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On the economic analysis of response to preventive measures

Reação diante de medidas preventivas em saúde: uma análise econômica

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IUNES, R. F. On the economic analysis of response to preventive measures. *Rev. Saúde públ.*, S. Paulo, **25**: 243-50, 1991. There are many circumstances in which the effectiveness of preventive measures depends to a large extent on the compliance of the patient in changing his or her behavior or lifestyle. It is shown how economic techniques can be used (i) to describe the rationale of individuals and predict their behavior (Section 2); and (ii) to assess preventive measures that, by requiring a change of conduct, imply "costs" to the individual due to a decline in the quality of life (Appendix). Cigarette smoking and coronary heart disease are used as an illustration. While the analysis of Section 2 uses graphical techniques, a simple textbook-type of lifetime utility model with a mathematical emphasis is used in the Appendix. It is also shown that techniques often used to assess health care programs such as the QALYs (Quality-Adjusted Life Years) are inappropriate to the evaluation of preventive programs aiming at behavioral changes. Finally, topics that call for further research are indicated.

Keywords: Primary prevention, economics. Atittude to health. Cost benefit analysis.

Introduction

Some forms of health care have outcomes that, are to a great extent, independent of the actions and behavior of the subject under intervention. Surgical operations and sanitary measures such as the provision of clean water are examples of programs in which the "patients" have more of a passive role in influencing their result. In immunization programs, on the other hand, we have an example of interventions in which individuals always have an important role in establishing their success: they not only have actually to go to the locations where the vaccines are being applied, but before that they have to feel the need of the immunization and be willing to be vaccinated. In cases like these the patient plays an active role in determining the effectiveness of the intervention**.

In developed countries, preventive care usually addresses the need for changes in sedentary habits, in diets, and in harmful practices such as smoking, whereas in developing countries it also involves attempts to change hygiene habits and existing negative attitudes toward vaccination or other interventions***.

Preventive medicine is, therefore, in most cases (but not exclusively) a form of intervention that has to produce changes in behavior.

The objective of this work is to provide an example of the application of economic instruments and rationale to the health care field. In particular these tools are used to describe the basic characteristics, and aid in the assessment of the economic benefits and costs of preventive programs designed to change attitudes and behavior. Of the essence of such approaches is the active role played by the patients. The case of cigarette smoking and coronary heart disease (CHD) will help illustrate the main aspects of the model.

The next section presents the basic issues involved in measures that imply changes in behavior. A graphical representation is also developed to describe the rationale used by smokers for not quitting. Section 3 concludes the discussion of the main body of paper while the Appendix outlines the characteristics of an economic model that can be used in the economic assessment of preventive measures. The Appendix relies somewhat more on mathematics and economics and can be skipped without loss of compreension of the main ideas of the work: its basic implications are put in to words in Section 3.

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** It is difficult, though, to see any type of health care as being totally independent of a patient's action.

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[1] Série comemorativa do 25º aniversário da Revista de Saúde Pública.

*** Reflecting in many cases the so called epidemiological transition.

Some Considerations Regarding Changes In Behavior

If, on the one hand, the ending of pain and suffering are concrete and immediate benefits deriving from healing, on the other, the gains from preventing an illness are spread throughout the whole period that a person is under risk of developing the condition. What is more important however, is that in the same way that the health benefits of prevention are less tangible, so are the health risks. Many individuals underestimate, ignore or are simply not aware of the health hazards that certain habits and attitudes might constitute. Measures intended to bring about changes in unhealthy behavior have, therefore, not only to overcome the natural resistance that we have against altering patterns of conduct to which we are used, and often enjoy, but would also have to provide information about those hazards and their real magnitudes.

In many instances behaviors that seem illogical are, in fact, "rational" decisions, given how an individual *perceives* their outcomes. These perceptions could be wrong due to the lack of information, to misinformation, or to an unconscious trend to misjudge the risks involved. The decision-making process is, however, necessarily based on the information available and on how this information is captured, and therefore should be judged accordingly*.

