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Allocating health care resources when people are risk averse with respect to life time

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Abstract

The criterion of cost-effectiveness in health management may be given a welfare-theoretical justification if people are risk neutral with respect to life years. With risk aversion, the optimal allocation of health expenditures change: Compared to the cost-effective allocation, more resources should be allocated to health cases for which the expected outcomes even after treatment are worse than average. The consequences of medical interventions are usually not known with certainty. Given this type of uncertainty, simple application of cost-effectiveness analysis would recommend maximization of *expected* health benefits given the health budget. We show that when people are risk averse with respect to the number of life years they live, the uncertainty associated with different types of interventions should play a role on allocating the health budget.

1. Introduction

To prioritize among different types of health expenditures, economists often argue that cost-effectiveness analysis should play an important role. Cost-effectiveness is defined as the minimum cost for a given health benefit, or equivalently, maximal health benefits for given expenditures on health care. To be able to use such an analysis, one needs some measure of "health benefits". While some analyses simply used the sum of life years saved due to a medical intervention, is more common so also take improvements in health status into account. A frequently used measure combining the number of lives lived and the health quality of these years is "quality adjusted life years", or QALYs. The use of QALYs as a welfare measure, and as an appropriate variable in cost-effectiveness analyses, has been extensively discussed in the literature.[1]

A number of authors have criticized the simple use of "minimum cost per QALY" as a criterion for allocating the health budget. A main criticism has been that the summation of QALYs across individuals lacks a good ethical or welfare theoretical basis, see e.g. Harris (1987), Wagstaff (1991), Nord (1994), Olsen (1997) and Dolan (1998). The criterion of cost-effectiveness may, however, be given a welfare-theoretical justification under certain circumstances: Imagine that a person must choose all health expenditures behind the Rawlsian veil of ignorance, i.e. before he/she knows his/her health state. If this person has preferences satisfying the axioms of expected utility theory, a cost-effective allocation of health expenditures will be optimal, provided the person is risk neutral with respect to his or her number of life years. However, risk neutrality with respect to life years is not a particularly realistic assumption (see e.g. the discussion given by Bleichrodt (1995)). In this paper we therefore consider how risk aversion with respect to life years affects the optimal allocation of health expenditures.

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[1] See e.g. Weinstein and Stason (1977), Pliskin et al. (1980), Mehrez and Gafni (1989), Broome (1993), Johannesson and Weinstein (1993), Gabler and Phelps (1997), Bleichrodt and Quiggin (1999), and Nord (1999).

The consequences of medical interactions are usually not known with certainty. Given this type of uncertainty, cost-effectiveness analysis is typically formulated as a recommendation to maximize *expected* health benefits given the health budget. We show that when people are risk averse with respect to the number of life years they live, the uncertainty associated with different types of interventions should play a role on allocating the health budget.

The rest of the paper is organized as follows. The main assumption regarding types of health states and preferences over these is given in Section 2. We avoid the use of the QALY concept, as it can be argued that QALYs can only be a representation of individual life cycle preferences if people are risk neutral with respect to life years (see Pliskin et al. (1980), Bleichrodt (1995) and Bleichrodt et al. (1997)). Instead, we use the concept of "healthy year equivalents", or HYEs (see e.g Mehrez and Gafni (1989), Culyer and Wagstaff (1993), Gafni et al. (1993), and Bleichrodt (1995) for a discussion of this concept)[2]. In Section 3 we derive the allocation of health expenditures that would be chosen by a person deciding behind the Rawlsian veil of ignorance. The special cases of risk neutrality and no uncertainty regarding health outcomes for a given health state are discussed in Sections 4 and 5, before the properties of the general case are discussed in Section 6. A brief summary of the main conclusions is given in Section 7.

2. Health states.

A health profile is characterized by a particular lifetime and a particular time profile of various health attributes during this lifetime. We assume that at the ex ante stage when people do not know their health profile, they have an identical preference ordering over health profiles. Moreover, we assume that for every health profile we can define a "healthy year equivalent" (HYE), i.e. a specific number of years in perfect health that

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[2] If we are only concerned with the number of life years, and not the health quality of these years, both HYEs and QALYs are identical to the number of years lived. Moreover, if preferences have the property that they can

the decision-maker regards as equivalent to the health profile considered. In this way, each health profiles may be summarized by a single number measuring "health standard" by HYEs.

We assume that there are m different health states at the ex ante stage, with health state i having probability p_i of occurring. Let h_i denote the number of HYEs in health state i. Obviously h_i will depend on what health care one is given. Moreover, for a given level of health care in a state i, the number of HYEs is generally random. The number of HYEs in health state i is thus given by a function $h_i(c_i; \theta)$, where the uncertainty is represented by the parameter θ, with each realization having a known probability q_θ. In particular, the HYEs in the absence of any treatment in health state i is $h_i(0; \theta)$. By assumption, the h_i functions are increasing in their first arguments. Moreover, we shall simplify our analysis by assuming that all h_i functions are differentiable and concave in their first argument. More precisely, using h_i' and h_i'' to denote first and second order derivatives with respect to c_i, we assume that $h_i' \geq 0$ and that $h_i'' < 0$ for all $h_i' > 0$. In reality, as health expenditure increases, there will typically be stages where one moves from one type of treatment to another. Therefore, the function may be discontinuous, and certainly non-differentiable, at some points. However, for the general ideas presented in this paper this is of minor importance. We therefore stick to our analytically simple h_i functions.

