HEALTH ECONOMICS
Health Econ. **16**: 307–317 (2007)
Published online 28 September 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hec.1168

DISCOUNTING IN ECONOMIC EVALUATIONS: STEPPING FORWARD TOWARDS OPTIMAL DECISION RULES

HUGH GRAVELLE[a], WERNER BROUWER[b,*], LOUIS NIESSEN[b], MAARTEN POSTMA[c] and FRANS RUTTEN[b]

[a] *National Primary Care Research and Development Centre (NPCRDC), Centre for Health Economics, University of York, UK*
[b] *Department of Health Policy & Management and Institute for Medical Technology Assessment, Erasmus Medical Centre / Erasmus University Rotterdam, The Netherlands*
[c] *Groningen University Institute for Drug Exploration / University of Groningen Research Institute of Pharmacy (GUIDE/GRIP), The Netherlands*

SUMMARY

The National Institute for Clinical Excellence has recently changed its guidelines on discounting costs and effects in economic evaluations. In common with most other regulatory bodies it now requires that health effects should be discounted at the same rate as costs. We show that the guideline leads to sub-optimal decisions because it fails to account for the changing value of health. NICE (and other regulatory bodies) should either use differential discounting or stipulate how the changing value of health should otherwise be dealt with. We also show how binding health service budget constraints should be incorporated in evaluations. Copyright © 2006 John Wiley & Sons, Ltd.

Received 22 December 2005; Revised 20 May 2006; Accepted 10 July 2006

JEL classification: I10; I18

KEY WORDS: cost-effectiveness; discounting; value of health

INTRODUCTION

Discounting in economic evaluations has long been controversial, especially whether the volume of health effects, when measured in non-monetary units such as QALYs, should be discounted at the same rate as costs (Cairns, 2001). The approach followed by most government and regulatory bodies is to discount both costs and health effects at the same rate, usually in the range of 3–5% (Drummond *et al.*, 1997; Gold *et al.*, 1996; Smith and Gravelle, 2001). It is generally accepted that the social value of health effects increases over time (Claxton *et al.*, 2006). But this is not allowed for in the conventional approach, leading to sub-optimal investment criteria (Parsonage and Neuburger, 1992; Van Hout, 1998; Gravelle and Smith, 2001; Viscusi, 1995; Spackman, 2004). One way to incorporate the growing value of health is through differential discounting by using a lower discount rate for health effects than for costs. This discount rate for health effects is equal approximately to the discount rate for costs minus the annual rate of increase in the value of health.[1] The implications of allowing for the changing value of health can be profound (Brouwer *et al.*, 2005).

*Correspondence to: iMTA, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands. E-mail: brouwer@bmg.eur.nl

[1] The assumption of growing value of QALYs is empirical rather than normative and requires no departure from the standard economic framework (Gravelle and Smith, 2001). If income levels were to fall over a sustained period then it is likely that the social value of QALYs would fall. But whether the value rises or falls, the change must be incorporated into economic evaluations of health care interventions. If the value of health falls and this is reflected by differential discounting then the discount rate on health would be larger than the discount rate on consumption.

The National Institute for Clinical Excellence (NICE) (NICE, 2001) and the English Department of Health (1996) were in a minority in stipulating that health effects should be discounted at a lower rate than costs (Smith and Gravelle, 2001). But NICE has recently changed its guidelines (NICE, 2004) to the conventional uniform discounting of costs and effects. NICE did not prescribe any other way of dealing with the increasing value of health; indeed the new guidelines do not discuss the issue. The change in the NICE guidelines has been questioned and it has been suggested that, in the absence in the NICE guidance of other ways of dealing with the increasing social value of health, differential discounting is required (Brouwer *et al.*, 2005).[2]

Claxton *et al.* (2006), (hereafter the NICE team), have now defended the new NICE guidelines (NICE, 2004). The NICE team suggests that differential discounting is inconsistent and that the increase in the social value of health, which they accept as 'uncontroversial', is not relevant for NICE. They argue that, because NICE makes decisions about NHS interventions within a fixed NHS budget, the NHS threshold incremental cost-effectiveness ratio (ICER) should be used to place a monetary value on health effects, which should then be discounted at the same rate as costs.

In this paper, we respond to these points. First, we set out a simple model to highlight the issues. We use it to derive a set of alternative equivalent welfare maximising rules which incorporate adjustments (a) for the changing value of health and (b) the opportunity cost of projects in a budget constrained health service. Comparing the welfare maximising rules with the rules implied by the NICE criterion shows that the NICE decision rules lead to sub-optimal decisions unless the NHS budget is set optimally, so that the threshold ICER is equal to the marginal social value of health. We then discuss the NICE team arguments against differential discounting and the need to allow for the changing value of health and show that they are not well founded.

