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HEALTH INSURANCE AND THE OBESITY EXTERNALITY

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ABSTRACT

If rational individuals pay the full costs of their decisions about food intake and exercise, economists, policy makers, and public health officials should treat the obesity epidemic as a matter of indifference. In this paper, we show that, as long as insurance premiums are not risk rated for obesity, health insurance coverage systematically shields those covered from the full costs of physical inactivity and overeating. Since the obese consume significantly more medical resources than the non-obese, but pay the same health insurance premiums, they impose a negative externality on normal weight individuals in their insurance pool.

To estimate the size of this externality, we develop a model of weight loss and health insurance under two regimes——(1) underwriting on weight is allowed, and (2) underwriting on weight is not allowed. We show that under regime (1), there is no obesity externality. Under regime (2), where there is an obesity externality, all plan participants face inefficient incentives to undertake unpleasant dieting and exercise. These reduced incentives lead to inefficient increases in body weight, and reduced social welfare.

Using data on medical expenditures and body weight from the National Health and Interview Survey and the Medical Expenditure Panel Survey, we estimate that, in a health plan with a coinsurance rate of 17.5%, the obesity externality imposes a welfare cost of about $150 per capita. Our results also indicate that the welfare loss can be reduced by technological change that lowers the pecuniary and non-pecuniary costs of losing weight, and also by increasing the coinsurance rate.

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1.0 Introduction

Adult obesity is a thorny health problem. Several studies document the rising obesity prevalence in the U.S., and measures the associated health and accounting costs. Over a decade ago, Wolf and Colditz (1994) measured the health care costs and lost workplace productivity due to obesity at over $68 billion annually. The morbidity and accounting costs associated with obesity have led public health experts (such as Nestle, 2003, Brownell and Horgen, 2003, Sturm 2002) to advocate vigorous public intervention.

However, economic theory suggests that measures of the direct (such as medical costs) or indirect (such as productivity loss) costs due to obesity are not germane to the debate over whether public actions to curb obesity are justified.[1] Rather, it is the costs of body weight decisions not borne by an adult making those decisions (hereafter, external costs) that are most relevant. If external costs are high, then public welfare can be improved by interventions that change the incentives adults face when making decisions about body weight. If external costs are small, then adults pay fully for their body weight decisions, and public interventions aimed at decreasing body weight can play only a limited role in improving public welfare.

The primary mechanism by which obesity is subsidized is through health insurance. Though there is a large literature on the differences in expected medical expenditures by obese and non-obese populations, the literature aimed at measuring the external costs of obesity that accrue through health insurance is small. Authors in this literature typically compare yearly medical expenditures by obese and non-obese individuals in public health insurance programs. Such calculations are incomplete.

It not enough to measure the extent to which obese individuals are subsidized through insurance programs. Intuitively, the welfare loss due to the health insurance externality depends upon both the size of the subsidy and upon the extent to which body weight decisions are distorted on the margin by the subsidy. If Homer Simpson would eat the same number of jelly donuts regardless of his health insurance coverage, then in his case,

[1] Cawley (2004) provides a detailed discussion of possible market failures related to obesity.

the subsidy does not generate any welfare loss due to the externality. Such a subsidy would simply represent a transfer from thinner to heavier individuals, with no net effect on social welfare.

In this paper, we take a different approach. We develop a simple model of optimal weight in the presence of insurance. We show that the welfare loss caused by health insurance externalities depends critically upon whether or not obese and non-obese individuals face pooled premiums. In other words, health insurance by itself, does not lead to an externality. The externality arises only if health insurance premiums do not reflect enrollee weight, such as if heterogeneous (obese and non-obese) enrollees are lumped into a single risk pool. In the case when premiums are actuarially fair, even if individuals are fully insured, they will still have an incentive to decrease expected medical care expenditures through weight loss as weight loss lowers health insurance premiums. We also show formally that the welfare loss caused by pooled over actuarially fair health insurance equals the product of the subsidy to obese individuals times the elasticity of changes in body weight with respect that subsidy. Finally, we calibrate a version of this model using data from the Medical Expenditure Panel Survey and estimate that the obesity induced per capita welfare loss due to pooled health insurance in the U.S. is about $150 per capita (in 1998 dollars). This estimate of the welfare loss is much smaller than the difference in medical expenditures between the obese and non-obese.

2.0 Background

Americans are increasingly overweight or obese.[2] The proportion of adults classified as obese increased from 12.0% in 1991 to 20.9% in 2001 (Mokdad et al., 1999; Mokdad et al., 2003). Obesity is associated with an increased risk of a range of chronic conditions, including diabetes, hypertension, heart disease, and stroke (Sturm, 2002). In this section, we provide a brief review of the large literature on the consequences of obesity for

[2] Body mass index (BMI) is the standard measure used to determine an appropriate weight in the medical literature. BMI is weight, measured in kilograms, divided by height, measured in meters, squared. Individuals with a BMI between 25 and 30 are considered overweight, while those with a BMI of 30 or more are considered obese (National Institute on Health, 1998). Henceforth, we use BMI and body weight interchangeably.

expected health care expenditures. We also provide a review of the smaller literature on the external effects of obesity induced by health insurance.

2.1 Obesity and health care expenditures

Not surprisingly, expected health care expenditures are higher for obese individuals than for normal weight individuals. A large number of studies document this fact. The vast majority of these studies use convenience samples consisting of individuals from a single employer or a single insurer (Elmer et al. 2004, Bertakis and Azari 2005, Burton et al. 1998, Raebel et al 2004). There are also studies of obesity related medical expenditure differences in an international setting. Both Sander and Bergemann (2003), in a German setting, and Katzmarzyk and Janssen (2004), in a Canadian setting, find higher medical expenditures for obese people.

There are a few studies that use nationally representative data. Finkelstein, et al. (2003) use data from the linked National Health Interview Survey (NHIS) and Medical Expenditure Panel Survey (MEPS). They estimate that annual medical expenditures are $732 higher for obese than normal weight individuals. On an aggregate level, approximately half of the estimated $78.5 billion in medical care spending in 1998 attributable to excess body weight was financed through private insurance (38%) and patient out-of-pocket payments (14%). Sturm (2002), using data from the Health Care for Communities (HCC) survey, finds that obese individuals spend $395 per year more than non-obese individuals on medical care. Thorpe et al (2004) also use MEPS data, but they are interested in how much of the $1,100 increase between 1987 and 2000 in per-capita medical expenditures is attributable to obesity. Using a regression model to calculate what per-capita medical expenditures would have been had 1987 obesity levels persisted to 2000, they conclude that about $300 of the $1,100 increase is due to the rise in obesity prevalence.

This is a large literature, which space constraints prevent us from surveying in more detail. The many studies that we do not discuss here vary considerably in generality—some examine data from a single company or from a single insurance source—though they all reach the same qualitative conclusion that obesity is associated with higher medical care costs.[3]

2.2 External costs of obesity associated with health insurance

Despite the lavish literature attention on medical expenditure differences, very few studies attempt to estimate the degree to which health insurance coverage leads to subsidies for the obese. Some studies have attempted to estimate how much of obesity related medical costs are subsidized by public insurance. Finkelstein, Ruhm and Kosa (2005), in a literature review of the causes and consequences of obesity, estimate that "the government finances roughly half the total annual medical costs attributable to obesity. As a result, the average taxpayer spends approximately $175 per year to finance obesity related medical expenditures among Medicare and Medicaid recipients." To arrive at this conclusion, they rely on a study by Finkelstein, Fiebelkorn, and Wang (2004), who calculate state and federal level estimates of Medicare and Medicaid expenditures attributable to obesity. Another study, conducted by Daviglus et al (2004), links together data from a sample of Chicago area workers in the labor force between 1967-73, to Medicare claims records from the 1990s. They estimate substantial obesity related differences in Medicare expenditures. For example, women workers who were obese between 1967 and 1973 spent $176,947 in the 1990s on Medicare, while analogous non-obese, non-overweight female workers spent $100,431 in undiscounted costs. Obese male workers spent $125,470, while non-obese non-overweight male workers spent $76,866.

However, estimating how much of obesity related medical costs are financed by public insurance is not sufficient for calculating the subsidy for obesity. Conceptually, calculating the size of the subsidy also requires estimating (in addition to the expected benefits of enrollment) payments by obese and non-obese individuals for enrolling in health insurance. For example, obese and non-obese people alike pay for Medicare when

[3] Some of the studies we reviewed, but arbitrarily do not discuss here include Bungam et al. (2003); Musich et al. (2004); Quesenberry, Jr. et al. (1998); Thompson et al. (2001); and Wang et al. (2003).

they are under 65, and spend (receive benefits) when they are older, roughly speaking.[4] Since obese people work, earn, are taxed, and die at different rates than non-obese people, looking at Medicare expenditure differences alone will paint a misleading picture of the Medicare subsidy for the obese.

Calculating the obesity subsidy induced by private insurance also requires estimating both payments for health insurance and medical expenditures. Since private insurance is typically provided in an employment setting, it is not enough to look at premiums for health insurance paid by employers and employees.[5] The key question is whether employers adjust the cash wages of obese workers with health insurance in order to account for the higher cost of insuring these workers. Although theory predicts that employers would have incentives to do so (Rosen 1986), in practice, it is not clear that they would be able to make these adjustments.[6] According to Gruber (2000), "...the problems of preference revelation in this context are daunting; it is difficult in reality to see how firms could appropriately set worker specific compensating differentials."

As is the case with Medicare, however, there is very little research on obesity related payment differences in a private insurance settling. An important exception is Bhattacharya and Bundorf (2005), who find some evidence that obese workers receive lower pay than non-obese workers primarily at firms that provide health insurance.

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[4] For example, McClellan and Skinner (1999, 2005) and Bhattacharya and Lakdawalla (2005), in estimating Medicare progressivity, estimate lifetime profiles of tax receipts for Medicare as well as Medicare expenditures.

[5] For employees enrolling in the same insurance plan, premiums do not depend upon body weight (see Keenan et al., 2001), so in that case, there are no obesity related payment differences. However, when employers offer multiple health plans, obese workers may tend to select into a different set of plans than their thinner colleagues. In that case, premiums may differ.

[6] The literature on medical expenditure associated obesity costs has a parallel and often intersecting literature on the labor market productivity costs associated with obesity (often these latter costs are called "indirect" costs of obesity). The theory of compensating wage differentials has important implications for whether these labor market costs are external; that is, whether obese individuals pay for lower productivity levels (such as through more sick days) associated with their body weight, or someone else pays. This theory suggests that obese workers will pay for lower productivity through reduced wages. The economics literature on obesity related wage differences—for example, Register and William (1990), Pagan and Davila (1997), and Cawley (2000)—unanimously finds that obese workers earn lower wages than their thinner colleagues, and that these differences are equal to or greater than the wages differences that would arise from measurable productivity differences. Hence, both theory and evidence suggest that these "indirect" costs of obesity are not external.

