Cost effectiveness of an outpatient multidisciplinary pulmonary rehabilitation programme

T L Griffiths, C J Phillips, S Davies, M L Burr, I A Campbell

Abstract

***Background*—Pulmonary rehabilitation programmes improve the health of patients disabled by lung disease but their cost effectiveness is unproved. We undertook a cost/utility analysis in conjunction with a randomised controlled clinical trial of pulmonary rehabilitation versus standard care.**

***Methods*—Two hundred patients, mainly with chronic obstructive pulmonary disease, were randomly assigned to either an 18 visit, 6 week rehabilitation programme or standard medical management. The difference between the mean cost of 12 months of care for patients in the rehabilitation and control groups (incremental cost) and the difference between the two groups in quality adjusted life years (QALYs) gained (incremental utility) were determined. The ratio between incremental cost and utility (incremental cost/utility ratio) was calculated.**

***Results*—Each rehabilitation programme for up to 20 patients cost £12 120. The mean incremental cost of adding rehabilitation to standard care was £ –152 (95% CI –881 to 577) per patient, p=NS. The incremental utility of adding rehabilitation was 0.030 (95% CI 0.002 to 0.058) QALYs per patient, p=0.03. The point estimate of the incremental cost/utility ratio was therefore negative. The bootstrapping technique was used to model the distribution of cost/utility estimates possible from the data. A high likelihood of generating QALYs at negative or relatively low cost was indicated. The probability of the cost per QALY generated being below £0 was 0.64.**

***Conclusions*—This outpatient pulmonary rehabilitation programme produces cost per QALY ratios within bounds considered to be cost effective and is likely to result in financial benefits to the health service.**

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Keywords: pulmonary rehabilitation programme; cost effectiveness; cost/utility analysis

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Respiratory disease is the third most common cause of chronic ill health in the UK. Patients may experience escalating disability and handicap with increasing burden on their carers. They are also heavy users of health care and social services resources, with £200 million spent on inpatient care, £71 million on pharmaceuticals, £17 million on community health services, £64 million on social services, and £83 million on community care services in England in 1992/93—a total of £435 million, equivalent to nearly £500 million at 2001 prices.[1]

Pulmonary rehabilitation aims to reduce the levels of morbidity, disability, and handicap and its role in improving health in chronically disabled patients has been recognised by the American, European, and British Thoracic Societies.[2–4] Pulmonary rehabilitation is a multidisciplinary intervention offered to patients and their carers providing a "set of tools and disciplines that attends to the multiple needs of the patient with chronic obstructive pulmonary disease".[5] A meta-analysis[6] and more recent reports have demonstrated positive impact on the quality of life in patients who have completed these rehabilitation programmes.[7–13] Estimates of the costs involved in providing pulmonary rehabilitation programmes have been published.[11 14 15] However, we are not aware of any study that has directly addressed the overall cost effectiveness of adding a rehabilitation programme to the standard care of these patients. The aim of this study was to assess the costs and benefits resulting from a 6 week outpatient rehabilitation programme which was being evaluated in a randomised controlled study of its clinical effectiveness[16] following its introduction in an NHS hospital in South Wales, UK.

Methods

SUBJECTS

Two hundred patients, mainly with chronic obstructive pulmonary disease (COPD) but including patients with other chronic disabling pulmonary pathologies agreed to participate. They all had forced expiratory volume in one second less than 60% of predicted with less than 20% reversibility to inhaled β agonists. The subjects had been referred to the rehabilitation service by primary and secondary care physicians. Full inclusion and exclusion criteria for the study and the characteristics of the subject groups have been published previously.[16] Participants were randomly assigned to either an 18 visit, 6 week outpatient rehabilitation programme or to continue standard medical management. Each programme was designed to accommodate up to 20 patients; however, during the early stages of the research phase recruitment was slow and so programmes commenced with 18–20 patients with approximately 16–17 completing each programme.

All patients referred were reviewed by TLG or associated physicians and, before randomisation, medical treatment—particularly inhaled bronchodilators and corticosteroids—was optimised for individual subjects and, if thought necessary, referrals were made for smoking cessation counselling, dietetic, occupational therapy, or physiotherapy assessment usually available at the hospital. If any changes were made to management, entry into the study was deferred for 2 months after the last change. We have previously reported details of the randomisation and allocation procedures.[16] The study was approved by the local medical research ethics committee and subjects gave written informed consent.

