Journal of Choice Modelling, 2(1), pp. 51-64
www.jocm.org.uk

Offsetting Behavior in Reducing High Cholesterol: Substitution of Medication for Diet and Lifestyle Changes

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Received 14 September 2007, revised version received 15 November 2008, accepted 13 February 2009

Abstract

Being diagnosed with a diet-related health condition like high blood cholesterol might compel an individual to choose a healthier diet, thereby reducing disease risks. Adding the option of medication, like statins, makes the direction of diet-quality choices theoretically ambiguous. This study estimates how dietary quality correlates with high cholesterol diagnoses and medicine use. Results indicate that individuals diagnosed with high cholesterol consume less cholesterol, fat, and saturated fat, and smoke less. However, using cholesterol-lowering drugs is correlated with increased fat and saturated fat intake, and larger waist size, after accounting for the endogeneity of choosing to use medicine. Findings highlight the inelasticity of diet choices.

Keywords: offsetting behaviour, cholesterol, diet, medication

1 Introduction

Worldwide, nearly 1.6 billion adults were overweight and over 400 million were obese in 2005. By 2015, it is projected that these numbers will rise to 2.3 billion overweight and 700 million obese (World Health Organization, 2006). Such trends are troubling, as scientific evidence indicates obesity is associated with 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, Public Health Service, Office of the Surgeon General, 2001). This widespread prevalence of obesity and diet-related illnesses begs the question why so many people are putting themselves at risk of serious illnesses.

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ISSN 1755-5345

The problem posed by many behaviours that jeopardize health is that such behaviour is itself often enjoyable. While the risks of smoking are well-known, the satisfaction from nicotine makes it hard for many to break the habit. And though a diet low in salt, cholesterol and saturated fat may promote cardiovascular fitness, many choose taste and convenience over long-term health. The enjoyment of such risky behaviours conceivably could have a major impact on the realized benefits from medical advances, safety enhancements to consumer goods or government-mandated safety regulations because individuals could respond by making riskier choices (offsetting behaviour), thus attenuating the direct health benefits of these improvements.

The question addressed in this study is whether or not technological change induces risky choices for chronic health conditions that are manageable with diet and lifestyle choices. We estimate the extent to which people diagnosed with high cholesterol manage the potential health risks by changing their diet and how much they compromise diet quality when they also use cholesterol-lowering statin drugs.

Thus for this study, we develop a theoretical model to show 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. For empirical support of our hypotheses, we use data from the National Health and Nutrition Examination Survey (NHANES) 1999-2000, 2001-2002, and 2003-2004, which contain detailed information on dietary intake, medical conditions and whether an individual takes medication for such conditions. These data are used to estimate how differences in dietary quality correlate with whether or not an individual has been diagnosed with high cholesterol, and whether or not an individual uses medication to manage his or her health condition.

2 Background

Peltzman (1975) initiated empirical work on offsetting behaviour, demonstrating that U.S. government-mandated automobile safety equipment had little impact on highway safety. Mandated safety equipment probably made cars safer for drivers and passengers, but simultaneously reduced the cost of reckless speed. Drivers responded by raising their "driving intensity," leading to more accidents. A vast literature estimating the magnitude of offsetting behaviour and deaths and injuries followed Peltzman's findings. (See Hause (2006), for findings related to traffic, workplace, and consumer product accidents).

Conceivably, improvements in drug treatments could induce a "lulling effect," (Viscusi, 1984). Kahn (1999) investigated a problem similar to ours—the diet and lifestyle choices diabetics made over a period in which drugs that help control blood sugar dramatically improved. His concern was that improved drugs could have made diabetics falsely think the drugs solved their health problems, reducing adherence to the diet regimes recommended to manage diabetes. The undesirable result would be additional complications of diabetes—heart disease, stroke, amputations, blindness, and renal failure. His empirical results showed no significant evidence of offsetting behaviour, but included the use of medication as an exogenous, explanatory variable.

For modelling risky choices like driving intensity, this is a reasonable assumption, as safety equipment mandated by government regulation is arguably exogenous. And while using medication to treat diet-related illnesses can be viewed as a kind of safety equipment, pharmaceutical use is often a choice influenced by many of the same factors that influence diet quality. As such, treating pharmaceutical use as

an exogenous variable will bias its estimated effect. If an overall concern for health is positively correlated with the probability of taking medication to improve health, then any estimator that does not account for the simultaneous nature of these choices will upwardly bias the estimated effect of taking medication. The other parameter estimates will be biased as well.

