Abstract

Purpose: To demonstrate that a social decision making approach to evaluation can be generalised to interventions which have multiple objectives and impact on multiple constraints within and beyond the health sector.

Background: The UK National Institute for Health and Clinical Excellence (NICE) has been given additional responsibilities for issuing guidance on public health interventions and national policies which will have an impact across public sector budgets and the wider economy. This poses the question whether the existing approach to the evaluation of health technologies within the health sector is sufficient to inform decisions across budget holders with multiple objectives and constraints.

Methods: The arguments put forward as to whether a social decision making or ‘welfarist’ approach to evaluation will be sufficient are examined. These include the existence of broader outcomes than health (e.g. crime and education), multiple budget holders, and external effects on the wider economy (e.g. productivity). We identify the generalisations of existing decision rules which are required.

Results: Current decision rules in CEA are based on maximising a single objective subject to a single exogenous budget constraint whereas a welfarist analysis regards budgets to be endogenous. Both fail to fully address the allocation problem posed by public health interventions. We demonstrate that a mathematical programming solution to this problem is possible but the information requirements make it impractical. Instead we propose a simple compensation test for interventions with multiple and cross sectoral effects. However, rather than compensation based on individual preferences, it should be based on the net benefits falling on different sectors. The valuation of outcomes is based on the shadow prices of the existing budget constraints which are implicit in existing public expenditure and its allocation across different sectors. We show that it is not necessary to pay compensation for each decision if the net compensation required is accounted for over a budget period and informs the marginal changes in subsequent allocations between sectors.

Conclusions: A generalisation of decision rules to multiple sectors is required based on compensation valued in a way which is consistent with the existing allocation between the public sector(s) and the wider economy. A ‘welfarist’ societal perspective is not sufficient; rather, a multiple perspective evaluation which accounts for costs and effects falling on each sector is required.
1. Introduction

The use of formal methods of evaluation to inform adoption and reimbursement decisions for health technologies has become well established. However, there is a much wider set of policy decisions, including the implementation of public health interventions which could be informed by such analysis. For example the UK National Institute for Health and Clinical Excellence (NICE) has been given additional responsibilities for issuing guidance on public health interventions and national policies which will have an impact across public sector budgets and the wider economy. This poses the question whether the existing approach to the evaluation of health technologies within the health sector is sufficient to inform decisions across budget holders with multiple objectives and constraints. The general approach to the evaluation in health care and health technology assessment (HTA) in particular can be characterised as ‘extra welfarist’ or more precisely as societal decision making: accepting a simple objective of maximising health gains (using some generally accepted pragmatic measure of health gain) subject to a single exogenous budget constraint.

Increasingly sophisticated methods to structure decision problems, synthesise evidence from a variety of sources, characterise uncertainty surrounding decisions and establishing the value of acquiring more information to inform these decisions have been developed. This development of methods within HTA has taken place in a somewhat sheltered world where a single objective and constraint are taken to be exogenous and regarded as legitimate on the basis that they are given to us (or at least accepted) by legitimate social decision makers. However, the simplification of constraints and objectives which may have been reasonable when restricting our attention to health technologies will not be appropriate when we take a wider view of the type of policies and interventions which are available in public health and wider social policies. If we wish to generalise and extend the type of decision analytic approaches to these wider questions we must address the question of whether a societal decision making approach is sufficient and what generalisations of decision rules maybe required.

The current debate about which methods of evaluation should be used inform these more complex decisions seems to focus on three broad alternatives: a somewhat ill defined presentation of costs and consequences (CCA); a welfarist cost-benefit analysis (CBA), and cost-effectiveness analysis (CEA) based on a social decision making approach. For example, some have recommended that CBA provides the most general approach in these circumstances but where a complete CBA is not possible the CCA can be regarded as a practical alternative. We start with a brief outline what is required to inform decisions in HTA and identify those methods which best meet these requirements. We then ask what is different about public health interventions and consider whether it is the nature of decisions that must be made, the evidence available, the objectives or the constraints faced. In doing so, we try to locate the fundamental choices and social value judgments that must be made in choosing between the alternative approaches to this broader evaluation problem.
2. Informing decisions in HTA

The Decisions

Two decisions need to be made in health care. Firstly, given existing evidence which interventions or strategies should be adopted for particular patient groups, for particular indications and in particular setting? Secondly, is the existing evidence a sufficient basis for such a decision or is there value in acquiring further evidence? If so, what type of evidence, what type of studies for which patient groups and how much evidence is required? Of course where a technology appears to be cost-effective but more evidence is required, it may be better to delay implementation until the additional evidence has been acquired. Whether adoption should be delayed depends on the costs of reversing a decision to adopt now and the impact of immediate adoption on whether further evidence will be generated.

