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DEMAND FOR MEDICAL CARE: A METHODOLOGICAL LITERATURE REVIEW

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Abstract
Existing conceptual models of demand for medical care remain compartmentalized according to the motives for the demand. For example, some models are motivated primarily by production. As well, there are models of demand for medical care motivated by survival and longevity. This essay attempts to synthesize and generalize models of demand for medical care by considering the models as a response to various economic and psychic costs of ill-health and death, as suggested by Kenneth Arrow (1963). The present essay synthesizes analytical models of demand for medical care into a cost-of-illness model in which the economic consequences of illness and death are delineated, as Arrow suggested. In what follows, only models of individual's demand (as distinguished from population or aggregate demand; for example, Rice 1968, Davis and Russell 1972) are reviewed. Section 2 presents the human-capital model of demand for medical care, both static and dynamic versions, with its emphasis on production purposes. Section 3 presents the value-of-life models, in which the demand for medical care is derived from a demand for survival. Cost-of-illness models are discussed in section 4. Section 5 reviews the concept of severity of illness. The conclusion is in section 6.

Note: The ideas and models presented in this essay are culled from the author's doctoral dissertation at the University of Wisconsin Madison.

Introduction

The demand for medical care has been relatively well-studied, compared with other aspects of health economics, but there is limited consensus on its methodology. An example is the concept and measure of health status in models of demand for medical care. Also, there is little distinction in the literature regarding possible differences between curative and preventive care, inpatient and outpatient care, etc. Further, existing models remain compartmentalized according to the motives for the demand, with some models motivated primarily by quality-of-life while some other models are motivated by survival and longevity (or quantity of life). Kenneth Arrow (1963 p.948-949) suggests that a person demands medical care (at least, curative care) only if and when sick, with the demand motivated by the desire to ameliorate risks associated with illness and death. In this essay, theoretical models of demand for medical care are categorized according to their emphases (or lack thereof) on particular motives.

In discussing motives, it is noted that the demand for medical care, or any commodity for that matter, may arise from a multiple of motives. As such, the demand for medical care is a derived demand (Grossman 1972 p.224), and the consumer's willingness to pay (WTP) for medical care can be traced and categorized and summed in terms of her willingness to pay for the relevant or associated individual motives. According to Weisbrod (1978 p.162), it can be useful to determine, for example, what proportion of a person's expenditures on a bottle of aspirin is motivated by the desire to cure a present ache or to prevent a worsened future ache. On the other hand, it is possible that a particular motive can generate simultaneous demands for several commodities. For example, the survival motive generates demands for medical care, fire alarms, etc. In which case, the consumer's willingness to pay for survival is the sum of all the survival-induced shares of expenditures she makes on each commodity (Weisbrod 1978).

All things considered, the demand for medical care, like the demand for other goods and services, is influenced by the opportunity costs of alternative uses of resources. It follows that the demand for medical care is not perfectly inelastic, in general. In one sense, medical care is a normal good (Newhouse 1981). To be exact, medical care is special as a commodity but not unique. Medical care is special because of its importance in the maintenance of life, among other things. But so also is food, for example.

The human-capital models of demand for medical care (Muurinen1982) are motivated by quality-of-life (primarily production). Each person has a stock of durable health capital and medical care is an investment the purpose of which is to counteract depreciations in the health capital. As a result, the model does not distinguish between sick persons from healthy persons (see, for example, Eze 2018).

There are models of demand for medical care motivated by quantity-of-life rather than quality-of-life. The reasoning is as follows. There are many activities and attitudes (or lifestyle) a person can undertake to influence her own survival or the survival of a loved one. That is, survival and longevity are endogenous to the extent that the probability of death at any time can be influenced prior to the occurrence of death. A model of demand for medical care can be generated from this survival concept because, in spite of the eventual inevitability of death, the person's risk of death or survival probability (survivability) at any instant depends on how healthy the person is (Fromm 1968, Conley 1976, Thaler and Rosen 1976, Gould and Thaler 1980, and Freeman (1985)). According to Weisbrod (1978), a person's WTP for life-saving includes her market and nonmarket expenditures on medical care, etc., her expenditures and efforts on safety-enhancing goods such as smoke-detectors, plus her willingness to contribute to the public projects. If the activity undertaken to affect survival is medical care, then the Value-Of-Life concept generates survival-induced demand for medical care. That is, the value of your life to you is your WTP for your survival, including your demand for medical care (Jones-Lee 1976, 1982).