WELFARE MAXIMISING DECISIONS

Consider a two period example (a fuller version is in the Appendix). The welfare function for society is

$$W = W(h_1, h_2, x_1, x_2) \tag{1}$$

where h_t is health in period t and x_t is consumption (measured in monetary units) in period t. Although we refer to (1) as the welfare function we make no assumptions about whether it is 'welfarist' or 'extra-welfarist'. It is merely a numerical representation of value judgements which satisfy very weak requirements, including more consumption or health being preferred to less. Denoting the marginal welfare from period t consumption and health by W_{xt}, W_{ht}, there are four marginal rates of substitution

$$-\left.\frac{\mathrm{d}x_2}{\mathrm{d}x_1}\right|_W = \frac{W_{x1}}{W_{x2}} \equiv 1 + r_x, \quad -\left.\frac{\mathrm{d}h_2}{\mathrm{d}h_1}\right|_W = \frac{W_{h1}}{W_{h2}} \equiv 1 + r_h, \quad -\left.\frac{\mathrm{d}x_t}{\mathrm{d}h_t}\right|_W = \frac{W_{ht}}{W_{xt}} \equiv v_t \quad t = 1, 2 \tag{2}$$

Fixing any three of these determines the fourth. In particular,

$$1 + r_h \equiv \frac{W_{h1}}{W_{h2}} = \frac{W_{x1}}{W_{x2}} \frac{W_{h1}}{W_{x1}} \frac{W_{x2}}{W_{h2}} = (1 + r_x)\frac{v_1}{v_2} = \frac{(1 + r_x)}{(1 + g_v)} \tag{3}$$

[2] The NICE team misrepresent (Brouwer *et al.*, 2005) by stating: "Brouwer and colleagues ... are not right in saying that when health is measured in physical units like QALYs ... any increasing value of health has to be reflected in a lower discount rate" (Claxton *et al.*, 2006). We simply argued that the growing value of health should somehow be accounted for and that: "When health effects are valued monetarily this can be done by using a growing value for health. When non-monetary quantities are used, such as QALYs (as proposed in the NICE guidelines), the growth can be accounted for by lowering the discount rate for effects relative to that of costs – that is, differential discounting" (Brouwer *et al.*, 2005). Brouwer *et al.* (2005) do not claim, *pace* Claxton *et al.* (2005), that health and wealth cannot be traded.

DOI: 10.1002/hec

where g_v is rate of growth in the value v_t of period t health in terms period t consumption. Provided the consumption and health interest rates (r_c and r_h) and the growth rate for v are not too large we can write $r_h \cong r_x - g_v$. The questions at issue are how r_h and r_x enter the welfare maximising criterion for accepting or rejecting a health service intervention and whether the NICE discounting rules are equivalent to welfare maximising rules.

Consider an intervention which will change the number of QALYs in period t by Δh_t and have period t costs, which are incurred only within the NHS, of Δc_t. The NHS has a fixed budget in each period, so that the cost of the intervention must be financed by an equal reduction in expenditure elsewhere in the NHS. Thus the intervention has direct health effects and also has an opportunity cost in terms of the reduction in QALYs due to the displaced NHS activities. Assume that the cost-effectiveness of the activities displaced equals the incremental cost-effectiveness threshold for the NHS in period t: the cost per unit of health gained by the marginal NHS activity in period t. Denote the threshold by k_t.

The threshold ICER k_t is determined by (a) technology (the increase in QALYs per £ spent) and (b) the level of the budget, since the threshold ICER will decline as more is spent (see Appendix). It is not directly affected by the marginal social value of health v_t , though it might be indirectly affected if v_t influenced the NHS budget. Denote the growth rate in the threshold ICER by $g_k = (1+k_2)/(1+k_1) - 1$.

If NHS budgets are set to maximise welfare then $k_t = v_t$ and $g_k = g_v$. If the NHS budget is less than optimal, then $k_t < v_t$: the cost of an additional QALY is less than its social value. Note that k_t being smaller or larger than v_t does not imply that g_k is smaller or larger than g_v.

The period t opportunity cost of the intervention in health terms is $\Delta c_t/k_t$. We can also use k_t to express the direct health effects of the new intervention in terms of the amount of NHS budget that would have to be spent to produce the same amount of health: $k_t\,\Delta h_t$.