Analytical Requirements

The choice of appropriate methods should be based on whether they can provide the information required to make these decisions. The first requirement of any decision is some claim of legitimacy, which will ultimately rest on the legitimacy of the scientific and social value judgments which are required. Therefore, appropriate methods must make these scientific and social value judgements explicit so that they are open to debate, alternative formulation and falsification.

These decisions require an estimate of the joint distribution of costs and outcomes, for all the alternative interventions or strategies available, i.e., not just alternative technologies but all the different ways existing technologies could be used, for the full range of possible patient groups that can defined and over an appropriate time horizon (the time horizon over which cost and benefits differ). Therefore a means of explicitly structuring the decision problem so that all alternative are compared and that enables the explicit extrapolation of cost and benefits overtime, between settings and patient groups is required.

A characterisation of the uncertainty surrounding the estimates of expected costs and benefits and the uncertainty surrounding the choice between the range of alternatives available is also required. No single study can provide all the information for the parameters relevant to costs and effects, nor is any single study going to be the only source of evidence. Therefore a means of combining evidence from a variety of sources while representing uncertainty is required. In principle all the evidence available for all the parameters is needed as well as methods to synthesise that evidence appropriately. Even when direct evidence about a parameter of interest is available it will often come from different types of study which will require explicit consideration of potential biases and exchangeability. But more often than not indirect evidence about parameters of interest will be available (evidence on functions of parameters, evidence on surrogate endpoints, and indirect and mixed comparisons of the alternative technologies). There will also be circumstances where no direct or indirect evidence for a parameter is available and formal elicitation of scientific value judgements will be required.
The framework of analysis needs to reflect the iterative nature of decisions and the accumulation of evidence over time: as new evidence becomes available the estimates of costs and effects must be updated and decisions revised. Therefore, a formal process of learning is required. Finally, the decision rules applied to the joint distribution of costs and effects must be consistent with stated objectives and the constraints faced by the health care system. With a single budget constraint and some view of its shadow price, and an objective of maximising health gains (where the measure of health gain has been agreed), the decision to adopt an alternative can be addressed. The second decision of whether the existing evidence is sufficient or whether further evidence is required can also be formally addressed using value of information analysis. Similarly the opportunity costs of delay while further information is acquired can also be established. In principle all these decisions can be made in a way which is consistent with objectives and constraints of the health care system.

These requirements suggest that the type societal decision making approach, based on a Bayesian decision analytic framework, which has been developed within HTA, is appropriate. It is this characterisation of the requirements of decision making in HTA which informed the selection of methods recommended in reference case for the NICE appraisal of health technologies. The question is whether this approach is sufficient when addressing the broader questions posed by public health interventions which move beyond the narrower concerns of HTA?

3. Public Health Interventions

What’s really different about public health interventions compared to HTA? It could be one of four things. Are the decisions faced in public health fundamentally different to the ones described in health technology assessment? The decision of which intervention or policy should be regarded as worthwhile given existing evidence seems to remain the central policy question. Similarly the question of whether additional evidence is required to support a decision to implement an intervention or policy and whether implementation should be delayed until further evidence is required also remains a policy questions that need to be addresses. In fact, the characterisation of the decisions faced in HTA, described above, is not specific to HTA at all, but draw on statistical decision theory which has been used to characterise decisions in general and has been applied to areas as diverse as business, engineering and environmental policy. If the nature of the decisions are essentially the same then why should the methods needed to address them differ? It maybe that type and quality of evidence available differs, that the objectives of public health interventions are much broader than simply improving health or it could be that the nature of the constraints faced are more complex.

The evidence

The mix of the type of evidence available will certainly differ in a number of important respects but the question is whether the existing approach to synthesis of evidence within a structured decision problem will be inappropriate? Within HTA, partly due to licensing requirements, RCT evidence of the relative effect of
interventions is often available, at least for pharmaceuticals. This experimental evidence provides the best opportunities to explore the counterfactual. However, even in HTA with a relative wealth of RCTs it is not without its problems, e.g., the external validity of protocol driven licensing trials, short follow-up periods and incomplete and inappropriate comparisons. It is the use of Bayesian methods of synthesis which have allowed these issues to be addressed as well as incorporating other observational evidence which is almost always available but often ignored. There have also been a number of circumstances where appraisals of technologies have been conducted where no direct RCT evidence is available.