The present essay attempts to show that the human-capital model as well as the value-of-life model of demand for medical care can be regarded as a special case of an alternative conceptual framework referred to as the cost-of-illness model of demand for medical care that attempts to delineate the economic consequences of illness and death (for example, Goodeeris 1983, Harrington and Portney 1987).

Review of Human-Capital Models of Demand for Medical Care

Consider a static version of the human-capital model (Grossman 1972, Pauly 1980). A person has a level of health H determined by a given initial health condition H_0, a health depreciation at a constant rate δ as well as the person's investments in health production during the time period. The health production function h(.) is a function of medical care M, time input in health production TH and education (or stock of knowledge) E. That is, h(.) = h(M,TH,E). If all health production inputs are suppressed except medical care M (Pauly 1980 pp.44-

45, Wagstaff 1986 p.200), then h(.) = h(M), h'(M) > 0 and h''(M) < 0. M is purchased at a per unit price p and the numeraire good is a vector of non-medical consumption C which can also be produced by combining time with other inputs in a household production. The non-medical consumption can include leisure. The person's income Y consists of labour earnings Y = wL, with non-labour earnings assumed to be zero. Both the potential labour time L and the wage rate w are functions of the person's health status or level of health H. Then income Y = w(H)L(H) = Y(H), Y' ≥ 0, Y'' < 0 (Wagstaff 1986, footnote #4). Wage rate w is a function of health because a person's productivity depends on how healthy the person is: MPL = MPL(H), with w = μMPL(H), μ > 0, then w = w(H). If the level of education also affects wages, then w = w(H,E). The consumer's problem is to choose medical and non-medical consumption to maximize her end-of-period utility subject to constraints. The static human-capital model is:

2.1 $\underset{C,M}{m}$ U(C,H) subject to

2.2 C + pM = Y(H)

2.3 $H = (1-\delta)H_0 + h(M)$

The budget constraint in Equation 2.2 is derived as follows. Low health increases the amount of time a sick person takes to satisfy biological necessities. This decreases the time available to the sick person to allocate to various purposes. A person's potential income is the maximum income the person can earn if she allocates all her available time to income-generating activities. Imagine a day with a total of TT = 24 hours divided into labour time L, time input in health production TH, leisure R and time for biological necessities (including sick time) S. That is,

2.4. TT = L + TH + R + S

Then the time available to the person is n:

2.5. n = TT – S

If unearned income is zero, potential income is w.n rather than w.TT. w.n depends on H because S depends on H; S = S(H), S' ≤ 0. From Equation 2.5, available time depends on health also:

2.6. n(H) = TT – S(H), where n' > 0.

From Equation 2.6, Equation 2.2 becomes

2.7. C + pM = wn(H) = Y(H)

What matters most is that income is a function of H, as in Equation 2.7. The Lagrangian is:

2.8. $\underset{C,M}{m}$ $L = U(C,H) + \lambda[Y(H) - C - pM]$

λ is a Lagrangian multiplier. Equilibrium conditions can be derived from Equation 2.8:

2.9. $\frac{U_h}{U_C}h'(M) + Y'(H)h'(M) = p$ where $U_h \equiv U_h(.)$ and $U_C \equiv U_C(.)$.

2.10. $\frac{U_h}{U_C} + Y'(H) = \frac{p}{h'(M)}$

Medical care is demanded solely as an input in health production (Equation 2.3), but health H can affect both income Y(H) and utility U(C,H). The demand for medical care is derived by solving the equilibrium Equation 2.9 which states that the marginal benefits of medical care (lhs) equal its price p. The marginal benefits of medical care are (a) the 'pure consumption' benefit or marginal contribution of medical care to utility, and (b) the 'pure investment' benefit or the marginal contribution of medical care to income. Both effects operate through health H. Rhs in Equation 2.10 is the opportunity cost of being less healthy (or shadow price of health capital).