Rehabilitation programme

The programme has been described previously.[16] Professional input was provided primarily by dedicated occupational therapy, physiotherapy, and dietetics staff with further input from a respiratory nurse specialist. Patients attended the rehabilitation unit in two groups of up to 10 people. Each group received rehabilitation on three half days per week for 6 weeks. Each session lasted for approximately 2 hours and included educational activities, exercise periods, and sessions addressing the psychosocial aspects of chronic disability. Individual goal setting, dietary intervention, physiotherapy, and occupational therapy were also included. At the conclusion of the 6 week programme patients were invited to join a patient run group meeting weekly at the local leisure centre.

Control group

These patients continued with their usual outpatient or primary care follow up and were offered pulmonary rehabilitation after 1 year.

TYPE OF EVALUATION AND PERSPECTIVE

An incremental cost/utility analysis was undertaken to assess the cost effectiveness of the programme. The costs incurred and utility gained in the rehabilitated group over and above those for the control group were determined. Thus, the net cost in pounds and net utility in terms of quality adjusted life years (QALYs) gained by adding pulmonary rehabilitation to standard care were calculated and expressed as a ratio. While the main costs analysed were those directly borne by primary and secondary health services, costs to the patients themselves were also taken into account. Analysis was by intention to treat.

OUTCOMES

Utility (QALYs)

Health status was measured using the medical outcomes survey Short Form 36 item questionnaire (SF-36)[17] before randomisation, at the end of the 6 week intervention period, and 12 months after entering the study. The SF-36 is a self-completed instrument which has been validated for use in patients with COPD.[18 19] In order to use this information in a cost/utility analysis, the SF-36 scores which measure health status on eight different scales were converted to a single "preference based" utility score indicating the value that would be given to their health state by the general population. This was done by extracting the appropriate SF-36 responses and using them to complete a six item health state classification, the SF-6D.[20] The health states described by the SF-6D have a known value placed on them by a reference population and can be used as a measure of utility.[20] In this way, the value placed on the different health states implied by subjects' responses to the SF-36 questions can be expressed on a single utility scale. On this utility scale, scores of 0 and 1 represent the worst and best possible health states, respectively. A notional overall SF-6D utility score pertaining for the year was derived for each patient, taking into account the unequally spaced timings of the observations. This SF-6D utility score was combined with survival data to produce QALYs, which combine the quantity and quality of life following healthcare interventions. They are the arithmetic product of the life duration and the utility score. Thus, 1 year of life with a utility score of 0.75 would result in 0.75 QALYs being produced. In the present study follow up was limited to 1 year. The product of the SF-6D score and the duration of life up to 1 year gave the QALYs produced for each subject.

Costs and health service usage

Data relating to the costs to the health service of providing the rehabilitation programme were gathered from the staff involved in managing the service provision and staff from the finance department of the NHS trust. The direct costs of providing the service consisted of staff costs, transport, all equipment, materials and consumables, and an allowance for overheads and facility usage of 20% as determined by the finance department of the trust (table 1). All direct costs were allocated to an individual 6 week period of the programme and it was assumed that there was no difference between the costs of delivering each 6 week period. The expected life of equipment was estimated by finance staff of the trust and the costs of purchasing the items were depreciated over this time period and allocated pro rata to each programme. Staff costs were based on salary costs plus on-costs and allocated to each programme on the basis of hours contributed to the programme. The transport cost was based on the estimate of cost provided by the local ambulance trust. The analysis was performed on the basis of 17 patients per programme. Thus, the total costs per programme were divided by 17 and allocated to each patient randomised to the rehabilitation group.

Patient costs incurred in attending the programme were collected by means of a questionnaire distributed to patients. Given that only a few patients indicated a cost, a proxy for patient costs was based on the average mileage multiplied by £0.2 per journey.