The evaluation of public health interventions will inevitably rest on more non experimental evidence of effect including longitudinal and panel data as well as natural experiments. In turn, these will require an integration of the econometric and statistical modelling approaches that have been taken to these problems (e.g., selection models etc) within a broader evidence synthesis. It will pose some new issues for methods of synthesis which have focused primarily but not entirely on synthesis of evidence from RCTs, e.g., how to synthesis the range of evidence of incentives on behaviour and consumption which have health effects.

In HTA evidence directly linking an intervention to health outcomes is sometimes available. However, more often the link between the intervention and long-term outcomes must be made through a chain of evidence, linking the intervention to surrogates and then linking surrogates to outcomes. This problem of linking surrogates (such as changes in behaviour/consumption) to long term health outcomes and resources use may well be more common outside HTA but the principles of how to address it remain the same. Finally the range of alternative interventions or policies which can be considered in public health will be large with limited evidence of direct comparisons. Again, this issue is also central in HTA where many comparisons are not made directly in the RCT evidence. The use of indirect and mixed comparisons is becoming central to HTA. In fact one of the most interesting aspects of extending this type of analysis to public health is the opportunity to compare the health technologies to the other alternative public health interventions and national policies which are available.

There are clearly differences in the mix of the type of evidence available but what do these differences imply? The need to use evidence from a variety of sources is, if anything, even more important and the synthesis of diverse sources of evidence must fully represent the uncertainty characterising potential biases and exchangeabilities. It becomes even more important to ask whether the evidence currently available is sufficient to support implementation of an intervention or policy and whether more evidence and of what type is required. Similarly, the question of whether to implement now or delay until additional evidence is available becomes more pressing when the potentially large costs of policy change and the impact that implementation will have on the possibilities of acquiring more information are considered. All the challenges associated with the nature of the evidence available emphasises the need for appropriate methods of synthesis which fully capture the uncertainties that are introduced when combining evidence from a variety of sources. Therefore, the type of approach to evidence synthesis and the analysis of uncertainty developed within HTA becomes even more relevant for broader public health questions.
Objectives

A naïve view

Current decision rules applied to the type of analysis described above are based on maximising a single objective subject to a single exogenous budget constraint. In essence, this societal decision making approach views HTA as simply providing the technical tools to solve this constrained optimisation problem. Even within HTA the characterization of the exogenous objective function has been somewhat naïve and limited to maximizing health outcome, often measured by Health Related Quality of Life (HRQL). It could be regarded as naïve for two similar but quite distinct reasons. Firstly, it is not at all clear that measures of HRQL measure utility as conceived by expected utility theory. Therefore, analysis which uses measures of HRQL can not claim to have firm foundations in welfare theory. This maybe of little concern for those who are sceptical as to whether utility theory can provide either: behavioural explanations and predictions; or provide a suitable basis for welfare propositions about the good for society.

However, even if a societal decision making approach is adopted, the specification of some exogenous objective must be in some way legitimate, which means it must capture everything that is of value to some legitimate societal decision maker (with all the dangers of paternalism at best and possible dictatorship that this implies). The concerns then are that: i) maximising health gains may be too restrictive and other arguments may be relevant, ii) that even if maximising health gain is the only argument our means of measuring health gain are inadequate (measures of HRQL don’t capture all changes in health outcome which maybe regarded as valuable); and iii) the means of aggregating health gains are not self evident and that regarding improvements in health is equally valuable is only one of very many equity positions to hold. These concerns are relevant even in the more restricted world of HTA where there is some consensus that maximising health outcome is a reasonable societal objective. It seems much less reasonable when considering interventions will have much broader outcomes than health (e.g., education, crime and the wider economy). It seems that the current characterisation of a simple exogenous objective in HTA will be inadequate.

