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WORK IN PROGRESS – PLEASE DON'T CITE

A weighted net benefit approach for prioritising resources

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Abstract

Innovative health interventions are often more effective and expensive than existing treatments. Incremental cost-effectiveness ratios show how much extra it costs to achieve an extra level of outcome. To stochastically analyse cost-effectiveness ratios it is necessary to calculate patient level ratios and then to make comparisons between patient groups. Bootstrapping is used to produce robust confidence intervals around ratios and to map ratios onto a cost-effectiveness plane. This approach is problematic due to (i) undefined ratios for patients with no change in outcome and (ii) the unclear interpretation of the polarity of ratios in a bootstrapped data set. This has led to the net benefit approach where net benefits are defined as the product of units of outcome gained and the (hypothetical) individual value (λ) of these units minus cost. Net benefits can be calculated for any patient in a dataset even if they have no change in outcome. Also, a positive or negative net benefit has clear meaning.

A variation of this approach is to adopt different levels of λ according to different levels of initial clinical status or quality of life. In this paper the cost-effectiveness of computerised cognitive behavioural therapy is compared to usual care. Rather than multiplying the same range of λs by the outcome gained for every patient in the sample, we explore the impact of weighting the λs according to the initial level of depression. The advantages and disadvantages of this weighted net-benefit approach are discussed.

Introduction

Cost-effectiveness analysis as usually practiced estimates an incremental cost-effectiveness ratio to show how efficient one form of care is over another. If absolute cost-effectiveness ratios are used (or if the comparator is 'do nothing'), and if the outcome measure is generic (such as a QALY), then interventions in divergent areas of medicine can be ranked. Assuming that all interventions for all conditions are included in this league table and that evaluation methods are appropriate and consistent, population utility is assumed to be maximised by choosing interventions from the top of the list until the health budget is used up (Weinstein and Stason, 1977). Clearly, these necessary assumptions are unlikely to be met in the near future and therefore the league-table approach probably has limited value. However, the use of incremental cost-effectiveness ratios still allows us to identify which one of a small number of interventions (usually two) for a specific condition maximises population welfare.

There are though alternatives to the classical Benthamite belief that social welfare is optimal when the sum of individual utilities is maximised (Dolan, 1998). For instance, the Pareto view would be that an optimal situation occurs when no person can be made better off without making someone else worse off. Rawls (1971) on the other hand argued that the most optimal situation was to give greater weight to the plight of the worst off in society. More recently, Willams (1997) has put forward a 'fair innings' argument where preference is given to those with a lower 'stock' of life years and quality of life.

Attempts to prioritise health care expenditure have tended to start off from a utilitarian (Benthamite) position of maximising the sum of individual utility. However, this has on occasion met with public and/or political opposition. In Oregon, for example, the ranking of interventions by cost-effectiveness ratios (which showed tooth capping to be more 'efficient' than treatment for ectopic pregnancy) soon gave way to the 'rule of rescue' (Hadorn, 1991) where life-saving interventions were preferred. In the UK, the National Institute for Clinical Excellence have appeared to be following a policy of recommending treatments with cost per QALYs below £30,000 (although this figure has never been explicitly stated). However, one recommended intervention (riluzole for motor neurone disease) has a cost per QALY which exceeds this by around one-third, whilst another (beta-interferon for multiple sclerosis) has a cost per QALY in the short term that some estimates show approaches £1 million per QALY,

and although initially the recommendation was against its use it is now being allowed as part of a long-term monitoring exercise. Motor neurone disease is a terminal and rare condition and therefore a relatively high cost per QALY was probably acceptable given the limited effect on budgets and the benefits accruing to patients. Beta-interferon is beneficial for some patients and an influential campaign took place against the NICE rejection.

The Oregon and NICE experiences suggest that classical cost-effectiveness ratios are not the most important instruments for resource allocation decisions, and that for some patients the same outcomes are more valuable than for others. Empirical evidence for prioritisation preferences that are not consistent with simple cost-effectiveness ratios has been provided (Cookson & Dolan, 1999; Olsen et al, 1998).

Until recently, the valuation of outcomes was not a major concern for those conducting economic evaluations in healthcare. Cost-effectiveness ratios were produced and then it was up to decisions makers to compare these to threshold values. However, there is now a growing tendency to use the *net benefit approach* where the value of a change in outcome is a fundamental part of the estimation of cost-effectiveness. This methodological development was adopted in the analyses presented below and it was realised that it would enable an exploration of the effect of using different values of outcome gains for patients with differing levels of illness.