For this study, we focus on high blood cholesterol, which is a major risk factor for heart disease (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2007). Coronary heart disease is the leading cause of morbidity and mortality in the United States, estimated to cause 481,000 deaths each year and require 11.8 million hospital days of care per year. It is the leading cause of disability adjusted life years and is second only to injuries as a cause of life-years lost (Gross et al., 1999).

However, high blood cholesterol is a modifiable risk factor. Dietary changes, increased physical activity, weight control, drug therapy, or a combination of these have been shown to lower cholesterol levels (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2007). Lowering cholesterol and other fats in the blood may help prevent medical problems caused by cholesterol clogging the blood vessels (Miller and Stagnitti, 2005) and substantially reduce health risks: a 10 percent decrease in total blood cholesterol can reduce the incidence of heart disease by as much as 30 percent (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2007).

In recent years, individuals have demonstrated a growing interest in drug therapy as a means of lowering blood cholesterol. While there have been cholesterol-reducing drug therapies available for many years, the statin drugs are more effective at reducing cholesterol[1] than older drugs (Pignone et al., 2001). Ranked by expenditures, the top two drugs in 2003 were cholesterol-reducing agents: Lipitor® (Atorvastatin calcium) and Zocor® (Simvastatin) (U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality, 2006).

3 Theoretical and Empirical Model

One response to a diagnosis of high blood cholesterol could be to strictly follow doctor's orders. However, desires for good health may compete against desires for familiar diets and lifestyle. These diet and lifestyle choices may be conditioned by a lifetime of habit as well as by family and community traditions. Thus, medication may be a substitute for diet and lifestyle changes as a means to reduce health risks because it lowers the health cost (increased probability of an adverse outcome) of failing to make diet and lifestyle changes. In this case, some offsetting behaviour is almost certain; the important question for forecasting a health outcome is how much offsetting behaviour 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.

[1] There are several patterns of blood lipids that are important risk factors for coronary heart disease. These include elevated total cholesterol (usually with a threshold of 240mg/dl), elevated low-density lipoprotein cholesterol (LDL), and low levels of high-density lipoprotein cholesterol (HDL) (Pignone et al., 2001). For ease of exposition, we refer to this class of health conditions as high cholesterol and drug therapy as cholesterol-reducing.

For a more precise understanding of how consumers will respond to a diagnosis of high blood cholesterol, we employ a straightforward utility maximization problem. We assume individuals gain utility from risky behaviours (R), their own health (H) and all other goods (C). We define H as a perceived health production function and assume that individuals manage health through behaviours and medication (M). For simplicity, risky behaviours over which utility is defined are selecting a nutritionally poor diet and having a sedentary lifestyle. Offsetting behaviour flows directly from utility maximizing behaviour. As long as good health enters the utility function, the health-compromising (undesirable) attributes of risky behaviours also influence the utility maximization. Also, how highly an individual assesses his 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 had high blood cholesterol would assess his 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

$$\begin{aligned} &\max \quad U(R, H(R, M; \eta), C) \\ &s.t. \quad P_R R + P_M M + C = I \end{aligned} \tag{1}$$

where I is income, P_R and P_M are the prices for risky behaviours and medication, and for simplicity, the price of all other goods, C, is defined as the numeraire. First order conditions imply the following equality:

$$\frac{U_R + U_H H_R}{U_H H_M} = \frac{P_R}{P_M}. \tag{2}$$

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

Rewriting equation (2) as

$$F \equiv U_H H_M - \frac{P_M}{P_R}(U_R + U_H H_R) = 0 \tag{3}$$

and invoking the implicit function rule yields a relation between risky behaviour and perceived health status.

$$\frac{\partial R}{\partial \eta} = -\frac{F_\eta}{F_R} = -\frac{U_H H_{M\eta} + H_M U_{HH} H_\eta - \frac{P_M}{P_R}(U_{RH} H_\eta + U_H H_{R\eta} + H_R U_{HH} H_\eta)}{U_H H_{MR} + H_M U_{HR} - \frac{P_M}{P_R}(U_{RR} + 2U_{RH} H_R + U_H H_{RR} + U_{HH}(H_R)^2)} \tag{4}$$