At the conclusion of the 1 year follow up period proformas were circulated to the patients' general practitioners. These were

Table 1 NHS costs of the 6 week programme assuming 17 patients per programme

	Cost (£)
Staff costs	
Senior occupational therapist (0.9 wte*)	2490
Consultant (5 hrs per week)	1500
Senior physiotherapist (0.5 wte)	1386
Senior dietician (0.3 wte)	834
Clerical coordinator (0.5 wte)	768
Therapy helper (0.6 wte)	690
Respiratory nurse specialist (0.5 hr per week)	42
Other costs	
Transport†	1875
Equipment and consumables‡	516
Overhead allowance§	2019
Total cost	12120

*wte = whole time equivalents.
†One third of patients used the minibus which is costed as an ambulance service. The ambulance trust estimated the cost at £15 000 per year which, allowing for eight programmes per year, gave a programme cost of £1875.
‡Equipment cost based on purchase price depreciated over expected lifetime.
§Based on 20% of costs.

completed from the primary care record of the number of consultations at the surgery, the number of home visits, and the number of contacts with other primary care staff. In a few cases this information was obtained by visiting the practice concerned and, for deceased patients, the centrally archived primary care records were examined. Each consultation with the GP was multiplied by the appropriate unit cost per consultation depending on whether it was a home visit (£30) or a surgery visit (£10).[21]

The information systems of the base hospital and the six surrounding district general hospitals were interrogated for patients' admissions to hospital and the number of days spent in hospital. Each inpatient day was multiplied by a unit cost of £195.19.[21]

The net cost per patient was computed from the programme costs and resources used in primary care consultations and hospital admissions. The mean overall cost per patient was used in conjunction with QALY estimates in the cost/utility analysis.

Cost/utility analysis

The mean numbers of QALYs generated by the intervention and control groups and the overall costs expended on the two groups were used to produce an incremental cost/utility ratio according to the following equation:

$$R = \frac{\overline{C}_T - \overline{C}_C}{\overline{U}_T - \overline{U}_C} = \frac{\Delta\overline{C}}{\Delta\overline{U}}$$

where R is the incremental cost/utility ratio, $\overline{C}_C$ and $\overline{U}_C$ are the means of the control group costs (in pounds sterling) and utility (in QALYs), respectively, $\overline{C}_T$ and $\overline{U}_T$ are the means of the treatment group costs and utility, respectively, and $\Delta\overline{C}$ and $\Delta\overline{U}$ are the incremental cost and incremental utility, respectively. The incremental cost/utility ratio provides a point estimate of the mean cost per QALY gained by adding rehabilitation to the standard care of patients. This value, being the ratio of two differences which may not have a normal distribution, has an unknown sampling distribution. It is therefore necessary to estimate the sampling distribution around the point estimate non-parametrically. This is most appropriately done using the "bootstrap" technique.[22] By this method, 1000 further hypothetical incremental costs and utilities (as in the equation) were modelled. To do this for the treatment group, the 99 observed cost values and 99 observed QALY values for the group were used as data pools. The whole of the cost and QALY data pools were then repeatedly sampled at random 99 times to produce a new estimate of $\overline{C}_T$ and $\overline{U}_T$. A similar process was used to produce a new estimate of $\overline{C}_C$ and $\overline{U}_C$ using the control group data. From the equation, new bootstrap estimates of $\Delta\overline{C}$ and $\Delta\overline{U}$ were derived. The whole process was repeated 1000 times and the resulting bootstrap re-sampling estimates of the incremental costs and effects were plotted with a vertical axis representing incremental cost (£) and a horizontal axis representing incremental effect (QALYs). The resulting plot has been described as a "cost effectiveness plane".[23 24] This plot provides an empirical estimate of the sampling distribution of the cost/utility ratio and can be used to determine, for instance, what the likelihood is that the intervention will provide utility benefit with reduced cost or the likelihood of the intervention being able to provide any given cost per QALY ratio.