A broader view

Of course the alternative to this naïve, and at best paternalistic, view is to take the broadest conception of outcome, i.e., maximise individual subjective utility. In doing so we can claim our objective to be to improve social welfare, where an improvement in social welfare takes place if those that gain can compensate those that lose from the policy or intervention. Compensation can be based on market prices which represent the social value of alternative activities (and, when they do not, they can be shadow-priced assuming a first-best world). Where markets don’t exist revealed preference in surrogate markets or hypothetical valuation can be use to form shadow prices. In principle this seems to have many advantages: all outcomes matter in so far as they are valued by individuals (who are willing to offer or accept compensation); it seems to avoid the explicit social value judgements and rather arbitrary paternalism of specifying some exogenous objective function; it provides clear guidance on
appropriate methods (how costs and benefits should be measured and what perspective should be taken); it provides a clear definition of what is meant by efficiency and a strong prescription for social choice. This much broader view of the objective of social policy is more general and claims legitimacy from its firm foundation on individual preferences as revealed through the market. It seems ideally suited to public health interventions and the evaluation of broader social policies. This view is clearly expressed by Mark Pauly,

“[Public] Heath care programmes should be judged in the same way as any other proposed change: ie the only question is do they represent a potential Pareto improvement not do they improve health outcomes as measured in either physical units or health state utility. It is possible that a programme may increase the health of some but reduce the health of others. If those that gain health outcome can compensate those that lose health (measured by individual willingness to pay) then the programme may be a potential Pareto improvement even if the health outcomes overall are lower.”

However, Pauly’s customary clarity starts to expose the implicit social value judgements required to accept this type of approach. The strong normative prescriptions come at a price: the values implicit may not necessarily be shared by legitimate societal decision makers, are certainly not universally accepted and seem to contradict some quite basic values which are widely held. This is clearly expressed by Luke,

“And he looked up and saw the rich putting their gifts into the treasury and He saw a poor widow putting in two small copper coins [mites]. And he said, “Truly I say to you, this poor widow put in more than all of them: for they all out of their surplus put into the offering but she out of her poverty put in all that she had to live on.”’ Luke 21, v1-4, NAS.

So for Mark this is clearly nonsense: the rich gave much more than the widow (they would require or could offer more compensation). Presumably he would justify this by observing that the widow was poor because she had made free choices over her life cycle income and consumption, including her decisions to participate in the labour market and her investment in human capital consistent with her rates of time preference! There is no reason to intervene: to do so would be to violate individual preferences and would be a dangerous attack on freedom itself.

Mark or Luke?

Choosing between Mark or Luke comes down to two issues. Firstly do you regard the current distribution of income (and the associated distribution of opportunities to invest in human capital and participate in the labour market) to be optimal? If not, and if you believe redistribution to be possible, then we can in principle estimate compensation for a particular distribution, but we would need to specify which one and then adjust all compensation including shadow prices for marketed and non marketed goods. Secondly we must view society as a collection of individuals participating in perfectly competitive markets, maximising their subjective utility following some axioms of rationality. When this view of society is applied to the presumed nirvana of a first-best neoclassical world, market prices do indeed represent
the social value of alternative activities (and, when they do not, they can be shadow-priced assuming a first-best world). This maybe regarded as either a peculiarly optimistic or complacent view of the world which denies or abstracts from issues such as discrimination, class, imperialism, and history.

In addition, there are a number of substantial problems in the application of the prescriptions of welfare theory: the conditions of rationality and consistency required for individuals maximising their utility have been show to be violated in most choice situations; the problem of aggregating individual compensating variations; the paradox of choice reversal with non marginal changes; issues of path dependency; and the problem of second best. The last of these has generally received very little attention, despite the well known but devastating result that first best solutions (and the shadow pricing associated with them) in a second best world may move us away from a Pareto optimum and not towards one. Since no one would argue that the world is first best, then even if the values implicit in welfare economic theory were acceptable its successful application in a second best world seems impossible.

It seems clear that the strength of the normative prescriptions for social choice which flow from welfare theory rest on the strength of the social value judgements (and the ideological content) which are implicit. The notion that a welfarist view can avoid the strong social value judgements required by a societal decision making approach can not be sustained. The difference is that the social value judgements required and the basis of claims for legitimacy are forced to be made explicitly.

If not the invisible fist?

If the broader view of outcome based on individual preferences expressed through the market is rejected then what are the alternatives? There seems to be two: i) maintain a somewhat naïve and simple objective for which there is some consensus (the objective of health technologies and public health interventions is to improve health); or ii) attempt to specify a more complex objective. To do so would require specification of the arguments to be included, the weights attached to each and some means to claim legitimacy. Unfortunately it is not clear how to resolve any of these issues and no single legitimate societal decision maker exists to specify them. However, in the absence of Leviathan, it maybe useful to look to those institutions which have been given the remit, and therefore some form of legitimacy, to make social decisions about health care and other sectors which may be relevant to public health interventions e.g., education and crime.