Our goal is to sign the derivative $\frac{\partial R}{\partial \eta}$ — the change in risky behaviour given bad health news — for a typical individual, not all mathematically possible utility and production functions. We make conventional assumptions that

$$\begin{aligned} &U_i > 0 \text{ and} \\ &U_{ii}, H_{ii} < 0 \text{ for } i = R, H, C. \end{aligned} \tag{5}$$

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

$$\begin{aligned} &H_j > 0 \text{ for } j = M \text{ and} \\ &H_j < 0 \text{ for } j = R, \eta. \end{aligned} \tag{6}$$

Conventional utility and production function assumptions, however, are not sufficient to sign the derivative. In addition, we assume that $U_{RH} = U_{HR} \geq 0$. That is, bad behaviour can be more rewarding when in better health. The equality also allows for the possibility that the rewards from bad behaviour are independent of health status. We assume $H_{M\eta} \geq 0$, $H_{R\eta} \leq 0$, $H_{MR} = H_{RM} = 0$. Medicine becomes more important to health when health news is bad (or does not change), risky behaviours compromise health more (or equally) when health news is bad, and the efficacy of medicine is independent of poor diet and lifestyle choices. For example, we assume that a statin drug's marginal impact on health is unaffected by one's level of physical activity. Under these conditions, $\frac{\partial R}{\partial \eta}$ is negative, indicating that the net effect of bad health news is to reduce risky behaviours that compromise health. Individuals will adjust to bad health news by making healthier diet and lifestyle choices.

To determine the impact of medication on risky behaviours, we use the following relation between pharmaceutical use and risky behaviour:

$$\frac{\partial R}{\partial M} = -\frac{F_M}{F_R} = -\frac{U_H H_{MM} + U_{HH}(H_M)^2 - \frac{P_M}{P_R}(U_{RH} H_M + U_H H_{RM} + H_R U_{HH} H_M)}{U_H H_{MR} + H_M U_{HR} - \frac{P_M}{P_R}(U_{RR} + 2U_{RH} H_R + U_H H_{RR} + U_{HH}(H_R)^2)}. \tag{7}$$

Under the same conditions imposed on partial derivatives and cross partials, $\frac{\partial R}{\partial M}$ is positive. In effect, medicine makes it easier to return to risky behaviours that compromise health. The impact of making health benefits possible from pharmaceuticals means that many will forego some, if not all, of the possible health benefits. Some individuals will find they improve their overall well-being by taking medication while also choosing diets and lifestyles that are less healthy than they would choose if they had to rely on diet and lifestyle alone to manage a diet-related disease.

This analysis of partial and cross partial derivatives yields three hypotheses that can be tested empirically:

- There is a negative relationship between being made aware of a health condition, such as high blood cholesterol, and specific behaviours, such as choosing to eat an unhealthy diet;
- There is a positive relationship between taking medication for a health condition and these same risky behaviours; and
- The effect of medication on increasing risky behaviours may offset the reductive effect of better health awareness.

Empirically, our model suggests that an individual's chosen level of risky behaviours (R_i) can be modelled as a function of income, prices, and health status (H_i), which is determined by behaviours, awareness of a health condition (η_i), and use of prescribed medication (M_i). This specification illuminates the simultaneous nature of behavioural choices, medication and health status. The empirical model can be written as:

$$R_i = \beta' X_i + \delta\eta_i + e_i \tag{8}$$

where X_i is a vector of exogenous explanatory variables that relate to individual behavioural choices, η_i indicates whether or not an individual is aware of a specific health condition, and e_i is a random disturbance term. Among individuals who have been diagnosed with a health-condition, their behavioural choices can be modelled as follows

$$R_{i,D} = \beta' X_i + \delta\eta_i + \phi M_i + e_i \tag{9a}$$

$$M_i = \xi Z_i + \varepsilon_i \tag{9b}$$

where 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 health condition through medication, and ε_i is a random disturbance term.

An estimation approach that does not explicitly address that individuals with a health condition can use both medication and behavioural modification to manage health will produce biased estimates of the relationship between explanatory variables and observed behaviours. Thus, among individuals diagnosed with high cholesterol, we estimate each behavioural choice equation simultaneously with a treatment effect. 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 how the choice to take medication correlates with differences in diet and activity choices recommended to control levels of cholesterol. Following the estimation strategy of Lakdawalla et al. (2006), to allow for correlation between use of medication and risky

behaviours, we assume that the errors e_i and ε_i are correlated and jointly distributed as bivariate normal. We use maximum likelihood to estimate this joint model. To obtain robust variance estimates, we use the "treatreg" command in STATA 9.0, controlling for survey sample weights and inter-strata variation.

