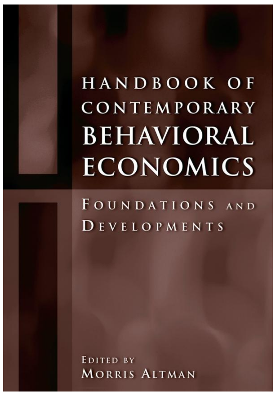

Handbook of Contemporary Behavioral Economics Foundations and Developments

Morris Altman

Rational Health-Compromising Behavior and Economic Intervention

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CHAPTER 28

RATIONAL HEALTH-COMPROMISING BEHAVIOR AND ECONOMIC INTERVENTION

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Health-compromising (HC) behaviors are behaviors practiced by people that undermine or harm their current or future health (Taylor 1995, ch. 6). Alcohol consumption, smoking, and use of psychoactive substances, all of which bear potential for dependency and addiction, are the most important HC behaviors, accounting for hundreds of thousands of deaths annually and billions of dollars in economic loss and treatment costs. Yet the range of HC behaviors is much wider, involving junk food consumption, excessive eating, insufficient sleep, driving at excessive speed, engaging in unsafe sex, lying in the sun on the beach, chatting on a cellular phone, delaying medical care, not adhering to doctors' orders, or attempting suicide. Although HC behaviors are traditionally considered to lie within the domain of psychologists, they have recently attracted the interest of economists, who have applied optimization techniques to show that HC behavior may be consistent with rational behavior, that is, that people may rationally choose to engage in activities that are harmful to their health. While psychologists stress treatment and reeducation as means of achieving behavioral changes, economists emphasize the role of incentives.

This essay surveys the growing economic literature on HC behaviors, highlighting the insights gained by economists with regard to their determinants and to possible economic interventions. The essay focuses on theoretical contributions only, placing special emphasis on the modeling of rational addiction, which has gained most of the attention in the literature. Other topics include rational harmful (excessive or cholesterol-rich) nonaddictive eating, rational engagement in unsafe sexual activity, rational delay in seeking medical diagnosis, and rational mental disorders (agoraphobia and insomnia). Because this handbook includes an essay on the economics of suicide (see Yang and Lester, this volume), the present survey abstains from reviewing this subject.

RATIONAL HARMFUL ADDICTION

Addiction to harmful goods such as drugs, tobacco, caffeine, or alcohol is undoubtedly the most researched topic of rational HC behavior. A review of EconLit reveals more than a hundred articles and a number of volumes on the subject. The seminal and most influential paper in this area is Becker and Murphy (1988), although related contributions had already appeared earlier or at the same time (e.g., Becker and Stigler 1977; Winston 1980; Iannaccone 1986; Michaels 1988; Lee 1988; Barthold and Hochman 1988; Leonard 1989). Most of the literature that followed has been devoted to empirical testing of the major theoretical prediction of Becker and Murphy's model, which is that even addicts negatively respond to a change in price (e.g., Chaloupka 1991; Becker, Grossman, and Murphy 1994; Waters and Sloan 1995; Olekalns and Bardsley 1996;

Grossman and Chaloupka 1998; Keeler 1999; Baltagi and Griffin 2002). Several contributions have interpreted, enriched, or offered simplified versions of the model (e.g., Becker, Grossman, and Murphy 1991; Orphanides and Zervos 1995; Skog 1999; Ferguson 2000; Gruber and Koszegi 2001), whereas others have suggested different theoretical approaches that highlight different aspects of addictive behavior (e.g., Frank 1996; Guth and Kliemt 1996; Suranovic, Goldfarb, and Leonard 1999; Jones 1999; Cameron 2000; Yuengert 2001; Boymal 2003).

This section reviews the two major approaches to modeling rational addiction in the economic literature: the reinforcement approach (introduced by Becker and Murphy 1988), which views the stimulating effect that past consumption has on current consumption as the key feature of addiction, and the withdrawal cost approach (introduced by Suranovic, Goldfarb, and Leonard 1999), which views as the key feature the discomforts and psychic effects experienced by addicts when attempting to reduce their addiction or quit altogether. Both approaches perceive addiction as the outcome of consumer choice. Both define addiction as rational if it involves forward-looking maximization (with stable preferences), that is, if in deciding on addictive consumption, a utility-maximizing consumer also considers the harmful consequences that current behavior might have on his or her future health (e.g., liver damage, lung cancer). Both seek to explain not just how addiction is initiated and sustained but also how it eventually ends.

The Reinforcement Approach

Becker and Murphy consider a consumer whose instantaneous utility function at time t is strictly concave with respect to three arguments:

$$U(t) = U[x(t), c(t), S(t)] \tag{1}$$

where $x(t)$ is the consumption of the (potentially) addictive good at time t, $c(t)$ is the consumption of a nonaddictive (composite) good, and $S(t)$ is the stock of "addictive capital," built up as a result of past consumption of the addictive good. The marginal utilities of x and c are assumed to be positive (i.e., $U_x > 0$ and $U_c > 0$), but the marginal utility of S is negative (i.e., $U_S < 0$), implying that greater past consumption of the addictive good lowers current utility. Becker and Murphy argue that this assumption captures the "tolerance" aspect of addiction, which means that given levels of current consumption are less satisfying the greater the level of past consumption. However, the negative impact of S on current utility may also reflect the recognition that addiction is harmful to the consumer's health.[1] The motion equation for addictive capital is

$$\dot{S}(t) = x(t) - \delta S(t) \tag{2}$$

where $\dot{S}(t)$ denotes the change in S at time t and δ is an instantaneous depreciation rate which measures the exogenous rate of disappearance of the mental and physical effects of past consumption. That is, the change in the capital stock at time t is the difference between current consumption and the exogenous depreciation on past consumption. Becker and Murphy also allow for expenditure on endogenous depreciation to reduce the stock of capital, which, for simplicity, is ignored here.

But addiction is not merely the accumulation of a harmful capital. Becker and Murphy's perception of addiction also involves the notion of "reinforcement," which means that greater past consumption increases the desire for current consumption. A necessary prerequisite for this behavior is that an increase in past consumption raises the marginal utility of current consumption (i.e. $U_{xS} > 0$). While this assumption is sufficient for reinforcing the current consumption of a myopic consumer, it is insufficient for doing so in the case of a *rational* consumer, who must also consider the future harmful consequences of his or her current behavior. For him or her, reinforcement requires that the positive effect of an increase in S on the marginal utility of x exceed the negative effect of greater x on future utility. Becker and Murphy seek conditions for the fulfillment of this requirement, which implies that even a rational consumer may become addicted.

Assuming a time-additive utility function, an infinite lifetime, and a constant rate of time preference, σ, the consumer is now allowed to maximize his or her lifetime utility function

$$V(0) = \int_0^\infty e^{-\sigma t} U[x(t),\ c(t),\ S(t)]dt \tag{3}$$

subject to the motion equation for addictive capital (equation 2) and the budget constraint (assuming perfect capital markets)

$$\int_0^\infty e^{-rt}[c(t) + p_x(t)x(t)]dt = Z(0) \tag{4}$$

where $c(t)$ is the numeraire with a constant price over time, $p_x(t)$ is the price of the addictive good at time t, r is a constant-over-time interest rate, and $Z(0)$ is the discounted value of the consumer's lifetime income and assets. Becker and Murphy assume that future earnings (which are part of Z) are negatively dependent on S, but this assumption has no qualitative implications in the model (it just gives rise to an additional adverse effect of current consumption on future well-being) and is therefore ignored here. Maximizing lifetime utility with respect to $x(t)$ and $c(t)$ yields the optimum conditions

$$U_x(t) = \mu p_x(t)e^{(\sigma-r)t} - \int_t^\infty e^{-(\sigma+\delta)(k-t)} U_S(k)dk = \Pi_x(t) \tag{5}$$

$$U_c(t) = \mu e^{(\sigma-r)t} \tag{6}$$

where μ is a Lagrange multiplier for the budget constraint (interpreted as the marginal utility of wealth). The term $\Pi_x(t)$ is the full price of the addictive good, consisting of two components: the market price of the good and the (discounted) future utility cost of consuming an additional unit of the good incurred due to the resulting increase in the addictive stock. Because $U_S(t)$ is negative, the full price of the addictive good is greater than its market price. Hence, a rational utility maximizer will consume less of the addictive good than he or she would if he or she were a myopic consumer who ignores the future consequences of his or her current behavior. As intuitively expected, the greater the rate of preference for the present (σ) or the depreciation rate on past consumption (δ), the lower the full price of the addictive good and the greater its consumption.