The decision-maker is assumed to have a von Neuman-Morgenstern utility function over HYEs, denoted by $U(h_i(c_i; \theta))$. This function is assumed to be strictly increasing and concave. The case of risk neutrality in life years is a limiting case. For the case of risk aversion in life years U is strictly concave.

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be represented by the number of QALYs, then this number is equal to the number of HYEs (see Bleichrodt (1995).

3. The optimal allocation of the health budget

At the level of the society, the probabilities p_i are shares of persons in each of the m health states. From the notation of the previous sections we can write the government's budget constraint (per capita) as

$$\sum_i p_i c_i \leq C \tag{1}$$

where C is an exogenously given health budget.

The decision-maker must choose all health expenditures c_j behind a veil of ignorance, and does this so that his or her expected utility is maximized[3]. In other words, the following maximization problem is solved

$$\text{Maximize } \sum_{i,\theta} p_i q_\theta U\big(h_i(c_i;\theta)\big) \quad \text{subject to (1)} \tag{2}$$

which gives the optimality condition

$$E\big\{U'\big(h_i(c_i;\theta)\big)h_i'(c_i;\theta)\big\} = \lambda \qquad i=1,...,m \tag{3}$$

or, equivalently

$$EU'\big(h_i(c_i;\theta)\big) \cdot Eh_i'(c_i;\theta) + \text{cov}\big\{U'\big(h_i(c_i;\theta)\big), h_i(c_i;\theta)\big\} = \lambda \quad i=1,...,m \tag{4}$$

Before discussing the general case, we shall briefly consider two special cases in the next two sections.

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[3] A similar approach is used by Pratt and Zeckhauser (1996) for a related problem.

4. The special case of risk neutrality

If we have risk neutrality with respect to life years, U' is constant, so that *(3)* may be rewritten as

$$Eh_i{}'(c_i;\theta) = \frac{\lambda}{U'} \tag{5}$$

It follows from *(5)* that under risk neutrality the optimal allocation is characterized by the expected marginal health benefits (measured by HYEs) of additional health expenditures being the same for all types of health expenditures. This is the same allocation as one would get from maximizing the sum of expected HYEs for a given budget for the sum of direct health expenditures. In the literature, this allocation is often referred to as the cost-effective allocation, see e.g. Weinstein and Stason (1977) for a further discussion.

5. The special case of a health state defining a non-random health outcome

As mentioned in the Introduction, it seems plausible that people are risk averse with respect to lifetime, and thus with respect to HYEs. Let us first ignore uncertainty regarding health outcomes for a given health state. Formally, let h_i depend only on c_i, and not on θ. If this is the case, we can rewrite *(3)* as

$$U'(h_i(c_i)) \cdot h_i{}'(c_i) = \lambda \quad i=1,...,m \tag{6}$$

It is clear from *(6)* (and the concavity of the functions U and h_i) that the health budget should be allocated so that the marginal health benefits (measured by HYEs) of additional health expenditures should be higher in states where the equilibrium number of HYEs is low than when this number is high. In other words, risk aversion implies that health expenditures directed towards more serious health problems (measured by HYEs) should be given a higher priority than they would in the simple case of cost effectiveness.

6. The general case of uncertain health consequences of health care

We want to investigate the consequences of uncertainty of a specific health defect j. To do this, let the functions $h_i(c_i;\theta)$ be given for all $i \neq j$. We compare the case of uncertainty in the relationship between c_j and h_j with the case of certainty where the certain relationship between health expenditure and HYEs is equal to the expected value of the function $h_j(c_j;\theta)$, denoted $Eh_j(c_j;\theta)$. (The latter case corresponds to the degenerate case in which the function values $h_j(c_j;\theta)$ are independent of the value of θ). Since we are changing the h_j-function for only one j, it is reasonable to expect λ to have (approximately) the same value for the two cases compared.

Assume first that the marginal health benefit of health expenditures in health state j is non-random, i.e. that $h_j{'}(c_j;\theta)$ is independent of θ. This means that although health outcomes may be uncertain, the differences in health outcomes due to different levels of health care are certain. In this case the covariance term in *(4)* is zero. The l.h.s. of (4) is larger or smaller with uncertainty than without, depending on whether *E(U')* is larger or smaller under uncertainty than under certainty. This in turn depends on the sign of *U'''*. If *U'''* is positive (as it is e.g. under constant relative risk aversion), then *E(U')* is larger under uncertainty than under certainty. From the second order condition of the optimization problem, it therefore follows that health expenditure directed towards health defect j should be higher under uncertainty than under certainty. The opposite will be true if *U'''* is negative.