This paper compares the cost-effectiveness of computer-delivered cognitive behavioural therapy for patients with depression and/or anxiety with usual care provided by general practitioners. The specific aims were:

i. to compare the cost effectiveness of the two treatment options where a reduction in depression is valued the same for all patients,

ii. to compare the cost effectiveness of the two treatment options where a reduction in depression is valued most highly for those with more severe depression, and

iii. to compare the aggregate level of net-benefit gained from applying a constant value for reductions in depression to that gained from applying a variable value according to severity level.

Methods

Background to study

Depression and anxiety are common problems and impose large economic and social burdens (Berto et al, 2000; Simon et al, 1995; Meltzer et al, 1995; Kessler et al, 1999; Spitzer et al, 1995). These costs can be substantially reduced by effective treatment (Simon et al, 2000). Patients generally prefer psychological therapies (Angermeyer & Matschinger, 1996; Tylee, 2001) and the National Service Framework for Mental Health (Department of Health, 1999) has called for increased availability of such treatments for common mental health problems. A shortage of trained therapists (Goldberg & Gournay, 1997), has directed attention to alternative methods for delivering psychological therapies that offer rapid and acceptable care-pathways (Lovell & Richards, 2000). 'Beating the Blues' is an effective computerised therapy programme for anxiety and depression (Proudfoot et al, submitted).

Sample

Patients were recruited in two phases from twelve general practices in South East England and included if they were between 18 and 75; were suffering from depression, mixed depression/anxiety, or anxiety disorder; and not currently receiving face-to-face psychological therapy (including counselling). Patients who consented were then randomised to 'Beating the Blues' (BtB) with usual care or treatment as usual (TAU) alone. If recruits who were randomised to BtB had also been referred to face-to-face counselling or psychological intervention, then this was assumed to be covered by the BtB programme for the duration of the study.

Intervention

BtB consisted of one 15-minute introductory video followed by eight 50-minute sessions of therapy. GPs and practice nurses were kept informed as to the patient's progress via automatically generated computer printouts following each session. TAU consisted of a variety of interventions including discussions with the GP, referral to a counsellor, practice nurse or mental health professional and treatment of physical conditions.

Outcome measures

Clinical measures were taken at baseline and at a number of follow-up points. The primary outcome measure for the economic evaluation was the change in the level of depression, as measured by the Beck Depression Inventory II (BDI; Beck et al, 1996), between randomisation and six-month follow-up. The BDI consists of 21 items that are rated according to level of severity (0-3). A total score is produced between 0 (least severe state) and 63 (most severe state). Where follow-up scores were missing the ratings taken following treatment, one-month follow-up or three-month follow-up were carried forward.

Service utilisation

Service use data were collected from GP notes and other primary care sources by nurses for patients in each arm of the trial for two time periods: the six months prior to randomisation and the eight months following randomisation. These periods of time would be sufficiently long to capture the utilisation of rare (but often expensive) services. The reliability of this method of data collection clearly depends on the reliability of the record keeping of primary care staff, but in earlier work it seemed to be more reliable than patient self-report. The aim was to be comprehensive so that the effects on all health care services of providing the BtB intervention or TAU could be observed. Because data were collected from primary care sources it was not possible to measure social care service utilisation other than home helps. Other recent studies have also focused on health care costs (Bower et al, 2000).

Services measured included contacts with mental health care staff (psychiatrists, psychologists, community mental health nurses, counsellors and other therapists); primary care staff (GPs, practice nurses, district nurses and health visitors); hospital services (in-patient care for psychiatric and physical health reasons, out-patient care, day surgery and accident and emergency attendances); home helps; medication (all medication was recorded but only data on anti-depressants, anxiolytics and sedatives were used in the analyses); and other services (chiropodists, physiotherapists, dieticians). The number of contacts with each service was recorded or, in the case of medication, the length of the course and the dosage.

Service costs

Unit costs (which aim to reflect the long-run marginal costs) for most services were obtained from a recognised national source (Netten and Curtis, 2000) where staff costs were calculated

by dividing the total cost (salary, oncosts, overheads, capital, land and training) of the service over one year by an appropriate unit of activity. Hospital costs (accident and emergency, day surgery, generic in-patient, generic out-patient, psychiatric in-patient) were also obtained from the above source. Medication costs were taken from the British National Formulary (British Medical Association and the Royal Pharmaceutical Society of Great Britain, 2001). Unit costs were multiplied by the service utilisation data to generate service costs per patient.