The constraints

The decision rules applied to the type of analysis conducted for HTA are based on maximising a single objective subject to a single exogenous budget constraint. We have already established that the notion of a single objective may well be too restrictive but a welfarest CBA may not be either acceptable or practicable. Similarly the notion of a single budget constraint even within HTA is somewhat restrictive (e.g., budget constraints over time, equity and capacity constraints). When considering intervention which will have an impact on resource use across a number of sectors
and the wider economy, the notion of a single constraint seems wholly inadequate. It is useful to consider the allocation problem the health sector alone, with and without exogenous constraints, before exploring the implications of extending an analysis to multiple sectors with multiple constraints.

**A perfect institutional world**

The budget for health care may not be fixed and exogenously given by some political process, if the decision maker has the remit to set both the budget and allocate resources within it. Any project which improves ‘social welfare’ can be implemented and the budget for health care will be determined by the resources needed to implement all projects with positive net benefit in CEA or net present value in CBA. This could be characterised as a perfect political or institutional world where budgets are consistent with the productivity of health care and the social value of health. The appropriate decision rules for CEA are quite clear, implement the new technology if:

$$\frac{\Delta c}{\Delta H} < \lambda', \text{ or } \Delta H \lambda' - \Delta c > 0$$

Where health gain is the only benefit (appropriately measured by $\Delta H$) and valued based on some social value of health gain $\lambda'$. The additional cost of the technology ($\Delta c$) may include net costs falling outside the health care budget.

The decision rules in CBA are also quite clear, implement the new technology if:

$$\frac{\Delta c}{\Delta B} < 1, \text{ or } \Delta B - \Delta c > 0$$

Where the benefits ($\Delta B$) are valued based on individual compensation and $\Delta C$ include all shadow priced costs, not just those falling on the health care sector.

Both CEA and CBA require a monetary valuation of health outcome. The distinction is the source of these valuations (individual compensation or some social value of health). In some circumstances CEA and CBA will be equivalent (measures of $\Delta H$ are related to utility, $\lambda'$ is related to income and risk aversion and all future costs are included). Clearly, and as discussed previously, a CEA must ensure that all aspects of outcome that are valuable are included in $\Delta H$. This may be difficult within HTA but when applied to multiple sectors with diverse outcomes it is not clear what should be measured, how it should be measured and how these diverse outcomes should be valued. Alternatively, if the social value judgements required by a welfarist approach are regarded as acceptable, then CBA appears much more general (all outcomes are included if individuals require or are willing to accept compensation) as long as the budgets for all other sectors are not fixed and the decision maker has the remit to allocate across as well as within all sectors.

**A more realistic world**

Unfortunately decisions are not made in a perfect institutional and political world. Those with the remit to allocate resources within health and other sectors generally don’t also have the remit to set their budget and allocated resource between sectors.
A more realistic world is one of exogenous budget constraints. The decision rules for CEA in health care are again quite clear, implement the new technology if:

$$\frac{\Delta c^H}{\Delta H} < \lambda, \text{ or } \Delta H \lambda - \Delta c^H > 0,$$

Where $\lambda$ represents the $\Delta C^H/\Delta H$ of the health care that will be displaced by the additional costs of the new technology ($1/\lambda$ represents the shadow price of the budget constraint). There is no particular reason to believe that $\lambda = \lambda'$ and we can regard the health care system to be under funded if $\lambda < \lambda'$ and if all costs are health care costs ($\Delta C^H$).

Appropriate decision rules using CBA are now less clear. Simply observing that the cost benefit ratio is less than 1 or that net present value is positive is no longer sufficient. We need to know whether the benefits offered by the new technology exceed the benefits which will be displaced elsewhere in the health care system. The technology should only be implemented if:

$$\frac{\Delta c^H}{\Delta B} < \gamma$$

Where $\gamma$ represents the cost benefit ratio of the health care which will be displaced and $1/\gamma$ represents the shadow price of the budget constraint. Now we can regard the health care system to be under funded if $\gamma < 1$ and if $\Delta C = \Delta C^H$.