The dynamic version of the above model is presented next in order to discuss extensions of the human-capital model. In a lifetime that lasts from birth at t = 0 to death at t = T, a person owns physical assets A(t) with initial value A_0. The person solves the following lifetime utility-maximization problem, where U(.) is the single-period utility of the consumer:

2.11. $\underset{C,M}{m} \int_{t-0}^{T} e^{-\rho}\, U[C(t), u(H(t)]d$

and u(.) is some function of the person's level of health. $C = C(t) = C_t$ and $M = M(t) = M_t$. Medical care M has a per unit price p. The maximization is subject to

2.12. $\dot{H}(t) = h(M(t)) - \delta H(t)$

2.13. $\dot{A}(t) = rA(t) + w(H)L(H) - C(t) - pM(t)$

2.14. $H(0) = H_0 > 0$, given

2.15. $H(T) = H_d \geq 0$, given

2.16. $A(0) = A_0 > 0$, given

2.17. $A(T) \geq 0$

2.18. $C(t) \geq 0,\ M(t) \geq 0.$

2.19. $U(0) = 0,\ U'(t) > 0,\ U''(t) < 0,\ \lim_{C\to 0} U'(C(t)) = \infty,\ h'(t) > 0,\ h''(t) < 0,\ Y' > 0,\ Y'' < 0.$

Muurinen (1982 p.10) and Wagstaff (1986 p.197) interpret u(.) as sick time, u' < 0, but u(.) can also be interpreted as pain and suffering due to ill-health. $H(t) > H_d$, for all $0 \leq t < T$. Note that the person's lifetime T can be endogenous (Grossman 1972, Erhlich and Chuma 1989) because T can depend on how healthy a person is, other things being equal. This illustrates a special feature of medical care: medical care can influence longevity through influence on health status. Current value Hamiltonian for this model is:

2.20. $L = U(C,H) + \lambda_h(t)[h(M) - \delta H] + \lambda_a(t)[rA(t) + Y(H) - C(t) - pM(t)]$

where $\lambda_a(t)$ and $\lambda_b(t)$ are current value multipliers. The optimality conditions are (in addition to equation 2.12 and 2.13):

2.21. $U'(C) - \lambda_a(t) = 0$

2.22. $\lambda_h(t)h'(M) - p\,\lambda_a(t) = 0$

2.12. $\dot{H}(t) = h(M(t)) - \delta H(t)$

2.13. $\dot{A}(t) = rA(t) + w(H)L(H) - C(t) - pM(t)$

2.23. $\dot{\lambda}_h(t) = (\rho + \delta)\,\lambda_h(t) - U_h(.) - \lambda_a(t)Y'(H)$

2.24. $\dot{\lambda}_a(t) = (\rho - r)\,\lambda_a(t)$

2.25. $e^{-\rho}\, U(C(T)) + \lambda_h(T)[h(M(T)) - \delta H(T)] + \lambda_a(T)[rA(T) - C(T) - pM(T)] = 0.$

Equation 2.25 is the transversality condition. From Equations 2.21 and 2.22,

2.26. $U'(C) = \lambda_a(t)$

2.27. $\frac{\lambda_h}{\lambda_a} = \frac{p}{h'(t)}$

Equation 2.23 can be rearranged as follows, making use of equations 2.26 and 2.27.

2.28. $\frac{U_h}{U_c} + Y'(H) + \dot{\lambda}_h(t)/\lambda_a(t) = \frac{p}{h'(M)}(\rho + \delta)$

Note that Equation 2.10 is a special case of Equation 2.28 with $(\rho + \delta) = 1$and capital gains equal zero (see Muurinen 1982 p.12, Wagstaff 1986 p.198 Equation 4a). Equation 2.28 states that in order for an individual to want to invest in health, the marginal benefits of that health investment (lhs) which now includes capital gains (marginal change in the unit value of health, third term in Equation 2.28) must be as high as the shadow price of health weighted by the sum of the person's rate of health depreciation δ and her rate of time preference (or rate of impatience) ρ.