It is easily seen from optimum condition 5 that if addictive capital rises over time, reinforcement emerges only if the marginal utility of the addictive good rises more than its full price. Becker and Murphy now use a quadratic utility function (in x and S) to further investigate this requirement, showing (under the assumption of $\sigma = r$) that a necessary and sufficient condition for reinforcement is

$$(\sigma + 2\delta)U_{xS} > -U_{SS} \tag{7}$$

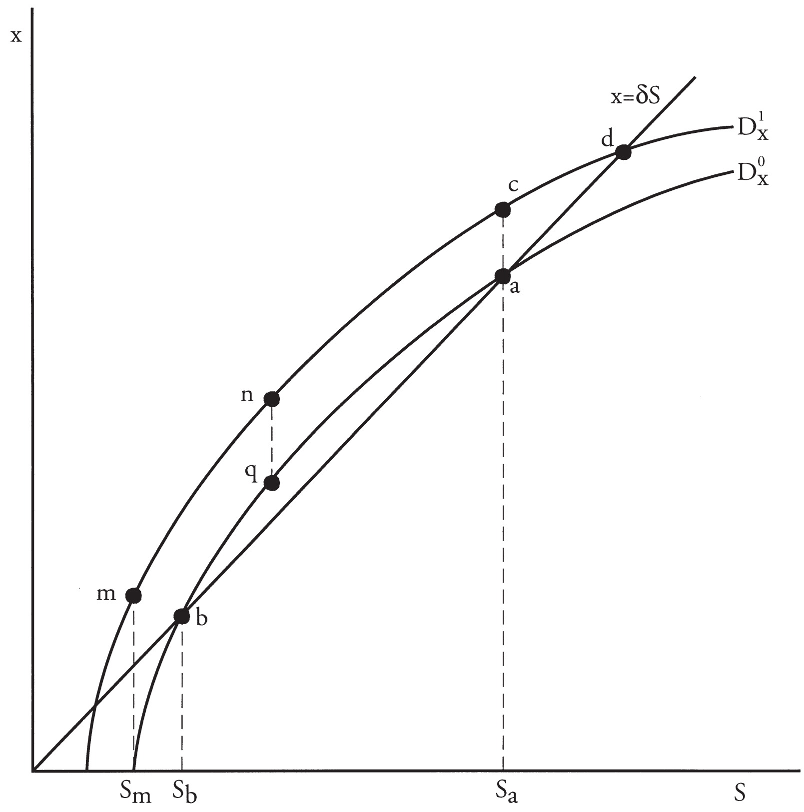
If condition 7 is satisfied, the consumer is said to be *potentially* addicted. This is so because actually becoming addicted requires a mechanism that triggers an increase in S. Clearly, $U_{xS} > 0$ is necessary to satisfy condition 7 if tolerance increases with S (i.e., if $U_{SS} < 0$). It also follows from condition 7 that the consumer is more likely to become potentially addicted the more heavily he or she discounts the future (i.e., has a higher σ) or the more rapidly addictive capital depreciates (i.e., has a larger δ). This is so because in the former case he or she is paying less attention to the future consequences of current behavior, whereas in the latter case current behavior has a smaller effect on the future.

Reinforcement implies that over time x varies in the same direction as S. However, the motion equation for addictive capital (equation 2) reveals that S may also remain steady over time. This will happen if $\dot{S} = 0$, or if current consumption of the addictive good, $x(t)$, equals the depreciation of past consumption, $\delta S(t)$. In this case, known as a steady (or a stationary) state, current consumption will remain constant as well. Figure 28.1 depicts the stationary locus of x and S (i.e., all combinations of x and S satisfying $x = \delta S$) as a straight line from the origin (with slope δ). Figure 28.1 also depicts the demand for current consumption (derived from the optimum conditions 5–6) as a function of addictive capital for a potentially addicted consumer with a cubic utility function (curve D_x^0). An intersection between the D_x^0 curve and the stationary locus reflects a steady-state choice, which may be stable or not. A quadratic utility function, under which condition 7 has been derived, would yield a linear demand curve that could only result in a single steady state. But Becker and Murphy use the quadratic utility function only as an approximation (near a steady state) to a higher-order utility function, such as the cubic utility function. The latter can be shown to generate a demand curve with decreasing marginal rates and consequently to produce two steady states, one stable (point a) and one unstable (point b).

Figure 28.1 may now be used to illustrate that whether or not a potentially addicted consumer actually becomes addicted depends on his or her initial stock of addictive capital and the position of his or her demand curve. Given the demand curve D_x^0, suppose first that the addictive stock is below S_b. Current consumption will then lie below the stationary line ($x = \delta S$), implying that $\dot{S} < 0$. Consequently, both S and x will decrease over time until the consumer fully abstains from consuming the addictive good. However, if the addictive stock is between S_b and S_a, current consumption will lie above the stationary line, exceeding the depreciation of the capital stock. Consequently, $\dot{S} > 0$, implying that both S and x will increase over time, converging eventually to a long-run equilibrium at point a. A rational consumer will therefore end up at the stable steady state where he or she keeps consuming sizable quantities of the addictive good.

But how does a rational consumer happen to accumulate an addictive stock greater than S_b? Becker and Murphy argue that stressful life events, acting like an exogenous shock, may help establish that level of addictive capital by temporarily raising the consumer's demand for current consumption. To understand this, suppose that the consumer is initially at S_m, where he or she entirely abstains from consuming the addictive good. Suppose further that following a stressful life event (e.g., the death of a loved one), the consumer's demand curve shifts upward from D_x^0 to

Figure 28.1 **Demand for Current Consumption and the Effect of a Fall in Price (or of a Stressful Life Event)**



$D_x{}^1$. Consumption then rises abruptly to point *m,* which lies above the stationary line. As time progresses and stress continues, current consumption rises further, as the consumer moves upward along the $D_x{}^1$ curve. At some point *n* stress supposedly ceases. Consequently, consumption drops down to point *q* on the no-stress curve $D_x{}^0$. Unfortunately, the consumer has now accumulated addictive capital greater than S_b, sufficient to ensure his or her convergence to the stable steady state at point *a.*

Being hooked at the steady state for a while, suppose now that a favorable life event (e.g., finding a job) shifts the consumer's demand curve downward. If, by the time the temporary effects of the favorable event disappear and the demand curve shifts back to $D_x{}^0$, the addictive stock has fallen to a level between S_b and S_a, consumption will converge back to the steady state at point *a.* However, if the addictive stock has fallen to a level below S_b, the consumer will move away from the unstable steady state at point *b* toward abstention. Overall, he or she will move from being strongly addicted to quitting consumption altogether. If reinforcement is very powerful below S_b (i.e., if the demand curve is very steep at this interval) the consumer will quit his or her addiction cold turkey (laying off the addictive good abruptly). In fact, the model implies that strong addiction can only end cold turkey. Becker and Murphy view the unstable steady state as an important part of their analysis, because it helps explain why the same consumer is sometimes heavily addicted to a harmful good while at other times abstains completely.

The major predictions of the Becker and Murphy model concern the consumer's response to a change in the price of the addictive good. Suppose that the consumer is initially in a steady state equilibrium at point *a* and consider a permanent and unanticipated fall in p_x. This would shift the demand curve for *x* upward, from D_x^0 to D_x^1. Consequently, point *a* would no longer be an equilibrium point. Current consumption would first increase from point *a* to point *c,* and then, because point *c* lies above the stationary line, would grow further over time toward a new steady-state equilibrium at point *d.* Hence, a rational addict does respond to a change in price, and to a greater extent in the long run, because in the short run addictive capital is fixed. Furthermore, the steeper the demand curve, the greater the long-run response to a price change. Since reinforcement is stronger when the demand curve is steeper, strong addictions, contrary to intuition, do not imply weak price responses. These predictions of the Becker and Murphy model have been confirmed empirically over a wide range of addictive goods, suggesting that consumption can effectively be reduced, in both the short and long runs, through increasing the price of the addictive good via, for instance, the imposition of a consumption tax.

The Withdrawal Cost Approach

Contrary to Becker and Murphy, who entirely ignored the discomforts and psychic effects experienced by addicts when attempting to reduce their consumption or quit altogether, Suranovic, Goldfarb, and Leonard view the withdrawal effects as the key feature of addiction, arguing that repetitive (and even increasing) usage of a good over time is not sufficient to call its consumption an addiction. Rather, addiction requires that the consumer would wish to reduce or cease his or her habitual consumption but is unable to do so without a considerable cost. By explicitly recognizing the existence of withdrawal costs, Suranovic, Goldfarb, and Leonard seek to explain why addicts may wish to do one thing (quit their addiction) but choose another (remain addicted).

Suranovic, Goldfarb, and Leonard assume that the effects of addictive consumption at a given age can be decomposed into three additively separable components: current benefits (B), future losses (L), and withdrawal costs (C). Current benefits reflect relaxation and other pleasurable effects produced by consuming the addictive good, *x,* and are assumed to increase with *x* at a decreasing rate. That is, $B = B(x)$, where $B'(x) > 0$ and $B''(x) < 0$. Still, current consumption is detrimental to future health. Suranovic, Goldfarb, and Leonard assume that the harmful effects of addiction occur in the distant future and take the form of reduced life expectancy. Specifically, every unit of the addictive good (consumed at present or in the past) is assumed to reduce life expectancy by a fixed amount, α. Current consumption thus reduces life expectancy by αx. Future losses from current consumption are captured by the present value of the utility loss resulting from a shorter life expectancy, and are shown to increase with *x* at an increasing rate. That is, $L = L(x)$, where $L'(x) > 0$ and $L''(x) > 0$.

Withdrawal costs are assumed to arise if consumption is reduced below some habitual consumption level, x_h. They depend on past consumption history, *H,* and current consumption, *x.* There are no withdrawal costs when consumption is greater than (or equal to) the habitual level. That is, $C = C(x, H)$ for $x < x_h$, but $C = 0$ for $x \geq x_h$. The greater the fall in consumption below the habitual level, the greater the discomforts and psychic effects of withdrawal, hence $C_x < 0$. The sign of C_{xx} reflects the degree of addiction: if $C_{xx} > 0$, addiction is said to be weak, because a slight reduction in consumption below the habitual level will not hurt the consumer considerably; however, if $C_{xx} < 0$, addiction is said to be strong, because even a slight reduction in consumption will have painful effects.