The apparent generality of CBA is only realised in a perfect political and institutional world with no explicit budget constraints. Once an exogenous constraints is introduced similar problems are faced by both CEA and CBA. In both cases we now need to know, or at least have some estimate, of the shadow price of the budget constraint. We also need to know which costs fall on the constraint, since these are the only costs which will displace other activities. Similarly other benefits, in the form of cost savings, which don’t accrue to the health care budget can not off set costs which do. For this reason generally HTA and the reference case within the NICE methodological guidance, has restricted the perspective for costs to health and personal social services. However, there are clearly important elements of cost which fall outside (e.g., costs to patients and carers) and benefits (e.g., productivity gains) which don’t accrue to the NHS. These are acknowledged to be important in the guidance and it suggests these should be presented in a non reference case analysis.

However, the guidance is vague about how these costs and benefits will be balanced against the health care costs and health benefits, simply stating that they maybe taken into account. The problem of costs and benefits falling outside the health sector already exists within HTA and is dealt with in a generally unsatisfactory way because there are no mechanisms to internalise these external effects. Similarly the existence of an exogenous constraint also undermines the rationale for shadow pricing in CBA since the relevant costs are those that actually fall on the constraint, not the shadow price costs, e.g., the shadow price of new pharmaceuticals will be substantially lower than the price actually faced by the health care system (due to monopoly rights granted by patent protection). Public health interventions with substantial costs and benefits falling on many different exogenous budgets pose these problems more clearly for both societal decision making and welfareist approaches.
A more complex world

The allocation problem with exogenous constraints can be examined more completely when formulated as a mathematical program. Initially consider the health sector alone with an objective to maximise health outcome (H) or monetary value of health benefit (B_H) by choosing treatment j within programme k for population i subject to a single budget constraint for health C_H.

\[
\max_{\Psi} \left( \sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_i} H_{ijk} x_{ijk} \right) \\
\Psi = \left( x_{ijk}, i = 1...I_k, j = 1...J_k, k = 1...K \right)
\]

or

\[
\max_{\Psi} \left( \sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_i} B_{ijk} x_{ijk} \right) \\
\Psi = \left( x_{ijk}, i = 1...I_k, j = 1...J_k, k = 1...K \right)
\]

\[
\text{sto} \\
\sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_i} c_{ijk}^H x_{ijk} \leq C_H \\
0 \leq x_{ijk} \leq 1 \quad i = 1...I_k, j = 1...J_k, k = 1...K \\
\sum_{j=1}^{J_k} x_{ijk} = 1 \quad i = 1...I_k, k = 1...K
\]

The solution to the dual of this simple linear programme would provide \(1/\lambda\), or \(1/\gamma\), which if used in the simple decision rules described would provide an optimal selection of health technologies. However, there are three problems. Firstly, the information requirements for this very simple problem are enormous, requiring knowledge of the costs (falling on the constraint) and health outcomes (or monetary benefits) of every competing alternative treatment for each programme and for every definable population group. For this reason estimates of \(\lambda\), or \(\gamma\) are made based on incomplete and imperfect information and then applied using the simple decision rules above. Secondly, even when restricting attention to the health care system, recognition of multiple constraints leads to much more complex solutions. For example, the introduction of a simple budget constraint in each time period means that decision rules based on \(\lambda\), or \(\gamma\) are no longer adequate. Finally once the costs and benefits outside health are recognised then the allocation problem becomes much more complex.

For example, consider education with an objective to maximise educational outcomes (E) or the monetary value of education benefit (B_E) by choosing policy j within programme k for population i subject to a single budget constraint for education C_E. The allocation problem within education could be considered in isolation from the impact on health outcomes and costs just as the allocation problem in health has
ignored any impact on educational outcomes and costs. But in principle the allocation problem within these sectors can be solved simultaneously accounting for their respective budget constraints (solving for their respective shadow prices, $1/\lambda_i^{H}$ and $1/\lambda_i^{E}$) and the effect of health technologies on education outcomes and costs and educational programmes on health outcomes and costs. This requires specification of a single objective. Where outcomes are measured in natural or physical units this requires specification of the relative weight of educational outcome compared to health outcome ($\delta$). Where all benefits are valued in monetary terms using CBA they maybe regarded as commensurate and the objective will be to maximise total monetary benefit.