Review of Value-Of-Life Models of Demand for Medical Care

Value-Of-Life models are motivated by survival or longevity rather than quality-of-life. The original idea is expressed by Thomas Schelling (1968 p.127): "What is it worth to reduce the probability of death – …?" How much money or effort would society or individual be willing to expend in order to reduce by a small amount the risk to life. Alternatively, how much would a society or individual be willing to accept in compensation for a small increase in the risk of death? First, consider social projects or programmes such as a local government hospital, ambulance service, etc., that can save lives, increase life expectancy or decrease mortality rates (Rice 1968, Klarman 1968, Rottenberg 1968). Before it is known who will have a heart attack and need the ambulance service or the hospital, each resident can be asked how much she would be willing to contribute towards the project. The project is undertaken only if the aggregate WTP is high enough to cover the purchase price of the project; only if 'enough' persons are willing to pay enough for it (Mishan 1971, Deaton 1988). A person's willingness to contribute ex-ante to the extra life-saving the project helps make possible is a measure of the person's demand for life-saving. Life-saving is possible because survival is considered endogenous in the sense that the probability of death can be influenced prior to occurrence.

Social investments apart, there are many activities and attitudes (including medical care) a person can undertake to influence the risk of her own death or the death of a loved one. As such, a person's attitude towards the risk of death is relevant in calculating the value the person attaches to life. In general, a person's WTP for life-saving includes her market as well as nonmarket expenditures and efforts on safety-enhancing goods such as smoke-detectors, in addition to her willingness to contribute to the public projects (Weisbrod 1978).

Risk of death is the expected costs of death which equal to the probability of death in each state of nature times the cost of death in that state, summed over discrete states of nature. Death is a cost because it implies the lowest possible utility value relative to other possible states of nature. If mortality cost is assumed fixed, the individual's actions can only affect her survival probability (Fromm 1968, Conley 1976, Thaler and Rosen 1976, Gould and Thaler 1980, and Freeman (1985)). Reductions in a person's probability of death are possible because, in spite of the eventual inevitability of death, the person's survival probability at any instant depends on how healthy the person is. According to Berger, Blomquist, Kenkel and Tolley (1978 p.970), "it is reasonable to assume that the healthier a person is, the greater the chances of survival of a given period. In other words, probability of survival can be expressed as an increasing (decreasing) function of good (bad) health characteristics." According to Fromm (1968 p.170), "The price of life-saving must equal (or be less than) the marginal rate of substitution of survival and income-asset utilities." If the activity undertaken to affect survival is medical care, then the VOL concept can generate a survival-induced demand for medical care. That is, the value of your life to you is your WTP for your survival, including your demand for medical care (Jones-Lee 1976, 1982).

In order to illustrate the formalization of the VOL models of demand for medical care, consider the following static model. Let H be the person's level of health in the period. H_0 is the level of her health at the beginning of the period (Freeman 1985, Harrington and Portney 1987). The person's survival probability (the probability that she will live until the end of the current time period) q at any instant is a function of her level of health, $q = q(H)$, $q' \geq 0$. The probability of her death is $1 - q(H)$. If the person's initial survival probability is $q_0 = q(H_0)$, then it is possible to imagine that $q(H) = q_0 + \propto(H)$, for an appropriate function $\propto$. Let the person's level of health be a function of medical care utilized M as in Equation 2.3, $H = (1\text{-}\delta)H_0 - h(M)$, $h' > 0$, $h'' < 0$, where δ is the health depreciation rate. M is traded in a competitive market at price p. In some models, it is assumed instead that survival probability q can be traded directly in a competitive market (Jones-Lee 1974). Imagine that at the beginning of the single period under consideration a person is given an income Y which she can spend on current consumption C that yields utility U(C), on bequest $B \geq 0$ to her survivors yielding utility D(B), and/or on medical care M that influences her survival probability. Consumption C is a numeraire good, consumed only if the person survives. Other than the utility from the bequest D(.), it is assumed that a person derives zero utility in death. That is, a dead person has zero consumption, $C = 0$, and $U(0) = 0$. In this case, the person's expected utility is $q(H)U(C)$ since bequest does not take effect until death. If the choices are made to maximize the person's end-of-period expected utility subject to her budget constraint, then the consumer's problem is:

3.1. $\overset{m}{C, B, M}\{EU = q(H)U(C) + [1\text{-}q(H)]D(B)$

3.2. s.t. $C + pM + B = Y$

3.3. $H = (1\text{-}\delta)H_0 + h(M)$

Assume that bequest $D(B) = 0$ because the person left no bequest or because she does not care about her survivors (Freeman 1985). Specifically, let $B = 0$. Then the Lagrangian is:

3.4. $L = q(H)U(C) + \mu[Y - C - pM]$

The first-order conditions are:

3.5. $\frac{\partial}{\partial} = q(H)U'(C) - \mu = 0$

3.6. $\frac{\partial}{\partial} = q'(H)h'(M)U(C) - \mu p = 0$

By substituting for μ from Equation 3.5 and rearranging gives

3.7. $\frac{q'(H)h'(M)U(C)}{U'(C)} - pq_0 = p\alpha(H)$ where $q = q_0 + \alpha(H)$

3.8. $\frac{q'(H)U(C)}{q(H)U'(C)}h'(M) = p$

3.9. $\frac{q'(H)U(C)}{q(H)U'(C)} = \frac{p}{h'(M)}$

In Equation 3.9, the expected marginal benefits of health equal its shadow price; marginal rate of substitution equals the price. The expected benefits in Equation 3.9 consist of two terms. The numerator implies that if a person can survive one more period, she would have utility U(C) but this will occur with a marginal probability q'(H). The denominator is the expected marginal utility of consumption. Conley (1976) assumes that $q(H) = 1$, in which case the denominator in Equation 3.9 is simply the marginal utility of consumption. This model in

Equations 3.1 -- 3.9, illustrates how to convert a VOL concept into a model of demand for medical care, with the individual in only two states, alive or dead. In general, an individual may be in multiple states of health (Harrington and Portney 1987) with the death state as only one of the possible health states. Such a model has been termed cost-of-illness model.

Cost-Of-Illness Models: Amalgamation of Analytical Models

Conceptually, cost-of-illness models of demand for medical care are a synthesis of previous models of demand for medical care. This fact is not apparent in the literature. It is especially obvious that human-capital models have not been considered as cost-of-illness models. Yet, the motivation for medical care utilization in human-capital models is the individual's desire to avoid or reduce sick-time and other costs associated with ill-health or low levels of health. It seems important to recognize that most of the results of human-capital models can be obtained from a model of consumer optimization that takes into consideration the whole range of morbidity motives for medical care use. For an annotated bibliography of cost-of-illness models see Jarvinen (1988). If the value-of-life model is expanded to incorporate the probability of falling ill as well as the probability of death, then a cost-of-illness model ensues. This is accomplished by assuming that there are more than two (life, death) states of nature, that there are multiple states of illness or wellness, and each state has a probability that the person will be in that state (Goddeeris 1983). In the value-of-life model presented above, one could have assumed that utility and income both depend on a person's level of health, U = U(C,H) and Y = Y(H). The resulting model is the cost-of-illness model which presumably considers all the possible motivations for medical care use, and attempts to attach economic values to these motivations. The individual solves the following single period problem:

4.1. $\underset{C,B,M}{mx}\{EU = q(H)U(C,H) + [1-q(H)]D(B)\}$

4.2. s.t. $C + pM + B = Y(H)$

4.3. $H = (1-\delta)H_0 + h(M)$, $h'(M) \geq 0$.

