Marginal costs and benefits

David J Torgerson, Anne Spencer

Decision makers are interested in measuring the costs and benefits of various interventions, and sometimes they are presented with the average costs and benefits of alternative interventions and asked to compare these. Usually a newer intervention is being compared with an existing one, and the most appropriate comparison is not of average costs (and benefits) but of the extra—or marginal—costs (and benefits) of the new intervention. Reanalysis of the cost effectiveness ratio of biochemical screening of all women for Down's syndrome compared with age based screening shows that the marginal cost effectiveness of biochemical screening is £47 786, compared with an average cost effectiveness of £37 591. It may sometimes be difficult or costly to calculate marginal costs and benefits, but this should be done whenever possible.

National Primary Care Research and Development Centre, Centre for Health Economics, University of York, York YO1 5DD
David J Torgerson, *research fellow*

Department of Economics, University of York
Anne Spencer, *PhD student*

Correspondence to:
Mr Torgerson.

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Some economic evaluations compare alternative health care interventions only by assessing differences in the average costs and benefits and express their results as average cost effectiveness ratios. This ratio is calculated by dividing the total cost of a health care intervention by the total benefits of such intervention.

This approach can be misleading as it describes inaccurately the different costs and benefits occurring with alternative health care interventions. A better method is to compare the extra costs and benefits between different health care interventions in the form of a marginal cost effectiveness ratio. This is calculated by dividing the extra or incremental costs by the extra benefits of the intervention. This paper explains why marginal analysis is essential if decision makers are to use scarce NHS resources efficiently.

Table 1—*Marginal analysis of Down's syndrome screening*

	Maternal age screening (500 women given amniocentesis)	Biochemical screening (20 000 women screened)	Incremental cost and benefits of biochemical screening
Biochemical test cost (£)*	0	290 000	290 000-0=290 000
Amniocentesis cost (£)	75 000	112 500†	112 500-75 000=37 500
Abortion cost (£)‡	4000	11 000	11 000-4000=7000
Total (£)	79 000§	413 500	413 500-79 000=334 500
No of avoided births	4	11‖	11-4=7
Average cost effectiveness (£)	79 000/4=19 750§	413 500/11=37 591	
Marginal cost effectiveness (£)			334 500/7=47 786

*Assumes a cost of £14.50 per woman.[1]
†Assumes a cost of £150 each and 75% acceptance rate.[1]
‡Assumes a cost of £1000.[1]
‖Assumes 90% acceptance of abortion.[1]
§If maternal age screening were introduced where no screening had previously existed then this would equate to the marginal cost and the marginal cost effectiveness ratio.

Table 2—*Marginal analysis of shared care for hypertension*

	Nurse practitioner care (n=270/202)* (75% reviewed)	Shared care (n=267/220)* (82% reviewed)	Incremental costs and benefits of shared care
NHS cost (£)	5343	6319	6319-5343=976
No of reviewed patients	202	220	220-202=18
Average cost effectiveness (£)	26·45	28·72	
Marginal cost effectiveness (£)			976/18=54

*Sample size/reviews completed.

Example 1: Down's syndrome

Consider screening for Down's syndrome based on maternal age. In 20 000 pregnant women 26 cases of Down's syndrome would occur, and eight of these (30%) would be in women aged 37 years or over, who comprise 5% of the pregnant population.[1] If 500 women aged 37 years or older have an amniocentesis this detects four affected pregnancies with an amniocentesis cost of £75 000 and an abortion cost of £4000, giving a total cost of £79 000. Hence the cost effectiveness ratio of maternal age screening is £19 750—that is, £79 000/4.

Changing from maternal age screening to biochemical screening requires marginal analysis to estimate the budgetary expansion needed to introduce biochemical screening and to describe its extra benefits. Only with such data can an efficient choice be made.

An evaluation of such a change was reported by Wald *et al.*[1] They estimated that implementing biochemical screening would result in an average cost of about £38 000 for each affected birth avoided. In column 2 of table 1 the calculations are replicated for a population of 20 000 pregnant women. The total costs of biochemical screening amount to £413 500. However, some of those costs (£79 000) would have been incurred in the absence of biochemical screening. Column 3 of table 1 shows that implementing biochemical screening requires £290 000 to fund extra test costs, £37 500 in extra amniocentesis costs, and £7000 in extra abortion costs—thus, the screening budget requires expansion by £334 500, not £413 500. Hence, average cost analysis overstates the total cost of implementing biochemical screening by 24%.