Although GPs were not charged for the use of the BtB system, in routine practice they would purchase a licence to use BtB on a computer in the practice. The average price per patient using BtB was estimated by the manufacturer to be £100, taking into account the expected throughput of patients. To this was added £16 to cover overhead and capital costs of the primary care setting where the application would be used. This latter figure was derived from costs reported by Netten and Curtis (2000). This total cost was then divided by eight to calculate the cost per session (£14.50). The baseline and follow-up service use and cost periods differed in length. In order to make meaningful comparisons the baseline six-month costs were all multiplied by 1.33 in order to generate 8-month cost figures.

Statistical analysis

The analyses were conducted on an intention-to-treat basis with the main focus being between the BtB and TAU patients. The characteristics of the TAU and BtB samples were compared using Pearson's chi-square and t-tests. Significance tests for the difference in mean total costs were conducted by generating bootstrapped 90% confidence intervals (with 5000 repetitions) due to the expected non-normality of the cost data. In the comparison of follow-up costs, we controlled for baseline cost differences. (The rationale for using 90% confidence intervals rather than those at the more conventional level of 95% was that we are less risk averse when making financial decisions than we are when making clinical decisions.) There may have been differences in costs between GP practices and therefore we used a clustered analysis.

Cost-effectiveness analysis

The cost-effectiveness of BtB compared to TAU was determined using the net-benefit approach (Hoch et al, 2002). There is a theoretical, but unknown, value (represented by the

term λ below) that society would place on a one-unit reduction in depression as measured by the BDI. The net benefit to society of BtB can be defined as:

$$NB=(\lambda \times E)-SC,$$

where NB = net benefit, E = effectiveness (i.e. reduction in BDI score over six months) and SC = service costs. For example, if for a particular patient the BDI score is reduced by eight points during the follow-up period and if their service cost is £250 then we can calculate their net benefit if we know λ. If λ=£0 then the net benefit is -£250, whereas if λ=£40 then the net benefit is +£70. To be cost-effective, an intervention must result in a net benefit that is greater than zero.

To address the first aim of the study we estimated net benefits for all patients in the sample by assuming different values for λ ranging between £0 and £100 in £10 increments. Then a regression model was used to determine the mean difference in net benefit between the BtB and TAU groups for every value of λ, controlling for baseline costs and the phase of data collection. For each model, 1000 regression coefficients for the BtB/TAU variable were generated using bootstrapping, and the proportion of these that were greater than zero indicated the probability that BtB was cost-effective (i.e. it resulted in a mean incremental net benefit greater than zero). These probabilities were subsequently used to generate a cost-effectiveness acceptability curve.

To address the second aim of the study we used values of λ that *on average* ranged between £0 and £100 but where they were weighted according to the initial level of depression as measured by the BDI. This was done in three ways. First, if the initial BDI score was between 31 and 40 λ was increased by 50% and if the BDI score was above 40 λ was increased by 100%. The value of λ was then reduced for all other patients in order to maintain the average of £0, £10, £20, ..., £100. Second, all patients with an initial BDI score of below 31 were given a λ of £0 whilst those with a score of 31 or above were given a value of which maintained the average at £0, £10, £20, ... £100. Finally, λ was weighted by the entire range of initial BDI scores. An example of the base case (where all are given the same λ values) and the first two alternative distributions is provided in Table 1.

Finally, a comparison of the aggregate net benefit accruing to society of using these different distributions of was made by simply multiplying the average net benefit by the number of participants in the study.

Results

A total of 274 patients attending the surgeries were randomised into the two groups (146 BtB, 128 TAU), with cost data available for both baseline and follow-up periods for 261 (95%) patients (138 BtB, 123 TAU). The analyses presented in this paper refer to these 261 patients whose characteristics are shown in Table 2. There were no substantial or significant differences between the BtB and TAU patients.

Service Utilisation

During the six months prior to randomisation (baseline) a large majority of patients had contacts with GPs (Table 3). Slightly under half of patients in each group had contact with practice nurses and approximately a quarter had out-patient appointments. The latter were predominantly for physical health reasons as were all in-patient episodes. TAU patients were more likely to use services in the 'other' category. (Other services identified from casenotes were: dietician, midwife, support worker, chiropodist, complementary healthcare and a BUPA medical.)