Consider, for instance, the case of cigarette smoking. Although for many of us it should be clear that such a habit is hazardous to health, several recent studies, and polls from 1978 to 1980, indicate that the perceived health risks it embodies are much smaller than the actual ones (the results and quotes below are from Shiffman[4], 1986):

- "37% of all smokers and 40% of heavy smokers "were unaware that smoking causes heart disease, and a majority were unaware that smoking is a *major* cause of heart disease."
- "Although *most* (though not all) smokers knew that smoking was linked to lung cancer, half did not know that smoking causes most lung cancer. Smokers also underestimate the fatality of lung cancer."
- 54 to 58% of women smokers "were unaware that smoking is associated with miscarriage and stillbirth, and only one-third were aware of its relationship with low birth weight... college students were even less well-informed on these matters than the general population."
- "Over 40% of American adults did not know that smoking would shorten the life expectancy of a person smoking in his 30s." Those who were aware of that fact would estimate the loss in life expectancy to be from 2 to 4 years instead of the actual 6 to 8 years.
- In general nonsmokers showed more awareness of the health risks of smoking than smokers, and light smokers more than heavy smokers. "Perhaps the 'knowing' smokers are already ex-smokers. Or perhaps smokers' ignorance is part of the cognitive defense they use to rationalize continued smoking."

(Apud Shiffman[4], 1986) - Data published in 1981 by the U.S. Federal Trade Commission show that 40% of smokers believe that smoking up to a pack a day would not imply any excess risk. Moreover, according to other surveys 36% of smokers believed that low tar and nicotine cigarettes would not be harmful at all.

These results show that "illusion" is an important component of smokers' behavior. As Shiffman[4] puts it: "...American smokers' health information is crucially inaccurate and incomplete, largely as a result of cognitive distortions and misrepresentations.. they do not recognize or acknowledge how dangerous *their* smoking is to *them*" (author's italics). The model described below uses this concept to analyze the rationale for continuing smoking.

In Figure 1 the curve OE describes the utility derived from income for a risk averse smoker**. The horizontal axes measures the level of income, while the vertical axes the actual and expected levels of utility***. If this smoker does not develop CHD

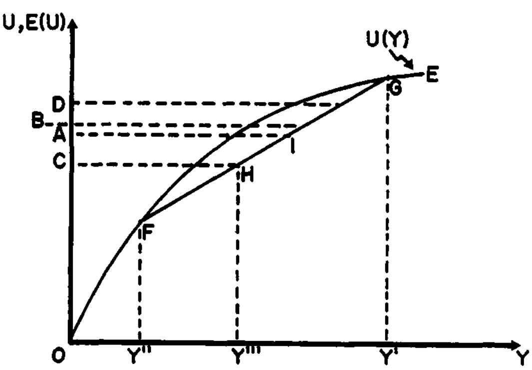

Figure 1

* Baumol[1] (1986) provides many examples of the importance of perceptions, "illusions", or as he calls them in economic behavior.

** The shape of the curve reflects a declining marginal utility of income. In some very crude terms it means that, as a person gets wealthier, extra units of income will *add* less and less to his level of utility. For an explanation of these issues please refer to any textbook of microeconomics.

*** The utility function expresses formally the set of preferences of a person. In this sense, its value reflects his or her "happiness" or level of well-being.

his/her income will be Y', while Y" is the income when the disease strikes. Even though this person knows that cigarette smoking constitutes a health hazard, for some reason he or she perceives the risks involved to be smaller than they actually are, therefore also distorting the gains from quitting. As a consequence, the expected utility level (as perceived by this individual) is OA instead of the "actual" OC. Similarly, the expected utility if a nonsmoker would be OB instead of the "true" OD*.

Most people find it very difficult to alter a habit. This is true for addictive habits such as cigarette smoking, drugs and alcohol, as well as for changes in diets (diet modification here refers not only to eating less but also to changes in its components such as salt, sugar, etc.), and most lifestyle patterns**. As a result, changing a habit may mean a decline in overall utility to a person if he or she is no longer able to enjoy other things with the same intensity as before. The magnitude of this "withdrawal-effect" will obviously depend on the habit that is changed. In Figure 2 the "pre-quitting" cigarette smoking utility curve OE is shown together with the lower "post-quitting" curve OE'. According to the health perceptions of this person, if he or she quits smoking the resulting expected utility would be OB', which is smaller than the previous level OA. This person, therefore, believes that he or she would be better off by continuing to smoke.