The intervention should be accepted if and only if the sum of the health effects valued in terms of consumption and discounted at the consumption rate of interest is positive, where the health effects include the opportunity costs of the activities displaced to finance the intervention within fixed NHS budgets:

Rule 1 (*consumption discount rate*):

$$\text{Accept iff } \frac{\Delta W}{W_{x1}} = v_1\left[\Delta h_1 - \frac{\Delta c_1}{k_1}\right] + v_2\left[\Delta h_2 - \frac{\Delta c_2}{k_2}\right]\frac{1}{(1+r_x)} > 0 \tag{4}$$

NHS budgets are fixed so the intervention has no effect on consumption: it merely alters the time stream of QALYs. If budgets are optimal, so that $k_t = v_t$, (4) simplifies to:

Rule 1′ (*optimal budgets*):

$$\text{Accept iff } \frac{\Delta W}{W_{x1}}:\ [v_1\Delta h_1 - \Delta c_1] + [v_2\Delta h_2 - \Delta c_2]\,\frac{1}{(1+r_x)} \tag{4′}$$

Using definitions (2) and (3), (4) is equivalent to requiring that the intervention should be accepted if and only if it increases the sum of QALYs when discounted to the present at the health discount rate:

Rule 2 (*health discount rate*):

$$\text{Accept iff } \frac{\Delta W}{W_{h1}} = \left[\Delta h_1 - \frac{\Delta c_1}{k_1}\right] + \left[\Delta h_2 - \frac{\Delta c_2}{k_2}\right]\frac{1}{(1+r_h)} > 0 \tag{5}$$

We could also write Rule 1 with differential discounting, applying the consumption discount rate to future cost changes and the health discount rate to future health changes (after valuing them in terms of period 1 consumption):

Rule 1″ (*differential discounting*):

$$\text{Accept iff } \frac{\Delta W}{W_{x1}} = v_1\left[\Delta h_1 - \frac{\Delta c_1}{k_1}\right] + v_1\frac{\Delta h_2}{(1+r_h)} - \frac{v_2 \quad \Delta c_2}{k_2(1+r_x)} > 0 \tag{6}$$

We can equivalently express the welfare maximising rule in various cost-effectiveness forms. For example, we could write it using the health discount rate, or the consumption discount rate, or differential discounting, to compare the ratio of discounted costs to discounted health effects with the first period incremental cost-effectiveness ratio:

Rule 3 (*CEA*): *Accept iff*

$$\frac{\Delta c_1 + \left(\frac{1}{1+g_k}\right)\frac{\Delta c_2}{(1+r_h)}}{\Delta h_1 + \frac{\Delta h_2}{(1+r_h)}} = \frac{\Delta c_1 + \left(\frac{1+g_v}{1+g_k}\right)\frac{\Delta c_2}{(1+r_x)}}{\Delta h_1 + \frac{(1+g_v)\Delta h_2}{(1+r_x)}} = \frac{\Delta c_1 + \left(\frac{1+g_v}{1+g_k}\right)\frac{\Delta c_2}{(1+r_x)}}{\Delta h_1 + \frac{\Delta h_2}{(1+r_h)}} < k_1 \tag{7}$$

The optimal decision rule incorporates the changing value of health and the NHS budget constraint. Differential discount rates are one method of allowing for the changing value of health. If budgets are set optimally, so that $k_t = v_t$ and $g_k = g_v$, the optimal CEA rule is that the ratio of costs discounted at r_x and effects discounted at r_h should be less than the value of health. If the NHS is subject to non-optimal budget constraints it is also necessary to allow for effect of the budget constraints on the opportunity costs. This can be seen as a correction on costs to reflect the forgone health from activities displaced to fund the intervention.

THE NICE CRITERION

The NICE team's criterion for evaluating an intervention is to 'apply the appropriate cost-effectiveness threshold to QALYs gained in each time period and discount these costs and benefits at the same rate back to present values.' (Claxton *et al.*, 2006, p. 3). Since the costs and adjusted health effects have the dimension of consumption, we interpret this to mean that the NICE team criterion is (numbering the rules in the same way as the corresponding welfare maximising rules)

NICE Rule 1 (*consumption discount rate*):

$$\text{Accept iff } [k_1\Delta h_1 - \Delta c_1] + [k_2\Delta h_2 - \Delta c_2]\frac{1}{\left(1+r_x^N\right)} > 0 \tag{8}$$

Thus the criterion has current period consumption as the unit of account, uses the threshold ICER to place a monetary valuation on the health change in each period, and then applies a discount rate appropriate to consumption as set by NICE (r_x^{N}, where superscript N refers to NICE). Defining $r_h^{\mathrm{N}} = (1 + r_x^{\mathrm{N}})/(1 + g_k) - 1 \cong r_x^{\mathrm{N}} - g_k$, we can also express it using different discount rates for health and costs

NICE Rule 1″ (*differential discounting*):

$$\text{Accept iff } k_1\Delta h_1 + \frac{k_1\Delta h_2}{(1+r_h^N)} - \Delta c_1 - \frac{\Delta c_2}{\left(1+r_x^N\right)} > 0 \tag{9}$$

With current health as the unit of account the NICE rule is

NICE Rule 2 (*health discount rate*):

$$\text{Accept iff } \left[\Delta h_1 - \frac{\Delta c_1}{k_1}\right] + \left[\Delta h_2 - \frac{\Delta c_2}{k_2}\right]\frac{1}{\left(1+r_h^{\mathrm{N}}\right)} > 0 \tag{10}$$

Thus this version of the NICE team criterion can be described as using the ICER threshold to express the financial costs of the intervention as forgone QALYs and applying a health discount rate to future health changes.