In related work, Keeler et al (1989) and Manning et al. (1991), using data from the RAND Health Insurance Experiment (RAND HIE) and from the National Health Interview Survey (NHIS), report estimates of lifetime medical costs attributable to physically inactivity (rather than obesity): "At a 5 percent rate of discount, the lifetime subsidy from others to those with a sedentary life style is $1,900." Though they label this estimate the external costs of physical inactivity, like the rest of the literature they focus on physical inactivity related medical expenditure differences, while ignoring payment differences that occur outside experimental settings in their calculation of the subsidy.

Finally, one of the major themes of this paper is that estimating the welfare loss caused by the health insurance induced obesity externality also requires estimating the effect of health insurance subsidies on body weight decisions. Though, as we have seen, many studies examine health expenditure differences, there are no studies that measure the effect of health insurance subsidies on body weight decisions.

3.0 A model of the health insurance induced obesity externality

In this section we develop a simple economic model of weight choice to characterize the health insurance externality. The model highlights two important facts of the health insurance externality. First, dead weight loss due to this health insurance externality depends upon both the responsiveness of medical care expenditures to weight gain *and* the responsiveness of weight choice to the health insurance externality. Second, health insurance, by itself, does not lead to an externality. The externality arises only if health insurance premiums do not reflect enrollee weight, such as if heterogeneous (obese and non-obese) enrollees are lumped into a single risk pool. In that case, we show that, because individuals do not bear the medical care costs of weight gain, body weight choice will not be optimal. However, if premiums adjust to reflect weight gain (or loss) then the change in premiums internalizes the medical care costs of weight gain. In this actuarially fair premiums case, even if individuals are fully insured, they will still have an incentive to decrease expected medical care expenditures through weight loss. Unlike the pooling case, consumers recover lower medical expenditures through lower premiums.[7]

3.1 A model of optimal body weight

The model timeline in Figure 1 illustrates the basic setup of the model. Each consumer starts with an initial endowment of weight W_0. In the first stage consumers decide how much weight to lose, ω. Weight loss (exercising, dieting) gives consumers some disutility but has two associated benefits: (1) it increases productivity, consequently raising consumer income and (2) it improves health or decreases the probability of falling sick.[8] Falling sick entails additional medical care expenditures, but since consumers are insured, they are reimbursed for all of these additional medical care expenditures. In the second stage, nature reveals a health shock with i = 1…N points of support.[9] Each type of health shock entails additional medical expenses, M_i. Consumers first observe this health shock and then decide how much to consume. Thus the consumers' problem is to maximize expected utility by jointly choosing weight change (ω) and a consumption plan $\{C_i\}_{i=1}^{N}$ for each of the N possible health states:

$$\text{(1)} \qquad \max_{\omega,\{C_i\}_{i=1}^{N}} EU = \sum_{i=1}^{N} \pi_i\left(W_0 - \omega\right) U\left(C_i\right) - \Phi\left(\omega\right)$$

where $U(C_i)$ represents utility from consumption; $\pi_i(W_0 - \omega)$ is the probability of health state *i* given weight $(W_0 - \omega)$; C_i is the consumption in health state *i*; and, $\Phi(\omega)$ is the disutility from weight loss.

We divide our analysis now into two cases: (1) health insurance pools risk across people with heterogeneous risk (so that premiums do not change with body weight); and (2)

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[7] This result is similar in nature to Ehrlich and Becker's (1972) theoretical finding that when insurance premiums reflect risk, individuals have incentives to expend resources on self-protection.

[8] The model can also be interpreted as a model of weight gain, with a reinterpretation of the source of disutility from this gain (diminished body image, perhaps). The main point is that changes in weight away from optimal induce disutility.

[9] The results of the model are similar when health shocks are permitted to be continuous, but the solution technology is less transparent.

people pay the actuarially fair premiums for their own body weight. The primary difference between these cases manifests itself in consumer budget constraints.

3.2 Risk pooling

In this case, health risk is pooled across people of different body weight. As long as the pool size is large enough, a single individual's medical expenditures will have a negligible effect on the common premium, $\bar{P}$, charged to everyone in the pool. Hence, from the point of view of each individual, premiums are taken as fixed, and the budget constraint is:

$$(2) \qquad I\left(W_0+\omega\right)=C_i+\bar{P} \;\; \forall \mathrm{i}$$

In (2), $I\left(W_0+\omega\right)$ is the income earned given weight. By allowing income to depend upon weight, we are modeling the effect of health on labor market productivity. We assume that $I'(.)>0$.

The budget constraint specifies that in each health state *i*, income equals expenditures on consumption, medical care and health insurance premiums. An immediate consequence of (2) is that consumption is identical in each health state, which makes sense since consumers are fully insured against medical expenditures.

The consumer's problem is to maximize expected utility, (1), subject to the budget constraint, (2). We solve the consumer's problem using standard discrete numerical programming methods. In the first step, taking the amount of weight and as given, we calculate the optimal demand for consumption in each health state. Inputting the optimal consumption plan in the utility function gives the maximum utility attainable in each health state. In the second stage, we choose weight to maximize expected utility given optimal consumption in each health state.

Plugging the budget constraint into (1), we reformulate the consumers' problem in the second stage:

$$(3)\qquad \max_{\omega} EU = U\left(I\left(W_0 - \omega\right) - \overline{P}\right) - \Phi\left(\omega\right)$$

The first order condition for the consumer's maximization problem is:

$$(4)\qquad -I'\left(W_0 - \omega^*\right)U'\left(I\left(W_0 - \omega^*\right) - \overline{P}\right) - \Phi'\left(\omega^*\right) = 0$$

Here, ω^* is the consumer's optimal weight in the pooling case. The first term in equation (4) is the marginal gain from weight loss; it is entirely due to the marginal increase in income from increased productivity arising from weight loss (scaled by the marginal utility of consumption). In equilibrium, consumers will lose weight until the marginal gain from weight loss equals the marginal disutility from weight loss.

If the insurance market is in competitive equilibrium, then premiums will be actuarially fair. They will equal the expected medical expenses for individuals in the insurance pool:

$$(5)\qquad \overline{P} = \sum_{i=1}^{N} \pi_i\left(W_0 - \omega^*\right)M_i$$

Equation (4) also shows that since consumers are fully insured against medical expenses, the only incentive for weight loss is the increase in income due to weight loss. Thus, when insurance premiums do not depend on weight, consumers do not view the reduction in medical expenditures as an additional benefit of weight loss when making decisions about body weight. Insurance induces a form of moral hazard with respect to weight loss incentives since the benefits of weight loss are not fully internalized by the consumer. As a consequence, weight loss creates a positive externality for everyone else in the insurance pool, since it lowers their health insurance premiums.[10] Because this benefit is not fully captured by the consumer losing the weight, insured people will tend to lose less weight than would be optimal. By contrast, the productivity benefits of weight loss are fully internalized as changes in productivity lead to an increase in consumer income.

3.3 Actuarially fair insurance

We now turn to the case where health insurance premiums adjust to reflect the weight choice of consumers. In contrast to the previous case, where the premium is taken as fixed, consumers now face an actuarially fair schedule of health insurance premiums that depends upon their weight. In the context of employer provided insurance this could be achieved by wage reductions for obese employees, or simply by offering premium rebates to individuals who lose weight. In this case, the budget constraint is given by:

$$(6) \qquad I\left(W_0-\omega\right)=C_i+P\left(W_0-\omega\right) \quad \forall \text{i}$$

Here, $P\left(W_0-\omega\right)$ is the health insurance premiums for an individual with a given weight, $W_0-\omega$. Again, if the insurance market is competitive, premiums will be actuarially fair. Hence, they will be an increasing function of weight, reflecting the increase in expected medical expenses:

$$(7) \qquad P\left(W_0-\omega\right)=\left(\sum_{i=1}^{N}\pi_i\left(W_0-\omega\right)M_i\right)$$

The consumers' problem in this case can be reformulated as:

$$(8) \qquad \max_{\omega} EU=U\left(I\left(W_0-\omega\right)-P\left(W_0-\omega\right)\right)-\Phi\left(\omega\right)$$

The first order condition for the consumer's maximization problem is:

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[10] This argument is developed in more detail in Appendix A.

(9) $$-\left[I'\left(W_0-\omega^{**}\right)-P'\left(W_0-\omega^{**}\right)\right]U'\left(I\left(W_0-\omega^{**}\right)-P\left(W_0-\omega^{**}\right)\right)-\Phi'\left(\omega^{**}\right)=0$$

Here, ω^{**} is the consumer's optimal weight in the actuarially fair case. Clearly, (9) is necessary for ω^{**} to be individually optimal, but whether it is also socially optimal depends upon what is meant by social optimality. Suppose EU is the expected utility of the representative consumer in the economy, and all individuals start with the same initial weight, W_0. In that (unrealistic) case, ω^{**} can be said to be socially optimal, since the full social costs of body weight decisions are internalized. In Appendix A, we consider a more realistic case where W_0 differs across individuals in the population. We show that, aside from transfers that do not depend upon final weight, $W_0-\omega^{**}$, equation (9) is a necessary condition for the social optimum.

It is instructive to compare the first order condition, (9), with the analogous condition, (4), when there was a single risk pool. Both equations have a single term reflecting the marginal costs of weight loss: $\Phi'(.)$. However, equation (9) has two terms, $I'(.)$ and $P'(.)$, reflecting the marginal benefit of weight loss accruing from an increase in productivity and a decrease in the health insurance premium. By contrast, equation (4) has only a single term reflecting the marginal productivity benefit of weight loss: $I'(.)$. Thus, when premiums reflect individual health risk, consumers have two incentives for weight loss—productivity gains and lower health insurance premiums. In this case, there is no moral hazard induced by health insurance and consumer body weight decisions.

In Appendix B, we consider what implications the model has for optimal weight loss under pooled and actuarially fair premiums. The effect of moving from pooled to fair premiums depends upon whether an individual receives an *ex ante* subsidy from health under pooled premiums. There are three types of people: those at the margin, who receive no subsidy; supramarginal people whose initial weight is more than the average person in the risk pool and hence receive a positive subsidy; and inframarginal people whose weight is less than the average person in the risk pool and hence pay a subsidy. Our main finding is that people at the margin will optimally lose more weight under actuarially fair premiums than they will under pooled premiums.

The story is a bit more complicated for inframarginal and supramarginal people. Intuitively, moving from pooled to actuarially fair premiums alters weight loss incentives in two distinct ways: through a reduction in the price of weight loss and through a change in net income by eliminating the subsidy. For individuals at the margin, the only force operating in the switch from pooled to fair premiums is the price reduction, which leads to an unambiguous decline in optimal weight. For inframarginal individuals, switching from pooled to fair premiums leads to a removal of a negative subsidy and hence to an increase in income. While the reduction in price still encourages weight loss, the increase in income encourages weight gain. Hence, the net effect of the switch on the optimal weight of inframarginal individuals is theoretically ambiguous. By contrast for supramarginal individuals, the switch also eliminates a positive subsidy for weight gain, which decreases income. Since weight is a normal good in our model, the income and price effects work in the same direction—toward a lower optimal weight under fair premiums for supramarginal individuals.