Whether or not an intervention is deemed cost effective by a health purchaser depends on two things—firstly, its absolute cost effectiveness ratio and, secondly, the most expensive cost effectiveness ratio that a decision maker would consider to be a reasonable investment. Thus, if the highest or ceiling cost effectiveness ratio which a policy maker is willing to accept for a new treatment is known, the proportion of bootstrap estimates falling at or below this ratio will represent the probability that the intervention will prove cost effective by the policy maker's definition. If this process is repeated for a range of possible ceiling cost effectiveness ratios, a "cost effectiveness acceptability curve" can be constructed with the proportion of estimates falling below a given cost effectiveness ratio plotted against that ceiling cost per QALY.[25 26]

Results

COSTS OF PROGRAMME

The costs to the health service of providing each rehabilitation programme are shown in table 1. The total amount of £12 120 is composed mainly of staff costs (64%), with equipment and consumables comprising 4%, transport 15%, and overheads the remaining 17%.

Patients' costs were those incurred in travelling to the rehabilitation unit for the programme. One third of the patients were brought in the rehabilitation or ambulance service minibus while over 60% travelled by car. Most patients were accompanied (64%), mainly by their spouse (76%). The journey distance varied, but only 17% travelled for more than 10 miles to attend. Only 21%

Table 2 Mean (SD) net costs and QALYs generated in the control and rehabilitation groups

	Control group	Rehabilitation group	Difference (95% CI)	p value
Cost (£)	1826 (3295)	1674 (1588)	−152 (−880 to 577)	0.68
QALYs	0.351 (0.08)	0.381 (0.01)	0.03 (0.002 to 0.058)	0.03

reported that they actually paid for their transport. The average journey distance was computed at 7.5 miles, which amounts to a cost per patient of £18. On the basis that, on average, 17 patients attend per programme with 11 not using the minibus, the total costs for travel amounted to £204.

The overall costs of the rehabilitation programme thus amount to £12 324 or £725 per patient if 17 patients attend per programme.

IMPACT ON COSTS RESULTING FROM DIFFERENCES IN HEALTH SERVICE UTILISATION

Differences between the groups in terms of health service utilisation are reported elsewhere.[16] In the year after inclusion in the study, compared with the control group the net cost per patient in the rehabilitated group was £–39 from GP home visits, £13 from visits to the GP's surgery, and £–804 from days spent in hospital. For each individual an overall cost was constructed which included all the above and the cost of rehabilitation. The net costs are shown in table 2. No significant difference was observed between the control and rehabilitation groups in relation to the overall cost of their care.

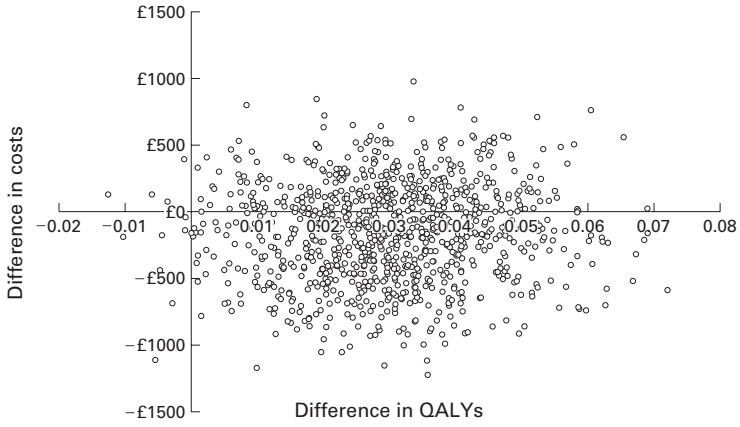

Figure 1 1000 Bootstrap re-samples of the difference in cost and QALYs produced between pulmonary rehabilitation and standard care plotted on a cost effectiveness plane.

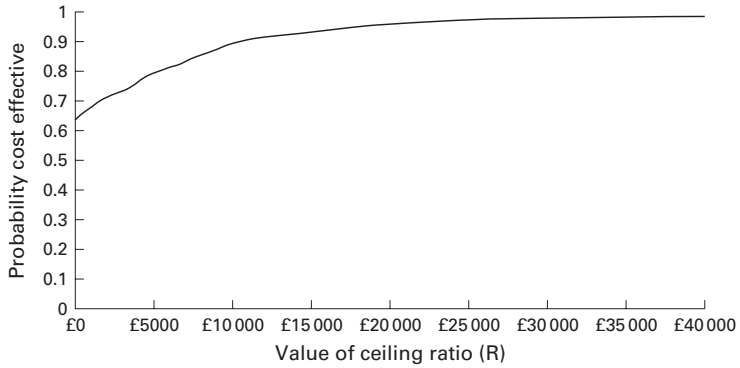

Figure 2 Cost effectiveness acceptability curve: probability that cost per QALY gained is cost effective as a function of the decision maker's ceiling cost effectiveness ratio.