We can also express the NICE decision rule in terms of three equivalent cost-effectiveness ratios

NICE Rule 3 (*CEA*): *accept iff*

$$\frac{\Delta c_1 + \dfrac{\Delta c_2}{(1+g_k)(1+r_h^{\mathrm{N}})}}{\Delta h_1 + \dfrac{\Delta h_2}{(1+r_h^{\mathrm{N}})}} = \frac{\Delta c_1 + \dfrac{\Delta c_2}{(1+r_x^{\mathrm{N}})}}{\Delta h_1 + \dfrac{\Delta h_2(1+g_k)}{(1+r_x^{\mathrm{N}})}} = \frac{\Delta c_1 + \dfrac{\Delta c_2}{(1+r_x^{\mathrm{N}})}}{\Delta h_1 + \dfrac{\Delta h_2}{(1+r_h^{\mathrm{N}})}} < k_1 \tag{11}$$

Both the welfare maximising rules and the NICE rules can be expressed (a) using current health as the numeraire and with a health discount rate, or (b) with current consumption as the numeraire and with either differential discounting or direct adjustment of health effects.

The key question is whether the NICE team criterion leads to welfare increasing decisions: does it lead to the best possible health stream given the NHS budget constraints? Comparison of the NICE rules with the welfare maximising rules shows that the NICE rules are welfare maximising if and only if the NICE health and consumption discount rats are equal to those derived from the welfare function ($r_x^{\mathrm{N}} = r_x$, $r_h^{\mathrm{N}} = r_h$) and if NHS budgets are set optimally ($v_t = k_t$) in all periods affected by the intervention.

Using the model we next deal with the NICE team's objections to allowing for the changing value of health by differential discounting.

WHAT DISCOUNT RATE?

The NICE team note, and we agree, that because of externalities, risk premia, and intergenerational issues, market rates of interest may not be useful as a guide to what discount rate to use in health care evaluations. But we do not use this fact as the basis for arguing for differential discounting as one means of allowing for the changing value of health. The consumption and health discount rates in the model are derived from the social welfare function. For the purposes of deciding how to deal with the changing value of health it is unnecessary to specify the relationship between these rates and market rates of interest. We merely need to recognise that in general, because of the changing value of health, the consumption and health interest rates will differ.

IS HEALTH TRADABLE?

The NICE team suggests that advocacy of differential discounting rests on the assumption that health is not tradable (Claxton *et al*., 2006, p. 1) i.e. that it is not possible to change the time stream of health. Nothing in our arguments requires the assumption of non-tradability: interventions will in general change the time stream of health. The question is how changes in health in different periods should be valued in order to decide whether the intervention is worthwhile. Tradability requires discounting but the fact that consumption and health are both tradable does not imply that they should be discounted at the same rate, as contemplation of the definitions of rates of interest in (2) makes clear. The rate at which society discounts a QALY and the rate at which it discounts consumption are linked by the rate at which the value of health changes.

CONSISTENCY

The NICE team suggest, drawing on the argument of Weinstein and Stason (1977), that the 'fundamental problem with differential discounting ... is really one of consistency between present and terminal values' (Claxton *et al*., 2006). By this they mean that the cost per QALY from an intervention should be independent of whether it is calculated by discounting future costs and health effects back to the present or compounding them forward to a future date. We agree that consistency is important.

DOI: 10.1002/hec

But it is not a demanding criterion: both the welfare maximising and the NICE rules are consistent in this sense. Multiplying the numerator in the cost-effectiveness ratio (7) by $(1+r_x)$ and the denominator by $(1+r_h)(1+g_v)$ gives costs and effects compounded forward to period 2 but has no effect on the cost-effectiveness ratio since $(1+r_h)=(1+r_x)/(1+g_v)$. Similarly, the NICE cost-effectiveness ratio in (11) is unaffected if the numerator is multiplied by $(1+r_x^{\mathrm{N}})$ and the denominator by $(1+r_h^{\mathrm{N}})(1+g_k)$ since $(1+r_h^{\mathrm{N}})=(1+r_x^{\mathrm{N}})/(1+g_k)$. (See Box 1 for an illustration.)