3.4 Deadweight loss from the obesity externality

In this section, we show that the size of the loss in social welfare from the obesity externality under pooled premiums depends upon both the fact that expected health expenditures are higher for the obese and also upon how responsive people would be in their weight loss decisions to a switch from pooled to actuarially fair premiums. This calculation is important because, while there is a lot of empirical evidence that obese people are more likely to have higher medical care expenditures than non-obese people, there is no empirical evidence on whether pooled insurance causes obesity or weight gain. Whether the rise in obesity prevalence is a public health crisis, or merely a private crisis for many people, depends on the evidence on both quantities.

We start with the expression for expected utility, evaluated at the optimum under actuarially fair insurance:

$$\text{(10)} \quad EU\left(\omega^{**}\right) = U\left(I\left(W_0 - \omega^{**}\right) - P\left(W_0 - \omega^{**}\right)\right) - \Phi\left(\omega^{**}\right)$$

We have imposed the condition that consumption does not vary with health outcome since consumers are fully insured under both cases.

Next, we consider a first order Taylor series approximation of (10) around ω^*:

$$\text{(11)} \quad EU\left(\omega^{**}\right) \approx EU\left(\omega^{*}\right) + \left.\frac{\partial EU}{\partial \omega}\right|_{\omega^*}\left(\omega^{**} - \omega^{*}\right)$$

The deadweight loss (*DWL*) from the obesity externality is the change in expected utility resulting from pooling. Equation (11) suggests an approximation to this quantity:

$$\text{(12)} \quad DWL = EU\left(\omega^{**}\right) - EU\left(\omega^{*}\right) \approx \left.\frac{\partial EU}{\partial \omega}\right|_{\omega^*}\left(\omega^{**} - \omega^{*}\right)$$

Here, $\Delta\omega \equiv \omega^{**} - \omega^{*}$ is difference between optimal weight under actuarially fair and pooled risk cases. Since weight is socially optimal in the actuarially fair case, $\Delta\omega$ also reflects the degree to which weight choice differs from socially optimal when pooling pertains.

Using a first order Taylor series approximation, the dead weight loss (DWL) in expected utility terms due to the obesity externality is:

$$\text{(13)} \quad DWL \approx \left\{U'\left(I\left(W_0 - \omega^{*}\right) - P\left(W_0 - \omega^{*}\right)\right)\left[-I'\left(W_0 - \omega^{*}\right) + P'\left(W_0 - \omega^{*}\right)\right] - \Phi'\left(\omega^{*}\right)\right\}\Delta\omega$$

Substituting the first order condition in equation (4) in equation (13) yields a simple expression for the dead weight loss from the obesity externality:

(14) $DWL \approx U'(.)P'\left(W_0 - \omega^*\right)\Delta\omega$

Equation (14) shows that the deadweight loss is proportional to two crucial factors: the extent to which body weight deviates from the optimal due to pooled health insurance, $\Delta\omega$, and the responsiveness of medical care expenditures to changes in weight, $P'\left(W_0 - \omega^*\right)$. The dead weight loss from the obesity externality is zero if individual weight choice does not respond to health insurance induced subsidies for obesity, or if medical expenditures do not change with body weight. While it is widely recognized in the public health and economics literatures that $P'(.)$ is an important component of the obesity externality, there is no work attempting to quantify $\Delta\omega$.

4.0 Calibrating the model

We turn now from our theoretical analysis of the obesity externality to a calibration exercise designed to generate dollar estimates of the size of the externality. The calibration exercise relies on a simplified version of our more general model. Our basic strategy involves three steps. First, we manipulate the parameters of a particular utility function so that the model predictions about body weight distribution under pooled premiums matches the observed body weight distribution in a nationally representative data set.[11] Second, using those same parameter estimates, we solve for optimal utility and body weight under actuarially fair insurance for each individual in the data. Utility under fair premiums will clearly exceed utility under pooled premiums, given the presence of the obesity externality in the latter case. Finally, we calculate the level of additional income that, if given to each individual in the data set, would equalize social welfare under actuarially fair and pooled premiums.

[11] Unlike the theoretical model, we take income as fixed and exogenous. The empirical literature suggests that body weight has only a small effect on productivity at the workplace—see Cawley (2004) and Bhattacharya and Bundorf (2005).

4.1 Medical expenditure panel survey data

For this exercise, we use nationally representative survey data from the Medical Expenditure Panel Survey (MEPS) because it contains all the data elements we need. In particular, we use the 1998 MEPS, linked to the 1997 National Health Interview Survey (NHIS) sample.[12] We restrict our analysis to insured individuals over 25 years old. We measure body weight in body mass index (BMI) units, which equals weight (measured in kilograms) divided by height (measured in meters) squared.

Table 1 shows some key characteristics of our MEPS sample. There are approximately 6,900 individuals in the sample, with about 2,900 normal weight, 2,500 overweight, and 1,500 obese individuals. Median annual medical care expenditures are rising in body weight, though there is only a small difference between normal and overweight individuals, and in fact mean expenditures are higher for normal weight than overweight individuals. Overweight individuals earn about $900 more on average per year than normal weight individuals, while obese individuals earn about $2,000 less. Insurance coverage is similar for obese, overweight, and normal weight individuals—about 60% have private insurance, 5% have Medicaid, 20% have Medicare, and 15% are uninsured. We exclude the uninsured from further analysis in this study, as they do not face the obesity externality.

4.2 Calibrating utility function parameters

We pick a particularly simple form for the utility function to minimize the number of unknown parameters:

$$U(c,\omega) = \ln c - \gamma\omega^2 \tag{15}$$

In equation (15), the only parameter we will need to choose in the utility function is γ, which is the utility cost per BMI unit squared of weight loss. To further simplify the

[12] This is the same sample of individuals analyzed by Finkelstein et al. (2004). The also excludes pregnant women.

calibration exercise, we restrict individuals to one of three body weight choices: normal weight (BMI = 20), overweight (BMI = 25), and obese (BMI = 30).

We need information on how the distribution of medical expenditures changes with body weight decisions. Since the change in distribution of medical expenditures due to bodyweight might vary with demographic variables, we estimate different expenditure distributions for obese, overweight, and normal weight individuals for 4 different demographic subgroups: (1) Males, aged 25 to 39, (2) Females, aged 25 to 39, (3) Males, Age 40+ and (4) Females, Age 40+. We calibrate the model separately for each demographic subgroup. In Appendix C, we describe our methodology for estimating these expenditure distributions from the MEPS data. Figure 2 shows that these distributions have three salient features. First, for all subgroups, the medical care expenditure distribution shifts to the right with an increase in body weight, so that obese individuals are more likely to spend more on medical care than normal weight individuals. Second, the gradient of medical care expenditures with respect to bodyweight is much higher for females. In other words, the increase in expected medical expenditures due to weight gain is much higher for females as compared to males. Finally, the gradient of medical care expenditures with respect to bodyweight also increases with age.

Our next step is to estimate the single utility function parameter, γ, for each demographic subgroup such that the model's prediction under pooled premiums about the proportion of obese individuals matches the observed proportion for that subgroup. We want to match the model with pooled premiums because: (1) the premiums paid by people with public insurance, to the extent any premiums are paid, are not risk adjusted for obesity; and (2) the nominal premium paid by people with employer provided private insurance is also typically not risk adjusted for obesity. [13]

[13] Although it is likely that premiums do not depend on weight we do not know the true extent of risk pooling among the insured population and on what characteristics the pooling occurs. We assume that health insurance premiums vary by gender and broad age categories only. Therefore, we conduct the analysis for each demographic subgroup separately. Population estimates of welfare loss and obesity are obtained by taking a weighted average (based on population proportions) of estimates for each demographic group.

In Section 3, consumers were completely insured against medical risks. In reality, under most health insurance plans in the U.S., consumers must pay coinsurance for medical expenditures. Let μ represent the coinsurance rate. For each person in the data, $k = 1 \ldots K$, let M_{ik} and C_{ik} represent medical expenditures and consumption associated with health shock $i = 1 \ldots N$. Let I_k represent consumer k's income. Consumer k's budget constraint under pooled premiums is:

(16) $I_k = C_{ik} + \bar{P} + \mu M_{ik}$ for $i = 1 \ldots N$ and $k = 1 \ldots K$.

In our calibration exercise, each individual picks consumption and weight loss so that utility—equation (15)—is maximized, subject to the budget constraint. We assume that a certain proportion of the population is "genetically normal weight." For these individuals weight is not a choice variable and is solely determined by their genetic endowment. We choose the value of this parameter to be the proportion normal weight under pooled premiums. In other words, we assume that people who are normal weight under pooled premiums must be endowed with normal weight, as there are few incentives to choose a normal weight with pooled premiums. In the remaining population everyone starts out obese (that is, with a BMI of 30) and then decides whether to lose zero, five, or 10 BMI points. For our main results we assume that the copayment rate is 17.5%, which corresponds roughly with the average level of out-of-pocket expenditures for health care among the insured population in the U.S.[14] Given these assumptions, it is simple to calculate optimal weight using the same backward recursion algorithm that we describe in Section 3.2. The MEPS data give us the distribution of M under alternate body weight choices, as well as income, I_k, for each individual. Consumption and body weight, ω_k, are endogenously determined by the model, as is $\bar{P}$. There is only one unknown parameters—the cost of weight loss, γ. Recall that we would like to find a value for γ such that the predicted weight distribution matches that observed in the MEPS data

[14] See Cohen JW et al. (1996).

We have one main computational problem. To solve the model for any given individual, we need to know γ and $\overline{P}$, but both variables depend upon the optimal choices made by all other individuals in the pool. Our approach is as follows. First, we fix a trial value for the cost of weight loss, γ_0. Second, we follow a four step procedure to calculate optimal choices given this value of γ: (1) we guess an initial premium level that is consistent with our assumption about the initial weight distribution; (2) we calculate optimal weight for each individual in the data based upon this guess; (3) we recalculate the actuarially fair premium that is associated with this new weight distribution; and (4) we iterate steps 2 and 3 until $\overline{P}$ converges. Convergence here means that the pooled premium level implied by step (3) yields the same (or rather, sufficiently close) premium level in the next iteration. This procedure generates a predicted body weight for all individuals in our sample, $W_k^*(\gamma_0)$, which is a function of our initial guess for γ. From this we calculate $Obese_k^*(\gamma_0) = 1\left(W_k^*(\gamma_0) = 30\right)$ and $Overweight_k^*(\gamma_0) = 1\left(W_k^*(\gamma_0) = 25\right)$, which are indicators of whether each individual is optimally obese or overweight. Third, we calculate the following loss function:

$$(17) \quad LOSS = \sum_{k=1}^{K} \left(Obese_k - Obese_k^*(\gamma)\right)^2 + \left(Overweight_k - Overweight_k^*(\gamma)\right)^2$$

Here, *Obese*$_k$ and *Overweight*$_k$ are an indicator of whether individual *k* in the sample is obese or overweight. Using a first and second difference approximation to the derivatives of equation (17) with respect to γ, we calculate a Newton-Raphson update for our estimated value of γ. Finally, using this updated guess, γ_1, we iterate on calculating equilibrium optimal choices and updating the loss function until we have a converged value of the costs of weight loss, γ^*. Using this converged value, we calculate the predicted probability of obesity in the population under pooling that corresponds with the observed data, $\frac{1}{K}\sum_{k=1}^{K} Obese_k^*\left(\gamma^*\right)$, as well as social welfare under pooled premiums, $SW^*\left(\gamma^*\right) = \sum_{k=1}^{K} EU_k^*\left(\gamma^*\right)$.