4 Data

This study uses recent data sets from the National Health and Nutrition Examination Survey 1999-2000, 2001-2002, and 2003-2004 (for simplicity NHANES 1999-2004). The NHANES data have been collected annually through the Centers for Disease Control and Prevention via the National Center for Health Statistics since 1999. Each year approximately 5,000 civilian, non-institutionalised persons in the United States receive a thorough medical examination, provide a 24-hour dietary recall, and answer questions related to health behaviours, 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, 2006). We limit our analysis to adults, aged twenty and older. Individuals under the age of 20 were not asked if they were diagnosed with high cholesterol. We also exclude pregnant and lactating women from our analysis since their dietary needs differ significantly from the rest of the population. In total, our sample includes observations on 11,446 individuals.

In general, individuals with high cholesterol are instructed to choose a diet that is low in cholesterol, fat, and saturated fat. They are told to quit smoking and maintain a healthy bodyweight. We therefore created several dependent variables based on these recommendations (Table 1). For cholesterol, fat, and saturated fat, the dependent variable is total daily consumption of each nutrient per day divided by that individual's total daily energy intake (calculated from 24-hour dietary recall reports).

For cigarettes, the dependent variable is constructed as the number of cigarettes consumed on average. As a measure of excess bodyweight, we use an individual's measured waist circumference relative to the gender specific overweight classification—88 centimetres for women and 102 centimetres for men (U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2004). We chose this measure over body mass index (BMI), or weight adjusted for height, because BMI measures do not distinguish between muscle and total fat.

The explanatory variables used in our econometric estimation are also described in Table 1. We present the analysis of income differences in terms of a households' income-to-poverty ratio (PIR)—the ratio of a household's income relative to the poverty threshold, given the size of a family. We also control for an individual's level of education (education up to and including high school or more than high school) because this variable is highly predictive of income and health knowledge.[2]

[2] Similar to other national surveys on dietary intake, NHANES does not collect information on food prices respondents pay or their food expenditures.

Table 1: Summary Statistics

Variable Name	Definition and units	Mean	Std. Err.
	Dependent variables		
Cholesterol	Cholesterol consumption adjusted for caloric intake: 100 × daily cholesterol intake (mg)/daily caloric intake	12.93	0.19
Total fat	Total fat share of calories: 100 × 9 × daily fat intake (g)/daily caloric intake	33.50	0.21
Saturated fat	Saturated fat share of calories: 100 × 9 × daily saturated fat intake (g)/daily caloric intake	10.92	0.10
Cigarettes	Average daily cigarette intake	3.07	0.20
Waist	Ratio of waist circumference (cm) to gender- specific overweight classification (88 cm for women, 102 cm for men)	1.00	0.00
	Explanatory variables for risky behaviors		
PIR	Poverty Index Ratio: Household income/poverty line for household size	3.29	0.06
More than high school	1 if individual went to school beyond high school; zero otherwise	0.64	0.01
Age	Age in years	44.41	0.41
Female	1 if female; zero otherwise	0.48	0.01
Black, Non-Hispanic	1 if black, non-Hispanic; 0 otherwise	0.09	0.01
Hispanic	1 if Hispanic; 0 otherwise	0.10	0.01
Other Ethnicity	1 if other ethnicity; 0 otherwise	0.04	0.01
Spanish	1 if Spanish is the primary language spoken at home; zero otherwise	0.04	0.01
Other language	1 if neither English nor Spanish are the primary languages spoken at home; zero otherwise	0.04	0.01
Other health condition	1 if individual has ever been diagnosed with diabetes, heart failure, coronary heart disease, heart attack, or stroke; zero otherwise	0.11	0.01
Diagnosed with high cholesterol	1 if individual has been diagnosed with high cholesterol; zero otherwise	0.26	0.01
Undiagnosed, but cholesterol high	1 if individual has not been diagnosed with high cholesterol, but LDL measures 160 mg/DL or above; zero otherwise	0.20	0.01
	Treatment variable		
Medication	1 if taking cholesterol-lowering medication; zero otherwise	0.10	0.01
	Instrumental variables for medication		
Insurance	1 if individual has health insurance; zero otherwise	0.84	0.01
Relative with hypertension	1 if relative has hypertension; zero otherwise	0.17	0.01
Relative with angina	1 if relative has angina; zero otherwise	0.35	0.01

We account for systematic differences in food demand. For example, two individuals' energy requirements may differ because of age and gender. Cultural norms and level of acculturation also have an influence on diet characteristics (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 the respondent's primary language.