Box 1. Consistency: an undemanding requirement

The NICE team use a simple numerical example to illustrate "the fundamental problem with differential discounting", which is that it would lead to inconsistencies between present and "terminal values".

Consider a health care technology which costs £10 000 now and provides one QALY in 10 years, while the cost discount rate is set at 3.5%. The ICER can be calculated either (a) by compounding current costs forward at the cost discount rate to derive a 'terminal value' and dividing this by the QALY gain in year 10 ([£10 000$(1.035)^{10}$]/1QALY), yielding £14 106 per QALY or (b) by discounting the volume of QALYs back at the cost discount rate (equalling 0.7089 QALY) and then dividing the current costs by the discounted QALY gain (£10 000/[1/$(1.035)^{10}$]), again yielding £14 106 per QALY. The fact that both approaches yield the same ICER demonstrates consistency.

In their example the NICE team do not state what is assumed about the value of health. If this value is increasing over time, then the ICER as calculated above is incorrect and will not lead to optimal decisions. It is, however, perfectly possible to be consistent *and* optimal.

Take the example of the NICE team and assume a 2% annual increase in the value of QALYs. Then, compounding costs forward at the cost discount rate to derive a 'terminal value' (i.e. £14 106) and dividing this by the volume of QALYs adjusted upwards to account for the growth in the value of QALYs ([£10 000$(1.035)^{10}$]/[1 $(1.02)^{10}$]) yields an ICER of £11 571. The same ICER results from dividing current cost by the adjusted number of QALYs discounted back by the cost discount rate: £10 000/[1 $(1.02)^{10}/(1.035)^{10}$] = £11 571.

Both methods are consistent but only the latter is optimal. Moreover, the latter calculation can be conveniently approximated using differential discounting, that is by dividing current costs by the number of QALYs discounted back using the health discount rate. In the example the health discount rate equals [(1.035/1.02) −1], which can be approximated by 1.5% (i.e. 3.5–2%), yielding an ICER of: £10 000/[1 $(1.015)^{10}$] = £11 605.

INCREASING VALUE OF HEALTH

The NICE team argue that the NHS has a fixed budget and therefore should judge projects using an ICER threshold which 'can then be used to convert QALYs into equivalent money terms which can be compared directly to costs' and therefore that 'it is not the societal valuation that is relevant for NICE but the shadow price of the NHS budget constraint, and this may or may not increase over time' (Claxton *et al.*, 2006).

First, the NICE team are correct in asserting that the criterion for evaluating interventions must take account of the any binding budget constraints but, as the formal model shows, they are mistaken in thinking that such constraints imply that the social marginal value of health should be replaced by the ICER threshold: both must be included in the decision rule. The role of the ICER threshold is to adjust the nominal cost effects of the intervention to reflect their true opportunity costs when the budget is constrained. But once the adjustment has been made, the health time stream must be valued using the social value of health. (See Box 2.)

Box 2. A question for the NICE team

The NICE team stress that the health care budget is fixed so that acceptance of a project with positive expenditure will have an opportunity cost in forgone health. We agree. Suppose that after allowing for the activities displaced in each period, a project reduces QALYs by 100 this year and increases them by 103 next year. Suppose the cost discount rate is 3.5% and that the value of a QALY increases by 2% per year (implying a discount rate for health of approximately 1.5%). We would accept the project since the QALY gain discounted at 1.5% (or the QALY gain adjusted by the growth in the value of QALYs and discounted at 3.5%) is higher than the opportunity costs of 100 QALYs this year. Would the NICE team accept or reject the project?

The decision rule put forward by the NICE team leads to socially inferior decision-making unless the ICER threshold is equal to the marginal social value of health in all periods affected by an intervention. Box 3 illustrates this for a case in which the current budget is optimal (so $v_1 = k_1$), but the future ICER threshold k_t is assumed constant even though the value of health is growing over time so that $g_k \neq g_v$ in the calculations. This may represent the decision context perceived by regulatory bodies.

Box 3. Optimal investment with optimal current budget but a sub optimal future budget

Assume NICE has to decide about the implementation of two independent projects:

- Project A costs £100 000 in the current year 1 and yields 10 QALYs in year 21
- Project B costs £100 000 in the current year 1 and yields 7 QALYs in year 11

Assume further that

(1) $v_1 = k_1$ (the current budget is optimal so that the current threshold equals the current social value of a QALY);
(2) the discount rate on costs is 5%;
(3) the value of QALYs will increase by 3% annually ($g_v = 0.03$);
(4) k is constant over time ($g_k = 0$) (so that $k_t < v_t$ for $t > 1$: future budgets are sub-optimal–too small)

According to the NICE team's CEA decision rule (11) the ICER of project A is £100 000/$10(1.05)^{-20}$ = £26 533. The NICE ICER of project B is £100 000/$7(1.05)^{-10}$ = £23,270. B has a more favourable ICER than A using the NICE rule.