4.3 Estimating welfare loss from the obesity externality

To find the welfare loss from the obesity externality, we will need to know what body weight and utility would have been absent the externality. Consequently, we calculate what body weight choices and utility would be if individuals faced actuarially fair insurance premiums, rather than pooled premiums. Since we already have a value for the costs of weight loss, γ^*, this is a substantially easier problem than the one we have already solved. As before, we start with a initial bodyweight distribution, and then individuals choose a BMI of 20, 25, or 30 to maximize utility—equation (15). In the actuarially fair case, however, individuals maximize the following budget constraint:

$$(18) \quad I_i = C_{ik} + P(\omega_k) + \mu M_{ik}$$

Here, $P(\omega_k)$ represents the actuarially fair premium associated with weight loss ω_k. We calculate this premium level for the various weight loss choices (zero, five, and 10 BMI points) using equation (7). We can calculate this using the medical expenditure distribution information that we derived from the MEPS. For each individual, this optimization yields a predicted body weight under actuarially fair insurance, $W_k^{**}(\gamma^*)$ and an indicator of predicted obesity, $Obese_k^{**}(\gamma^*)$. It also yields a measure of social welfare under actuarially fair insurance. $SW^{**}(\gamma^*) = \sum_{k=1}^{K} EU_k^{**}(\gamma^*)$, where $EU_k^{**}(\gamma^*)$ is the expected utility under actuarially fair insurance for each individual.

The final step in our calibration exercise involves measuring the welfare loss from the obesity externality in dollar units. Let $SW^*(Y,\gamma^*)$ be the optimal level of social welfare under pooled insurance when each individual k in the population has income equal to $I_k + Y$. In that case, individuals maximize equation (15) subject to the budget constraint: $I_k + Y = C_{ik} + \bar{P} + \mu M_{ik}$. $SW^*(Y,\gamma^*)$ can be calculated in exactly the same way as $SW^*(\gamma^*)$ for any given value of Y. A measure of the welfare loss from the obesity externality is the dollar amount that, if given to each individual in the pooled case, would equalize social welfare under pooling and actuarially fair cases. This compensating differential, Y^*, is defined by the following equation:

$$(19) \quad SW^*\left(Y^*,\gamma^*\right) - SW^{**}\left(\gamma^*\right) = 0$$

$Y^* > 0$ is guaranteed to exist since social welfare is clearly increasing in Y and since $SW^*\left(0,\gamma^*\right) < SW^{**}\left(\gamma^*\right)$. (That is, social welfare under actuarially fair insurance must exceed social welfare under pooling at the same level of income). We find Y^* using a univariate bisection search that involves recalculating $SW^*\left(Y,\gamma^*\right)$ for various levels of Y until equation (19) is satisfied.

5.0 Calibration results

Table 2 presents the main results from our calibration exercise.[15] We estimate the welfare loss from the obesity externality to be $149 per person. The welfare loss for the obesity externality varies substantially by demographic subgroups with the greatest losses for women in the 40+ age group and smallest losses for men in the 25 to 39 years age group. This wide variation in the welfare loss due the obesity externality can be explained by the two factors highlighted in equation (14): the extent to which body weight deviates from the optimal due to pooled health insurance, and the responsiveness of medical care expenditures to changes in weight. Figure 2 showed that medical care expenditures of women and older persons were most responsive to weight and therefore these demographic groups are likely to suffer a higher welfare loss.

Table 2 also shows the extent to which weight choices deviate from the optimal (actuarially fair insurance) under pooled premiums. Despite the theoretical possibility that actuarially fair insurance might induce people to weigh more (if the income effect outweighs the direct price effect), for all groups we find that pooled insurance increases the prevalence of obesity. Again, we find significant differences by demographic

[15] Appendix Table 1 lists the relative costs of weight loss for individuals in different demographic subgroups. These results show that women and older persons have higher costs of losing weight.

subgroups with the weight choices of women and older persons deviating more from the optimal under pooled premiums than the weight choices of men and younger persons. Thus, the pattern of weight choice deviations also implies that women and older persons are likely to suffer a higher welfare loss due to the obesity externality.

We turn next to a series of figures designed to graphically illustrate two important comparative statics results from the model. In particular, we look at how the prevalence of obesity and the welfare loss from obesity change with the coinsurance rate and with the utility cost of losing weight. These comparative statics are important, in part, because they are policy relevant. The coinsurance rate, at least for public insurance, is directly amenable to government control. The utility costs of weight loss depend strongly on prevailing dietary and exercise technology, as well as on the availability of pharmaceutical products that promote weight loss. These are also often amenable to government policy; direct through investment in scientific research and indirectly through the regulation of the market for weight loss products. These figures also give some sense of how sensitive our main results are to our assumptions. Without loss of generality, we illustrate the comparative statics only for men 40 years of age or older, rather than for all demographic subgroups.

Figure 3 displays the effect of changing the copayment rate, holding all else fixed. [16] Panel A shows that the prevalence of obesity declines strongly with increase in the coinsurance rate. Panel B shows that the welfare loss from the obesity externality declines with increases in the coinsurance rate. The most striking feature of this figure is that the welfare loss remains relatively stable up to coinsurance rates of about 15% but then declines sharply for increases in coinsurance rates beyond this level. At 15% copayment, the welfare loss is about $260 per person; at 25% it is about $115 per person; at 35% it is about $50 per person; at 45% it is about $25 per person; and at 55% it is nearly zero. At 100% coinsurance, of course, there is no welfare loss due to the obesity

[16] This simulation estimates the welfare loss due to obesity when coinsurance varies from 0 (full insurance) to 1 (uninsurance). Therefore, this simulation only includes individuals with income greater than $50,000. This is necessary because incomes less than $50,000 would result in negative consumption if individuals are uninsured and receive a health shock that requires $50,000 or more in health expenditures.

externality, though presumably there would be welfare losses from sources that we have not modeled. Clearly, imposing modest coinsurance can be an effective way of controlling the welfare loss due to the obesity externality under pooling.

Figure 4 displays the effect of changing the utility cost of weight loss, holding all else fixed. Panel A shows that decline in the costs of weight loss leads to a decrease in the prevalence of obesity. Panel B of Figure 4 shows that the welfare loss from the obesity externality declines steadily with decrease in the costs of weight loss. Reducing the costs of weight loss to half of its initial baseline level (see Appendix Table 1) reduces the welfare loss to about a quarter of its original value (from $80 per capita to $20 per capita). Similarly increasing the costs of weight loss by 50% from its baseline level increases the welfare loss by a 150%. Thus, our findings suggest that improvements in weight loss technology can play an important role in limiting the welfare loss from the obesity externality. They also suggest that any new developments (such as tastier junk food) that increase the costs of weight loss can dramatically increase the obesity externality.

6.0 Conclusions

This paper represents a first step in understanding what is known and not known about whether the obesity crisis is truly a public health crisis. There is little question that obesity is a serious issue for personal health.[17] But should obesity be a public health concern, or should adults decide their body weight unimpeded by public intervention? On this point, the debate is fierce. On one side, legislators in Congress are considering bills like the "Personal Responsibility in Food Consumption Act" that would limit lawsuits that hold restaurants responsible for obesity. On the other side, public health specialists urge interventions, such as taxing junk food and subsidizing healthier foods.[18]

[17] However, recently, Flegal et al. (2005) have found that overweight individuals (with a BMI between 25 and 30) live slightly longer than normal weight individuals (with a BMI between 18.5 and 25). There is no controversy about the fact that, all else equal, obese individuals (with a BMI over 30) tend to die before normal weight individuals.

[18] There is some dissent among public health experts about the desirability of higher food taxes. Drewnowski (2004) and Drewnowski and Darmon (2005) find that the price of unhealthy energy dense foods is less than more healthy, less energy dense alternatives. They argue that the reason why poorer

The notion of externalities suggests a useful framework to transform this contentious debate into a scientifically addressable problem. Decisions about body weight in the absence of government intervention can only be optimal if individuals face the full costs of their decisions about eating and physical activity—that is, in the absence of externalities. Cawley (2004) summarizes a well-known lesson of public economics: "Without a market failure, there is no economic justification for government intervention. A high prevalence of obesity is not in itself proof of market failure."

Given this background, we explore whether private or public health insurance that subsidizes medical expenditures for the obese leads to an obesity externality. One of our most important findings is that health insurance, by itself, does not lead to an externality. The externality arises when health insurance premiums do not adjust to reflect the weight choices of individuals so that individuals do not bear the full costs of their weight choice. However, if premiums adjust to reflect weight gain (or loss) then the change in premiums internalizes the medical care costs of weight gain. Therefore, even if individuals are fully insured, they will still have an incentive to decrease expected medical care expenditures through weight loss as consumers recover lower medical expenditures through lower premiums.

We also show that the welfare loss from the obesity externality is proportional to the product of the difference in medical expenditures between the obese and non-obese *and* the extent to which the health insurance subsidy induced by pooled insurance causes distortions in body weight decisions. The estimates from a simple calibration of our model using nationally representative data suggests that the health insurance induced obesity externality imposes a welfare cost of $150 per capita. This is lower than the literature estimates of the transfer induced by insurance to obese individuals. Women and older persons are hit the hardest by this externality as they show much a higher medical expenditure elasticity with respect to bodyweight and pooled insurance causes more severe distortions in body weight decisions of these demographic groups.

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individuals are more likely to be obese is that it is cheaper to buy energy dense foods. They caution that imposing additional taxes on these foods would have malign distributional consequences.

Our model also suggests some feasible ways of mitigating the external harms caused by the obesity crisis, to the extent that they exist. An important implication of our model is that obesity can have external effects through health insurance coverage only if premium setting ignores obesity. An obvious way to capitalize on this implication is to risk rate premiums to take body weight changes into account. This information is either readily available to insurance plans through medical records, or could be collected cheaply. In public insurance settings, subsidies could be given to individuals who maintain healthy body weight.

Our model results suggest two more policies that limit the social welfare harm from the obesity externality under pooled insurance. First, even moderate levels of cost sharing dramatically reduce the welfare harm. Second, technological developments that aid people in losing weight can substantially reduce welfare losses. Such developments potentially include the development of discrete products like low calorie food substitutes, improved and more enjoyable exercises and exercise equipment, and pharmaceutical products to control hunger. Developments could also include interventions in workplaces and homes to alter the environment in which dietary and exercise choices are made. As long as the public costs of such interventions are less than the external costs of obesity, it will be worth it to invest in them.