$$\max_{\Psi} \left( \sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_k} (H_{ijk} + \delta E_{ijk}) x_{ijk} \right)$$

$$\Psi = \{ x_{ijk}, i = 1...I_k, j = 1...J_k, k = 1...K \}$$

or

$$\max_{\Psi} \left( \sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_k} (B_{ijk}^{H} + B_{ijk}^{E}) x_{ijk} \right)$$

$$\Psi = \{ x_{ijk}, i = 1...I_k, j = 1...J_k, k = 1...K \}$$

sto

$$\sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_k} c_{ijk} x_{ijk} \leq C_H$$

$$\sum_{k=1}^{K} \sum_{j=1}^{J_k} \sum_{i=1}^{I_k} e_{ijk} x_{ijk} \leq C_E$$

$$0 \leq x_{ijk} \leq 1 \quad i = 1...I_k, j = 1...J_k, k = 1...K$$

$$\sum_{j=1}^{J_k} x_{ijk} = 1 \quad i = 1...I_k, k = 1...K$$

Of course this type of formulation can be extended to any number of sectors including the wider economy. Benefits for each sector maybe measured in any combination of natural units, some utility scale or monetary metric. Aside from the difficulty of measuring outcomes appropriately and specifying the relative value of each, the real problem is the informational requirements. Full information of the costs and benefits falling on every sector for each competing alternative intervention across all programmes and population groups for every sector would be required (it appears similar to the scale of the problem of second best). This doesn’t seem to offer a practical solution to evaluation of interventions with multiple effects and multiple constraints. However, it does demonstrate quite clearly that wefarist CBA offers no solution (the information requirements are the same) even if the implicit social value judgements are regarded as acceptable.

A more pragmatic world
The alternative to attempting to solve the whole allocation problem across all sectors simultaneously to evaluate a public health intervention is to focus on the impact of the intervention at the margin of each sector. Given explicit objectives, the outcomes (or monetary benefits) within each sector can be valued based on informed estimates of the shadow price of each of the budget constraints faced. The impact of an intervention can then be expressed in terms of the net benefits falling on each sector. For example, an intervention \((j)\) which has an impact on outcomes and costs in both health and education will generate net benefit in health \((NB_j^H)\) and net benefits in education \((NB_j^E)\):

\[
NB_j^H = (H_j \lambda_H - c_j^H) \text{ or } (B_j^H \gamma_H - c_j^H)
\]

\[
NB_j^E = (E_j \lambda_E - c_j^E) \text{ or } (B_j^E \gamma_H - c_j^E)
\]

The intervention should clearly be implemented if \(NB_j^H > 0\) and \(NB_j^E > 0\), since the gains in \(H\) and \(E\) are greater than the outcomes which will be displaced in each sector, similarly the intervention should be rejected if \(NB_j^H < 0\) and \(NB_j^E < 0\). However, in many circumstances net benefit will be positive in one sector and negative in another. In which case implementation can be based a simple compensation test where the compensation required by a sector is based on net benefit. This ensures that the valuation of outcomes (or monetary benefits) is consistent with the existing budget allocation between sectors. This is illustrated in table 1 for 6 alternative interventions.

<table>
<thead>
<tr>
<th>(j)</th>
<th>Health</th>
<th>Education</th>
<th>Decision</th>
<th>Compensation</th>
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<td>(NB_j^H &gt; 0)</td>
<td>(NB_j^E &gt; 0)</td>
<td>((NB_j^H + NB_j^E) &gt; 0)</td>
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<td>(NB_j^H &lt; 0)</td>
<td>(NB_j^E &gt; 0)</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>4</td>
<td>(NB_j^H &lt; 0)</td>
<td>(NB_j^E &lt; 0)</td>
<td>((NB_j^H + NB_j^E) &lt; 0)</td>
<td>Reject</td>
</tr>
<tr>
<td>5</td>
<td>(NB_j^H &lt; 0)</td>
<td>(NB_j^E &gt; 0)</td>
<td>..</td>
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<tr>
<td>6</td>
<td>(NB_j^H &gt; 0)</td>
<td>(NB_j^E &lt; 0)</td>
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For example, intervention 2 could represent an improvement the quality of school meals. The gains in educational outcomes may not offset the costs falling on education \((NB_j^E < 0)\) but the improvements in health outcomes and possible reduction in health care costs means that \(NB_j^H > 0\). The policy will be worth while if the health sector can compensate education for the loss in net benefit \((0- \(NB_j^E\)) and still regard the intervention to be cost-effective. Similarly, intervention 3 could represent the use of Ritalin for ADHD or parent training programmes which may not be cost-effective when only considering the impact in health outcomes and costs but the improvements in educational outcomes and possible reductions in costs means that the education sector could compensate health for the loss in net benefit. This suggest that the argument as to which single perspective is most relevant (e.g., societal or health system) is misplaced. What is required is a multi sectoral societal perspective to provide estimates of the impact on outcomes across each sector and costs (not the shadow prices) falling on each constraint.
It should be clear that the compensation required cannot be based simply on the costs falling on different sectors but should account for the impact on outcomes across sectors as well. By expressing compensation in terms of net benefit based on $\lambda_H$ and $\lambda_E$ the value of outcome and resource use in each sector is consistent with existing budget allocation across sectors. Indeed, $\lambda_H/\lambda_E$ represents the value of health relative to educational outcomes implied by the current budget allocation and the productivity of current health and education interventions (if $\lambda_H/\lambda_E = \delta$ then current allocations are consistent with a societal value of health compared to educational outcomes). Similarly, if a welfarist approach is acceptable then observing that $\gamma_H/\gamma_E = 1$ would suggest that current allocations are consistent with individual preferences, whereas observing that $\gamma_H/\gamma_E > 1$ would suggest that there should be a reallocation from health to education (and if $\gamma_H$ is also less than 1 then both are under funded).