Rather than following Becker and Murphy in assuming that the consumer chooses a consumption path over time to maximize his or her lifetime utility, Suranovic, Goldfarb, and Leonard allow the consumer to choose his or her current consumption only, releasing him or her from the duty of making "the superhuman calculations that are necessary to form a fully consistent lifetime consumption path." Subtracting L and C from B, the expected utility from current consumption of x is given by $U(x) = B(x) - L(x) - C(x)$. However, utility is also derived from the consumption of a composite good, z. The consumer is thus assumed to choose x and z so as to maximize his or her overall utility from both goods

$$W(x, z) = U(x) + V(z) \tag{8}$$

subject to the budget constraint

$$p_x x + p_z z = I \tag{9}$$

where p_x and p_z are the prices of x and z, respectively, and I is current income. The first-order conditions for utility maximization are

$$U'(x) - \mu p_x = 0 \tag{10}$$

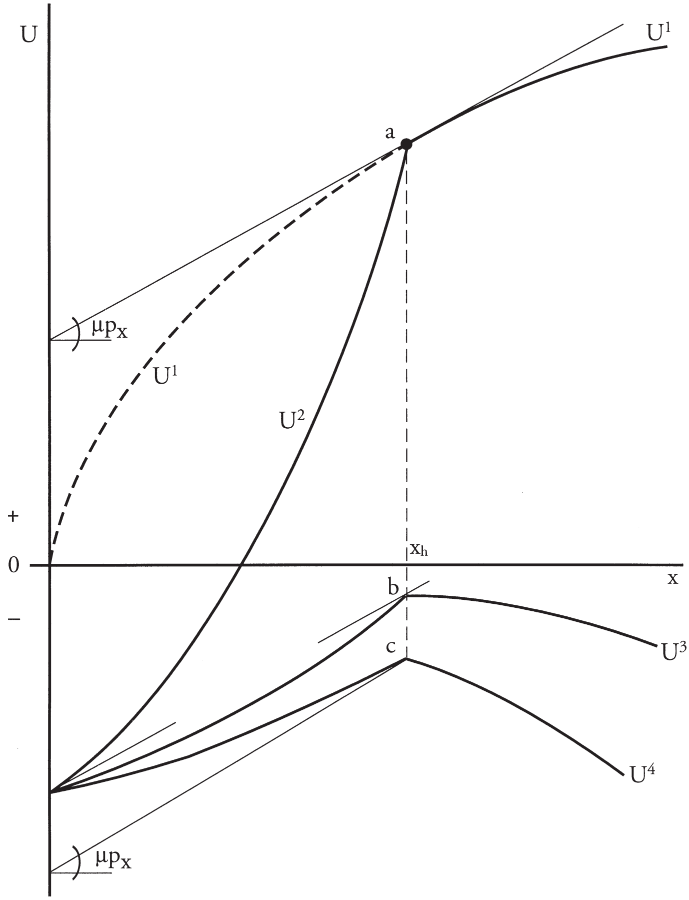
$$V'(z) - \mu p_z = 0 \tag{11}$$

where μ is the Lagrange multiplier of the budget constraint (i.e., the marginal utility of income).

To induce consumption of the addictive good, the marginal utility, $U'(x)$, must be greater than the marginal cost, μp_x, at $x = 0$. This requires that $B'(x)$ be sufficiently large at this point. Suranovic, Goldfarb, and Leonard assume that some exogenous shock, such as sudden exposure to other users, initiates a new consumer's interest in experimenting with the addictive good and brings about a sufficiently large increase in current marginal benefits. Figure 28.2 depicts the new consumer's equilibrium at point a, where the marginal utility from consuming the addictive good (i.e., the slope of the utility curve U^1) equates the marginal cost. Contrary to the Becker and Murphy model, there is no reinforcement effect to increase the marginal utility of future consumption. However, as time goes by, the consumer establishes a consumption history, and withdrawal costs develop. This causes the utility curve to shift downward, from U^1 to U^2, for all consumption levels below x_h (there are no withdrawal costs above x_h), producing a kink at point a. Consequently, $U'(x) > \mu p_x$ at this point (evaluated from the left), which may help explain why the addictive good is habit-forming: a small increase in price will no longer reduce consumption, establishing x_h as the habitual consumption level.

Suranovic, Goldfarb, and Leonard now argue that as the consumer gets older, future losses increase, because the discount factor used to weight end-of-life utility rises as one approaches his or her terminal date. Assuming that the benefit and cost functions remain unchanged, the utility curve shifts downward for all x. This is shown to happen along with a reduction in slope at each consumption level. Figure 28.2 demonstrates that even if the utility curve falls as low as U^3, implying that the utility gained from consuming the addictive good is negative, optimum consumption may still be obtained at the habitual level, x_h, where the marginal utility, evaluated from the left of point b, exceeds the marginal cost (notice, on the other hand, that the optimum may also be zero consumption). However, when the utility curve shifts further down with age to U^4, the

Figure 28.2 **Consumer's Equilibrium Under Strong Addiction**



consumer will unhesitatingly move away from his or her habitual consumption at point *c,* terminating the addiction cold turkey.

Figure 28.2 is drawn under the assumption that addiction is strong (i.e., that $C_{xx} < 0$): since withdrawal costs rise rapidly for slight reductions in consumption below the habitual level, strong addiction results in a convex shape of U^2. As in the Becker and Murphy model, strong addiction is required to terminate an addiction cold turkey. However, contrary to the Becker and Murphy model, the Suranovic, Goldfarb, and Leonard model generates this result without relying on an exogenous shock. Rather, it occurs when future losses from consuming the addictive good, net of current benefits, become more painful than the discomforts associated with abrupt quitting. Suranovic, Goldfarb, and Leonard also show that for a weak addiction (i.e., for $C_{xx} > 0$), the U^2 curve has a concave shape, which leads to a gradual reduction of consumption over time, a result not captured by the Becker and Murphy model. Furthermore, as noted before, total utility from consuming the addictive good at the optimal level may become negative with age. This means that the consumer would have preferred to cease consumption and attain zero utility, but he or she is unable to do so without a considerable cost. Quitting addiction is worse than staying addicted, since it would result in an even lower utility level. Consequently, the utility-maximizing consumer becomes trapped in his or her own choices, continuing the addictive consumption while at the same time wishing he or she did not. Suranovic, Goldfarb, and Leonard point out that this consumer is an "unhappy addict," unlike the Becker and Murphy counterpart, who seems to be happy with the addiction. Becker and Murphy claim that this is not necessarily so because addiction may be triggered by unhappy life events, in which case the addict is clearly unhappy and would be even more so if he or she was prevented from consuming the addictive good. Still, the Suranovic, Goldfarb, and Leonard model does not require an exogenous shock to generate an unhappy addict; all it needs is explicit recognition in the role played by withdrawal costs.

How would a Suranovic, Goldfarb, and Leonard consumer respond to the imposition of a consumption tax? If the consumer has already established consumption history sufficient to develop withdrawal costs, a kink will emerge in his or her utility curve at the habitual level, x_h. Consequently, small increases in price may not affect his or her consumption. However, a consumer that has just begun consuming the addictive good (and has not yet developed quitting costs) may reduce consumption or quit altogether. A consumer who is just about to start (for whom $U'(0) \geq \mu p_x$) may not. A longtime consumer who is in the process of gradual quitting (in case of weak addiction) may reduce consumption more rapidly, and a longtime consumer who is about to quit cold turkey (in the case of strong addiction) may quit sooner. In the aggregate, the Suranovic, Goldfarb, and Leonard model thus predicts responsiveness to price changes (consistent with aggregate empirical results), even though some consumers may not respond at all.

RATIONAL HARMFUL EATING

Two recent papers, appearing approximately at the same time, address rational nonaddictive HC eating. Levy (2002a) considers the trade-off between satisfaction from overeating and the risk to life due to overweight. Yaniv (2002a) considers the trade-off between satisfaction from cholesterol-rich eating and the risk of heart attack due to artery narrowing. Both papers view the risk as emerging from deviating from some critical (healthful) value: physiologically optimal weight in the former case, and a prescribed low-cholesterol diet in the latter. Both papers apply an optimal control approach to the consumer's problem of selecting a consumption path that maximizes lifetime expected utility, showing that overweight or failure to adhere to a low-cholesterol diet may be the result of rational choice.

Overeating

Levy (2002a) considers a consumer whose utility, $U(t)$, at any instant of time, t, is a strictly concave function of food consumption, $c(t)$, perceived as a single homogenous argument. Hence $U(t) = U[c(t)]$, where $U_c > 0$ and $U_{cc} < 0$. Food consumption contributes to weight, $W(t)$, which may deviate from the physiologically optimal weight, W^*. The larger the deviation from the physiologically optimal weight, the higher the risk to life. Levy assumes that the cumulative probability of dying by the end of time t rises with the quadratic deviation of $W(t)$ from W^*, allowing for both overweight and underweight to be causes of death. Consequently, the probability of staying alive beyond time t, $\varphi(t)$, diminishes with $[W(t) - W^*]^2$. It is also assumed to be concave in this argument, which, together with the concavity of the utility function, is necessary to ensure the existence of an interior solution to the consumer's problem.

The consumer is assumed to choose a food consumption path over time that maximizes the present value of his or her lifetime expected utility

$$J = \int_0^T e^{-\rho t} \varphi \{[W(t) - W^*]^2\} U[c(t)] dt \tag{12}$$

where ρ is a constant rate of time preference and T is an upper bound on life expectancy. The maximization problem is subject to the motion equation for weight

$$\dot{W}(t) = c(t) - \delta W(t) \tag{13}$$

where δ is a constant rate by which weight is reduced through burning calories in various activities and $\dot{W}(t)$ is the change in weight at time t, resulting from the opposing processes of gaining weight through consuming food and losing weight through burning calories.