Our theoretical model predicts that being aware of a health condition will influence risk-taking behaviour. We define an individual as being diagnosed with high cholesterol if, in the questionnaire regarding medical conditions, the respondent indicates that he or she has been diagnosed with the condition. We include a dummy variable to indicate if that individual has any other health conditions, such as diabetes, coronary heart disease, and angina or if that person had a past heart attack or stroke, as that could cause him to change risky behaviours. We include a variable for individuals who indicate that they have not been diagnosed with high cholesterol but who have cholesterol levels that put them at risk: levels of low density lipid (LDL) cholesterol--in excess of 160 mg/dL (American Heart Association, 2006).[3]

To identify whether or not taking medication is correlated with offsetting behaviour, we control for the endogeneity of this choice by first using instrumental variables to estimate the choice to take medication. One instrument available in this data set is whether or not any blood relatives have been diagnosed with related health conditions. A blood relative's health is arguably exogenous. We have very little control over whether a grandparent has a particular health condition. However, such conditions may 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. Thus, as instruments, we use whether a respondent had any blood relatives who had been diagnosed with either angina or hypertension. Prices of medication could also serve as additional instruments (Park and Davis, 2001). As a proxy for prices, we use whether an individual currently has health insurance.

5 Results

For each dietary choice and behaviour, we present the results of both the OLS and treatment effects estimations for the entire NHANES sample (Table 2). These results can be interpreted to answer whether being diagnosed with high cholesterol compels an individual to reduce risky behaviours. We are also able to test whether the subset that have been diagnosed with high blood cholesterol behave differently from those who have high blood cholesterol but have not been so diagnosed. This comparison is indicative of a behavioural change; past diet dietary choices of those diagnosed with high cholesterol are likely to be more similar to those with undiagnosed high cholesterol than to those who have healthy blood cholesterol levels.

[3] The American Heart Association' website states that LDL cholesterol level greatly affects risk of heart attack and stroke, and is a better gauge of risk than total blood cholesterol.

Table 2: OLS Estimation Results--Effect of risk awareness on risk behaviours

	Cholesterol		Total Fat		Saturated Fat		Cigarettes		Waist	
Explanatory variables	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)
Constant	8.37	(8.26)	26.98	(27.63)	10.34	(22.39)	4.92	(5.75)	68.14	(36.08)
PIR	0.03	(0.30)	0.11	(1.15)	0.00	(-0.07)	-0.76	(-10.05)	-0.8	(-5.63)
More than high school	-0.38	(-0.19)	-0.07	(-0.21)	-0.20	(-1.79)	-2.5	(-10.63)	-0.52	(-1.19)
Age	0.19	(4.13)	0.25	(5.51)	0.04	(2.33)	0.29	(8.22)	0.73	(8.75)
Age^2	0.00	(-3.00)	0.00	(-5.44)	0.00	(-2.82)	0.00	(-10.07)	-0.01	(-8.11)
Female	-0.54	(-2.25)	0.48	(2.14)	0.08	(0.69)	-1.19	(-5.33)	8.33	(16.41)
Black, Non-Hispanic	1.93	(5.33)	-0.63	(-1.75)	-0.90	(-5.94)	-2.49	(-8.23)	1.82	(3.57)
Hispanic	1.49	(2.64)	-0.61	(-1.49)	-0.39	(-1.69)	-2.94	(-6.87)	-0.28	(-0.47)
Other Ethnicity	-0.73	(-0.85)	-2.82	(-2.31)	-1.55	(-3.60)	-2.05	(-3.61)	-3.69	(-2.39)
Spanish	0.51	(0.85)	-3.30	(-5.29)	-1.49	(-5.60)	-2.94	(-7.32)	-3.02	(-3.21)
Other language	0.32	(0.42)	-4.68	(-5.45)	-1.58	(-4.48)	-0.87	(-1.64)	-5.6	(-4.31)
Other health condition	1.47	(3.61)	0.5	(1.22)	0.14	(1.17)	1.24	(3.44)	6.08	(7.27)
Undiagnosed, but cholesterol high	0.44	(1.72)†	0.43	(1.52)†	0.42	(3.87)†	1.42	(4.24)†	6.96	(13.35)
Diagnosed with high cholesterol	-0.33	(-1.03)	-0.19	(-0.60)	0.01	(0.11)	-0.12	(-0.44)	7.49	(10.16)
Model Fit										
R^2	0.02		0.04		0.03		0.09		0.19	
N	10865		10865		10865		10820		10542	