Public and the private sector

This type of approach can be generalised to a number of sectors which have explicit constraints as well as to the wider economy. It can also be generalised to consider policy decisions made by bodies which don’t hold their own budget but make decisions which impact on other budgets and the wider economy. For example, legislation about workplace safety will impose costs on the wider economy but will also improve health outcomes and may reduce health care costs. Whether such a policy should be regarded as worthwhile depends on whether the health sector could compensate the private sector for the additional costs but still regard the policy as cost-effective, i.e., do the health improvements valued at their opportunity cost (the additional health budget which would be required to generate the same improvement in health) net of health care costs, exceed the costs outside the health sector? If so, it is more efficient to generate health through the proposed policy than by expanding the budget for health care. Conversely where health care interventions provide benefits to the wider economy (gains in productivity) they may be regarded as worthwhile if the private sector could compensate health care sector for any loss of net benefit.

Clearly if the compensation required for each intervention is paid then the impact of a decision on the net benefits in other sectors will be internalised. However, there are currently no mechanisms for such transfers and the payment of compensation for each intervention may impose transaction costs. A more pragmatic approach would be to record the compensation required between sectors for implementation decisions made over a budgetary period. The net compensation required could be used to inform budget allocation for the next period. For example, if interventions 2 and 3 in table 1 are implemented, then the net compensation required maybe very small. This would only be sustainable if net compensation was either a small proportion of total budgets or if changes in budgets based on net compensation was really credible. For example, a public health intervention with substantial costs ($\text{NB}^{\text{hi}} < 0$) but substantial productivity benefits to the wider economy could only be implemented if there was confidence that the subsequent budget would reflect compensation needed from the private sector to the relevant public sector budgets.
4. Conclusions

There are pragmatic as well as principled reasons why this type of multi sectoral societal decision making approach offers advantages. In the absence of a perfect political and institutional world exogenous constraints exist and decisions must be based on some assessment of their shadow price. However, there are no simple ways to integrate the effects on costs and benefits in other sectors within existing decision rules. The information requirements to formally solve the whole allocation problem across all sectors, accounting for multiple effects and constraints, is not feasible and welfarist CBA offers no solution (the information requirements are the same) even if the implicit social value judgements are regarded as acceptable. Unfortunately, if they are not acceptable, no single legitimate societal decision maker exists to specify the arguments and relative weights which would form some overall objective function.

However, we can specify objectives and measure of outcome for each sector based on those institutions which have been given the remit, and therefore some form of legitimacy, to make social decisions about allocations within a particular sector. Similarly, rather than impose some relative valuation of these outcomes, we can use the valuation implied by the current allocation of resources within the public sector and between the private and public sector, i.e. using the allocation decisions of those who have the remit and some legitimacy to make them. This does not mean that the analysis must regard the status quo to be ‘correct’ but should conduct evaluation given the explicit objectives, existing allocations and their implied values. By making these explicit it exposes to public scrutiny the question of whether existing objectives are appropriate and whether the implied valuation of outcomes across sectors matches society’s preferences. Of course the legitimacy of any prescription will rest on the legitimacy of the decision makers, the processes and the institutions. Explicitness and transparency about what current decisions imply will pose the question of whether the claims for legitimacy are well placed.

References

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