Applying the optimal control technique, with λ as the shadow price of weight (in utility units), the solution for the consumer's problem involves the maximization of the Hamiltonian (omitting the time notation), $H = \varphi[(W{-}W^*)^2]U(c) + \lambda(c{-}\delta W)$. The necessary conditions for this maximization are $H_c = 0$ and $\dot{\lambda} = -H_W + \rho\lambda$, implying, respectively, that

$$\lambda = -\varphi[(W - W^*)^2]U_c \tag{14}$$

$$\dot{\lambda} = -\varphi_W[(W - W^*)^2] + (\rho + \delta)\lambda \tag{15}$$

where $\dot{\lambda}$ denotes the change in the shadow price over time, reflecting its evolution along the optimal consumption path. Because weight is assumed to be a bad, the shadow price, which is the subjective valuation that the consumer places on an additional unit of W, is negative. The necessary conditions for maximum lifetime expected utility also include the weight motion equation 13 and the transversality condition, $\lambda(T)W(T) = 0$, which requires that at the end of the planning horizon the shadow price of weight is zero.

Differentiating now equation 14 with respect to t, equating the result with equation 15 to cancel $\dot{\lambda}$ and substituting equation 14 for λ, the optimal food consumption and weight paths over time are found to satisfy

$$\frac{U_{cc}}{U_c}\dot{c} + \frac{\varphi_W}{\varphi}\left(\dot{W} - \frac{U}{U_c}\right) = \rho + \delta \tag{16}$$

At this point, Levy retreats to specific utility and probability functions, assuming $U = c^{\beta}$, where $0 < \beta < 1$, and $\varphi = \varphi_0 e^{-\mu(W-W^*)^2}$, where $0 < \varphi_0 < 1$ indicates the probability of surviving beyond time t if having the physiologically optimal weight ($W = W^*$) and $\mu > 0$ is the rate by which departure from W^* reduces the probability of survival. Substituting these functions and their derivatives into equation 16 and setting $\dot{c} = \dot{W} = 0$, the stationary values of c and W must satisfy $c(W{-}W^*) = (\rho + \delta)/2\mu$. Substituting now δW for c (since $\dot{c} = 0$) yields a quadratic equation in W, the solution of which reveals immediately that $W > W^*$. Hence, the rationally optimal weight at the steady state is greater than the physiologically optimal weight, the difference indicating the consumer's rationally optimal level of overweight. This level is shown to increase with β (i.e., the greater the satisfaction from eating) and with ρ (i.e., the smaller the concern for the future) and to fall with δ (i.e., the greater the rate of calories burning) and with μ (i.e., the greater the rate of decline in the probability of survival due to a marginal deviation from the physiologically optimal weight).

However, Levy shows that the stationary level of overweight is unstable: there is actually no convergence to the steady state but rather explosive oscillations around it, which is consistent with the observed phenomenon of binges followed by strict diets. Using a phase-plane diagram of food consumption and weight to graphically trace their optimal paths over time, he illustrates that there is also the possibility of a chronic decline in food consumption and weight in a late stage of life, which might lead to fatal underweight. Extending the model to the case where sociocultural norms of appearance exist, the stationary weight of a fat consumer is found to be lower and that of a thin consumer higher than would be the case in the absence of such norms.

Cholesterol-Rich Eating

Yaniv (2002) considers a consumer, who, at any instant of time, t, may spend his or her disposable income on the consumption of cholesterol-rich products, $c(t)$, and cholesterol-free products, $h(t)$, and whose instantaneous utility function, $U(t) = U[c(t), h(t)]$, diminishingly increases in both products (i.e., $U_c > 0$, $U_h > 0$, $U_{cc} < 0$, $U_{hh} < 0$). For any given allocation of income between the two products, the instantaneous marginal utility from cholesterol-rich products is assumed to exceed the instantaneous marginal utility from cholesterol-free products (i.e., $U_c > U_h$), implying that the former are more satisfying than the latter. Following, however, a blood test that reveals above-normal values of cholesterol in his or her blood, the consumer is advised by a physician to stick to a low-cholesterol diet under which cholesterol-rich products do not exceed a certain quantity, $\bar{c}$. Consuming cholesterol-rich products in excess of $\bar{c}$ bears the risk of suffering a heart attack in the future due to the narrowing of the arteries that supply blood to the heart. Let $F(t)$ represent the probability that an attack will occur by some time t in the future, and $\dot{F}(t)$ - the probability that an attack will occur exactly at time t. Suppose that the hazard rate, $\dot{F}(t) / [1 - F(t)]$, which is the probability of undergoing a heart attack at some time t in the future, *given that a heart attack has not occurred prior to that time,* is an increasing, convex function of high-cholesterol consumption and of a number of external risk factors, denoted by S, such as high blood pressure, diabetes, smoking, stress, genetic predisposition, etc. That is, $\dot{F}(t) / [1 - F(t)] = \lambda[c(t), S]$, where $\lambda_c > 0$ and $\lambda_S > 0$.[2] For simplicity, it is assumed that adhering to the prescribed diet eliminates the risk of a heart attack, hence $\lambda(c, S) = 0$ for $c \le \bar{c}$.

If the consumer suffers a heart attack at some time t in the future, he or she is assumed to either die, with probability g, or receive lifesaving treatment and completely recover. Treatment costs, by assumption, are fully covered by health insurance, and loss of income during recovery is fully compensated by sick-pay benefits. Hence, the only major harm caused to the consumer if he or she does not die from an attack is the psychological shock accompanying the dreadful event (which involves hospitalization in a coronary care unit), K. Suppose, however, that the psychological shock is sufficiently intense to induce the consumer to strictly adhere to the prescribed diet, $\bar{c}$, thereafter.

The consumer must now decide whether or not to adhere to the prescribed diet, and if not, by how much to deviate from the physician's prescription. A rational consumer would decide on these questions through maximizing the present value of his or her expected lifetime utility stream from the consumption of cholesterol-rich and cholesterol-free products, taking into account the adverse effect of high cholesterol intake on the risk of a heart attack and its psychological and possibly deadly consequences. This may be viewed as a problem in optimal control, formulated as

$$\text{Max} \int_0^\infty e^{-\delta t} \{[1 - F(t)]U[c(t), h(t)] + F(t)\,(1 - \gamma)\bar{U} - \dot{F}(t)\,K\}dt \tag{17}$$

$$\text{subject to: } \dot{F}(t) = [1 - F(t)]\lambda\,[c(t), S] \tag{18}$$

$$\text{and: } h(t) = Y - c(t),\ c(t) \geq \bar{c} \tag{19}$$

where d is the discount rate of future utility, Y is disposable income, assumed to be constant over time, and $\bar{U} \equiv U(\bar{c}, Y - \bar{c})$ is the individual's postattack utility level. For simplicity it is assumed that the two products, c and h, have the same price, regardless of their cholesterol content, which is normalized to unity.[3]

Substituting equations 18 and 19 into equation 17 and letting q be the shadow price of the cumulative probability of suffering an attack, the solution for the consumer's problem involves the maximization of the Hamiltonian (omitting the time notation) $H = (1 - F)[U(c, Y - c) - \lambda(c, S)(K - q) + F(1 - \gamma)\,\bar{U}$. The necessary conditions for this maximization are $H_c = 0$ and $\dot{q} = -H_F + \delta q$, implying, respectively, that

$$U_c(c, Y - c) - U_h(c, Y - c) = \lambda_c(c, S)(K - q) \tag{20}$$

$$\dot{q} = U(c, Y - c) - \lambda\,(c, S)\,(K - q) - (1 - \gamma)\,\bar{U} + \delta q \tag{21}$$

where $\dot{q}$ denotes the change in the shadow price over time. Because the accumulation of risk is undesirable, the shadow price, which is the marginal value to the consumer of a slight increment to the overall risk, F, must be negative.

Kamien and Schwartz (1971) show that an optimal control problem as such, where the hazard rate is independent of past consumption and the planning horizon is infinite, is solved with a constant value of the shadow price. Setting $\dot{q} = 0$ in equation 21, substituting into equation 20, and rearranging yields the optimum condition

$$U_c - U_h = \lambda_c(c, S)\left[K + \frac{U - (1 - \gamma)\bar{U} - \lambda\,(c, S)K}{\delta + \lambda\,(c, S)}\right] \tag{22}$$

Condition 22 states that high cholesterol intake at any instant of time preceding an attack should be determined such that the marginal benefit from cholesterol-rich products (left-hand side) equates the marginal cost (right-hand side). The marginal benefit is captured through the positive marginal utility differential between cholesterol-rich and cholesterol-free products, reflecting the net marginal craving for cholesterol-rich products. The marginal cost is captured through the additional risk of suffering a heart attack emanating from consuming an additional unit of cholesterol-rich products. The increased risk involves not only the harm of suffering a psychological shock but also the discounted value of the future utility loss due to having to adhere, if surviving, to a low-cholesterol diet, net of the expected psychological shock of an attack that might occur even if the additional unit of cholesterol-rich products is avoided.

A sufficient condition for not adhering to the prescribed diet is that at $\bar{c}$ the marginal benefit from nonadherence exceeds the marginal cost. Because $\lambda(\bar{c}, S) = 0$, the marginal cost at this point is reduced to $\lambda_c(\bar{c}, S)(K + \gamma \bar{U} / \delta)$. Hence, an incentive for nonadherence is more likely to arise the lower the risk of suffering an attack due to a marginal deviation from the prescribed diet ($\lambda_c(\bar{c}, S)$), the lower the psychological shock accompanying the dreadful event (K), the lower the probability of dying from an attack (γ), the lower the utility derived from adhering to the prescribed diet if surviving an attack ($\bar{U}$), the greater the consumer's rate of preference for the present (δ), and the greater his or her net marginal craving for cholesterol-rich products when adhering to the prescribed diet ($U_c(\bar{c}, Y - \bar{c}) - U_h(\bar{c}, Y - \bar{c})$).