In a similar fashion the benefits have been overstated by using average benefits. Thus, the extra benefit is seven avoided births, not 11, as four births would have been avoided anyway under the maternal age screening programme. Thus average benefit analysis overstates the benefits by 57%. Finally, the marginal cost effectiveness ratio is 27% greater than the average cost effectiveness ratio—that is, £47 786 not £37 591. A similar failure to undertake marginal analysis of biochemical screening was made by Piggot and colleagues.[2]

Example 2: hypertension

Failure to use marginal analysis occurred in an evaluation of shared care and nurse practitioner care for hypertension.[3] Table 2 shows the total NHS costs

for each scheme and the numbers of patients attending for review at the end of the evaluation (the outcome measure used). Shared care had more patients attending for review at a slightly higher average cost per review. Average analysis may lead purchasers to think that the extra benefits of shared care can be obtained for £28.72 per patient. However, the key information required by purchasers is the additional cost per extra review achieved by shared care, not the average cost. From table 2 it can be seen that nurse practitioner care achieved a 75% review completion rate compared with 82% for shared care. The key benefit is the extra 7% of completed reviews achieved by shared care and comparing these with its extra costs. Hence the benefit of shared care is 18 extra patients reviewed for an extra cost of £976. Therefore the marginal cost effectiveness of shared care is £54 per extra reviewed patient, not £28.72.

Comment

In these two examples of economic evaluations we can see how the production and use of average cost and benefit data can mislead decision makers. Estimates of marginal costs and benefits are always preferable to average costs and benefits, and this has been advocated for several decades.[4,5] Despite this, there are often large evaluation costs incurred by calculating marginal rather than average values,[6] and in some cases this may justify using average costs. Indeed, health economists recognise the cost of collecting marginal cost information, and solutions, such as reduced datasets, have been proposed.[6] In addition, sometimes coincidentally, average costs may equate to marginal costs. Nevertheless, the temptation to use average costs and benefits should be avoided whenever possible.

This note shows that if more care is taken in the economic analysis marginal values may often be derived with little or no extra research effort. Even when marginal costs and benefits are more difficult to estimate, the improved precision of the evaluation may justify the increased research effort. For example, if average costs had been used when evaluating an early discharge scheme for patients with hip fractures they would have overstated its financial benefit by 200%.[7] For evaluations of competing interventions to produce valid results marginal costs and benefits should be used—not averages.

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Lesson of the Week

Nephrotic syndrome in childhood complicated by life threatening pulmonary oedema

C J D Reid, M J Marsh, I M Murdoch, G Clark

Beware of infusing too much 20% albumin too quickly in children with nephrotic syndrome

A consensus statement on nephrotic syndrome from the British Association for Paediatric Nephrology has recently recommended intravenous 20% albumin for the management of hypovolaemia in this condition.[1] The suggested dose is 1 g/kg over one to two hours followed by frusemide. Caution is required with this treatment, however, as considerable fluid shift may occur.[2] We describe three children who were transferred to our paediatric intensive care unit because they had developed life threatening fluid overload and pulmonary oedema after receiving an excessive dose or too rapid infusion of 20% albumin.

Department of Paediatric Nephrology, Guy's Hospital, London SE1 9RT
C J D Reid, *senior registrar*
G Clark, *senior lecturer*

Department of Paediatric Intensive Care, Guy's Hospital
M J Marsh, *consultant*
I M Murdoch, *consultant*

Correspondence to:
Dr Reid.

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Case 1

A 4 year old girl presented to her local hospital with a 10 day history of periorbital and lower limb oedema, a three day history of diarrhoea and vomiting, and oliguria for the past 24 hours. Urine analysis showed heavy proteinuria. The plasma albumin concentration was 15 g/l, urea concentration 11·6 mmol/l, creatinine concentration 41 μmol/l, haemoglobin concentration 120 g/l, and urinary sodium concentration 11 mmol/l. Nephrotic syndrome was diagnosed, and oral prednisolone was started. Oliguria persisted and her weight increased. There was no response to intravenous frusemide. She was given 20% albumin at a dose of 3·5 g/kg ideal body weight over four hours. During the infusion she became breathless, cyanosed, and had a generalised seizure followed by respiratory arrest. At intubation pink frothy sputum welled from the trachea. Initial arterial blood gas tensions when she was ventilated with 100% oxygen were pH 6·87, P_{CO_2} 8·7 kPa, P_{O_2} 5·9 kPa, base excess −24·6. Central venous pressure was +20 cm H_2O. A chest *x* ray film showed severe bilateral pulmonary oedema (fig 1a). Immediate further management included venesection of 10 ml/kg, intravenous frusemide, and dopamine. After her transfer to the paediatric intensive care unit continuous venovenous haemofiltration was started. The pulmonary oedema improved within 24 hours (fig 1b). Renal failure was managed by continuous venovenous haemodiafiltration. Doppler ultrasonography showed patent renal veins and good arterial flow. Corticosteroid treatment was continued, and after her renal function recovered she went into remission.

Case 2

A 17 month old boy, admitted to his local hospital with generalised oedema, was found to have nephrotic syndrome. Oral prednisolone was started. Oedema and weight gain worsened, and he was given intravenous