QUALITY ADJUSTED LIFE YEARS

The SF-36 scores have been reported previously.[16] The derived SF-6D utility scores before intervention and 6 weeks and 12 months after entering the study were 0.34 (0.08), 0.37 (0.09), and 0.4 (0.09) for the control group and 0.33 (0.08), 0.43 (0.10), and 0.4 (0.11) for the rehabilitated group. Six of the 99 patients in the rehabilitation group and 12 of the 101 subjects in the control group died during the study. From these data the number of QALYs generated per group during the 12 month period were determined and are shown in table 2. Significantly more QALYs were generated in the group whose treatment included rehabilitation.

COST/UTILITY ANALYSIS

The programme resulted in an increase in the mean number of QALYs generated of 0.03 per patient (p=0.03) and a non-significant mean "cost saving" of £152 per patient (p=0.68). Investigation of the distribution of possible incremental cost/utility ratios generated by adding rehabilitation to standard care was performed using the bootstrapping technique. The result of carrying out 1000 bootstrap replications of the incremental costs and utility is shown on the cost effectiveness plane in fig 1. Inspection of the resulting plots confirmed that most of the modelled incremental costs and effects indicate that rehabilitation will generate QALYs while at the same time reducing the overall cost of patient care. A further proportion of the modelled costs and effects indicate QALY gain at increased cost. In very few of these simulations was loss of QALYs found.

These data were used to construct a cost effectiveness acceptability curve showing the proportion of cost/utility simulations with a ratio less than any given ceiling ratio that might be regarded by a decision maker as cost effective. The result of this exercise is shown in fig 2. This indicates that the probability of the true incremental cost/utility ratio of the programme being below £0 per QALY is 0.64. The probability that the true cost per QALY is below £3000 is 0.74, the probability that the cost per QALY is below £10 000 is 0.90, and the probability that the cost per QALY is below £17 000 is 0.95.

Discussion

This paper presents a comprehensive cost effectiveness analysis of the addition of multidisciplinary pulmonary rehabilitation to standard care for patients with chronic disabling lung disease, primarily COPD. We have shown that the pulmonary rehabilitation programme is likely to more than offset the cost outlay in providing such a service. There is a cost in providing the new service, but the reduction in downstream health service utilisation costs produced insignificant cost differences in the care of patients receiving the programme and those in the control group. When the analysis is re-calculated with 20 patients per programme,

the cost reductions become greater with a probability of 0.76 that the programme will cost less than £0 to generate one QALY.

We used the SF-36 questionnaire, a well developed health status questionnaire, in our clinical evaluation of the rehabilitation programme and derived a utility score from this (SF-6D). Since the inception of the study, other instruments for generating QALY values have been more thoroughly validated than the SF-6D. However, the bootstrapping technique of sensitivity analysis takes account of variability in the outcomes measured and, even in worst case type scenarios, revealed that the programme fell within bounds considered to show reasonable cost effectiveness.

Others have reported the cost of providing a predominantly inpatient rehabilitation programme with measurement of effectiveness in terms of disease specific health status.[15] However, as far as we are aware, ours is the first cost effectiveness analysis of pulmonary rehabilitation to be carried out using QALYs as an outcome and taking into account overall health service costs. Our findings can therefore be used to compare the cost effectiveness of investment in pulmonary rehabilitation with the cost effectiveness of other interventions in other conditions and hence inform health policy decisions.

The effectiveness of pulmonary rehabilitation in improving functional and health status is now proven.[6–13] Our previously reported study confirmed these substantial patient-centred benefits and showed reductions in health service usage in rehabilitated patients.[16] The present study conducted alongside the latter has confirmed that the cost per QALY of providing rehabilitation has a probability of 0.7 of being within an acceptable range.[27] Previous studies from rehabilitation centres in the UK have reported partial programme costings of £422.3 per rehabilitation graduate for a 14 session, 7 week programme designed for eight patients per group,[11] and £400 per rehabilitated patient for a 12 session, 6 week programme for 8–12 patients per group.[14] These analyses concentrate primarily on staff costings with some allowance for specific exercise equipment.[11] Our analysis has included transport costs, institutional overheads, and all the equipment, furniture, furnishings, and stationery, together with the many incidental costs incurred in setting up a new rehabilitation service.