Given that the sufficient condition for nonadherence holds, the consumer will opt to deviate from the prescribed diet, raising the hazard rate to a level above zero. As nonadherence increases, the hazard rate will follow suit, shortening the expected time until a forthcoming attack. Consequently, the future must be discounted at a higher rate than the regular time preference factor, which increases with the level of nonadherence. As is evident from equation 22, this acts to moderate the marginal cost of nonadherence, stimulating a greater consumption of cholesterol-rich products. Hence, the hazard rate is not just a deterrent to nonadherence; it also imputes a lower value to future loss the greater the deviation from the prescribed diet, driving the consumer to behave less respectfully toward his or her future. This implies that an increase in any of the external risk factors, S, might *increase* consumption of high-cholesterol products, conforming with the fatalistic notion that if a person believes that his or her time is short, he or she will seek to increase the quality of the time still left, adhering to the old maxim "Eat, drink, and be merry, for tomorrow we die" (Isaiah 22:13) rather than to a low-cholesterol dietary regimen.

A major reason for the high mortality rates following heart attacks is the delay occurring in obtaining emergency treatment. The paper (Yaniv 2002) further allows the consumer to determine not only the extent of deviation from the prescribed diet but also the extent of involuntary delay in obtaining emergency treatment by subscribing to a private intensive care ambulance service or to an emergency call-in center, which provides round-the-clock cardiac diagnosis by phone. The probability of dying from a heart attack is now assumed to increase with the delay in obtaining emergency treatment, whereas the expenditure on reducing delay is assumed to be greater the shorter the desired delay. The analysis reveals that greater protection against the risk of dying from a heart attack does not necessarily give rise to a "moral hazard" effect in the form of stimulating HC behavior. That is, dietary adherence and self-protection may be complements in the sense that a fall in price, which induces the latter, enhances the former. It thus follows that public health intervention might be able to reduce both the risk of a heart attack and the risk of dying from an attack by subsidizing the price of private emergency services.

RATIONAL UNRESTRAINED SEXUAL ACTIVITY

Economists have shown considerable interest in AIDS-related issues, yet only a small number of contributions have addressed people's behavioral responses to AIDS (e.g., Philipson and Posner 1993; Ahituv, Holtz, and Philipson 1996; Kremer 1996; Levy 2002b). Out of this group, only Levy offers a dynamic utility-maximization model of engagement in unsafe sex that takes account of the trade-off between the additional satisfaction from this activity (over the satisfaction derived from safe sex) and the risk of contracting AIDS. Levy considers an individual who at any instant of time t allocates a given amount of time, normalized to unity, between risky (unrestrained by condoms) sexual activity, $x(t)$, and risk-free (restrained by condoms) sexual activity, $1 - x(t)$, and whose instantaneous utility function, $U(t)$, is linearly increasing in both risk-free and risky sexual activities. For any given allocation of time, the instantaneous marginal utility from risky sex is assumed to exceed the instantaneous marginal utility from risk-free sex, implying that risky sex is more satisfying than risk-free sex. Hence, $U(t) = \alpha x(t) + [1 - x(t)] = 1 + (\alpha - 1)x(t)$, where $\alpha - 1$ represents the positive marginal utility differential between risky and risk-free sex, referred to as the "inducement factor."

Unrestrained sex is risky because the individual might contract AIDS and die. The risk of dying from AIDS depends on the interaction between the individual's intensity of engagement in risky sex, $x(t)$, and the prevalence of AIDS in his or her (uncoordinated) group of potential sex partners. Denoting by $s(t)$ the proportion of this group infected by AIDS, the cumulative probability of dying from AIDS by the end of time t is assumed to be $\beta x(t)s(t)$, where $0 \leq \beta \leq 1$ is a risk-factor coefficient that may moderate the risk associated with unrestrained sex (e.g., the availability of drug cocktails). The probability of staying alive beyond time t is therefore $1 - \beta x(t)s(t)$.

The individual is now assumed to choose an intensity of engagement in risky sex over time that maximizes the present value of his or her lifetime expected utility

$$J = \int_0^T e^{-\rho t} [1 - \beta x(t)\, s(t)][1 + (\alpha - 1)x(t)]dt \tag{23}$$

where ρ is a constant rate of time preference and T is an upper bound on life expectancy. The maximization problem is subject to the motion equation for the prevalence of AIDS within the group of potential sex partners

$$\dot{s}(t) = \gamma x(t) - \delta\, s(t) \tag{24}$$

where $0 < \gamma < 1$ is the AIDS-transmission coefficient, $0 < \delta < 1$ is the AIDS-attrition coefficient, and $\dot{s}$ is the change in the proportion of the group infected with AIDS at time t. While the AIDS-infected proportion is reduced by attrition, it is also increased by the current transmission of AIDS to formerly unaffected members of the group who are currently engaged in unrestrained sexual activity. That is, risky sex not only is affected by the prevalence of AIDS in the group but also affects it. The transmission coefficient is proportional to the intensity of risky sex, viewing the individual as a representative member of his or her group.

Applying the optimal control technique, with λ as the shadow price for the prevalence of AIDS in the group, the solution for the individual's problem involves the maximization of the Hamiltonian (omitting the time notation), $H = (1 - \beta xs)[1 + (\alpha - 1)x] + \lambda(\gamma x - \delta s)$. The necessary conditions for this maximization are $H_x = 0$ and $\dot{\lambda} = -H_s + \rho\lambda$, implying, respectively, that

$$(\alpha - 1 - \beta s) - 2\,(\alpha - 1)\,\beta sx = -\lambda\gamma \tag{25}$$

$$\dot{\lambda} = \beta x + (\alpha - 1)\beta x^2 + \lambda(\rho + \delta) \tag{26}$$

where $\dot{\lambda}$ denotes the change in the shadow price over time. Because the contraction of AIDS is undesirable, the shadow price, which reflects the individual's discontent with the prevalence of AIDS in the group, must be negative.

Differentiating now equation 25 with respect to t, equating the result with equation 26 to cancel $\dot{\lambda}$, substituting from equation 25 for λ and from equation 24 for x, and setting $\dot{x} = 0 = \dot{s}$, the steady-state proportion of the group infected with AIDS is found to satisfy a quadratic equation, the solution for which is a complex mathematical expression involving the parameters α, β, γ, δ, and ρ. Therefore, Levy assesses the effects of the model parameters on the stationary prevalence of AIDS by numerical simulations. Setting $\beta = \gamma = \delta = 0.5$ and $\rho = 0.05$, he finds that even under a moderate inducement factor (i.e., $\alpha - 1$) of 20 percent, the stationary prevalence of AIDS and risky-sex intensity are considerably high ($s^* = x^* = 0.2304$). The simulation indicates that the stationary prevalence of AIDS largely rises with the inducement factor and converges to 1 when the inducement factor is 166 percent. Because the inducement factor is negatively related to the sensual quality of condoms, free-of-charge distribution of sensually improved condoms may considerably reduce the prevalence of AIDS. Indeed, the numerical simulation reveals that an improvement in the sensual quality of condoms that reduces the inducement factor from 20 percent to 10 percent will lower the stationary prevalence of AIDS by almost 51 percent. The simulation reveals further that the stationary prevalence of AIDS largely declines with the risk-factor coefficient (β), slightly rises with the AIDS-transmission coefficient (γ) and the rate of time preference (ρ), and slightly declines with the AIDS-attrition coefficient (δ).

Using a phase-plane diagram for the intensity of risky sex and the prevalence of AIDS, as well as the above numerical values for the parameters of the model, Levy shows that only two paths converge to the steady-state point: one for which the initial prevalence of AIDS is high and along which the prevalence of the disease declines over time even though the intensity of risky sex increases, and another for which the initial prevalence of AIDS is low and along which the prevalence of the disease increases over time even though the intensity of risky sex declines. Other paths may lead to spontaneous containment (i.e., without intervention) of the disease, whereas some paths, for which either the initial intensity of risky sex or the initial prevalence of AIDS is very high, are bound to lead (in the absence of effective intervention) to the extinction of the group of rational individuals.

RATIONAL DELAY OF MEDICAL DIAGNOSIS

The self-discovery of a suspicious physical or mental symptom often brings about an emotional turbulence: while recognizing the importance of having the symptom diagnosed promptly, individuals frequently delay diagnosis, seeking to avoid the pain or discomfort associated with the diagnostic process and fearing to hear that they are developing a serious illness.[4] Delaying diagnosis of suspicious symptoms has been extensively researched by health psychologists, who have attributed such behavior to irrational senses of invulnerability and fatalism. In a recent paper, Yaniv (2002b) proposes an economic-oriented approach to explaining individuals' delay behavior, perceiving delay as reflecting a rational weighing of the costs and benefits associated with this decision.

Consider an individual who at a certain point in time, denoted by 0, becomes aware of the presence of a suspicious physical or mental symptom, which, to the best of his or her knowledge, has the probability λ of indicating a serious illness. Suppose that λ is strictly positive and less than unity, so that the individual does not know for sure whether he or she is ill or not and must undergo a diagnosis to find this out. The diagnostic procedure is assumed to be perfectly accurate and thus perceived by the individual to bear the probability λ of yielding a positive result ($P \equiv$ ill), and the probability $1-\lambda$ of yielding a negative one ($N \equiv$ not ill). Suppose further that the individual's well-being is dependent upon knowing whether or not he or she is ill, and denote his or her utility levels at the alternative states of knowledge by v^P and v^N, respectively.

Because knowing that one is seriously ill is likely to result in lowered body image and self-esteem and to be accompanied by feelings of anxiety and depression (e.g., Rodin and Voshart 1986), Yaniv assumes that $v^N > v^P$. Not knowing for certain whether or not one is ill is assumed to be inferior to knowing for certain that one is not ill, but superior to knowing for certain that one is ill. Denoting the utility level attained at the initial state of uncertainty by v^0, assume therefore that $v^N > v^0 > v^P$.