The high level of contact with GPs, practice nurses and out-patient services continued into the eight-month follow-up period. Large differences were observed for the proportion of patients attending accident and emergency, out-patient departments and having contacts with CPNs, counsellors and other therapists. Greater use was made by the TAU group for all these services. For psychotherapy services, including counselling, this may reflect the suppression of such services to the BtB group during the treatment period imposed by the study design. By follow-up, the proportion of patients who had had to stop working at some time was reduced slightly in the BtB group.

At follow-up, two of the BtB sample had psychiatric in-patient episodes (20 days and 30 days). On the basis of the available information, there was no evidence to suggest that the BtB intervention precipitated in-patient psychiatric care. In both cases the patients either did

not want the treatments offered in primary care or did not respond to them, and therefore more specialist mental health care was one option open to them. At baseline over one third of patients were prescribed anti-depressant medication and this increased slightly at follow-up.

Total service costs

The mean costs of individual services were generally quite low for the two groups at baseline (Table 4). The overall mean total service cost was £33 lower for the BtB group at baseline (90% CI, -£117 to £28; p=0.421). Few substantial differences between the groups had emerged by follow-up. The mean costs of both counsellors and other therapists over the eight months were though substantially higher for the TAU group. The mean service cost was £40 higher for the BtB group and, with baseline costs controlled for, this difference was not statistically significant (90% CI, -£42 to £181; p=0.350).

Cost-effectiveness analysis

With last values carried forward, there were 237 cases available for the economic analysis. BtB resulted in an incremental reduction in the BDI score of 3.6 points compared to TAU and this was statistically significant (95% CI, 0.7 to 6.5). Therefore BtB was more expensive and more effective than TAU. Figure 1 shows that if society places a zero value on a unit reduction in the BDI then there is only a 21.6% chance that BtB is more cost-effective than TAU. However, the probability of BtB being more cost-effective soon increases with positive values placed on such a reduction.

Distribution A refers to the use of the same value of λ for all patients. When this is equal to £40 there is an 82.8% chance that BtB is more cost-effective than TAU. However, if the values of λ applied to those with initial BDI scores of 31-40 and 41 and over are increased by 50% and 100% respectively (Dist B) then it can be seen that there is a greater chance (85.6%) of BtB being more cost-effective at an average λ value of £40. This is increased further to 89.9% if λ=£0 for those with initial BDI scores of below 31 (Dist C). Finally, if λ is weighted according to the entire distribution of BDI scores (Dist D) then the chance of BtB being cost-effective is 87.1%. It can be seen that the curves cross at different points, which means that the relative cost-effectiveness of BtB compared to TAU depends on the weight given to λ and its average value. At average λ values of below around £60, using a constant weight always

resulted in a slightly lower likelihood of BtB being cost-effective than TAU than for the other methods of weighting λ.

Figure 2 shows the aggregate net benefit accruing to society for these different distributions of λ values. Here the sample is taken as a whole with no comparison made between the BtB and TAU groups. It can be seen that by adopting a policy of weighting in favour of patients with more severe levels of initial depression a greater level of aggregate net benefit is achieved.

Discussion

The main findings of this paper are as follows:

- the service costs associated with BtB were greater than those for TAU but outcomes were better,
- with distributions of λ that favoured those with more severe initial levels of depression the probability that BtB was more cost effective increased for average values below around £60, and
- aggregate net benefits were substantially greater for distributions of λ that favoured those with more severe initial levels of depression.

There are a number of implications of this analysis. First, the net benefit approach readily allows us to value outcomes differently according to illness severity and other characteristics. This is helpful given that it enables such ideas as a 'generalised rule of rescue' (Cookson & Dolan, 1999) to be used in evaluations by giving greater weight for those in a sample with more severe problems. A second implication (and one that was not initially expected) is that a system of weighting like this may satisfy both a 'watered down' Rawlsian view of prioritisation (more priority for those in most need) *and* a classical utilitarian position where aggregate utility should be maximised. It is easy to see why this occurred here – greater values of λ were given to those with the highest levels for depression and these were also the patients who showed the most improvement.