Implications for Health Policy Analysis

The model just presented is clearly, and by definition, a simplification of the complex set of relations and factors that interact to affect the behavior of individuals. It purposely does not try to be an accurate representation of reality. What is relevant

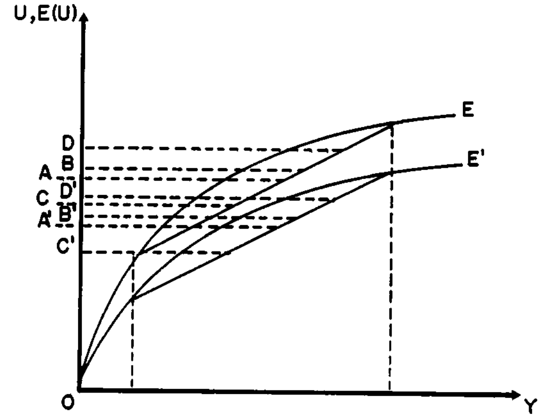

Figure 2

is the model's capacity to "predict" what will happen under different circumstances. It is along this line that the discussion continues.

Studies on cessation of smoking have indicated that concrete health threats are the major motivations for changes in behavior, however, "far more cessation is motivated by awareness of actual current, though minor, illnesses – colds, sore throats, etc. – than is motivated by fear of lung cancer and other major but distant, illnesses." (Shiffman[4], 1986). There are two ways to view this fact in the representation of Figures 1 and 2: in the first case due to these small illnesses or discomforts the curve OE shifts down towards OE', generating an expected utility (though still distorted) OA smaller than OB', setting the stage for the individual to quit smoking. In the other case the illnesses may call the attention of the individual to the health threats produced by this type of behavior, inducing changes in perception. These changes would be represented in Figure 2 by either lowering OA (toward OC), or by raising OB and OB' (closer to OD and OD'), or both. The final outcome is again OA < OB', which facilitates the change of behavior.

The discussion of the previous section shows to how great an extent the effectiveness or ineffectiveness of preventive programs depends on the compliance of the patients***. However, the question as to how to obtain this necessary cooperation still remains open . Traditionally the strategies followed in prevention attempt to remove existing cognitive distortions through the provision of large amounts of information. One example in which a somewhat different path was followed was the "health scare" tactic aimed at reducing cigarette smoking. Since

* To illustrate consider point H on the straight line FG. It reflects the expectation that the probability of developing CHD within the relevant time-frame is 0.4 (40%), thus distance FH is two-fifths of FG. This prospect corresponds to an expected income Y'", implying the expected utility OC. The "actual" probability described by point I is 0.6 (60%): FI = 0.6 x FG. Please note that these values are used only to illustrate and do not have necessarily any correspondence with real parameters.

** Another example that should be kept in the mind of the reader throughout this paper is the drug treatment for hypertension.
Generally, previous to the treatment, the patient is feeling perfectly well. The medical care of his condition, on the other hand, brings many undesirable and concrete side-effects (fainting and sexual impotency, for instance). It is, therefore, no surprise to see such a large proportion of these patients discontinuing their treatments. The key issue here is how large a person's discount rate in trading an unpleasant present for a healthful future is.

*** This fact and the pragmatic culture still prevailing in medicine from its curative practice could help to explain the resistance that still exists among many physicians with respect to preventive care.

smoking is an addictive habit, instead of using the spread of information, expecting to generate a "rational" behavior in the smokers, it tried to produce a sensation of "guilt" or fear. In the diagrammatic representation of Figures 1 and 2 the "health scare" tactic means a lowering of the curve OE, reducing the pleasure of smoking and leaving the feeling of "guilt" or fear in the minds of the smoker. This type of tactic can obviously be criticized in terms of the "ethics" of the means used to obtain the desired outcome, but it also has another weakness: if the reduction in the utility schedule is not enough to produce a fast decision to quit, the person may get used to those initially uncomfortable feelings. The partial or total fading of the restless sensation that once prevailed means, in the diagrams, a shift back of the curve OE towards the left.

Consider the case of coronary heart disease: preventing a person from developing this disease incorporates efforts to induce smoke cessation. The effects of such change in behavior will introduce adjustments in the utility specification of former smokers, for as previously discussed, after quitting the consumer perceives a decline in the pleasure he or she derives from the elements that constitute the utility function.