† Can reject the hypothesis that the coefficients for diagnosed and undiagnosed are equal using 5% level of significance

Tests for differences among coefficients ($\alpha = 0.05$) shows that compared to those who have high cholesterol but have not been diagnosed, those who have been diagnosed report a lesser degree of some risky dietary and lifestyle choices. On average, an individual who consumed 2200 calories a day, ate approximately 18 fewer milligrams of cholesterol and about one less gram of saturated fat per day. The diagnosed also smoke significantly fewer cigarettes than those who have high levels of cholesterol that have not been diagnosed. These findings suggest that high blood cholesterol diagnoses do induce behavioural changes the public health community recommends. Findings also indicate no difference in waist size between the diagnosed and undiagnosed. Thus, there is no evidence that waist size is leading physicians to test for high cholesterol.

The main hypothesis we want to test is that taking medication to manage health may cause an individual to increase risky behaviour and may even offset the effect of increased awareness about the ill-health effects of risky diet and lifestyle choices (Table 3). While intake of cholesterol and cigarette consumption do not increase, our results indicate that when people diagnosed with high blood cholesterol choose medication they also consume higher amounts of total fats and saturated fat. Again assuming 2200 calories per day, an individual who is diagnosed with high cholesterol and takes medication for this condition is estimated to eat roughly about 18 more grams of total fat and 12 more grams of saturated fat, respectively.[4] Their waist sizes are also significantly higher. Among those taking cholesterol reducing medication, waist circumferences are estimated to be roughly 16 and 12 centimetres larger for men and women. Thus, these estimates far outweigh the reductions associated with being diagnosed with high cholesterol and provide evidence of offsetting behaviour. Even when armed with the knowledge of both how and why to adopt a healthier lifestyle, many individuals choose not to make significant changes.

First stage results show support for our hypothesis that choosing to use medication is significantly and positively correlated with having a relative with hypertension. Use of medication is significantly and negatively associated with education, being a female, and having any other health condition (Table 3).

6 Discussion

The worldwide increasing prevalence of overweight and obesity, along with diet-related illnesses, suggests there must be something that compensates for accepting such risks. Such dietary problems are becoming increasingly more common throughout developed countries. Given these strong preferences, the task in store for the public health community—changing individuals' 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 healthy diet, those who have been told they have high levels of serum cholesterol, and show that they resist change.

[4] There are many ways these extra nutrients can be derived from additional foods. Only a few individual foods yield these particular proportions of fat and saturated fat. The extra fat and saturated fat could be realized with an extra 2 tablespoons of butter or an extra one-fourth cup of cream cheese every day.

Table 3: Treatment Effect Estimation Results--Effect of medication on risk behaviours