Suppose that the suspicious symptom, while potentially life-threatening, is not too painful or incapacitating. The individual may thus consider the possibility of delaying diagnosis, fearing both the diagnostic process and finding out that he or she is actually ill, and hoping that the symptom will disappear by itself. Given that the symptom does not indicate severe illness, suppose that there is a differentiable cumulative probability distribution, $F(t)$, of the symptom disappearing by itself at or before time t. However, given that the symptom does indicate severe illness and that the individual avoids treatment, suppose that there is a differentiable cumulative probability distribution, $P(t)$, of dying at or before time t, and that after-death utility is zero. Suppose further that the functions $F(t)$ and $P(t)$, as well as their time derivatives, $\dot{F}(t)$ and $\dot{P}(t)$, are known to the individual.

If the symptom persists, the individual, at some point in time, θ (≥ 0), will seek a diagnosis. If the diagnosis is positive, the individual is assumed to follow doctors' orders concerning immediate and future treatment. Following doctors' orders ensures, by assumption, that the individual sustains his or her life. However, the longer the delay in diagnosis, the greater the irreversible damage to health incurred from not diagnosing the illness promptly. Specifically, suppose that the damage to health inflicted by the illness, $m(\theta)$, consists of a fixed component, g (≥ 0), reflecting damage that cannot be avoided by prompt diagnosis, and a self-induced, variable-with-delay component, $\mu(\theta)$. Hence, $m(\theta) = g + \mu(\theta)$, where $\mu'(\theta) > 0$ and $\mu''(\theta) > 0$. Suppose further that the greater the damage to health, the greater the intensity of treatment required constantly, at each time t following diagnosis, to sustain life, thus the greater the pain and discomfort involved in obtaining treatment. The pain and discomfort of treatment are assumed to be proportionate to the accumulated health damage, thus expressible as $sm(\theta)$, where $s > 0$ is a disutility coefficient. Diagnosing the symptom might inflict pain and discomfort as well, the disutility of which (henceforth the "psychic cost of diagnosis") is denoted by $z \geq 0$. The monetary costs of diagnosis and treatment are assumed to be covered by health insurance.

Denoting by δ (<1) the individual's time preference rate, he or she will apply for diagnosis at time θ^*, which maximizes the expected present value of his or her lifetime utility stream resulting from delayed diagnosis[5]

$$\begin{aligned} V \;=\; & (1-\lambda)\{\int_0^\theta \dot{F}(t)[\int_0^t v^0 e^{-\delta\tau} d\tau + \int_t^\infty v^N e^{-\delta\tau} d\tau]\, dt \\ & + [1-F(\theta)][-ze^{-\delta\theta} + \int_0^\theta v^0 e^{-\delta t} dt + \int_\theta^\infty v^N e^{-\delta t} dt]\} \\ & + \lambda\{\int_0^\theta \dot{P}(t)\int_0^t v^0 e^{-\delta\tau} d\tau\, dt \\ & + [1-P(\theta)][-ze^{-\delta\theta} + \int_0^\theta v^0 e^{-\delta t} dt + \int_\theta^\infty (v^P - sm(\theta))e^{-\delta t} dt]\} \end{aligned} \tag{27}$$

Table 28.1

Conditions Determining the Desirability of Delayed (D) and Prompt (M) Diagnosis

		Probability that the symptom indicates severe illness			
		LOW	HIGH	LOW	HIGH
Damage to health incurred by a slight delay in diagnosis	LOW	M	D	D	D
	HIGH	M	M	D	M
		LOW		HIGH	
		Psychic cost of diagnosis			

Solving the maximization problem, the optimal time of applying for diagnosis, θ*, is found to be that which balances, at the margin, the benefit from delaying diagnosis with the cost of doing so. On one hand, delaying diagnosis yields the benefit of not knowing for sure that one is actually ill as well as the opportunity to avoid painful or uncomfortable medical procedures. On the other hand, delaying diagnosis entails not only the loss of relief brought about by finding out that one is actually healthy, but also the risk of incurring increased health damage or dying before getting lifesaving treatment. Put differently, the optimal time of applying for diagnosis reflects a struggle between two opposing fears: fear of the diagnostic procedure and of finding out that one is actually ill (net of the hope that one is actually healthy) encourages further delay, at the risk of dying or of incurring increased health damage; fear of the consequences of further procrastination discourages further delay. Optimality is obtained at time θ* (≥ 0) for which these opposing fears balance.

Table 28.1 summarizes the conditions on the parameters of the model, ensuring that θ* > 0, that is, that diagnosis delay (denoted by D) will be preferable to prompt diagnosis (denoted by M). The psychic cost associated with the diagnostic procedure plays a crucial role in determining the desirability of delay, which is due to the fact that this cost must be borne irrespective of the diagnostic result. While prompt diagnosis dominates the left-hand side of Table 28.1 (low psychic cost), delayed diagnosis dominates its right-hand side (high psychic cost). Still, prompt diagnosis will be desirable to the individual even if the diagnostic procedure entails considerable pain and discomfort, given that the probability of severe illness and the potential damage to health incurred by slightly delaying diagnosis are high as well. On the other hand, delay in diagnosis will be desirable even if the diagnostic procedure entails no pain or discomfort, given that the probability of illness is high but the potential damage to health from avoiding prompt treatment is low.

Table 28.1 provides a rational explanation for a variety of observed behavior concerning individuals' responses to the self-discovery of potentially life-threatening symptoms. Consider, for example, the "worried well," who frequently rush to emergency rooms upon the discovery of minor symptoms that "rational" individuals tend to ignore. Table 28.1 (left side, bottom row) suggests that if the perceived discomfort of being examined in an emergency room is negligible, it is perfectly rational to seek an immediate diagnosis even when suffering from minor chest pain, since standard cardiac diagnosis by means of an EKG is painless, whereas if the symptom does happen to indicate an impending heart attack, any delay might be crucial in physicians' ability to save the patient's life or prevent irreversible heart damage. On the other hand, Table 28.1 (right side, bottom row) suggests that it may also be rational for a senior executive, who following a stormy board meeting experiences extreme fatigue and dizziness, to delay summoning help, interpreting the symptoms as a mild disorder. Only if additional life-threatening symptoms appear that substantially increase the likelihood that he is developing a heart attack will the humiliation of being carried out of his office on a stretcher and undergoing emergency-room helplessness be justified. By the same token, Table 28.1 (left side, upper row) suggests that prior to the recent breakthroughs in combination drug therapy, it was very rational for people at risk of infection with AIDS to delay the simple and painless HIV antibody test, since being diagnosed as a carrier of the virus would adversely affect their well-being while having little or no effect on the progress of the disease. Those who do not belong to any of the groups at high risk for AIDS would normally not hesitate to take the HIV test upon the request of a new sex partner, anticipating an immediate sense of relief. However, if both the probability of illness and the damage incurred by a slight delay in diagnosis are high, as is the case with a sunburned construction worker who becomes aware of a change in color of a mole on his hand, Table 28.1 (right side, bottom row) suggests that avoiding prompt diagnosis is irrational, even if the psychic cost of diagnosis is high.

RATIONAL MENTAL DISORDER

HC behavior is detrimental not only to physical health. Two recent papers apply utility-maximization to the analysis of behaviors that might lead to the onset or exacerbation of mental disorders: agoraphobia (Yaniv 1998), which is the fear, and consequently the avoidance, of public places, and insomnia (Yaniv 2004), which is the inability to fall asleep or to stay asleep sufficiently long. In the former case, rational behavior may affect only the severity of an already existing disorder. In the latter case, rational behavior may also *initiate* the disorder. Unlike psychotic disorders (such as schizophrenia or paranoia), which are characterized by thought disturbances and misperceptions of reality, agoraphobia and insomnia do not involve a confusion of subjective impressions with external reality and must not interfere with the rationality premise.

Agoraphobia

Agoraphobia is the fear of being alone in public places from which escape might be difficult or in which help might not be available in case of sudden incapacitation, such as busy streets, crowded stores, closed-in spaces (tunnels, bridges, elevators), and closed-in vehicles (subways, buses, airplanes). Passing unaccompanied by friends or relatives through public places might provoke an episode of acute anxiety, associated with dramatic physiological, cognitive, and emotional symptoms, known as a panic attack. During an attack, agoraphobics often attempt to escape whatever situation they are in to seek help at home or in an emergency room. Recurrences of the frightening event, usually followed by prolonged physical exhaustion, may lead to a desire to avoid independent traveling through public places, resulting, in the more severe cases, in refusal to leave the house altogether. Time lost from work and the financial difficulties that arise due to loss of work are the major socioeconomic consequence of agoraphobia. While fear of an environment that is objectively safe is irrational, full or partial avoidance of this environment may be rational (i.e., resulting out of cost-benefit considerations) given that fear.

Consider the dilemma faced by an agoraphobic worker who, at the beginning of a given day, must make a binding commitment to her employer or clients regarding the number of her working hours, k, on that particular day. Suppose that the worker lives in the suburbs and works in the city, thus facing the risk of experiencing a panic attack on the way to/from work. Suppose further that the (subjective) probability of a panic attack occurring in either direction is identical. If, with probability $1 - p$, a panic attack does not occur on the way to work, the worker will successfully stand by her commitment, earning a total of $w(k)$ per day, where $w'(k) > 0$ and $w''(k) \leq 0$. If, with probability p, a panic attack does occur on the way to work, the worker is bound to return back home, where she will rest and recover for r hours. On that particular day, she will not attempt leaving for work again. Not only will she lose her daily earnings, but she will also incur additional costs of $z(k)$, where $z'(k) > 0$ and $z''(k) \geq 0$, for breaking her work commitment (e.g., damage to professional reputation, loss of clients, legal claims for compensation in case of substantial harm to clients). If, with probability $(1 - p)p$, the worker suffers an attack on her way *from* work, she will bear no financial loss, but will still need to recover at home (at the expense of leisure).

