International Journal of Technology Assessment in Health Care, **22:4** (2006), 478–483.

Comprehensive cardiac rehabilitation: A cost assessment based on a randomized clinical trial

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Objectives: The costs of comprehensive cardiac rehabilitation are established and compared to the corresponding costs of usual care. The effect on health-related quality of life is analyzed.
Methods: An unprecedented and very detailed cost assessment was carried out, as no guidelines existed for the situation at hand. Due to challenging circumstances, the cost assessment turned out to be ex-post and top-down.
Results: Cost per treatment sequence is estimated to be approximately €976, whereas the incremental cost (compared with usual care) is approximately €682. The cost estimate is uncertain and may be as high as €1.877.
Conclusions: Comprehensive cardiac rehabilitation is more costly than usual care, and the higher costs are not outweighed by a quality of life gain. Comprehensive cardiac rehabilitation is, therefore, not cost-effective.

Keywords: Cardiac rehabilitation, Costing, Health-related quality of life

Comprehensive cardiac rehabilitation (CCR), a mostly secondary prevention scheme offered to patients after a hospital discharge on grounds of cardiac disease, is increasingly applied in Europe. Previously, cardiac rehabilitation focused primarily on physical exercise (1;4;6;8;9), whereas CCR as a much broader concept offers patient education, physical training, smoking cessation, dietary advice, psychosocial support, and risk factor management as well as clinical follow-up. Although European cardiologists agree that CCR should be an integrated part of cardiac care (5), studies reveal a great potential for improving CCR services across Europe (12;13;15).

The CCR scheme is regarded as secondary prevention and may as such not be a natural part of hospital treatment. In a healthcare system facing scarce resources, the decision of whether or not to implement CCR depends on the cost of the intervention, as well as cost-effectiveness considerations. Ex ante, it is expected that CCR hospital expenditure per patient is relatively small. It is not known whether CCR is

The project is part of a comprehensive health technology assessment, financed by the Danish Centre for Evaluation and Health Technology Assessment. When carrying out the actual cost assessment, the personnel at the economics unit as well as the department of cardiology at Bispebjerg Hospital in Copenhagen were very helpful and supplied valuable information.

actually cost-effective, compared to usual care. Internationally, few studies exist. A 1997 meta-analysis (2) concentrating on years of life saved (YLS) found the cost per YLS to be US$4.950 (~€4,110) in 1995, rendering CCR highly attractive according to a commonly used classification scheme (7). A recent study in Hong Kong (14) found CCR to be cost-saving compared to usual care. In addition, the authors found a quality of life gain in CCR compared to usual care. A British health technology assessment (3) found the costs per patient joining the scheme to be £371 (~€535). Costs were not related to effects.

Ideally, a cost assessment of an intervention such as cardiac rehabilitation would be based on observations from a time study alongside a randomized controlled trial (RCT). However, as no such study exists, this assessment follows an alternative path. No guidelines exist in this field, nor have any preceding studies provided a sufficient degree of detail to shed light on this path.

Aim

This analysis aims to estimate the costs of comprehensive cardiac rehabilitation in a hospital setting, to compare these costs with the costs of usual care, and finally, to relate incremental costs induced by comprehensive cardiac rehabilitation to the effect, measured as change in health-related quality of life.

METHODOLOGY AND DATA

Data

During the period 2000–03, an RCT ("DANREHAB") aiming to establish the effect of CCR on patient mortality, cardiac morbidity, and quality of life was conducted at the department of cardiology at Bispebjerg Hospital in Copenhagen. Patients with coronary heart disease were randomly divided into either the intervention group, who were offered CCR (380 patients), or the control group, who were offered usual care (390 patients). Cases received a comprehensive intervention, consisting of three lifestyle components (smoking cessation, physical training, and dietary advice) as well as medical advice, for a 6-week period, while controls received ordinary follow-up, without further specifications. Both groups were assessed at baseline and at 12 months. For the present project, the DANREHAB study population was examined and data on quality of life were derived from the study.

In addition, the hospital made the following information available: the accounts of the rehabilitation ward and the outpatient ward where the usual care was carried out; the accounts of the cardiology department and the accounts concerning mutual expenditure for the entire hospital; and average wage expenditure per staff category (i.e., physicians, nurses, etc.).

Furthermore, the department of cardiology assisted in describing work schedules, personnel categories, and so on. Finally, a detailed data set from the patient administrative system was used for the analyses of treatment schedules.

Costing

Only direct costs related to the treatment are included, that is, all healthcare costs induced during intervention or usual care. Healthcare costs induced subsequent to the analyzed treatments (e.g., readmissions) are not incorporated, as these costs are the subject of a separate analysis. Indirect costs, that is, production losses, are not included. The cost assessment compares the costs related to the intervention with the costs related to usual care. Usual care is defined as "the routine treatment." As this concept is very wide and ill-defined, usual care is in this context regarded as identical to the treatment offered to the controls in the randomized study.

The cost computations are based on information from the hospital department. As the original research project did not include a costing component, it proved necessary to use a top-down approach. This method is complicated by the financial organization of the Danish healthcare system. Generally, the hospitals are tax-financed and operate on a block grant. Therefore, no cash flows can be examined when analyzing expenditure. Costing is subdivided into remuneration of health personnel and other operational expenditure.