	Cholesterol		Total Fat		Saturated Fat		Cigarettes		Waist	
Explanatory variables	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)	Estimated Parameter	(*t*-stat.)
Constant	8.30	(2.12)	32.31	(11.49)	13.47	(10.88)	-0.46	(-0.24)	79.11	(11.88)
PIR	0.01	(0.08)	-0.18	(-0.87)	-0.05	(-0.39)	-0.76	(-4.23)	-0.81	(-2.91)
More than high school	-0.63	(-0.99)	0.23	(0.40)	0.11	(0.31)	-1.82	(-3.78)	0.07	(0.06)
Age	0.22	(1.34)	0.04	(0.28)	-0.11	(-2.08)	0.46	(5.64)	0.51	(1.79)
Age^2	0.00	(-1.28)	0.00	(-1.12)	0.00	(0.84)	0.00	(-7.20)	-0.01	(-2.62)
Female	-1.08	(-1.68)	1.11	(2.12)	0.62	(3.30)	-0.42	(-1.06)	9.86	(11.21)
Black, Non-Hispanic	2.50	(4.02)	-1.02	(-1.51)	-1.04	(-3.08)	-2.47	(-4.91)	2.38	(1.88)
Hispanic	2.08	(1.75)	-1.78	(-2.12)	-0.55	(-1.27)	-1.76	(-2.40)	-1.88	(-1.33)
Other Ethnicity	1.15	(0.59)	-3.51	(-1.25)	-2.48	(-2.37)	-3.81	(-5.79)	-8.90	(-2.25)
Spanish	-1.17	(-0.68)	-4.74	(-4.32)	-2.14	(-4.08)	-3.54	(-5.65)	-2.06	(-1.34)
Other language	-1.64	(-1.26)	-4.01	(-2.53)	-1.45	(-1.90)	1.05	(0.86)	-2.91	(-0.82)
Other health condition	1.00	(1.06)	-1.36	(-1.37)	-0.89	(-2.34)	2.13	(3.09)	0.99	(0.57)
Medication-treatment effect	0.12	(0.04)	7.22	(1.93)	4.86	(4.47)	-3.14	(-1.46)	14.33	(2.58)
Treatment effect: Explanatory variables										
Constant	-4.15	(-6.42)	-4.13	(-6.25)	-3.80	(-5.96)	-4.27	(-6.32)	-4.02	(-5.75)
PIR	-0.03	(-1.02)	-0.02	(-0.88)	-0.02	(-0.65)	-0.03	(-1.24)	-0.03	(-1.14)
More than high school	-0.20	(-2.28)	-0.22	(-2.44)	-0.21	(-2.29)	-0.20	(-2.26)	-0.20	(-2.22)
Age	0.12	(5.42)	0.12	(5.60)	0.11	(5.17)	0.12	(5.50)	0.11	(4.96)
Age^2	0.00	(-4.39)	0.00	(-4.57)	0.00	(-4.23)	0.00	(-4.51)	0.00	(-4.00)
Female	-0.27	(-4.80)	-0.27	(-4.62)	-0.27	(-4.23)	-0.26	(-4.43)	-0.26	(-4.28)
Black, Non-Hispanic	-0.06	(-0.76)	-0.09	(-1.03)	-0.05	(-0.67)	-0.05	(-0.66)	-0.10	(-1.33)
Hispanic	0.06	(0.42)	0.06	(0.43)	0.10	(0.70)	0.07	(0.44)	0.08	(0.49)
Other Ethnicity	0.31	(1.20)	0.24	(0.92)	0.25	(1.05)	0.30	(1.18)	0.27	(0.97)
Spanish	-0.12	(-0.62)	-0.15	(-0.76)	-0.16	(-0.87)	-0.12	(-0.59)	-0.14	(-0.72)
Other language	-0.16	(-0.81)	-0.13	(-0.68)	-0.16	(-0.81)	-0.15	(-0.81)	-0.15	(-0.74)
Other health condition	0.59	(6.23)	0.60	(6.45)	0.59	(6.24)	0.59	(6.35)	0.63	(6.35)
Insurance	0.40	(1.64)	0.35	(1.48)	0.34	(2.14)	0.48	(1.53)	0.41	(1.79)
Relative with angina	0.06	(0.74)	0.00	(-0.08)	-0.01	(-0.05)	0.05	(0.61)	0.07	(0.92)
Relative with hypertension	0.16	(2.17)	0.20	(3.11)	0.14	(2.14)	0.13	(1.61)	0.19	(2.86)
Model Fit										
Correlation (ρ)	0.04		-0.46*		-0.50**		0.17		-0.44*	
N	3037		3037		3037		3034		2936	

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

We show that the threat of severe adverse health consequences can induce significant improvements in diet quality (improvements from the perspective of the public health community, not from consumers' perspectives). Cigarette smoking and dietary intake of cholesterol, total fat, and saturated fat are lower for those whose physicians told them they have high cholesterol, compared to those with undiagnosed high cholesterol. But, some also choose to compromise diet quality. We find that dietary intake of cholesterol is unaffected by the decision to take cholesterol-lowering medication. However, for those taking cholesterol-lowering medication, diets are higher in total fats and in saturated fats than are diets of those with unmedicated high cholesterol. The waist circumference of those on medication is also larger, although some of the increase may be associated with reduced cigarette consumption. The increased dietary intake of fat and saturated fat, along with increased waist size are telling evidence of offsetting behaviour, as medication lowers the health price of unhealthy choices.