This model is being used here only because of its illustrative simplicity. In general, $EU = \sum_i q_i(H_i)U_i(C_i,H_i) + [1 - \sum_i q_i(H_i)]D(B)$, where i is an index of the various states of healthiness while the person is alive. $0 \leq q_i \leq 1$ is the probability that the person will be in state i: $\sum_i q_i(H) \leq 1$. If the person is in states i, her level of health is H_i, her utility is U_i, and she chooses nonmedical consumption C_i. In the special case being considered here, the Lagrangian is:

4.4. $L = q(H)U(C,H) + [1-q(H)]D(B) + \mu[Y(H) - C - pM]$

As was done previously, assume that B = 0 and D(B) = 0. The indicated optimization yields

4.5. $\frac{\partial}{\partial} = q(H)U_C(.) - \mu = 0$

4.6. $\frac{\partial}{\partial} = [q'(H)h'(M)U(C) + q(H)U_H(.)]h'(M) - \mu[Y'(H)h'(M) - p] = 0$

Solving equations 4.5 and 4.6 gives

4.7. $[\frac{U(.)q'(H)}{U_C(C)q(H)} + \frac{U_h}{U_C} + Y'(H)]h'(M) = p.$

Comparing Equation 4.7 with Equations 2.9 and 3.8, note that whereas human-capital and VOL models consider only portions of an individual's motivations for medical care (morbidity or mortality, respectively), cost-of-illness models consider the person's reactions to the incidence of both illness and death. Cost-of-illness models are a synthesis because they combine survival motives of the value-of-life framework with the quality-of-life motives of the human-capital framework to derive a generalized model of demand for medical care.

Severity of Illness as a Concept of Health Status

Human-capital models stylize health depreciation as: $H(t) = H_0e^{-\delta}$, δ is the rate of depreciation and H_0 is the initial health stock (Muurinen 1982). Health depreciation may be adequate for modeling human aging process but is an inadequate illness process because of failure to distinguish sick from healthy persons, contrary to Arrow's (1963) suggestion. Eze (2013) proposes that, at least for curative medical care such as hospital inpatient care, the appropriate measure of health status is the severity of a person's illness. Imagine that each person's level of health when healthy H_i^* is personal and regarded as a benchmark (van de Ven and van der Gaag, 1982, p.173, Williamson 1981, Harris and Kohn 2015). Imagine also that the person has a health index H_i denoting his or her actual level of health whether healthy or ill. Then illness is defined as a deviation of H_i from H_i^*. The severity of the person's illness S_i is the magnitude of this health deviation. The key idea is that a person is considered healthy or otherwise relative to herself and not relative to other persons. Generalizing this concept for a lifetime, $0 \leq t \leq T$, let the severity of the person's illness at any time be s(t) and defined as:

5.1 $S_i(t) \equiv H_i^*(t) - H_i(t) \geq 0.$

5.2. $S_i(t) = 0$ if Person i is healthy.

5.3. $S_i(t) > 0$ if Person i is sick.

Let s_0 be a measure of how ill a person is at the beginning of a period; M is the amount of medical care the person utilizes within the period. Let h(M) be an index of the effectiveness of medical care, where $h'(.) > 0$, $h''(.) < 0$. h(.) (Grossman 1972, Pauly 1980, p.44, Jack 1999). The technical relationship between severity of the person's illness and her medical care usage is:

5.4. $S = S_0 - h(M) \geq 0.$

Equation 5.4 will appear as a constraint in models of demand for medical care. It states that how ill a person is in a time period depends, all else equal, on the initial health conditions and on the effectiveness of curative care utilized in that period. In Equation 5.4, medical care M is utilized in order to cure existing illness S_0.

Conclusion

If an activity is undertaken at all, to what extent should it be undertaken? Each model of demand for medical care responds that, because economic resources are scarce, each undertaking has its opportunity costs and, as a result, the activity should be undertaken up to levels where its marginal benefits equal its marginal costs. In a market system, the consumer's activities should be undertaken until the marginal rates of substitution (MRS) between any two of the activities is equal to the ratio of their prices. Likewise, for the firm, marginal costs equal the marginal revenues in equilibrium; in the market, the marginal rate of transformation (MRT) equals the ratio of marginal costs of any two undertakings. It follows that the demand for medical care is determined by equating the marginal benefits of medical care to the marginal costs of illness and death. According to Bergstrom (1982 p.3), even in 'matters of life and death' there is a logic of choice. For example, the Rand Corporation insurance experiments in the United States showed that the elasticity of demand for medical care responds to coinsurance and to time prices (Phelps and Newhouse 1974). Finally, note that existing models do not usually distinguish between healthy and ill persons.

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