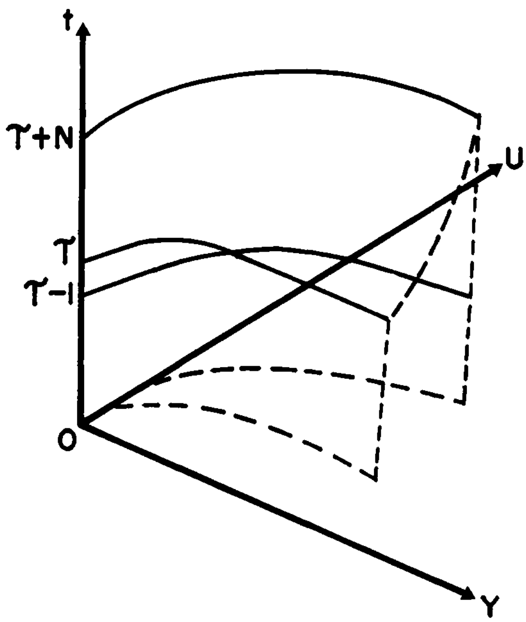

Figure 3

The decline in perceived utility is, however, usually temporary, and as time progresses the utility level moves toward its customary status. In the three dimensional diagram shown by Figure 3 the quitting period is indicated by $t = \tau$, with the utility schedule returning to the level prior to cessation in period $t = \tau + n$*. The drop in the level of well-being, as well as the time lapse until the withdrawal effect is over, will be more significant for those more addicted.

These transitions in perceived utility can be formally described by a function of the following kind:

$$\phi(Z)U_t, \tau \geq t \tag{1}$$

Where U_t expresses the utility function. The subscript refers to post-cessation periods, and

$$\phi(Z) = 1 - e^{-bZ}, \ b > 0 \tag{2}$$

with

$$Z = t - (\tau - 1), \ t = \tau ... T \tag{3}$$

Z is, therefore, the distance in time from the period immediately before quitting. As it increases, the function described by (2) tends to one. The constant b present in the function determines the speed at which the utility will return to its usual level, i.e., the function reaches the unit. Figure 4 displays the sigmoid curves of $\phi(Z)$ for three different values of the constant: $b < b' < b''$.

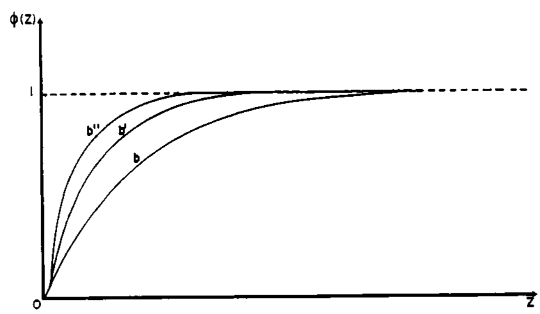

Figure 4

Final Comments

Preventive measures have often been criticized as ineffective because their results depend to a great extent on the patient, i.e., the patient has an active role in determining the final outcome of preventive care.

In this paper I have shown through the example of cigarette smoking what a difficult task it is trying to induce people to change their behavior. People will only alter their habits if they *want* to, not

* The case of $U_1 = U_2 = ... = U_{\tau-1} = U_{\tau+n}$ is shown in Figure 3.

because they *ought* to. If the health condition of a person is such that a change in behavior becomes medically necessary, he or she has to leave the physician's office convinced of this fact: the *need* has to become a *want*, otherwise nothing (or very little) will happen. If these difficulties are true when there is a medically diagnosed case requiring the change of behavior, what can be said for those cases in which the person feels well and nothing is apparently wrong?

The fact is, that it is not enough for a health professional to be a supplier of information. He or she has to be a promoter of changes in attitudes, for not has only this professional to compensate for the lack of information that reaches the population, but also has to correct for the errors that occur in the diffusion of this data. Moreover, studies have shown that individuals also tend to rationalize their attitudes by unconsciously distorting the information available to them.

However, this is a task too big for a single solitary profession. Society as a whole is the possessor of the best means to diffuse information. It has to become a social decision, and therefore a measure of public health, the provision of knowledge on preventive care. The constant flow of information will, through time, reduce the cognitive distortions and/or change perceptions. In terms of the model described by Figure 2 it means shifts in the expected utilities (OA, OB, and OB').

What seems more difficult to alter by means of public health measures is the value of b in expression (2), i.e., the speed at which the person moves back to the previous utility schedule, recovering from the withdrawal effect. Apparently this is still a task left to the health worker's strategy of persuasion. It could be argued that the cumulative effect of information would also bring about changes in b, for the person would be moving into a pattern of behavior that society as a whole values positively, and therefore increasing his or her self-esteem. However, this is not at all clear and remains a subject for investigation.