The ICER of programme A calculated by the welfare maximising CEA rule (7) is £100 000/[$10(1.03)^{20}/(1.05)^{-20}$] = £14 691, which may be approximated by £100 000/$10(1.02)^{-20}$. The ICER of programme B is £100 000/ [$7(1.03)^{10}/(1.05)^{-10}$] = £17 315, which may be approximated by £100 000/$7(1.02)^{-10}$. According to the welfare maximising rule A has a more favourable ICER than B.

The final decisions depend on k_1. As an illustration we indicate the decisions under the NICE rule and the welfare maximising rule for different thresholds:

	NICE rule		Welfare maximising rule	
k_1	project A	project B	project A	project B
£30 000	accept	accept	accept	accept
£25 000	reject	accept	accept	accept
£20 000	reject	reject	accept	accept
£15 000	reject	reject	accept	reject
£10 000	reject	reject	reject	reject

Socially preferable programme A is the first to be rejected under the NICE rule and both programmes are less likely to be accepted for a given $k_1 = v_1$, illustrating the risk of socially inferior decision-making under the NICE rule.

DOI: 10.1002/hec

Table I. An application of the three investment decision rules when budgets are not set optimally

	Year 1	Year 10	
Intervention			
Change in costs Δc	25 000	0	
Change in QALYs Δh	0	1	
Assumptions			
ICER threshold k	30 000	36 570	$g_k = 2\%$
Value of QALY v	35 000	40 619	$g_v = 1.5\%$
Consumption discount rate r_x			3.5%
Decision rules			
	Cost-effectiveness ratio	Present value	
Washington Panel rule: No adjustment for k, v	$\dfrac{\Delta c_1}{\Delta h_{10}/(1+r_x)^{10}} = 35\,265$	$-\Delta c_1 + \dfrac{\Delta h_{10}}{(1+r_x)^{10}} = -188$	
NICE rule: Adjustment for k only	$\dfrac{\Delta c_1}{(1+g_k)^{10}\Delta h_{10}/(1+r_x)^{10}} = 28\,930$	$-\Delta c_1 + \dfrac{k_{10}\Delta h_{10}}{(1+r_x)^{10}} = 3796$	
Welfare maximising rule: Adjustment for k and v	$\dfrac{\Delta c_1}{(1+g_v)^{10}\Delta h_{10}/(1+r_x)^{10}} = 30\,387$	$-\dfrac{v_1}{k_1}\Delta c_1 + \dfrac{v_{10}\Delta h_{10}}{(1+r_x)^{10}} = -371$	

Second, if the ICER threshold increases or decreases over time, the NICE team decision rules require that the volume of future and current QALYs be valued differently. This could be done through differential discounting or through explicit adjustment of the volume of QALYs. Hence the claim that their decision rule is 'entirely consistent with the recommendations of the Washington Panel' (Claxton *et al.*, 2006) is too strong since the Panel, following Weinstein and Stason (1977), assumes a 'steady-state relationship between money and health benefits' (Gold *et al.*, 1996) i.e. a monetary value of QALYs that remains constant over time.

Table I illustrates the differences between the Washington Panel, NICE team, and welfare maximising rules for an intervention which has a period 1 cost of £25 000 and produces 1 additional QALY in 10 years time. In this example, the NHS has too small a budget in both periods: the value of a QALY exceeds the threshold ICER in both periods and both increase over time. The cost-effectiveness ratio computed using the Washington Panel rule[3] exceeds the period 1 threshold ICER (equivalently, the discounted value of the project in terms of period 1 consumption is negative) and therefore leads to a rejection of the intervention. The NICE team criterion uses the period 10 threshold ICER to value period 10 health. It produces a positive net present value and a cost-effectiveness ratio less than the period 1 threshold ICER (£30 000) and so would accept the project. A sufficiently low period 10 ICER, however, would yield a negative NICE net present value or NICE cost-effectiveness ratio in excess of £30 000. This highlights the sub-optimality of the NICE rule. Since the project has no expenditure in period 10, it has no opportunity cost in period 10, and the value of the ICER threshold in period 10 should have no effect on whether the project should be accepted. In this case, only the social value of the additional QALYs in period 10 is relevant. Applying the welfare maximising rule leads to rejection of the project because its opportunity cost in terms of forgone health in the current period is greater than the value of the future increase in health.