This suggests that, if life-threatening illnesses are not sufficient motivation for individuals to improve their diets and health behaviours, general public health admonitions to the population at large are unlikely to have much impact. The remaining policy question is whether those with high blood cholesterol are fully informed about the health benefits of medication. If individuals over assess the efficacy of medications, their utility maximizing choices could lead 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.

Acknowledgements

We would like to thank the anonymous reviewers for their detailed comments on the paper. The opinions expressed here are those of the authors and not necessarily those of the U.S. Department of Agriculture.

References

Aldrich, L., Variyam, J. N. 2000. Acculturation erodes the diet quality of U.S. hispanics. Food Review 23 (1), 51-55.

American Heart Association, 2006. What are healthy levels of cholesterol? http://www.americanheart.org/presenter.jhtml?identifier=183.

Frosch, D. L., Krueger, P. M., Hornik, R. C., Cronholm, P. F., Barg, F. K., 2007. Creating demand for prescription drugs: A content analysis of television direct-to-consumer advertising. Annals of Family Medicine 5 (1), 6-13.

Gross, C. P., Anderson, G. F. Powe, N. R., 1999. The relation between funding by the National Institutes of Health and the burden of disease. New England Journal of Medicine 340 (24), 1881-87.

Hause, J. C., 2006. Offsetting behavior and the benefits of safety regulations. Economic Inquiry 44 (4), 689-98.

Kahn, M. E., 1999. Diabetic risk taking: The role of information, education and medication. Journal of Risk and Uncertainty 18 (2), 147-164.

Lakdawalla, D., Sood, N., Goldman, D., 2006. HIV breakthroughs and risky sexual behaviour. Quarterly Journal of Economics 121 (3), 1063-1102.

Miller, G. E., Stagnitti, M. N., 2005. Trends in statin use in the civilian noninstitutionalized medicare population, 1997 and 2002. Statistical Brief #43. July. Agency for Healthcare Research and Quality, Rockville, MD.

http://www.meps.ahrq.gov/mepsweb/data_files/publications/st97/stat97.pdf.

Park, J., Davis, G. C., 2001. The theory and econometrics of health information in cross-sectional nutrient demand analysis. American Journal of Agricultural Economics 83 (4), 840-851.

Peltzman, S., 1975. The effects of automobile safety regulation. Journal of Political Economy 83 (4), 677-725.

Pignone, M. P., Phillips, C. J., Atkins, D., Teutsch, S. M., Mulrow, C. D., Lohr, K. N., 2001. Screening for lipid disorders, systematic evidence Review No. 4 (prepared by the Research Triangle Institute—University of North Carolina Evidence-based Practice Center, under contract No. 290-98-0011). AHRQ Publication No. AHRQ 01-S004. Rockville, MD: Agency for Healthcare Research and Quality. April. http://www.ahrq.gov/clinic/ajpmsuppl/pignone1.htm.

United States Department of Agriculture, 2006. Pyramid Servings Database for USDA Survey Food Codes Version 2.0, http://www.ars.usda.gov/Services/docs.htm?docid=8503.

U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality, 2006. Spending on drugs and other health services to treat high cholesterol has increased 350 percent. AHRQ News and Numbers, February 15. Agency for Healthcare Research and Quality, Rockville, MD. http://www.ahrq.gov/news/nn/nn021506.htm.

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2007. State heart disease and stroke prevention programs address high blood cholesterol. Fact Sheets and At-a-Glance Reports. http://www.cdc.gov/dhdsp/library/fs_state_cholesterol.htm

United States Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2006. National Health and Nutrition Examination Survey. http://www.cdc.gov/nchs/nhanes.htm.

U.S. Department of Health and Human Services, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2004. Weight-control information network. http://win.niddk.nih.gov/.

U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General, 2001. The surgeon general's call to action to prevent and decrease overweight and obesity. Washington: U.S. Government Printing Office.

Viscusi, W. K., 1984. The lulling effect: The impact of child-restraint packaging on aspirin and analgesic ingestion. American Economic Review 74 (2), 324-327.

World Health Organization, 2006. Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/index.html.