyramid (DFP) and their chosen level of physical activity. In general, diabetics are instructed to choose a diet that is rich in vegetables, fruits, whole grains, beans, lean meats and fiber while limiting consumption of fats and sugars. We therefore created several dependent variables (Table 1). For five of the six food groups[2] defined in the DFP—grains and starches; vegetables; fruit; milk; meat and meat substitutes—the dependent variable for each individual is the number of servings consumed during his or her 24-hour dietary recall divided by the number of servings recommended for their caloric intake[3]. For fat, the dependent variable is the percent of daily calories derived from fat. For fiber and sugar the dependent variable is the total grams or teaspoons divided by the number of calories consumed that day. For physical activity, we create a score using both the amount and intensity of time an individual spent being physically active in leisure time.

The explanatory variables used in our econometric estimation are also described in Table 1. To gauge income effects, we include a household's poverty income ratio. We also control for an

[2] The Diabetes Food Pyramid (DFP) provides no specific quantity recommendation for the sixth group, fats, sweets and alcohol. It is simply advised that these foods be saved for special occasions.

[3] The DFP is not completely congruent with either the previous Food Guide Pyramid (FGP) or more recent MyPyramid. Specifically, starches in the DFP include the categories grains, potatoes, starchy vegetables and legumes as counted in the FGP; The DFP vegetables only include dark green vegetables, deep yellow vegetables and tomatoes; and under the FGP, cheeses are counted as a serving of meat instead of a serving of dairy.

individual’s level of education (less than high school, high school alone or more than high school) because this variable is highly predictive of income and health knowledge. We include a dummy variable to indicate whether or not an individual lives in a household that is owned or rented. Similar to other national surveys on dietary intake, there is no information on the food prices or expenditures. Typically, researchers have circumvented this problem by including geographic indicators, such as state, region or whether an individual lives in an urban or rural setting (Variyam, Blaylock, and Smallwood, 1996). Due to confidentiality concerns, this information is not released to the public. Also missing is information on household size, and whether or not an individual has children living in the household. Currently, we can only assess whether an individual is married/living with an adult partner or single.

From the literature, we know that some characteristics correlate with shifts in food demand. For example, two individuals’ energy requirements may differ because of age, gender and size. Rather than BMI, we use an individual’s measured waist circumference relative to the gender specific overweight classification (88cm for women, 102 cm for men). Cultural norms and level of acculturation also have an influence on our diet (Aldrich and Variyam, 2000). We attempt to capture these through an individual’s reported ethnicity and whether a language other than English is considered to be one’s primary language.

We define an individual as having diabetes if, in the questionnaire regarding medical conditions, he or she indicates that he has been diagnosed with the disease. We also include a dummy variable to indicate if an individual currently takes either insulin or blood sugar pills for this condition. As mentioned earlier, this variable is endogenous. Possible instruments could include whether any blood relatives had been diagnosed with any related health problems. A blood relative's health is most arguably an exogenous variable; we have very little control over whether or not a grandparent had a heart condition. It may also be highly correlated with our own health and level of health information; our family's health history is a strong predictor of our own health and watching a family member struggle with ill health may provide motivation to adopt healthier practices.

Prices of medication could also serve as additional instruments (Park and Davis, 2001). Due to data limitations, however, we simply use whether or not an individual currently has health insurance as proxies for prices. Additionally, having health insurance should also increase the probability that an individual is aware of his or her health condition. Finally, we use whether or not an individual was diagnosed with diabetes as an adolescent or younger (age 18 or below). This is meant to be a proxy, albeit imperfect, for whether or not an individual has Type I or Type II diabetes. Individuals with Type I (also called juvenile diabetes) almost always need to take insulin while individuals with Type II (or adult on-set diabetes) can often manage their symptoms through lifestyle changes alone.

Results

Results of the treatment effects estimations are presented in Tables 2. Looking across the intake and other behavior equations, the sign pattern on the variable labeled "diabetic" suggests that people do respond to being told they are diabetic. For those told they are diabetic, signs are negative for intake of all foods and nutrients: starches, milk, meat, fat, sugar, vegetables, fruit, and fiber. Similarly, signs on the diabetes variable on use of cigarettes and alcohol are also negative. However, for many of the behaviors, we find there is no significant correlation between being diagnosed with diabetes and healthful behaviors. The only statistically significant differences are that diabetics are estimated to eat less added sugar and to eat fewer servings of dairy products. Not surprisingly, the diabetes variable in the physical activity and waist size equations are also statistically insignificant. At most, the diabetes variables hint at the possibility of some limited behavioral changes in response to being informed about diabetes status. Even when armed with the knowledge of both how and why to adopt a healthier lifestyle, many individuals choose not to make significant changes.

The more compelling results are those related to medication. We do find a statistically significant relationship between diabetes medication and an individual's behavior. We find that diabetics on medication consume more added sugar, more total fat, more starchy foods, more dairy products, and more meat. While the coefficient of medication on fiber intake is positive, it is clear that the additional fiber intake is not coming from sources health professionals recommend; coefficients of medication on vegetable and fruit intake are negative, albeit insignificant. The waist size equation corroborates the intake equations: in the waist size equation, the medication coefficient is positive and statistically significant.