Comparisons of cost effectiveness between studies are difficult because of variations in case mix, the outcome measures used, and the time points at which outcomes are measured. Differing comprehensiveness of the economic analysis also mitigates against direct comparison. However, one randomised controlled trial of pulmonary rehabilitation which has included rigorous economic evaluation of programme cost and effectiveness is that of Goldstein *et al.*[15 28] These papers reported the clinical results and costs of a Canadian rehabilitation programme involving 2 months inpatient rehabilitation followed by 4 months outpatient supervision. The estimated cost per patient was Canadian $11 597 (£4935 at a rate of 2.35 Canadian dollars to the pound), the bulk of which was contributed by hospitalisation costs. Our own estimate of the cost of a purely outpatient programme of proven effectiveness was £725. Goldstein and colleagues determined the number of patients needed to be treated (NNT) to produce one patient by the end of their programme with the minimum clinically important difference in each of the four domains of the Chronic Respiratory Disease questionnaire[29] together with the associated cost. These were calculated for dyspnoea (NNT = 4.1, cost £20 233); fatigue (NNT = 4.4, cost £21 714), emotion (NNT = 3.3, cost £16 285), and mastery (NNT = 2.5, cost £12 337).[15] The corresponding figures at the end of our own outpatient programme using the data from our randomised controlled trial were: dyspnoea (NNT = 2.3, cost £1730), fatigue (NNT = 2.5, cost £1880), emotion (NNT = 2.2, cost £1654), and mastery (NNT = 2.9, cost £2181).[16] Thus, outpatient multidisciplinary pulmonary rehabilitation appears highly cost effective in comparison with a programme incorporating a substantial period of inpatient care. However, without knowing the effect of the programme on subsequent health service costs, comparisons of overall cost effectiveness from a purchaser's point of view are impossible.

The value for QALYs produced as a result of rehabilitation, although statistically significant, appears small in absolute terms. This is explained by (a) the relative insensitivity to change of single score measures of utility compared with the larger changes seen in multidimensional disease specific health status measures,[19] (b) the fact that there was a difference of only six deaths between the groups out of a total of 200 patients, (c) the follow up time was short, only allowing for differences in the first year of follow up and neglecting any ongoing effect on QALYs produced by the differential death rate in subsequent years. We therefore believe that we have demonstrated important changes in utility at no extra overall cost to the health service.

Our cost effectiveness findings probably err on the conservative side. For example, we have chosen to use 17 patients as our baseline whereas the programme was set up to provide rehabilitation for 20 patients. The 12 month cut off may have underestimated the ongoing benefit in terms of mortality and health status. Our analysis was by intention-to-treat. Finally, the control group comprised patients who were on the rehabilitation waiting list having had treatment reviewed and optimised and who knew they would commence the programme after 1 year. It is therefore probable that their SF-6D scores were inflated by optimised care and expectations vis-à-vis the benefits that the programme would provide.

Despite these caveats, the cost effectiveness acceptability curves for the programme provide evidence of a 0.645 probability of rehabilitation resulting in a negative cost per QALY. This is in distinction to the positive costs per QALY generated by other interventions such as hip

replacement (£1180),[30] coronary artery bypass graft (£2090),[30] hospital haemodialysis (£21 970),[30] hypertension treated with beta blockade in middle aged men and women (£26 796 and £67 678, respectively),[31] adopting an intensive insulin based strategy for appropriate type II diabetic patients (£13 000),[32] and interferon beta for multiple sclerosis (£74 500).[33]

While further work is needed to assess the utility profile and mortality rate of rehabilitated patients in the medium to long term, the findings of this study show that the rehabilitation programme is comparable with those interventions which are generally regarded as being good value for money. It is reasonable to conclude that the programme is cost effective, produces cost per QALY ratios within the bounds considered to be cost effective, and is likely to result in financial benefits to the health service.

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