[3] We take the Washington Panel rule to imply that no adjustment for the changing value of a QALY is made but that v_1 is applied to value health in all periods and that no adjustment for the binding budget constraint is made.

DOI: 10.1002/hec

AN NHS PERSPECTIVE?

NICE takes a narrow view of what should be taken into account in evaluating NHS interventions. Its guidance is intended to represent 'an efficient use of limited NHS and PSS (Personal Social Services) resources. For these pragmatic reasons, the appropriate...perspective on costs is that of the NHS and PSS' (NICE, 2004, p. 11). A failure to consider some costs, for example, those borne by patients, can lead to non-welfare maximising decisions. But this is not the reason for the divergence between the welfare maximising and NICE discounting decision rules set out above since we assume that all costs fall on the NHS.

NICE's objective is 'maximising health gain from limited resources' (NICE, 2004, p. 11). Given fixed budgets, the NHS seeks the best time stream of health. Operationalising this objective requires specification of the relative value of future and current health: i.e. a discount rate on health. But as we showed above, all welfare functions imply that the rate of discount on health will differ from the consumption discount rate unless the value of health in terms of consumption is constant over time. The NICE team's acceptance of a changing value of health over time is therefore incompatible with the NICE guidance to use the same discount rate on QALYs and costs. This is true even if NICE took the rather odd view that the objective function the NHS differs from the welfare function, so that the NHS should have a marginal rate of substitution of current and future health which differs from society's.

CONCLUSION

We welcome the explanation provided by the NICE team indicating why NICE has moved from differential discounting to equal discount rates. We are in broad agreement on a number of important issues: health is tradable, binding NHS budget constraints must be reflected in the investment decision rules, and the social value of health is likely to increase over time. But we have two substantive disagreements: the NICE team use the threshold ICER to adjust health effects, rather than using them to adjust cost effects to get the correct measure of opportunity cost; and they do not use the social value of health to value QALYs.

The question of how the changing value of health should be incorporated in the investment criterion is secondary. But some adjustment for the increase in the value of health over time must be made. Differential discounting is one way to do so and a practical one at that. NICE, and almost all other regulatory bodies, should therefore change their guidance to instruct evaluators that they should follow one of the welfare maximising rules and (a) adjust costs using the threshold ICERs if budgets are not set optimally and (b) either adjust the volume of health effects to take account of the changing value of health (after which the discount rate used for costs can be used) or use differential discounting and apply a discount rate to health effects which is adjusted for the changing value of health. NICE must therefore provide guidance on a number of crucial parameters: the discount rates for costs (consumption) and health, current and future values of QALYs and, if budget constraints are binding, current and future threshold ICERS. Its current guidelines promulgate the wrong decision rules and fail to provide the information to make them operational. A return to differential discounting would therefore be a practical way of moving toward optimal decision rules.

APPENDIX A

This appendix provides an explicit policy model to support the analysis in the text.

There are two policy makers. The Treasury chooses a budget for health care. The Department of Health decides how to allocate the budget. They have the same objectives and perceive the same constraints. The Lagrangean for the policy problem of choosing an optimal consumption and health

DOI: 10.1002/hec

stream is

$$W(h_1, h_2, x_1, x_2) + \sum_t \lambda_t[B_t - c_t] + \theta f(h_1, h_2, c_1, c_2) + \sum_t \mu_t[y_t - B_t - x_t] \tag{A1}$$

y_t is income in year t, assumed exogenously determined. B_t is the NHS budget, and the technological constraints are summarised in the implicit production function $f(h_1,h_2,c_1,c_2) \geq 0$ where $f_{ht} < 0$, $f_{ct} > 0$.

The DH chooses a set of projects that exhausts its budgets, is efficient ($f = 0$) and produces the most socially valuable time stream of health according to the welfare function. It takes consumption and its budget as given. First-order conditions on h_t and c_t are

$$W_{ht} + \theta f_{ht} = 0, \; t = 1, 2 \tag{A2}$$

$$\lambda_t = \theta f_{ct}, \; t = 1, 2 \tag{A3}$$

The incremental cost-effectiveness thresholds are the period t marginal costs of period t health evaluated at the DH optimal choices:

$$k_t \equiv \frac{\partial c_t}{\partial h_t} = -\frac{f_{ht}}{f_{ct}} = \frac{W_{ht}}{\lambda_t} \tag{A4}$$

The Treasury chooses consumption and the NHS budget over time to satisfy

$$W_{xt} = \mu_t \tag{A5}$$

$$\lambda_t - \mu_t = 0 \tag{A6}$$

(If the government has access to credit markets or can influence private sector investment then it will be possible to link the discount rate on consumption $r_x = W_{x1}/W_{x2} - 1$ to market rates of interest and the marginal productivity of private sector investment.)