The estimated coefficients suggest far bigger behavioral changes than what is usually described as offsetting behavior. Peltzman (2004) concluded that the 1970s mandated safety equipment for automobiles encouraged more risky driving. The additional deaths of pedestrians, bicyclists, and motorcyclists completely offset the safety benefits to automobile occupants. In our study, for intake of starches, milk, meat, fat, and sugar, estimated coefficients on medication variables appear to be an order of magnitude larger than diabetic variables. That is, medication is consistent with a considerable loss of restraint in making dietary choices.

Conclusion

The policy question raised by this analysis depends on whether diabetics' perceived health production functions are correct. One possibility is that diabetics have generally overassessed the productivity of medicine, guessing that medicine adds so much to their health stock that they are healthier than non-diabetics. As long as they do not recognize the mistake, their utility maximizing choices could be to diets and lifestyles that are even worse (for health) than the diets and lifestyles they chose before discovering their compromised health condition. In that case, the public health community could consider focusing attention on accurately portraying the health benefits of medication.

Of course, the continued development of new and superior medications could alter the situation. Overassessments could decline if diabetics adopted better drugs without revising their perceived health production functions. However, the more likely scenario is that better drugs would be perceived as better, leading to upward revisions in perceived health production functions. Thus, the magnitude of overconfidence might not be reduced; the more-than-offsetting behavior could continue, albeit with ambiguous health implications.

Table 1: Summary Statistics

Category	Variable Name	Definition and units	Mean	Std. Err.
Dependent Variables	Fiber	Grams of fiber	0.008	0.000
	Sugar	Teaspoons of added sugar	0.009	0.000
	Total Fat	Percent of calories from fat	0.331	0.003
	Starch	startch servings	0.966	0.010
	Vegetables	Vegetable servings	0.300	0.009
	Fruit	Fruit servings	0.585	0.024
	Milk	Dairly servings	0.394	0.012
	Meat	Meat servings	1.206	0.014
	Cigarettes	Average cigarette intake	3.124	0.228
	Alcohol	Average alcoholic beverages when drinking	1.979	0.064
	Waist	Ratio of waist circumference (in centimeters) to gender specific overweight classification (88cm for women, 102 cm for men)	0.992	0.004
	Physical Activity	Physical activity coefficient-Ranges form 1 if sedentary to 1.45(1.48 for men) if very active	1.323	0.010
Explanatory Variables for behaviors	PIR	Poverty Index Ratio	3.325	0.069
	Homeowner	1 if living in household owned home; zero otherwise	0.719	0.016
	Less than high school	1 if individual did not complete high school; zero otherwise	0.129	0.009
	More than high school	1 if individual went to school beyond high school; zero otherwise	0.633	0.017
	Single	1 if unmarried; zero otherwise	0.319	0.015
	Age	Age in years	43.960	0.453
	Female	1 if female; zero otherwise	0.473	0.007
	Black, Non-Hispanic	1 if black, non-Hispanic; 0 otherwise	0.075	0.009
	Hispanic	1 if Hispanic; 0 otherwise	0.112	0.018
	Other Ethnicity	1 if other ethnicity; 0 otherwise	0.035	0.006
	Spanish	1 if Spanish is the primary language spoken at home; zero otherwise	0.044	0.009
	Other language	1 if neither English or Spanish are the primary languages spoken at home; zero otherwise	0.035	0.005
	Diabetic	1 if diabetic; zero otherwise	0.048	0.003
Treatment Variable	Medication	1 if taking insulin or blood sugar pills; zero otherwise	0.038	0.003
Explanatory variables for treatment	Insurance	1 if individual has health insurance; zero otherwise	0.854	0.010
	Relative with diabetes	1 if relative with diabetes; zero otherwise	0.495	0.011
	Proxy for type 1	1 if individual was diagnosed with diabetes before 19 yrs; zero otherwise	0.004	0.0008