There are of course limitations. First, outcomes were measured housing a non-cardinal scale. Arguably, using QALYs would have been a superior method but no quality of life scale was used in the study and we were not confident in mapping the BDI scores to QALY values. However, the problem that the BDI is not a cardinal measure may be addressed by the very fact that we applied different weights to different initial BDI scores (i.e. a by-product of using a weighted net-benefit approach to allow for different distribution preferences may be to provide a way of dealing with non-cardinal measures). Second, the weighting of λ was arbitrary. Empirical work would be needed to determine acceptable weights, but this would be particularly challenging given that one could weight by almost anything. Current work to establish the value of QALYs may though inform such weighting. Finally, this work was largely driven by the opportunity to use the net benefit approach in the evaluation of BtB. The task is now to backtrack and underpin the empirical work with theory!

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Table 1. Example of distribution of λ.

Initial BDI score	**N**	**λ constant**	**λ * 1.5 for BDI 31-40, λ * 2.0 for BDI 41+**	**λ = 0 for BDI < 31**
<31	173	£40	£30.52	£0
31-40	46	£40	£60	£148.25
41+	18	£40	£80	£148.25
Average λ		£40	£40	£40

This table shows the different values of λ that apply under the alternative distributions when the average = £40. Similar adjustments were made for other values in the range between £0 and £100.

Table 2. Characteristics of sample

Characteristic	**TAU (n=128)**	**BtB (n=146)**	**P**
Age; mean (SD)	43.4 (13.7)	43.6 (14.3)	0.931
Gender; n (%)			0.653
Female	96 (75)	106 (73)	
Male	32 (25)	40 (27)	
Marital status; n (%)			0.831
Single	33 (26)	35 (25)	
Married	54 (43)	60 (43)	
Cohabiting	11 (9)	16 (11)	
Separated	7 (6)	4 (3)	
Divorced	15 (12)	18 (13)	
Widowed	5 (4)	8 (6)	
Ethnic status; n (%)			0.417
White	100 (87)	120 (90)	
Other	15 (13)	13 (10)	
Years of education; n (%)			0.963
<5	1 (1)	1 (1)	
5-10	16 (13)	16 (11)	
11-12	28 (23)	34 (24)	
13-15	30 (25)	31 (22)	
>15	46 (38)	58 (41)	
Employment			0.201
Yes	72 (58)	92 (66)	
No	52 (42)	48 (34)	

TAU = treatment as usual, BtB = Beating the Blues

Table 3. Number (percentage) of patients using services and with lost employment during baseline and follow-up periods; comparison of treatment as usual (TAU) and Beating the Blues (BtB).

Cost item	Baseline six months		Follow-up eight months	
	TAU (n=123)	BtB (n=138)	TAU (n=123)	BtB (n=138)
BTB	0 (0)	0 (0)	0 (0)	131 (95)
General practitioner	119 (97)	131 (95)	117 (95)	126 (91)
In-patient (physical)	3 (2)	6 (4)	8 (7)	6 (4)
In-patient (psychiatric)	0 (0)	0 (0)	0 (0)	2 (1)
Out-patient	35 (29)	36 (26)	53 (43)	45 (33)
Day surgery	7 (6)	4 (3)	7 (6)	9 (7)
A & E	7 (6)	9 (7)	16 (13)	7 (5)
Practice nurse	52 (42)	58 (42)	43 (35)	46 (33)
District nurse	1 (1)	1 (1)	1 (1)	1 (1)
CPN	3 (2)	1 (1)	7 (6)	2 (1)
Nurse practitioner	0 (0)	2 (1)	4 (3)	9 (7)
Counsellor	3 (2)	3 (2)	23 (19)	8 (6)
Clinical psychologist	2 (2)	0 (0)	3 (2)	5 (4)
Psychiatrist	2 (2)	2 (1)	3 (2)	2 (1)
Health visitor	1 (1)	0 (0)	2 (2)	2 (1)
Social worker	0 (0)	2 (1)	2 (1)	2 (1)
Physiotherapist	4 (3)	1 (1)	6 (5)	5 (4)
Therapist	0 (0)	0 (0)	9 (7)	2 (1)
Medication	52 (42)	59 (43)	58 (47)	60 (44)
Other services	7 (6)	0 (0)	3 (2)	1 (1)

TAU = Treatment as usual, BtB = Beating the Blues

Table 4. Mean (standard deviation) cost of individual services used during baseline and follow-up periods and lost employment; costs in 2000/2001 £s.