These open questions show that the study of the diffusion of health information is a topic of increasing importance, calling for further research.

In the Appendix, Section A.1. presents the basic characteristics of an economic model that tries to detect the differences between the life-cycles of a smoker, a nonsmoker and a former smoker. Or more generally, of a person that is a subject for preventive care, of one that has not, and another that has undergone a change in behavior. The model is purposely very simple, but is sensitive to the modifications (costs to the individual) imposed by the changes in behavior, and should be incorporated as part of a broader economic evaluation of preventive medicine.

A direct implication of this discussion is that the economic assessment of preventive programs that require behavioral changes should necessarily use a model, such as that of Section A.1., that incorporates the quality of life into consideration. But one important remark must be made: the QALYs (Quality Adjusted Life Years) or similar measures usually assess life quality for *given* changes in health status, i.e., these models only incorporate changes in utility *due to* changes in health status. Thus, as preventive programs may change the quality of life immediately without introducing any simultaneous change in the level of health, they will produce outcomes insusceptible to detection by these techniques. What is needed therefore, in assessing preventive programs, is a methodology that reflects all the components of the utility function and captures a person's general level of well being.

It is well known that there are serious difficulties and limitations involved in the application of any technique that intends to quantify the quality of life. Unfortunately there is no alternative but to recognize them and attempt to minimize their impact*. For, as I have shown, a person's perception of his level of well-being is critical in determining the effectiveness of preventive measures and therefore cannot be excluded from the evaluation. A true researcher, however, would see in this challenge a rich field open for investigation.

IUNES, R. F. Reação diante de medidas preventivas em saúde: uma análise econômica. *Rev. Saúde públ.*, S. Paulo, 25: 243-50, 1991. A efetividade de muitas intervenções preventivas depende da capacidade do paciente em alterar seu comportamento ou estilo de vida. São intervenções nas quais o indivíduo exerce um papel ativo. Procurou-se mostrar como o instrumental econômico pode ser usado para: (i) prever comportamentos e descrever sua lógica; e (ii) avaliar medidas de prevenção que, por implicarem mudança de comportamento, geram "custos" em termos de queda na qualidade de vida (Apêndice). O caso do fumo e doença coronariana do coração é utilizado como ilustração. Enquanto a análise do primeiro item utiliza técnicas gráficas, a do segundo (Apêndice) utiliza-se de um modelo mais formal, porém simples (de livro-texto) para a representação de utilidade ao longo do ciclo de vida. Mostrou-se também que técnicas freqüentemente utilizadas na avaliação de programas de saúde como os "QALYs" ("Quality-Adjusted Life Years" ou Anos de Vida Qualitativamente Ajustados) são inadequados

* It is not intended to discuss these techniques here. For an analysis see: Torrance[5], 1986; the entire issue of Health Policy[3] 10(3), 1988; and Gafni[2], 1989.

para programas preventivos voltados à alteração de comportamento. São sugeridos alguns tópicos que necessitam de investigação mais profunda.

Descritores: Prevenção primária, economia. Atitude frente à saúde. Análise custo-benefício.

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APPENDIX

Some Issues Relating to the Economic Assessment of Preventive Measures

In terms of policy, the discussion of the first two sections shows that preventive measures aiming at a change of behavior have costs to the individual through the decline in the intensity at which he or she enjoys other things. The implications for the economic assessment of preventive measures are: (i) the impact of those measures has to be evaluated throughout a lifetime, or what in epidemiology is called the incidence approach; (ii) it becomes necessary to use techniques that adjust for changes in the quality of life (such as a modified QALY: Quality-Adjusted Life Years).

What follows is the outline of the basic characteristics of a textbook-type of economic, non-stochastic, lifetime utility model*. As I will show, it is an instrument to be used in the assessment of an individual's quality of life. It should be stressed that this model would be only part of any cost-benefit or cost-effectiveness analysis. The costs of implementing and the savings brought by the preventive measures are not discussed at all. The assessment of costs are included only when they refer to the person's life quality. As it is an economic model, economic variables are used to describe the person's set of preferences. Even though the graphic representation of Section 2 is based on uncertainty, most of its features can also be represented in the model below, as will be shown.