Suppose now that the worker's utility, U, is defined over daily income, I, and leisure hours, L, assumed to be spent at home after work. A decision to work thus gives rise to three possible outcomes (in utility terms): $U(I^p, L^p)$—if a panic attack occurs on the way *to* work, $U(I^q, L^q)$—if a panic attack occurs on the way *from* work, and $U(I^n, L^n)$—if a panic attack does not occur at all. Obviously, $I^q = I^n$. Suppose also that the utility function is strongly separable in income and hours of leisure, so that $U(I, L) = v(I) + \phi(L)$. Suppose further that the marginal utility of income is positive and strictly decreasing (i.e., $v'(I) > 0$, $v''(I) < 0$), so that the worker is risk-averse. Separability thus implies that risk aversion is independent of leisure consumption and that leisure is a normal good. Finally, suppose that the marginal utility of leisure is positive and strictly decreasing as well (i.e., $\phi'(L) > 0$, $\phi''(L) < 0$).

Assuming now that the worker has T waking hours to allocate between work and leisure, and an unearned income of size N, suppose that she chooses the volume of work commitment that maximizes her expected utility[6]

$$E(U) = (1-p)[v(I^n) + (1-p)\phi(L^n) + p\phi(L^q)] + p[v(I^p) + \phi(L^p)] \tag{28}$$

where $I^n = N + w(k)$, $I^p = N - z(k)$, $L^n = T - k$, $L^p = T - r$, and $L^q = T - k - r$. When $p = 1$, equation 28 reduces to $v(I^p) + \phi(L^p)$, implying that expected utility is maximized at $k = 0$ (i.e., full work-avoidance). Assuming, however, that $0 < p < 1$ and maximizing equation 28 with respect to k yields the optimum condition

$$\Omega(k) \equiv w'(k)v'(I^n) - \phi'(L^n) = \frac{1}{1-p}\{pz'(k)v'(I^p) + q[\phi'(L^q) - \phi'(L^n)]\} \tag{29}$$

In the absence of agoraphobia ($p = q = 0$), $\Omega(k) = 0$ at the optimum, and the model collapses to the classical (deterministic) labor/leisure choice model. The worker's (normal) supply of labor, k^n, would then be determined at the point where the marginal rate of substitution between leisure and income ($\phi'(L^n) / v'(I^n)$) equals the marginal return to labor efforts ($w'(k^n)$). However, in the presence of agoraphobia, $\Omega(k) > 0$ at the optimum. Since $\Omega(k)$ varies inversely with k, it follows that agoraphobia results in the supply of less labor, k^*, than the normal level. The magnitude of deviation from normal work behavior, $k^n - k^*$, may thus serve as a measure for the severity of agoraphobia.

Condition 29 implies that the work-avoidance effect of agoraphobia increases with the probability of experiencing a panic attack on the way to/from work (p or q). It also increases with the size (absolute and marginal) of the financial loss borne by the worker in the case of not being able to stand by previous commitments ($z(k)$ and $z'(k)$), as well as with the time needed to recover after an attack (r). Notice that the work-avoidance effect is positive even if the financial loss due to the occurrence of an attack is zero or independent of the volume of work commitments (i.e., even if $z(k) = 0$ or $z'(k) = 0$). The possibility that recovery following an attack may be needed even if work has been successfully completed is sufficient to drive the supply of labor below its normal level, so as to ensure time for leisure activities that might involuntarily decrease.

A sufficient condition for the agoraphobic worker to avoid work altogether is that $d[E(U)]/dk \leq 0$ at $k = 0$. This yields

$$w'(0) \leq \frac{\phi'(T) + p[\phi'(T-r) - \phi'(T)]}{v'(N)} + \frac{p}{1-p} z'(0) \tag{30}$$

with the right-hand terms representing the worker's risk-adjusted reservation wage. Clearly, agoraphobia raises the worker's reservation wage above its normal level, $\phi'(T) / v'(N)$, the rise being an increasing function of p, r, and $z'(0)$. If the (subjective) probability of experiencing a panic attack on the way to work is too high, if the dread of an attack and the discomfort accompanying it are too intense, or if the marginal damage incurred for breaking her work commitment is too high, it will be worth the worker's while to stay at home and forgo the workday's earnings.

Assuming that psychiatric treatment may help reduce the (subjective) risk of experiencing a panic attack on the way to/from work, the paper (Yaniv 1998) proceeds to examine the effectiveness of psychotherapy in restoring normal work behavior, focusing on the role of costs (i.e., therapist's fee) in the psychotherapeutic process. The analysis reveals that psychotherapy costs generate two opposing income effects on work avoidance: on one hand, because leisure is a normal good, psychotherapy costs reduce leisure, driving the worker to increase her work efforts; on the other hand, psychotherapy costs make the worker less wealthy, which, given that (absolute) risk aversion decreases in income, discourages risk taking, therefore inducing a reduction in work effort. The analysis shows further that the costs of psychotherapy have a net favorable effect on work effort in severe cases of agoraphobia (particularly when the worker avoids work altogether) but might encourage work avoidance in less severe cases, counteracting the favorable effect of treatment per se. Costly psychotherapy might then aggravate the mental disorder, as measured by its work-avoidance effect. This suggests that mild cases of agoraphobia may be more effectively treated in public-funded community clinics or through corporate-financed mental health programs than by costly private practice.

The possible relationship between the cost of psychotherapy and its outcome has been a subject of interest to psychologists ever since Sigmund Freud (1913), who suggested that the payment of a fee to the therapist might contribute to the success of the treatment, since patients who pay a fee may try harder in order to justify their financial commitments. Empirical and experimental studies (e.g., Pope, Geller, and Wilkinson 1975; Yoken and Berman 1984), however, do not seem to support this hypothesis. Moreover, despite its popularity in the treatment of phobic disorders, there is little scientific evidence supporting the effectiveness of psychotherapy in these conditions (Griest, Jefferson, and Marks 1986), and much evidence pointing toward the effectiveness of noncostly self-administered behavior therapy. The discouraging effect that psychotherapy costs might have on the *tendency* to take risks may help explain why, despite reducing the risk of an attack, psychotherapy has proven less successful in the treatment of agoraphobia.

Insomnia

Insomnia is the inability to fall asleep or to stay asleep sufficiently long. While this phenomenon can be a symptom of various mental and physical illnesses, it is frequently diagnosed as a sleep disorder in its own right, caused often by stressful life events that occupy the individual's mind and lead to cognitive and emotional arousal when attempting to fall asleep. However, insomnia may also be triggered by desynchronization of the individual's biological sleep-wake cycle with the one she chooses to practice (Morin 1993). Because of irregular work schedules, late-night entertainment, or rapid crossing of several time zones, the individual's *desired* sleep-wake cycle may not be aligned with her biological cycle. Consequently, she might retire to bed earlier or later than her biological bedtime (which is the time she feels drowsy), thus experiencing difficulties falling asleep. Hence insomnia may also be the outcome of a rational choice: by choosing to deviate from her biological bedtime, the individual inflicts upon herself a disorder she finds too costly to avoid.

Consider an individual who intends to allocate her daily twenty-four hours between wakeful out-of-bed activities, A, and in-bed sleep, S. Suppose that the individual retires to bed at time θ every night and must wake up every morning at time θ^w to fulfill whatever obligations she may have (e.g., go to work, go to class, prepare her children for school, etc.). The number of hours she spends in wakeful activities will then be $A = \theta - \theta^w$, where θ is measured on a scale ranging from θ^w to $\theta^w + 24$. If the individual were able to fall asleep at the exact moment she retires to bed, the number of hours she spends sleeping would be given by $24 - A$. However, suppose that sleep is not guaranteed at any desired point in time, and so the individual's attempt to fall asleep right away might result in insomnia. The number of hours she spends in bed before falling asleep, I, may serve as a measure for the severity of her insomnia. It is positively related to the level of her psychological stress, R, and to the extent by which θ deviates from her biological bedtime, θ^b. Both R and $\theta - \theta^b$ may be viewed as inputs in an insomnia "production function," only the former is an exogenous factor, generated by the individual's attempt to cope with the challenges of daily life, whereas the latter is a decision variable, subject to the individual's choice. Formally, the insomnia production function is given by $I = I(\theta - \theta^b, R)$, where $I(0, 0) = 0$, $I_R > 0$, and $I_\theta \gtrless 0$ for $\theta \gtrless \theta^b$. Given the levels of A and I, the number of hours the individual will end up sleeping will be $S = 24 - A - I$, assuming that once she falls asleep her sleep is not interrupted until her alarm clock wakes her up at θ^w.

Suppose now that the individual derives utility from wakeful activities and sleep and suffers discomfort from not being able to fall asleep whenever she attempts to do so. Her utility function may thus be written as

$$V = U(A, S) - \psi(I) \tag{31}$$

which, by assumption, increases in both A and S at decreasing marginal rates (i.e., $U_A > 0$, $U_S > 0$, and $U_{AA} < 0$, $U_{SS} < 0$). The discomfort stemming from insomnia, $\psi(I)$, is assumed to increase in I at nondecreasing marginal rates (i.e., $\psi'(I) > 0$ and $\psi''(I) \geq 0$). Notice that insomnia adversely affects utility in two ways: it reduces hours of intended sleep and it generates direct discomfort.