Hence, if the budget is set optimally,

$$k_t = -\frac{f_{ht}}{f_{ct}} = \frac{W_{ht}}{\lambda_t} = \frac{W_{ht}}{W_{xt}} = v_t \tag{A7}$$

and the ICER equals the marginal value of health.

In general, whether or not the NHS budget is set optimally, the period t reduction in welfare arising from the Δc_t period t cost of an intervention which must be financed from the given budgets is, using (A2) and (A3), $\lambda_t \Delta c_t = (W_{ht} \partial h_t / \partial c_t) \Delta c_t = (W_{ht}/k_t) \Delta c_t$. Hence the change in welfare from an NHS intervention which changes the health stream by Δh_1, Δh_2 and has costs of Δc_1, Δc_2 which must be financed from the fixed budgets is, in terms of current consumption,

$$\begin{aligned} \frac{\Delta W}{W_{x1}} &= [\Delta h_1 W_{h1} - \lambda_1 \Delta c_1 + \Delta h_2 W_{h2} - \lambda_2 \Delta c_2] \frac{1}{W_{x1}} \\ &= \frac{W_{h1}}{W_{x1}} \Delta h_1 - \frac{\lambda_1}{W_{x1}} \Delta c_1 + \frac{W_{h2}}{W_{x2}} \frac{W_{x2}}{W_{x1}} \Delta h_2 - \frac{\lambda_2}{W_{x2}} \frac{W_{x2}}{W_{x1}} \Delta c_2 \\ &= v_1 \Delta h_1 - \frac{v_1 \Delta c_1}{k_1} + v_2 \frac{1}{(1 + r_x)} \Delta h_2 - \frac{v_2}{k_2} \frac{\Delta c_2}{(1 + r_x)} \end{aligned} \tag{A8}$$

which yields Rule 1 (4) in the text.

DOI: 10.1002/hec

ACKNOWLEDGEMENTS

We thank Xander Koolman for his helpful and insightful comments and Karl Claxton for confirming our interpretation of the new NICE rule. NPCRDC receives funding from the Department of Health. The views expressed are those of the authors and not necessarily those of the funders.

REFERENCES

Brouwer WBF, Niessen LW, Postma MJ, Rutten FFH. 2005. Need for differential discounting of costs and health effects in cost effectiveness analyses. *British Medical Journal* **331**: 446–448.

Cairns J. 2001. Discounting in economic evaluation. In *Economic Evaluation in Health Care: Merging Theory with Practice*, Drummond MF, McGuire A (eds). Oxford University Press: New York.

Claxton K, Sculpher M, Culyer A *et al*. 2006. Discounting and cost-effectiveness in NICE—stepping back to sort out a confusion. *Health Economics* **15**(1): 1–4.

Department of Health. 1996. *Policy Appraisal and Health: A Guide from the Department of Health*. Department of Health: London, GO7/038 3901, February 2004.

Drummond MF, O'Brien B, Stoddard GL, Torrance GW. 1997. *Methods for the Economic Evaluation of Health Care Programmes* (2nd edn). Oxford University Press: Oxford.

Gold MR, Siegel JE, Russell LB, Weinstein MC (eds). 1996. *Cost-effectiveness in Health and Medicine*. Oxford University Press: Oxford.

Gravelle H, Smith D. 2001. Discounting for health effects in cost-benefit and cost-effectiveness analysis. *Health Economics* **10**: 587–599.

NICE. 2001. *Technical Guidance for Manufacturers and Sponsors on Making Submissions for a Technology Appraisal*. NICE: London, March 2001.

NICE. 2004. *Guide to the Methods of Technology Appraisal*. NICE: London, April 2004.

Parsonage M, Neuburger H. 1992. Discounting and health benefits. *Health Economics* **1**: 71–79.

Smith DH, Gravelle H. 2001. The practice of discounting in economic evaluations of healthcare interventions. *International Journal of Technology Assessment in Health Care* **17**(2): 236–243.

Spackman M. 2004. Time discounting and of the Cost of Capital in Government. *Fiscal Studies* **25**(4): 467–518.

Van Hout BA. 1998. Discounting costs and effects: a reconsideration. *Health Economics* **7**: 581–594.

Viscusi WK. 1995. Discounting health effects for medical decisions. In *Valuing Health Care: Costs, Benefits, and Effectiveness of Pharmaceuticals and Medical Technologies*, Sloan FA (ed.). Cambridge University Press: New York, 125–147.

Weinstein MC, Stason WB. 1977. Foundations of cost-effectiveness analysis for health and medical practices. *New England Journal of Medicine* **296**: 716–721.

DOI: 10.1002/hec