Cost item	Baseline 8 months [1]		Follow-up 8 months	
	TAU (n=123)	BtB (n=138)	TAU (n=123)	BtB (n=138)
Beating the Blues	0 (0)	0 (0)	0 (0)	92 (39)
General practitioner	77 (50)	77 (55)	71 (50)	62 (55)
In-patient (physical)	8 (50)	21 (125)	53 (303)	28 (168)
In-patient (psychiatric)	0 (0)	0 (0)	0 (0)	55 (468)
Out-patient	53 (106)	49 (97)	71 (131)	57 (115)
Day surgery	26 (106)	13 (77)	22 (95)	32 (130)
A & E	5 (19)	6 (23)	8 (23)	4 (18)
Practice nurse	10 (17)	10 (15)	7 (16)	8 (15)
District nurse	2 (22)	1 (16)	1 (9)	1 (9)
CPN	1 (6)	0.3 (3)	2 (9)	0.4 (3)
Nurse practitioner	0 (0)	1 (8)	2 (16)	5 (21)
Counsellor	4 (29)	1 (10)	30 (97)	7 (38)
Clinical psychologist	3 (32)	0 (0)	2 (10)	13 (94)
Psychiatrist	3 (22)	4 (32)	4 (28)	2 (15)
Health visitor	1 (14)	0 (0)	3 (33)	0.4 (4)
Social worker	0 (0)	6 (65)	4 (34)	4 (32)
Physiotherapist	2 (9)	1 (11)	3 (20)	1 (9)
Therapist	0 (0)	0 (0)	18 (78)	2 (15)
Psychotropic medication	13 (32)	12 (26)	27 (55)	23 (44)
Other services	29 (297)	0 (0)	28 (298)	0.3 (3)
Total	236 (404)	203 (262)	357 (575)	397 (589)

[1] Six month service use was measured at baseline and costs were multiplied by 1.33 to generate 8 month cost figures. TAU = Treatment as usual, BtB = Beating the Blues

Figure 1. Cost-effectiveness acceptability curves.

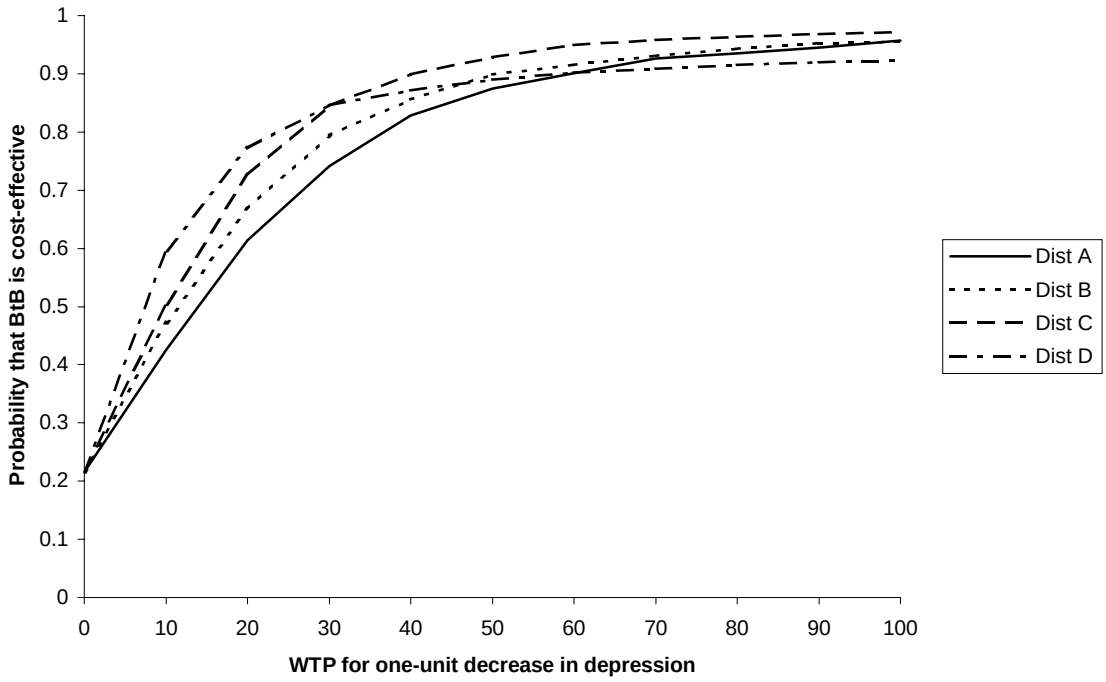

Figure 2. Aggregate net benefits for 237 patients in sample.