The individual is assumed to choose θ^* so as to maximize her utility function subject to the insomnia production function. The optimum condition for utility maximization is

$$U_A = U_S + I_\theta(U_S + \psi') \tag{32}$$

implying that a solution to the individual's problem may be obtained at a positive, negative, or zero value of I_θ. Hence, the individual might find it optimal to retire to bed earlier than her biological bedtime (choose $\theta^* < \theta^b$), later than that (choose $\theta^* > \theta^b$), or exactly at her biological bedtime (choose $\theta^* = \theta^b$). Based on this choice, the individual is termed a sleep-advancer, a sleep-postponer, or a sleep-adherer, respectively. Condition 32 states that the optimal bedtime is determined at the point where the marginal benefit from delaying bedtime (U_A) equals the marginal cost of doing so $[U_S + I_\theta(U_S + \psi')]$. The marginal benefit is simply the utility derived from staying awake an additional hour, U_A. The marginal cost is composed, in contrast, of two elements: the first is the utility of sleep forgone because of staying awake an additional hour, U_S; the second involves the effect of bedtime delay on insomnia, I_θ, and varies with the individual's type. For a sleep-postponer the second element is positive, reflecting the utility forgone because of sleep deprivation and the discomfort caused by insomnia as a result of delaying bedtime beyond θ^b. For a sleep-advancer the second element is negative, reflecting the utility gain stemming from the reduction in insomnia due to delaying bedtime toward θ^b.

The model is first used to examine the effect of stress on optimal bedtime and the severity of insomnia, showing that a sleep-postponer will respond to stress by going to bed earlier than before, negatively adjusting her self-inflicted insomnia to the emergence of stress-induced insomnia. A sleep-adherer will go to bed earlier as well, only she will now be deviating from her biological bedtime, turning into a sleep-advancer and adding a self-inflicted element of insomnia to her stress-induced insomnia. A sleep-advancer might respond either way: going to bed closer to her biological bedtime or advancing her sleep even further.

Empirical evidence reveals that people suffering from insomnia tend to spend excessive amounts of time in bed (Spielman, Saskin, and Thorpy 1987). Unfortunately, excessive time awake in bed heightens arousal and undermines the discriminative properties of the stimuli (bed, bedtime, bedroom) previously associated with sleep. Therefore, the most significant component of the insomnia treatment is behavioral, aiming to curtail the time spent in bed so that it equals total sleep time, as well as to strengthen the association between sleep and stimulus conditions under which it typically occurs. However, patients often exhibit difficulties adhering to a bed restriction procedure, as its core recommendation appears to be counterintuitive. For many people with insomnia, a more plausible approach would involve *increasing* time in bed in an attempt to acquire more sleep (Riedel and Lichstein 2001). The model's results provide a rational support for such behavior. While sleep therapists aim at minimizing insomnia, patients may have a different objective in mind, such as utility maximization, which may justify an opposite strategy for coping with insomnia.

The model is finally applied to jet lag, which is a travel-induced sleep disorder that afflicts a healthy individual when, due to the crossing of several time zones in a short period of time, her internal clock becomes desynchronized with her external environment. More specifically, when the individual travels west, local clocks will be earlier than her internal clock, and when she travels east, local clocks will be later. The application shows that it is rational for the individual to postpone bedtime when traveling west and advance bedtime when traveling east. For a sleep-adherer, this response will trigger insomnia (irrespective of whether she travels west or east), which is the symptom of jet lag most frequently complained about. For a sleep-postponer, insomnia will be exacerbated when traveling west and weaken when traveling east, whereas for a sleep-advancer, the opposite will occur. Jet lag thus emerges as a rationally self-inflicted disorder that the individual finds too costly to avoid.

CONCLUSION

The present survey has reviewed a growing (yet still small) literature that applies an economic approach to the analysis of HC behaviors, traditionally researched by health/clinical psychologists. While psychologists stress weakness of will, absence of self-control, or irrational senses of invulnerability and fatalism as determinants of harmful and potentially self-destructive behavior, economists suggest that such behavior could be the outcome of rational choice and therefore respond to incentives. If addiction were an irrational behavior, a change in price would have little or no effect upon consumption. Yet a major conclusion of the rational addiction literature is that addictive consumption, like any other consumption, negatively responds to a change in price. Hence, imposing a sales tax on the addictive good is likely to reduce its consumption. While prices have not been explicitly incorporated into the nonaddictive harmful eating models, it is relatively easy to specify prices for cholesterol-rich and cholesterol-free products so as to show that an increase in the price of the former or a decrease in the price of the latter (which is often much higher) would enhance adherence to a low-cholesterol diet. Furthermore, the analysis shows that dietary adherence and self-protection through subscribing to private emergency services might be complements. Hence, subsidizing the price of such services could help reduce both the risk of a heart attack and the risk of dying from an attack. Similarly, subsidizing the price of sensually improved condoms is likely to discourage engagement in risky sexual activity and reduce the prevalence of AIDS, and subsidizing the cost of psychotherapy may reduce the severity of phobic disorders, contrary to the commonly held view that paying a high fee to the therapist is necessary for treatment success. Public health intervention often attempts to enhance good health behavior through community-wide health education programs. The present survey suggests that rather than trying to change people, public health intervention could try changing the costs they face.

NOTES

1. Chaloupka (1991) suggests a more basic formulation of the utility function that takes explicit account of the harmful effect of the addictive stock on the consumer's health and from which equation 1 can easily be derived. He formulates utility as a positive function of three arguments, $u(t) = u[H(t), R(t), c(t)]$, where H is health, R is the relaxation produced by consuming the addictive good, and c is a composite of other goods. Health is assumed to be positively related to a composite of medical care goods, m, but negatively related to the stock of addictive capital, S (i.e., $H(t) = H[m(t), S(t)]$, where $H_m > 0$, $H_S < 0$). Relaxation is assumed to be positively related to current consumption of the addictive good, x, but negatively related to the stock of addictive capital, S (i.e., $R(t) = R[x(t), S(t)]$, where $R_x > 0$, $R_S < 0$). Because H is a function of S and R is a function of x and S, utility can be expressed as in equation 1, incorporating m into c. The partial derivative signs of U now follow from the assumptions on the partial derivative signs of u, H, and R (for example, $U_S = u_R R_S + u_H H_S < 0$).

2. Notice that the hazard rate is defined on *current* consumption of high-cholesterol products rather than on *accumulated* consumption. Because a heart attack is caused by the accumulation of cholesterol deposits on the artery walls, one first tends to relate the hazard rate to the overall amount of past consumption. This, however, implies that the risk of suffering an attack continues to increase even if the individual restricts his or her high-cholesterol consumption to $\bar{c}$. Yet recent evidence suggests (e.g., Pickering 1997) that adhering to a low-cholesterol diet *reduces* the risk of an attack, because it acts to dissolve the cholesterol deposits and widen the diameter of the arteries. Even if cutting down on cholesterol consumption did not help dissolve cholesterol plaques, the important point in modeling nonadherence is how people *perceive* the risk of a heart attack. Casual observation suggests that people believe (either because this is what doctors are telling them so as to induce them to keep to a diet or because this is how they interpret doctors' orders) that the risk of an attack can be drastically lowered through reducing current consumption of cholesterol-rich products.

3. The integrand (equation 17) discounts the expected stream of lifetime utility over an infinite time horizon. At any given time t in the future, the individual faces the cumulative probability $1 - F(t)$ of not yet

suffering a heart attack, deriving the utility $U[c(t), h(t)]$ from consumption. However, with probability $F(t)$, he or she will suffer a heart attack by this time, which, with probability γ, will be fatal, resulting in his or her death (the utility of which is assumed to be zero). Given the probability $1 - \gamma$ of surviving the event, the individual will thereafter adhere to the recommended diet, deriving utility $\overline{U}$ from consumption. In addition, with probability $\dot{F}(t)$, a heart attack will occur exactly at time *t,* causing a psychological shock of size *K.*

4. Doherman (1977) found that patients experiencing myocardial infarction symptoms waited, on average, 4.5 hours before seeking medical treatment, which is one of the reasons for the high rates of mortality and disability following heart attacks. Antonovsky and Hartman (1974) concluded that at least three-fourth of cancer patients delayed visiting a physician for at least one month after first noticing a suspicious symptom, and that somewhere between 35 and 50 percent of patients delayed seeking treatment for over three months.

5. The expected present value of the lifetime utility stream comprises two major terms, one multiplied by $1 - \lambda$ and the other by λ. The former term relates to the possibility that the symptom does not indicate severe illness. In this case, the symptom either disappears, with probability $\dot{F}(t)$, at any time t preceding time θ, or, with probability $1 - F(\theta)$, remains intact until time θ when the individual applies for diagnosis. The latter term relates to the possibility that the symptom does indicate severe illness. In this case the individual either dies, with probability $\dot{P}(t)$, at any time t preceding time θ, or survives, with probability $1 - P(\theta)$, to apply for diagnosis at time θ. Expression 27 attaches the alternative utility levels, v^0, v^N, v^P, as well as the psychic costs of diagnosis and treatment, z and $sm(\theta)$, to the appropriate cases in accordance with the time of revelation.

6. Equation 28 states that if, with probability $1 - p$, the worker does not experience a panic attack on the way to work, he or she will gain utility $v(I^n)$ from income. The utility gained from leisure would then depend on whether or not a panic attack occurs on the way *from* work. If, with probability $1 - p$ it does not, the utility gained from leisure will be $\phi(L^n)$; if with probability p it does, utility from leisure will be $\phi(L^q)$. However, if, with probability p, the worker suffers a panic attack on the way to work, he or she will gain utility $v(I^p) + \phi(L^p)$ from income and leisure.

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