Table 2: Estimation Results

	Starches			Milk			Meat			Fat			Sugar			Waist Circumference		
Variable	Parameter Estimate	T Statistic		Parameter Estimate	T Statistic		Parameter Estimate	T Statistic		Parameter Estimate	Z Statistic		Parameter Estimate	Z Statistic		Parameter Estimate	Z Statistic	
Diabetic	-0.230	-0.42		-0.244	-2.37	**	-0.350	-0.49		-2.420	-0.44		-3.741	-2.05	**	0.047	1.85	*
Medication	6.413	9.86	**	2.409	16.82	**	7.673	10.82	**	70.942	10.53	**	29.487	15.42	**	0.275	10.27	**
PIR	0.024	0.56		-0.005	-0.29		8.812	15.24	**	0.658	1.67	*	-1.025	-5.7	**	-0.011	-5.33	**
Homeowner	0.064	0.41		-0.077	-1.79	*	-0.022	-0.15		1.185	0.83		0.667	0.69		0.004	0.74	
Less than high school	-0.322	-1.66	*	-0.004	-0.08		-0.107	-0.95		-5.220	-3.98	**	0.255	0.29		-0.001	-0.18	
More than high school	0.033	0.25		0.073	1.38		-0.168	-1.63		-2.719	-1.72	*	-1.337	-1.78	*	-0.011	-1.65	*
Single	0.051	0.31		0.026	0.72		0.013	0.08		2.748	1.63		0.022	0.03		-0.002	-0.32	
Age	-0.039	-2.12	**	-0.001	-0.23		0.053	2.69	**	0.644	3.36	**	-0.436	-4.75	**	0.010	11.72	**
Age2	0.000	-0.15		0.000	0.49		-0.001	-4.79	**	-0.011	-6	**	0.001	1.53		0.000	-9.82	**
Female	-2.267	-20.93	**	-0.150	-4.16	**	-2.480	-22.51	**	-26.453	-22.59	**	-5.678	-10.31	**	0.072	18.51	**
Black, Non-Hispanic	-1.028	-5.12	**	-0.468	-10.45	**	0.426	2.46	**	-7.245	-3.25	**	0.655	0.75		0.000	0.05	
Hispanic	0.106	0.52		-0.121	-1.93	*	-0.343	-1.51		-5.615	-2.57	**	-2.140	-2.72	**	-0.006	-0.75	
Other Ethnicity	-0.584	-1.73	*	-0.473	-4.76	**	-0.309	-0.8		-20.009	-6.88	**	-1.233	-0.56		-0.024	-0.98	
Spanish	0.237	1.11		-0.068	-0.95		0.022	0.07		-6.580	-2.38	**	-4.099	-4.13	**	-0.028	-3.07	**
Other language	0.384	1.11		0.042	0.5		0.026	0.08		-7.771	-1.72	*	-7.562	-4.83	**	-0.073	-5.03	**
Constant	12.952	19.71	**	1.158	7.62	**	1.584	0.14		117.278	19.66	**	50.088	0.00	**	0.666	30.49	**

	Vegetables			Fruits			Fiber			Average Cigarettes			Physcial Activity			Average Alchohol		
Variable	Parameter Estimate	T Statistic		Parameter Estimate	T Statistic		Parameter Estimate	Z Statistic		Parameter Estimate	Z Statistic		Parameter Estimate	Z Statistic		Parameter Estimate	Z Statistic	
Diabetic	-0.005	-0.05		-0.049	-0.2		-0.146	-0.14		-1.150	-1.21		0.100	1.36		-0.374	-1.39	
Medication	-0.048	-0.22		-0.099	-0.42		2.373	0.26		-0.028	-0.03		0.006	1.5		-0.556	-1.72	*
PIR	0.035	2.32	**	0.113	4.35	**	0.400	4.07	**	-0.629	-5.22	**	0.006	1.5		0.034	0.77	
Homeowner	-0.075	-1.83	*	-0.202	-2.4	**	-0.487	-1.67	*	-1.530	-4.09	**	0.028	1.39		-0.345	-3.37	**
Less than high school	-0.073	-2.00	**	-0.326	-4.58	**	-1.036	-2.91	**	1.078	2.73	**	-0.029	-1.39		0.286	2.52	**
More than high school	0.206	5.05	**	0.283	4.3	**	1.529	5.30	**	-2.782	-7.38	**	-0.020	-1.31		-0.411	-4.21	**
Single	0.026	0.56		-0.001	-0.02		0.058	0.21		1.105	3.74	**	0.051	2.52	**	0.453	4.24	**
Age	0.015	2.76	**	0.004	0.37		0.140	4.25	**	0.382	8.93	**	-0.008	-1.7	*	-0.053	-3.91	**
Age2	0.000	-2.69	**	0.000	1.79	*	-0.001	-3.69	**	-0.004	-10.90	**	0.000	1.45		0.000	1.00	
Female	-0.106	-3.48	**	-0.166	-3.42	**	-3.939	-14.74	**	-1.163	-4.90	**	-0.086	-7.91	**	-1.220	-14.21	**
Black, Non-Hispanic	-0.168	-3.69	**	0.237	2.6	**	-2.673	-7.43	**	-3.159	-9.23	**	0.008	0.44		-0.738	-4.76	**
Hispanic	-0.075	-1.27		0.259	2.64	**	0.974	2.63	**	-3.358	-5.26	**	0.004	0.12		0.153	0.90	
Other Ethnicity	-0.241	-1.79	*	-0.107	-0.54		-2.734	-3.54	**	-1.528	-3.81	**	-0.034	-1.05		-0.190	-0.61	
Spanish	0.038	0.59		0.536	4.55	**	3.049	8.18	**	-2.846	-4.19	**	-0.044	-1.12		-0.027	-0.12	
Other language	0.344	2.23	**	1.271	4.93	**	2.431	3.83	**	-2.033	-3.70	**	0.006	0.2		-0.645	-2.52	**
Constant	0.811	5.42	**	0.789	2.76	**	16.827	16.00	**	3.351	3.330	**	1.615	14.62	**	6.178	11.41	**

*Parameter estimated to be significant at the 10% level.
**Parameter estimated to be significant at the 5% level

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