A.1. A Simple Non-Stochastic Lifetime Utility Model

Because the benefits of prevention are not restricted to a single period, the model has to be designed to represent the impact of those benefits throughout the whole time-span over which they take place. A preventive program of the type discussed in this paper, if effective, would leave individuals stick to a new lifestyle, and try to adjust to it; a process that, as seen in Section 2, is not without "costs". The framework outlined below is able to capture the impact of those changes that have to be borne up by the individual himself.

The "lifetime" (or life-cycle) span under analysis is indexed by t = 1,2, . . T, where T is the death or retirement period.

The assets accessible to the individual at the end of any period are:

$$A_t=Y_t - (C_t + P_t S_t) \qquad (4)$$

Where c_t describes the consumption expenditures that occurred during the period; S_t the number of sick days; and p_t the daily cost of medical treatment. Y_t, the person's total (gross) income in period t, is the sum of the monetary income available with the assets brought from the previous period:

$$Y_t = A_{t-1} + M_t \qquad (5)$$

M_t is the monetary income earned. From these two expressions it can be seen that the assets accumulated during the period are:

$$A_t = A_{t-1} + M_t - (c_t + p_t S_t) \qquad (6)$$

That is, the savings accrued over the period (M_t - [c_t + $p_t S_t$]), plus the resources brought forward from the previous one.

If any period has D_t working days, the number of days that a person is present in his job is J_t:

$$J_t = (1 - k_t) D_t, \; k \leq 1 \qquad (7)$$

Here k_t is the proportion of the total number of working days in the period that the person was unable to work due to any sickness. Clearly the number of those sick days is determined by $S_t = k_t D_t$**.

* The model bellow is based on Hadar [2], 1971.

** Thus expression (7) could be rewritten as: $J_t = D_t - S_t$. In this simple model J_t is also equal to the number of healthy days in the period.

The monetary income received during any period amounts to:

$$M_t = wJ_t = w[(l - k_t)D_t] = w[D_t - S_t] \quad (8)$$

The real daily wage rate, w, is assumed to remain constant over time.

At the end of any period the value of the accumulated assets is:

$$A_t = [A_{t-1} + M_t - (c_t + p_t S_t)](1+r) \quad (9)$$

Where r is the real rate of interest or discount rate, which is assumed to remain constant throug out the cycle. Using (9) we have:

$$A_1 = [A_0 + M_1 - (c_1 + p_1 S_1)](1+r)$$

$$A_2 = [A_1 + M_2 - (c_2 + p_2 S_2)](1+r) =$$

$$= A_0(1+r)^2 + M_1(1+r) - [(c_1 + p_1 S_1)(1+r)^2 +$$

$$+ (c_2 + p_2 S_2)(1+r)]$$

An initial endowment, A_0, greater than zero results either from a bequest left from the previous generation, or from previous periods in which t = 1, the first relevant period of the span, is not the first year of the economic life. By induction:

$$A_T = A_0(1+r)^T + \sum_{t=1}^{T} M_t(1+r)^{T+1-t} - \sum_{t=1}^{T}(c_t + p_t S_t)(1+r)^{T+1-t} \quad (10A)$$

The present value of these assets at the beginning of the cycle is given by:

$$A_T(1+r)^{-T} = A_0 + \sum M_t(1+r)^{1-t} - \sum(c_t + p_t S_t)(1+r)^{1-t} \quad (10B)$$

or using (8),

$$A_T(1+r)^{T} = A_0 + \sum w[(1 - k_t)D_t](1+r)^{1-t} - \sum(c_t + p_t S_t)(1+r)^{1-t} \quad (10C)$$

In this sense, the variable A_T, the total value of the assets available to him or her at the end of the cycle – or to his or her descendents if T is the end of life – is in fact an indicator that summarizes the lifetime concerns of the individual*.

Now remember that the utility function expresses the set of preferences of a person, and therefore its value reflects his or her "happiness" or well-being. Based on the expressions above, and incorporating a person's valuation of his or her health status H, the general form of the lifetime utility function can be written as follows**:

$$U = U(c_1, c_2, \ldots, c_T; H_1, H_2, \ldots, H_T; A_T) \quad (11A)$$

or,

$$U = \sum_{t=1}^{T-1} U_t(c_t, H_t) + U_T(c_T, H_T, A_T) \quad (11B)$$

The utility function above shows that a person derives pleasure from the consumption of goods and services, and from how he or she is feeling, i.e., how healthy he/she is. The amount in assets available at the end of the cycle allows the person to acquire these items after retirement (or to leave a desired bequest for the next generation)***.