To see the importance of the covariance term in *(4)*, let us now assume that *U'''=0*. From the result above we know that if the covariance term in *(4)* is zero, then the health expenditure directed towards health defect j should not be affected by the presence of uncertainty. Consider next the case in which

$$\text{cov}\{U'(h_j(c_j;\theta)), h_j{'}(c_j;\theta)\} > 0 \tag{7}$$

For any level of health expenditure, U' is lower for "good" values of θ than for "bad" values of θ (since $U''<0$). The assumption *(7)* therefore means that the marginal benefit of health care (measured in HYEs) is lower for good health outcomes than for low health outcomes. In other words, health care reduces the uncertainty of the health outcome.

When $U'''=0$ and *(7)* holds, the l.h.s. of *(4)* is higher under uncertainty than under certainty. From the second order condition of the optimization problem, it therefore follows that health expenditures directed towards health defect j should be higher under uncertainty than under certainty.

Consider the opposite case from *(7)*, i.e.

$$\text{cov}\{U'(h_i(c_j;\theta)), h_j'(c_j;\theta)\} < 0 \qquad (8)$$

In this case health care increases the uncertainty of the health outcome. We then get the opposite conclusion from above: Health expenditures directed towards health defect i should be *lower* under uncertainty than under certainty when $U'''=0$ and *(9)* holds.

7. A comparison with a simple rule of cost-effectiveness

We have shown that a simple type of cost-effectiveness is optimal if the decision-maker is risk neutral with respect to life years. With risk aversion, the optimal allocation of health expenditures changed. The analysis indicates how the optimal allocation deviates from the cost-effective allocation. Loosely speaking, we have shown the following:

- More resources should be allocated to health cases for which the expected outcomes even after treatment are worse than average.

- If the utility function has the property that $U'''>0$ (implied by e.g. constant risk aversion), more resources should be allocated to cases for which the health outcome is more uncertain than average, unless the treatment increases this uncertainty.
- Even if medical treatment for a particular health defect increases the uncertainty of the health outcome, it is not obvious that less resources should be allocated to such a health defect than to a health defect with a less uncertain development, since we cannot rule out the possibility that $U'''<0$.

References

Bleichrodt, H. (1995), "QALYs and HYEs: Under what circumstances are they equivalent?", Journal of Health Economics 14, 17-37.

Bleichrodt, H. and Quiggin, J. (1999), "Life-cycle preferences over consumption and health: when is cost-effectiveness analysis equivalent to cost-benefit analysis?", Journal of Health Economics 18, 681-708.

Bleichrodt, H., Wakker, P. and Johannesson, M. (1997), "Characterizing QALYs by risk neutrality", Journal of Risk and Uncertainty 15, 151-165.

Broome, J. (1993), "Qalys", Journal of Public Economics 50, 149-167.

Culyer, A.J. and A. Wagstaff (1993), "QALYs versus HYEs", Journal of Health Economics 12, 311-323.

Dolan, P. (1998), "The measurement of individual utility and social welfare", Journal of Health Economics 17, 39-52.

Gabler, A.M. and Phelps, C.E. (1997), "Economic foundation of cost-effectiveness analysis", Journal of Health Economics 16, 1-31.

Gafni, A., Birch, S. and Mehrez, A. (1993), "Economics, health and health economics: HYEs versus QALYs", Journal of Health Economics 12, 325-339.

Harris, J. (1987), "QALYfying the value of life", Journal of Medical Ethics, 13, 117-123.

Johannesson, M. and Weinstein, M.C. (1993), "On the decision rules of cost-effectiveness analysis", Journal of Health Economics 12, 459-467.

Mehrez, A. and Gafni, A. (1989), " Quality-adjusted life years, utility theory, and healthy-years equivalents", Medical Decision Making, 9, 142-149.

Nord, E. (1994) "The QALY – A measure of social value rather than individual utility?", Health Economics, 3, 89-93.

Nord, E. (1999), Cost-value analysis in health care: making sense out of QALYs. Cambridge University Press.

Olsen, J.A. (1997), "Theories of justice and their implications for priority setting in health care", Journal of Health Economics 16, 625-639.

Pliskin, J.S., Shepard, D.S. and Weinstein, M.C. (1980), "Utility functions for life years and health status", Operations Research 28, 206-224.

Pratt, J.W. and Zeckhauser, R.J. (1996), "Willingness to pay and the distribution of risk and wealth", Journal of Political Economy 104, 747-763.

Wagstaff, A. (1991), "QALYs and the equity-efficiency trade-off", Journal of Health Economics 10, 21-41.

Weinstein, M.C. and Stason, W.B. (1977) "Foundations of cost-effectiveness analysis for health analysis and medical practices", New England Journal of Medicine 296, 716-721.