References

Bertakis KD; Azari R. "Obesity and the Use of Health Care Services" *Obesity Research*, 2005, 13(2):372-379.

Bhattacharya J and Bundorf K. "The Incidence of the Healthcare Costs of Obesity" National Bureau of Economic Research Working Paper #11303, 2005

Bhattacharya J and Lakdawalla D, "Does Medicare Benefit the Poor?" forthcoming at *Journal of Public Economics,* 2005

Brownell K and Horgen KB. Food Fight : The Inside Story of the Food Industry, America's Obesity Crisis, and What We Can Do About It. New York: McGraw-Hill, 2003.

Bungam, T; Satterwhite, M; Jackson, AW and Morrow, JR. "The Relationship of Body Mass Index, Medical Costs, and Job Absenteeism." *American Journal of Health Behavior*, 2003, *27*(4), pp. 456-62.

Burton, WN; Chen, CY; Schultz, AB and Edington, DW. "The Economic Costs Associated with Body Mass Index in a Workplace." *Journal of Occupational and Environmental Medicine*, 1998, *40*(9), pp. 786-92.

Cawley, J. "An Instrumental Variables Approach to Measuring the Effect of Body Weight on Employment Disability." *Health Services Research*, 2000, *35*(5 Pt 2), pp. 1159-79.

Cawley J. "An Economic Framework for Understanding Physical Activity and Eating Behaviors" *American Journal of Preventive Medicine*. 2004,27(3S):117-125.

Cohen JW, Machlin SR, Zuvekas SH, et al. "Health care expenses in the United States, 1996," Rockville MD: Agency for Health Care Research and Quality, MEPS Research Finding #12.

Dannenberg AL; Burton DC; Jackson RJ. "Economic and Environmental Costs of Obesity: The Impact on Airlines" *American Journal of Preventive Medicine*, 2004, 27(3).

Daviglus ML; Liu K; Yan LL; Pirzada A; Manheim L; Manning W; Garside DB; Wang R; Dwyer AR; Greenland P; Stamler J. "Relation of Body Mass Index in Young Adulthood and Middle Age to Medicare Expenditures in Older Age" *JAMA*, 2004, 292(22):2243-2749.

Drewnowski A "Obesity and the Food Environment: Dietary Energy Density and Diet Costs" *American Journal of Preventive Medicine*. 2004, 27(3S):154-162.

Drewnowski A; Darmon N. “Food Choices and Diet Costs: An Economic Analysis” *Journal of Nutrition*, 2005, 135(4):900-4.

Ehrlich, Isaac and Becker, Gary S. "Market Insurance, Self-Insurance, and Self-Protection." *Journal of Political Economy*, 1972, *80*(July/August), pp. 623-48.

Elmer PJ; Brown JB; Nichols GA; Oster G “Effects of Weight Gain on Medical Care Costs” *International Journal of Obesity*, 2004, 28:1365-73.

Finkelstein, EA; Flebelkorn, IC and Wang, G. "National Medical Spending Attributable to Overweight and Obesity: How Much, and Who's Paying?" *Health Affairs*, 2003, pp. W3-219-26.

Finkelstein, EA; Flebelkorn, IC and Wang, G. “State-Level Estimates of Annual Medical Expenditures Attributable to Obesity” *Obesity Research*, 2004, 12(1):18-24

Finkelstein EA; Ruhm CJ; Kosa KM “Economic Causes and Consequences of Obesity.” *Annual Review of Public Health*, 2005, 26:239-57.

Flegal KM; Graubard BI; Williamson DF; Gail MH. “Excess Deaths Associated With Underweight, Overweight, and Obesity” *JAMA.* 2005;293:1861-1867.

Gruber, Jonathon. "Health Insurance and the Labor Market," A. J. Cuyler and J. P. Newhouse, *Handbook of Health Economics.* Elsevier, 2000, 645-700.

Gruber, Jonathon. "The Incidence of Mandated Maternity Benefits." *American Economic Review*, 1994, *84*(3), pp. 622-41.

Katzmarzyk PT; Janssen I “The Economic Costs Associated with Physical Inactivity and Obesity in Canada: An Update” *Canadian Journal of Applied Physiology*, 2004, 29(1):90-115.

Keeler EB; Manning WG; Newhouse JP; Sloss EM; Wasserman J. “The External Costs of a Sedentary Lifestyle” *American Journal of Public Health*, 1989, 79:975-81.

Keenan, Patricia Seliger; Buntin, Melinda J. Beeuwkes; McGuire, Thomas G. and Newhouse, Joseph P. "The Prevalence of Formal Risk Adjustment in Health Plan Purchasing." *Inquiry*, 2001, *38*(Fall), pp. 245-59.

Manning WG; Keeler EB; Newhouse JP; Sloss EM; Wasserman J. The Costs of Poor Health Habits. Cambridge, MA: Harvard University Press, 1991.

McClellan M and Skinner J. (1999) “Medicare reform: who pays and who benefits?” *Health Affairs*, 18(1):48-62.

McClellan M and Skinner J. (2005) “The Incidence of Medicare.” *J Public Economics.*

forthcoming..

Mokdad, A.H.; Serdula, M.K.; Dietz, W.H.; Bowman, B.A.; Marks, J.S. and Koplan, J.P. "The Spread of the Obesity Epidemic in the United States, 1991-1998." *JAMA*, 1999, *282*(16), pp. 1519-22.

Mokdad, Ali H.; Ford, Earl S.; Bowman, Barbara A.; Dietz, WIlliam H.; Vinicor, Frank; Bales, Virginia S. and Markes, James S. "Prevalence of Obesity, Diabetes, and Obesity-Related Health Risk Factors, 2001." *JAMA*, 2003, *289*(1), pp. 76-79.

Musich, S; Lu, C; McDonald, T; Champagne, LJ and Edington, DW. "Association of Additional Health Risks on Medical Charges and Prevalence of Diabetes within Body Mass Index Categories." *American Journal of Health Promotion*, 2004, *18*(3), pp. 264-68.

National Institute on Health. "Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report," National Heart, Lunch and Blood Institute in cooperation with The National Istitute of Diabetes and Digestive and Kidney Diseases, 1998.

Nestle M. Food Politics: How the Food Industry Influences Nutrition and Health, Berkeley, CA: University of California Press, 2003.

Pagan, JA and Davila, A. "Obesity, Occupational Attainment, and Earnings." *Social Science Quarterly*, 1997, *78*(3), pp. 756-70.

Quesenberry, C. P., Jr.; Caan, B. and Jacobson, A. "Obesity, Health Services Use, and Health Care Costs among Members of a Health Maintenance Organization." *Archives of Internal Medicine*, 1998, *158*(5), pp. 466-72.

Raebel MA; Malone DC; Conner DA; Xu S; Porter JA; Lanty FA. "Health Services Use and Health Care Costs of Obese and Non-obese Individuals" *Archives of Internal Medicine,* 2004, 164:2135-2140.

Register CA and Williams DR "Wage Effects of Obesity Among Young Workers" Social Science Quarterly, 1990, 71(1):130-41.

Rosen, Sherwin. "The Theory of Equalizing Differences," O. Ashenfelter and R. Layard, *Handbook of Labor Economics.* Elsevier Science Publishers, 1986,

Sander B; Bergemann R. "Economic Burden of Obesity and its Complications in Germany." *European Journal of Health Economics*, 2003, 4(4):248-53.

Sturm, R. "The Effects of Obesity, Smoking, and Drinking on Medical Problems and Costs." *Health Affairs*, 2002, *21*(2), pp. 245-53.

Thompson, D; Brown, JB; Nichols, GA; Elmer, PJ and Oster, G. "Body Mass Index and Future Healthcare Costs: A Retrospective Cohort Study." *Obesity Research*, 2001, *9*(3), pp. 210-18.

Thorpe KE; Florence CS; Howard DH; Joski P. “The Impact of Obesity on Rising Medical Spending” *Health Affairs*, 2004, Web Exclusive W4:480-486.

Wang, F; Schultz, AB; Musich, S; McDonald, T; Hirschland, D and Edington, DW. "The Relationship between National Heart, Lung, and Blood Institute Weight Guidelines and Concurrent Medical Costs in a Manufacturing Population." *American Journal of Health Promotion*, 2003, *17*(3), pp. 183-89.

Wolf AM and Colditz GA. “The Cost of Obesity.” *Pharmacoeconomics,* 1994, 5(Suppl 1):34-37.

Appendix A: A Characterization of the Social Optimum

In this section, we derive necessary conditions characterizing the socially optimal level of weight loss for a society of $j = 1 \ldots J$ individuals. Each has the following expected utility, taken from equation (1):

(A-1) $$EU_j = \sum_{i=1}^{N} \pi_i \left(W_{0j} - \omega_j\right) U\left(C_{ij}\right) - \Phi\left(\omega_j\right)$$

We define total social welfare, $\mho$, as the sum of expected utilities over all individuals in the society:

(A-2) $$\mho = \sum_{j=1}^{J} \gamma_j EU_j$$

In (A-2), γ_j represents the Pareto weight that individual *j* has in the social welfare function. In the social budget constraint, total income equals total expenditures on consumption plus total medical expenditures over all individuals. Both income and the distribution of medical expenditures depend upon body weight decisions:

(A-3) $$\sum_{j=1}^{J} \left\{ I\left(W_{0j} - \omega_j\right) - \sum_{i=1}^{N} \pi_i \left(W_{0j} - \omega_j\right)\left(M_i + C_{ij}\right) \right\} = 0$$

Equation (A-3) builds in our assumption that expectations about the distribution of medical expenditures in the population correspond to the observed distribution of expenditures.