Through the observation of the expressions above, it can be seen that all parameters, except H, can be easily determined empirically. To make the model more clear the utility function has been constructed incorporating explicitly a person's health status. Note, however, that even if this were not the case, because J is a function of health status, H would be present (implicitly) in the model (indirectly in the utility function by affecting a person's economic capacity to consume)****.

The discussion of the first two sections has shown that individuals tend, to a great extent, to quit smoking because of minor health problems. In this formal representation, this fact is shown through a decline in the perceived *present* health status, and therefore *present* utility level. Smoking cessation can also be induced by the reduction or removal of the cognitive distortions, which means an expected decline in the perceived *future* levels of the health status (*future* level of utility). If the first reason is generally observed to be more important than the second, economic agents greatly discount their future levels of health.

Expressions (10) display the lifetime budget constraint, that is to say, how the available re-

* If T is the retirement period, the assets may be used to cover future expenditures, long-term medical care, and any desired bequest.

** Therefore H is *perceived* health status. An assymptomatic health problem does not affect a person's well being as long as he or she is not aware of the problem. Once the disease becomes known, the level of well-being may decline, at least psychologically.

*** Also note that there is nothing in the general formulation of (11B) that restricts the specification of the utility function to being the same for each period of time.

**** Since it may be affected by the health behavior of the individual, J is in fact a decision variable.

sources are allocated not only between the items that are relevant for the individual as expressed in the utility function, but also over time. The last representation (10D) below, shows on the left-hand side the receipts and on the right-hand side the expenditures.

$$A_0 + \sum w[D_t - S_t](1+r)^{1-t} = A_T(1+r)^{-T} + \sum(c_t + p_t S_t)(1+r)^{1-t} \quad (10D)$$

The economic rationale describes the individual as wanting to maximize his or her level of well-being, represented by the utility function in (11), given the limitation of resources available to him/her, and described by the budget constraint (10).

In this very general specification, how would a smoker differ from a non-smoker? Basically in two important ways. If smoking induces health hazards, a typical non-smoker will live longer, thus $T^n > T^s$. They would also differ in the proportion of sick days K_t, thus a non-smoker is likely to have less sick days during the life-cycle than a smoker. $\Sigma S^s_t \geq \Sigma S^n_t$ As a result of both, the nonsmoker will accumulate relatively more assets, $(A^n_t > A^s_t)$ and therefore, all else being constant, will accumulate more utility. In words it simply means that the nonsmoker had a "happier" life*.

The modelling of the life-cycle, for those that changed their behavior (or, in the example used here, those that quit smoking), incorporates the transitional decline in the utility schedule due to the withdrawal effect discussed in the second section:

Expressions (12A) and (12B) show the set of utility functions of what is refered to as a former smoker (thus the superscript). Note that in U^f there are included periods as a smoker $t = 1, 2, ..., \tau-1$, and after quitting $t \geq \tau$. The values of T, A_T, and the number of sick days during the life-cycle, depend on the duration and intensity of the smoking habit.

$$U^f = \sum_{t=1}^{\tau-1} U_t(c_t, H_t) + \sum_{t=\tau}^{T-1} \phi(Z)[U_t(c_t, H_t)] + \phi(Z)[U_T(c_T, H_T, A_T)] \quad (12A)$$

$$U^f = \sum_{t=1}^{\tau-1} U_t(c_t, H_t) + \sum_{t=\tau}^{T-1} \phi\,[t-(\tau-1)]U_t(c_t, H_t) + \phi[T-(\tau-1)]\,U_T(c_T, H_T, A_T) \quad (12B)$$

There are some evidences, for instance, that former smokers reach the probability of dying from coronary heart disease of a non-smoker after two years of cessation (relative risk ≈ 1. See Rosenberg et al.[5], 1985).** The estimation of these parameters is crucial in determining the effectiveness of preventive programs, for a program would be desirable in terms of improving the quality of life of individuals if $U^f > U^s$. It is this type of assessment that the model presented here helps to implement.

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* The superscritps n and s are used to differentiate the two types of individuals according to their smoking habits.

** Even though the results in that respect vary, most studies show that the coronary death risk of a former smoker reduces substantially faster than the risk of dying from other diseases such as lung cancer (see Hammond and Garfinkle[3], 1969; Gordon et al.[1], 1974; and Kannel[4], 1981).