The social problem is to pick consumption and body weight for all individuals in every state of the world — $\left\{C_{ij},\ \omega_j\right\}\ \forall i, j$ — to maximize $\mho$ subject to the social budget constraint. To this end, we construct the following Lagrangian function, where λ is the multiplier associated with the social budget constraint, (A-3):

(A-4) $$\begin{aligned} L = & \sum_{j=1}^{J}\sum_{i=1}^{N} \gamma_j \pi_i \left(W_{0j} - \omega_j\right) U\left(C_{ij}\right) - \gamma_j \Phi\left(\omega_j\right) \\ & - \lambda \sum_{j=1}^{J} \left\{ I\left(W_{0j} - \omega_j\right) - \sum_{i=1}^{N} \pi_i \left(W_{0j} - \omega_j\right)\left(M_i + C_{ij}\right) \right\} \end{aligned}$$

There are two sets of first order conditions:

(A-5) $$\frac{\partial L}{\partial C_{ij}} = \gamma_j U'\left(C_{ij}\right) + \lambda = 0 \quad \forall i, j \text{, and}$$

(A-6)
$$\frac{\partial L}{\partial \omega_j} = -\sum_{i=1}^{N} \pi_i'\left(W_{0j}-\omega_j\right)\gamma_j U\left(C_{ij}\right) - \gamma_j \Phi'\left(\omega_j\right) + \lambda\left(I'\left(W_{0j}-\omega_j\right) + \sum_{i=1}^{N} \pi_i'\left(W_{0j}-\omega_j\right)\left(M_i + C_{ij}\right)\right) = 0 \quad \forall j$$

An immediate implication of (A-5) is that at the social optimum, each individual *j* in the society must set his (or her) consumption level to the same value, say C_j^*, across all the *N* different health states:

(A-7) $C_{ij} = C_j^* \ \forall i, j$

Applying (A-7) to (A-6) yields the following:

(A-8)
$$-\left(\gamma_j U\left(C_j^*\right) + \lambda C_j^*\right)\sum_{i=1}^{N} \pi_i'\left(W_{0j}-\omega_j\right) - \gamma_j \Phi'\left(\omega_j\right) + \lambda\left(I'\left(W_{0j}-\omega_j\right) + \sum_{i=1}^{N} M_i \pi_i'\left(W_{0j}-\omega_j\right)\right) = 0 \quad \forall j$$

By definition, $\sum_{i=1}^{N} \pi_i\left(W_{0j}-\omega_j\right) = 1$, so we have $\sum_{i=1}^{N} \pi_i'\left(W_{0j}-\omega_j\right) = 0$. Furthermore, differentiating equation (7), which defines the actuarially fair premium, $P\left(W_{0j}-\omega_j\right)$, yields the fact that:

(A-9) $P'\left(W_{0j}-\omega_j\right) = -\sum_{i=1}^{N} \pi_i'\left(W_{0j}-\omega_j\right) M_i \quad \forall j$.

These equations and (A-5) permit a further simplification of equation (A-8):

(A-10) $-\Phi'\left(\omega_j\right) - U'\left(C_j^*\right)\left(I'\left(W_{0j}-\omega_j\right) - P'\left(W_{0j}-\omega_j\right)\right) = 0 \quad \forall j$

Hence, the social optimum requires each individual to equate the marginal (utility) costs of weight loss with the marginal (utility) benefits from the weight loss—an increase in income and a reduction in expected medical costs.

One feasible allocation that meets (A-10) would set consumption for each individual equal to income, less the actuarially fair premium given weight:

(A-11) $C_j^* = I\left(W_{0j}-\omega_j\right) - P\left(W_{0j}-\omega_j\right) \ \forall j$

It is easy to show that this allocation would be optimal for some distribution of initial body weight, $\left\{W_{0j}\right\}$, and some set of Pareto weights, $\left\{\gamma_j\right\}$. In this allocation, there are no transfers between individuals with different initial body weights. Other optimal and feasible allocations are possible, but these would involve fixed transfers between individuals that do not depend upon final body weight (though they might depend upon initial body weight). Optimal transfers would clearly vary with $\left\{\gamma_j\right\}$, though all optimal allocations would need to obey condition (A-10).

Appendix B: Optimal Weight Loss Under Actuarially Fair and Pooled Insurance

In this section, we compare optimal weight loss under pooled and actuarially fair health insurance pricing. As in Appendix A, we consider an economy where there are J individuals, each with an initial weight, W_{0j}. Throughout, we assume that J is large. As before, we let ω_j^* represent the j^{th} individual's optimal weight loss under pooling, while we let ω_j^{**} represent j's optimal weight loss under actuarially fair insurance.

It will be useful to divide these individuals into three groups based upon their final weight, $W_{0j} - \omega_j$. Let $P\left(W_{0j} - \omega_j^*\right) = \sum_{i=1}^{N} \pi_i \left(W_{0j} - \omega_j^*\right) M_i$ be the expected medical expenditures of individual j under pooling, and let $\overline{P} = \frac{1}{J}\sum_{j=1}^{J} P\left(W_{0j} - \omega_j^*\right)$ be the average pooling premium in the economy. We define an individual j to be at the margin if he would receive no *ex ante* subsidy under pooled health insurance—that is, if $P\left(W_{0j} - \omega_j^*\right) = \overline{P}$. An individual j is said to be inframarginal if his expected medical expenditures would be less under pooling than the average pooling premium $P\left(W_{0j} - \omega_j^*\right) < \overline{P}$. Clearly, inframarginal individuals are thinner than those at the margin. Finally, an individual j is said to be supramarginal if he would receive a subsidy under pooling: $P\left(W_{0j} - \omega_j^*\right) > \overline{P}$. These individuals are heavier than those at the margin.

We first consider individuals at the margin. We will need the following function, based upon the first order condition in the pooling case:

(B-1) $$pool\left(W_0, \omega\right) = -I'\left(W_0 - \omega\right) U'\left(I\left(W_0 - \omega\right) - P\left(W_0 - \omega\right)\right) - \Phi'\left(\omega\right)$$

Clearly, for those at the margin, the first order condition under pooling, equation (4), implies that $pool\left(W_{0j}, \omega_j^*\right) = 0$. We now consider $pool\left(W_{0j}, \omega_j^{**}\right)$ evaluated at the optimal weight under actuarially fair pricing:

(B-2)

$$pool\left(W_{0j}, \omega_j^{**}\right) = \left[-I'\left(W_{0j} - \omega_j^{**}\right) + P'\left(W_{0j} - \omega_j^{**}\right)\right] U'\left(I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right)\right)$$
$$- \Phi'\left(\omega_j^{**}\right) - P'\left(W_{0j} - \omega_j^{**}\right) U'\left(I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right)\right)$$

In (B-2), we have added and subtracted $P'(.)U'(.)$ from the right hand side of (B-1). Next, we apply equation (9), which is the first order condition in the actuarially fair case, to (B-2). This yields:

(B-3) $$pool\left(W_{0j},\omega_j^{**}\right)=-P'\left(W_{0j}-\omega_j^{**}\right)U'\left(I\left(W_{0j}-\omega_j^{**}\right)-P\left(W_{0j}-\omega_j^{**}\right)\right)$$

We assume that utility increases with consumption, so $U'(.)>0$. Intuitively, expected medical expenditures should increase with weight, so that $P'(.)>0$. With these assumptions, we have $pool\left(W_{0j},\omega_j^{**}\right)<0$, and hence:

(B-4) $$pool\left(W_{0j},\omega_j^{**}\right)< pool\left(W_{0j},\omega_j^{*}\right)=0$$

The second order condition for the pooled premium case implies that:

(B-5) $$\frac{\partial pool\left(W_0,\omega\right)}{\partial\omega}<0.$$

(B-4) and (B-5) together imply that $\omega_j^{**}>\omega_j^{*}$. Hence, individuals at the margin will optimally lose more weight under actuarially fair premiums than they will under pooled premiums.

We next consider the inframarginal and supramarginal cases. The logic of the analysis is similar to the logic in the marginal case, with a crucial difference—individuals in these cases are subsidized for their body weight decisions in the pooled premium case. For inframarginal individuals, who are thinner, the subsidy is negative, while for supramarginal individuals, who are heavier, the subsidy is positive. Intuitively, moving from pooled to actuarially fair premiums alters weight loss incentives in two distinct ways: through a reduction in the price of weight loss and through a change in net income by eliminating the subsidy. For individuals at the margin, the only force operating in the switch from pooled to fair premiums is the price reduction, which leads to an unambiguous decline in optimal weight. For supramarginal individuals, the switch also eliminates a positive subsidy for weight gain, which decreases income. Since weight is a normal good in our model, the income and price effects work in the same direction—toward a lower optimal weight under fair premiums for supramarginal individuals. By contrast, for inframarginal individuals switching from pooled to fair premiums leads to a removal of a negative subsidy and hence to an increase in income. While the reduction in price still encourages weight loss, the increase in income encourages weight gain. Hence, the net effect of the switch on the optimal weight of inframarginal individuals is theoretically ambiguous.

Let $S_j = P\left(W_{0j} - \omega_j^*\right) - \overline{P}$ represent the amount of the subsidy under pooled premiums. We need an altered version of our *pool* function that includes the subsidy as an additional argument:

(B-6) $pool\left(W_0, \omega, S\right) = -I'\left(W_0 - \omega\right)U'\left(I\left(W_0 - \omega\right) - P\left(W_0 - \omega\right) + S\right) - \Phi'\left(\omega\right)$

As before the first order condition under pooled premiums, equation (4), implies that $pool\left(W_{0j}, \omega_j^*, S_j\right) = 0$. We consider the value of *pool* under actuarially fair premiums:

(B-7)

$$pool\left(W_{0j}, \omega_j^{**}, S_j\right) = -I'\left(W_{0j} - \omega_j^{**}\right)U'\left(I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right) + S_j\right) - \Phi'\left(\omega_j^{**}\right)$$

Because of the subsidy, $U'(.)$ is no longer evaluated at the full income level that would pertain under actuarially fair premiums— $I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right)$. Hence we cannot exact mimic our analysis for the marginal individuals. However, since *U* is concave by assumption so that $U''(.) < 0$, we have:

(B-8) $pool\left(W_{0j}, \omega_j^{**}, 0\right) < pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ for inframarginal individuals, and

(B-9) $pool\left(W_{0j}, \omega_j^{**}, 0\right) > pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ for supramarginal individuals.

By the same logic as that preceding equation (B-3), we have:

(B-10) $pool\left(W_{0j}, \omega_j^{**}, 0\right) = -P'\left(W_{0j} - \omega_j^{**}\right)U'\left(I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right)\right)$.

Further, by the logic preceding equation (B-4), we have:

(B-11) $pool\left(W_{0j}, \omega_j^{**}, 0\right) < 0 = pool\left(W_{0j}, \omega_j^*, S_j\right)$.

Combining (B-9) and (B-11), we have:

(B-12) $pool\left(W_{0j}, \omega_j^*, S_j\right) > pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ for supramarginal individuals.

As before, by the second order condition of the pooled premium problem, we have that *pool* is declining in ω: $\dfrac{\partial pool\left(W_0, \omega, S\right)}{\partial \omega} < 0$. Consequently, (B-12) implies that

$\omega_j^{**} > \omega_j^{*}$ for supramarginal individuals. Thus, optimal weight is lower under fair premiums for supramarginal individuals.

By contrast, the combination of (B-8) and (B-11) place no restriction on the relative values of $pool\left(W_{0j}, \omega_j^{*}, S_j\right)$ and $pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ for inframarginal individuals. There are two possibilities (excluding the knife edge equality case):

(B-13) $pool\left(W_{0j}, \omega_j^{**}, 0\right) < pool\left(W_{0j}, \omega_j^{**}, S_j\right) < pool\left(W_{0j}, \omega_j^{*}, S_j\right)$, and

(B-14) $pool\left(W_{0j}, \omega_j^{**}, 0\right) < pool\left(W_{0j}, \omega_j^{*}, S_j\right) < pool\left(W_{0j}, \omega_j^{**}, S_j\right)$.

If (B-13) holds, then $\omega_j^{**} > \omega_j^{*}$ and inframarginal individuals will lose weight in the switch from pooled to fair premiums. Since $pool\left(W_{0j}, \omega_j^{*}, S_j\right) = 0$ for all values of S_j, while $pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ increases with S_j, this is most likely to be true for smaller values of S_j.[19] On the other hand, if (B-14) holds, then $\omega_j^{*} > \omega_j^{**}$ and inframarginal individuals will gain weight in the switch from pooled to fair premiums. This latter case is most likely to be true when the subsidy, S_j, is largest.

A first order Taylor series expansion of the expression for $pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ in (B-7) around $S_j = 0$ lends some intuition for our results:

(B-15)

$$pool\left(W_{0j}, \omega_j^{**}, S_j\right) \approx pool\left(W_{0j}, \omega_j^{**}, 0\right) - I'\left(W_{0j} - \omega_j^{**}\right) U''\left(I\left(W_{0j} - \omega_j^{**}\right) - P\left(W_{0j} - \omega_j^{**}\right)\right) S_j$$

The first term in this approximation, $pool\left(W_{0j}, \omega_j^{**}, 0\right)$, is always negative by (B-11), and represents the pure price effect of a switch from pooled to fair premiums. The second term in the approximation represents the income effect of the switch. Its sign will depend upon whether the subsidy induced by pooling is positive, negative, or zero, since $I'(.) < 0$ and $U''(.) < 0$. For individuals at the margin, there is no subsidy so $S_j = 0$ and no income effect. For them, the switch induces a pure decrease in the price of weight loss, which leads to weight loss. By definition supramarginal individuals, who tend to be heavy, receive positive subsidies under pooling, so $S_j > 0$. For them, the income effect term is negative, which reinforces the negative price effect from the first term. The total effect is negative, and supramarginal individuals will lose weight in the switch. Finally,

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[19] Equation (B-7) implies that $pool\left(W_{0j}, \omega_j^{**}, S_j\right)$ increases with S_j, since the marginal utility of income is declining in income.

inframarginal individuals, who tend to be lighter, receive negative subsidies. For them, $S_j < 0$ and the income effect term in (B-15) is positive. The price and income effects work in opposite directions—the former promotes weight loss in the switch, while the latter promotes weight gain. The model produces no prediction about which effect will dominate.

Appendix C: Estimating the Medical Expenditure Distribution by Body Weight

In this Appendix, we describe how we estimate the distribution of medical care expenditures for obese, overweight, and normal weight individuals in the Medical Expenditure Panel Survey (MEPS) data. Our goal here is to estimate a discrete distribution over medical expenditures, $P(M = \theta_i \mid weight)$, where M is medical expenditures and θ_i, $i = 1 \ldots N$, are the points of support in the distribution. We want a discrete distribution so that our empirical work is consistent with our theoretical treatment. We permit six points of support: {$0, $50, $100, $1,000, $10,000, $50,000}. The probability of expenditures greater than $50,000 for this mostly working age population is small.[20] We estimate this distribution separately for each demographic subgroup in the data. For convenience in the notation, we suppress the conditioning on demographic subgroups.

We start by estimating a standard two-part model of medical expenditures:

(C-1) $P(M > 0) = \Phi(\alpha_0 + \alpha_1 overweight + \alpha_2 obese)$

(C-2) $\ln M = \beta_0 + \beta_1 overweight + \beta_2 obese + \varepsilon$ if $M > 0$

Here, overweight is an indicator of whether an individual in the sample has a BMI between 25 and 30, while obese is an indicator of a BMI over 30. We estimate equation (16) on the entire subgroup, while we estimate equation (17) on the subsample of people who have positive medical expenditures.

We next take our estimates $\hat{\alpha}$ and $\hat{\beta}$ from the two-part model and derive a discrete empirical distribution function for medical expenditures for obese, overweight, and normal weight individuals within each covariate subgroup. We assume that $\varepsilon \sim N(0, \hat{\sigma}^2)$. $\hat{\sigma}^2$ is the estimated variance from the regression in (C-2). Since we estimate equations (C-1) and (C-2) separately for individuals from different covariate subgroup, we are effectively allowing the variance of the error to be heteroskedastic.

Equation (C-1) implies a simple estimate of the probability of zero expenditure:

(C-3) $\Pr(M = 0 \mid weight) = 1 - \Phi(\hat{\alpha}_0 + \hat{\alpha}_1 overweight + \hat{\alpha}_2 obese)$

For $i > 1$, we calculate:[21]

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[20] We have experimented with adding additional points of support above $50,000 with no substantive difference in our final results.

[21] We set θ_7 equal to ∞.

$$P\left(M=\theta_i \mid weight, M>0\right)=P\left(\ln M=\ln\theta_i \mid weight, M>0\right)$$

(C-4) $$\approx P\left(\frac{\ln\theta_i+\ln\theta_{i-1}}{2}<\widehat{\beta}_0+\widehat{\beta}_1 overweight+\widehat{\beta}_2 obese+\varepsilon<\frac{\ln\theta_i+\ln\theta_{i+1}}{2} \mid weight\right)$$

$$=\left\{\begin{aligned}&\Phi\left(\frac{\ln\theta_i+\ln\theta_{i+1}}{2}-\left(\widehat{\beta}_0+\widehat{\beta}_1 overweight+\widehat{\beta}_2 obese\right)\right)\\&-\Phi\left(\frac{\ln\theta_i+\ln\theta_{i-1}}{2}-\left(\widehat{\beta}_0+\widehat{\beta}_1 overweight+\widehat{\beta}_2 obese\right)\right)\end{aligned}\right\}$$

The second step in (C-4) follows from an approximation to the cumulative density function of ε taken at the midpoint of the intervals between the points of support. The third step follows from our normality assumption. The Law of Conditional Probability implies the following identity:

(C-5) $$P\left(M=\theta_i \mid weight\right)=P\left(M=\theta_i \mid weight, M>0\right)P\left(M>0 \mid weight\right)$$

We estimate the first term in (C-5) using the expression in equation (C-4), while we estimate the second term using the expression in equation (C-3). Together, the equations in (C-3) and (C-5) give us empirical estimates of the discretized distribution over medical expenditures, $P\left(M=\theta_i \mid weight\right)$, which is what we set out to find in this appendix in the first place.

Figure 1: Model Timeline

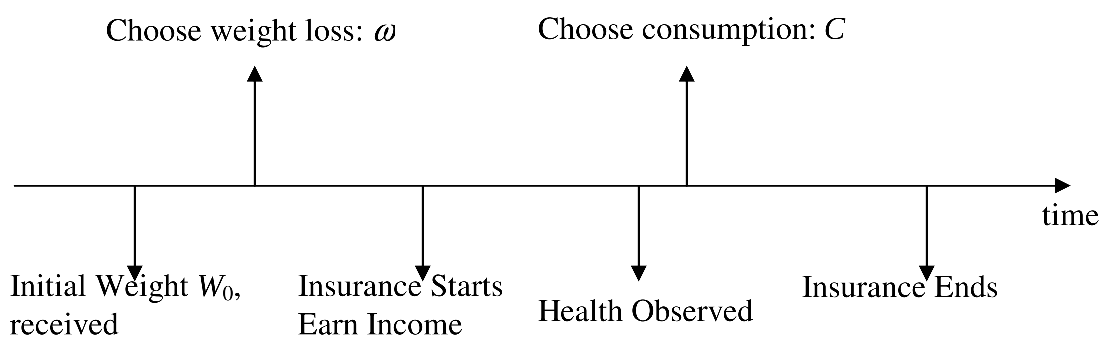


Figure 2: Obesity and the Empirical Medical Expenditure Distribution

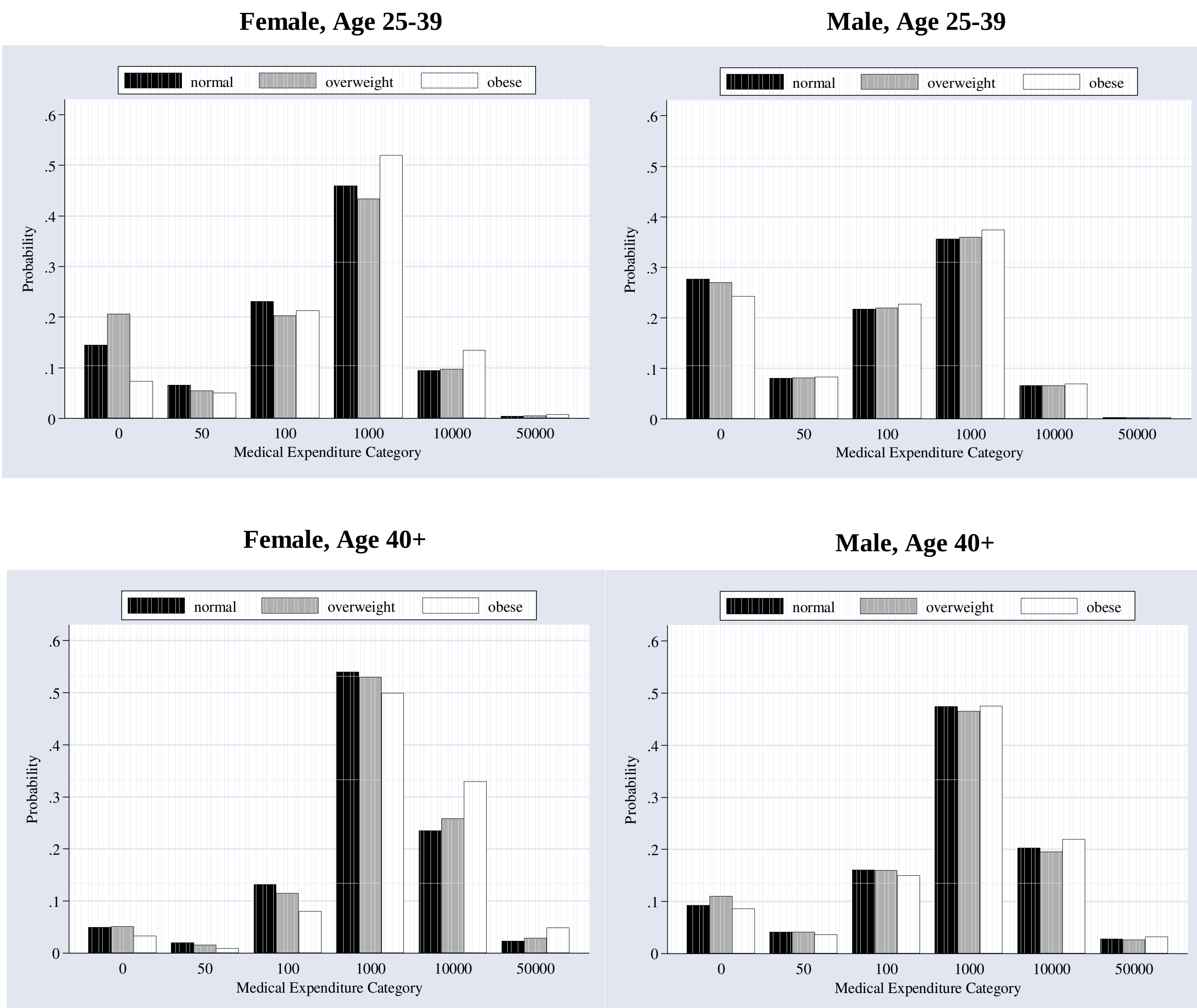
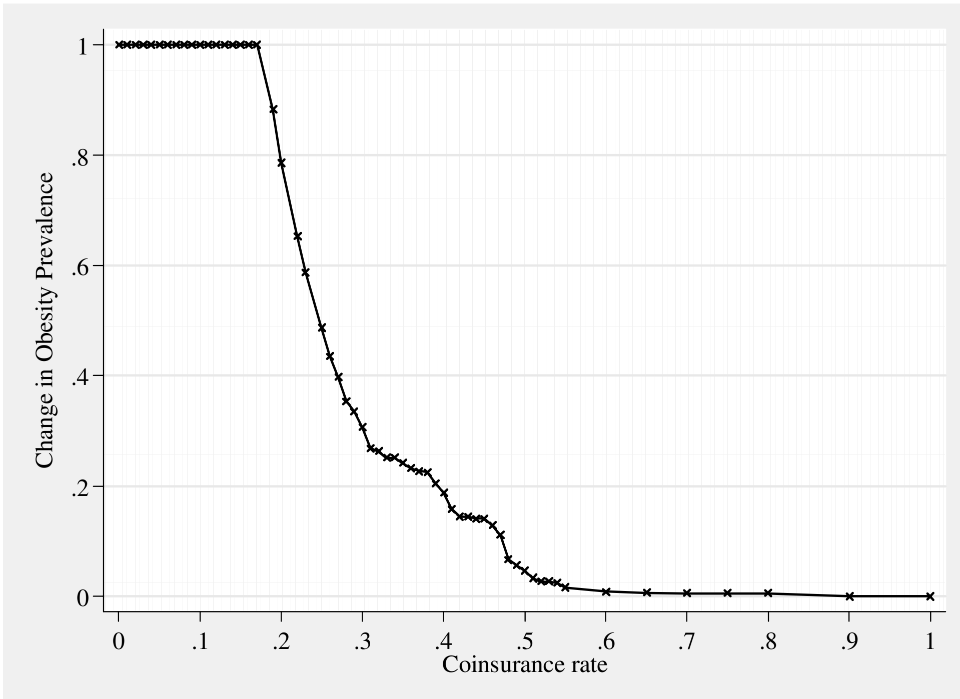


Figure 3: Response to Changes in Copayment Rate

Panel A: Change in Obesity Prevalence (Pooled vs. Actuarially Fair)



Panel B: Welfare Loss from Pooling

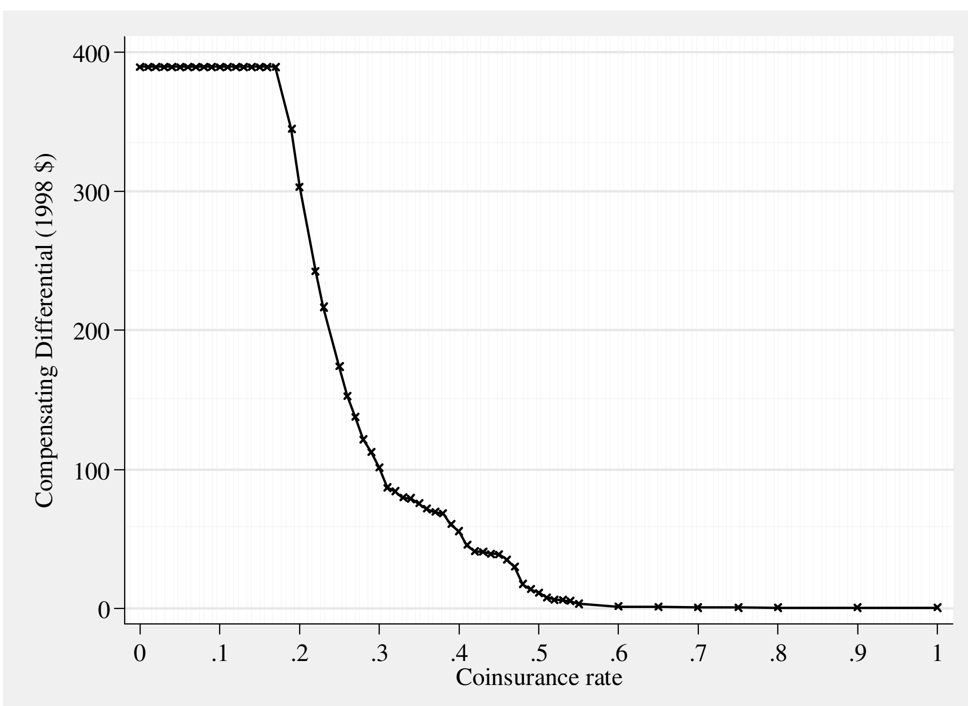
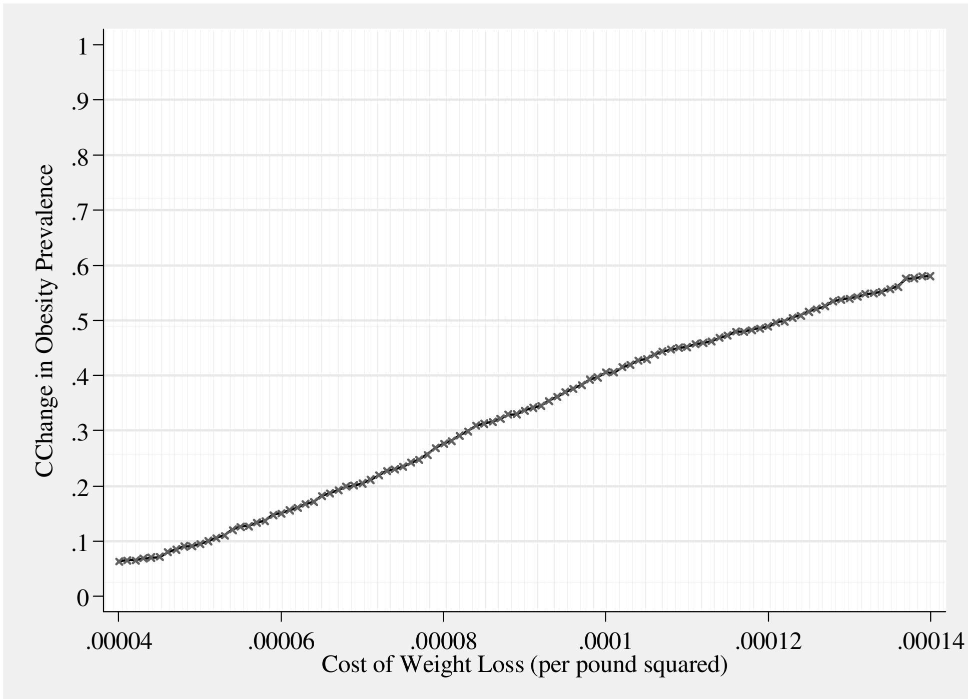


Figure 4: Response to Changes in the Cost of Losing Weight

Panel A: Change in Obesity Prevalence (Pooled vs. Actuarially Fair)



Panel B: Welfare Loss from Pooling

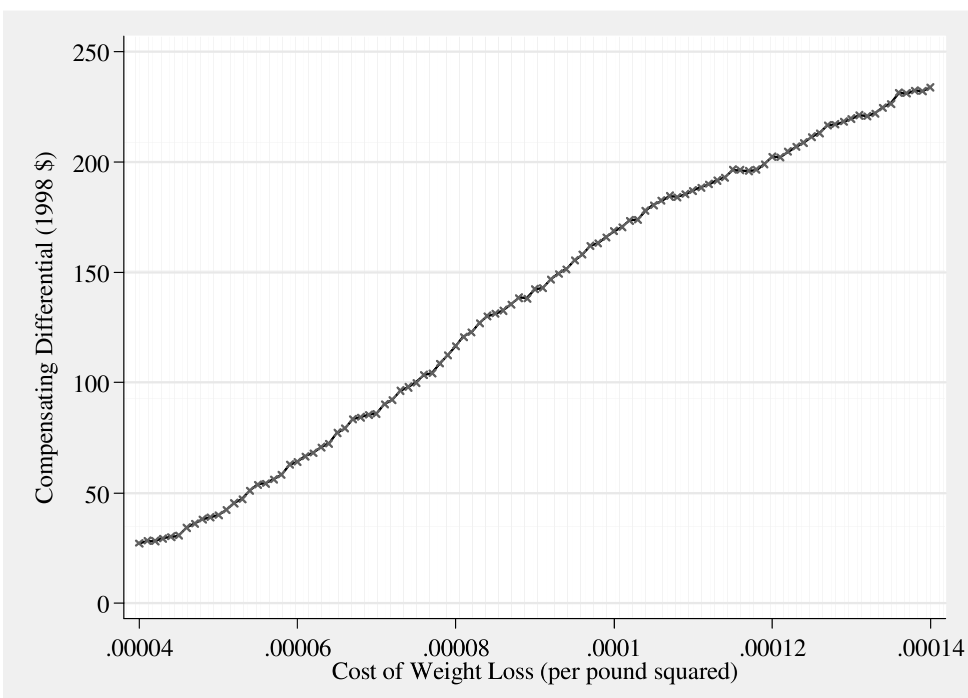


Table 1: Medical Care Expenditures and Demographic Characteristics by Weight

	Normal (BMI 18.5–24.9)	Overweight (BMI 25–29.9)	Obese (BMI > 30)	All BMI Categories
Sample Size	N = 2,962	N = 2,458	N = 1,484	N = 6,904
1998 Expenditures				
Mean	$1,987	$1,976	$2,804	$2,132
Median	$476	$502	$837	$542
Age in years	46.2 yrs	48.2 yrs	48.9 yrs	47.4 yrs
Income	$28,084	$28,968	$26,107	$28,040
Insurance				
Private	60.7%	61.5%	57.0%	60.3%
Medicaid	4.9%	3.8%	7.9%	5.1%
Medicare	19.0%	20.8%	21.5%	20.1%
Uninsured	15.4%	13.9%	13.6%	14.5%

Source: Authors calculations using linked 1998 MEPS-1996/7 NHIS population.

Table 2: Welfare Loss from the Obesity Externality

	Change in Distribution of Weight Due to Pooled Premiums			Welfare Loss from Obesity Externality (*Y*)
Group	**Normal**	**Overweight**	**Obese**	
Age 25-39				
Males	-5%	-9%	14%	$7
Females	0%	-16%	16%	$78
Age 40+				
Males	0%	-19%	19%	$80
Females	-7%	-14%	21%	$304
All Groups	-3%	-15%	19%	$149

Appendix Table 1: Estimated Utility Cost of Weight Loss

Group	Cost of Weight Loss (γ)
Age 25-39	
Males	0.000009
Females	0.000140
Age 40+	
Males	0.000081
Females	0.000449