Wages

Intervention Costs. The costs of the intervention were assigned to the rehabilitation ward in the hospital, only treating patients from the intervention group. Thus, the total remuneration expenditure of that specific ward was assigned to the intervention. The number of healthcare professionals employed in the ward was established by using results from a previous costing exercise. These figures were multiplied by the average annual wage expenditure for each category, which was supplied by the hospital administration. By applying this method, personnel costs other than wages, such as pension and vacation allowances, were also included.

Usual Care Costs. The control group went for follow-up in the cardiology outpatient ward, where they comprised only a minor share of the patient population. To establish the true share of the outpatient ward costs, a detailed data set from the patient administrative system was applied in dividing the resources spent in the outpatient ward into three categories: those concerning cases, those concerning controls, and those concerning all other patients. From analyses on this data set, it is concluded that controls receive similar services as all other outpatients. All visits were grouped by resource use, and the distribution was quite similar among controls and all other patients. Table 1 displays the visits, divided into physician's consultations and nurse visits, in the two groups of patients. The difference between the two groups is small and ambiguous, with a tendency toward controls having relatively more nurse visits. The number of visits was not a subject for analysis as controls visits were defined as

https://doi.org/10.1017/S0266462306051403

Table 1. Composition of Visits in Control Group Compared to All Other Outpatients

	Average			
	2000	2001	2002	2001–02
Percentage of visits being consultation with a physician				
Control group	50.7	33.2	42.9	38.0
All other patients	53.7	38.9	41.0	39.9
Percentage of visits being nurse visits				
Control group	49.2	66.8	57.1	62.0
All other patients	46.0	60.5	59.0	59.8

being within 1 year from the randomization date, and no such definition existed for the group of all other patients. On these grounds, it is considered safe to apply the controls' share of the patient population as a proxy for their share of the total ward costs. The control visits constituted 3.1 percent of the total outpatient visits; thus, it was estimated that the control group accounted for 3.1 percent of the outpatient ward expenditure. Remuneration costs were established from the same source as for the intervention group.

The inaccuracy associated with using expenditure instead of costs cannot be ignored; however, it is assumed that the two groups experience the same inaccuracy and, thus, to some extent outbalance each other. For comparison purposes, personnel expenditure, therefore, is used as proxy for wage costs.

Other Current Costs

Other operational expenditure was in some categories assigned the specific ward; however, in other cost categories, there was no subdivision of department or hospital expenditure. A system of allocation keys was developed based on those cost components being assigned to the wards. The relevance and scope for each allocation key was discussed with relevant staff members at the department. An allocation key would suggest, for example, that pharmaceuticals in the rehabilitation ward accounted for 1.3 percent of total department pharmaceuticals expenditure. The allocation keys were then applied to total expenditure in each category to deduce the true expenditure in these cases. Also in this cost category 3.1 percent of the total cardiology outpatient ward expenditure was assigned to controls. On the whole, costs were assumed to equal expenditure, as the hospital is operated on a block budget, suggesting no cash flows exist within the hospital. Furthermore, there are no profits or subsidies involved in other current costs. Generally, the imprecision in this case is minor compared to the imprecision in the case of wages.

The study period is 3 years, from March 2000 to March 2003. Thus, the observations made in 2001 and 2002 cover entire calendar years. The cost estimates are based, therefore, on the average costs from 2001 and 2002. After the project completion in 2003, CCR became part of the treatment offered to patients at the hospital. The magnitude of the department increased, and now approximately 400 patients embark on the treatment each year. Expenditure information from this period of normal production (and full utilization of capacity) is included for comparison purposes. Costs were assessed by the same means as in the study period.

Number of Sequences in CCR

The total costs in the two categories are divided by the number of sequences to obtain the cost per sequence for comparison purposes. Although this computation is based on actual figures in the case of usual care, some ambiguity is related to the number of sequences for cases. On average, slightly less than 130 patients per year embarked on the treatment. However, spare capacity remained, and due to the project being an RCT, eligible patients had to consent to participate, which may have reduced participation markedly. Furthermore, ineligible patients were excluded from participation. The present analysis is based on an estimated full capacity of 300 patients embarking on the scheme and 250 patients completing treatment with a maximum of two absences. This assumption is shrouded in vast uncertainty and is a topic for sensitivity analysis. Due to the top-down approach, potential costs of spare capacity, thus, is included in the cost measure.

Effectiveness

A cost-effectiveness analysis applies cost data, cf. above, and a relevant effectiveness measurement. YLS is disregarded as an effect measure because the data display a very small mortality with insignificant difference between the groups, as the relative risk of dying is .96 in the intervention group. The 95 percent confidence interval ranges from .46 to 1.98, as there are few deaths in both groups. Quality-adjusted life-year as an effect measure is disregarded on the same grounds. Health-related quality of life (HRQL) gains were measured and remain useful for the effect measurement. The HRQL gains were not discounted.

For assessment of HRQL, two approaches, based on the EQ-5D questionnaire, were used. The questionnaire contains a visual analogue scale (VAS). Respondents are asked to mark their current state of health on this scale, where 1 (or 100) is the best possible health state, and 0 is the worst. The interpretation of the score would be that a score lower than 1 leaves room for improvement of the health state.

The rationale behind the VAS score has been questioned, especially from an economics theory perspective. It is argued that preference-weighted EQ-5D replies instead of the VAS replies are more theoretically sound, as the preference weights are deduced by interviews applying the time trade-off method (10;11). The official Danish weights for EQ-5D are used for transforming the five-dimensional replies into a single HRQL measure.

Only a minor subsample of the population in the DANREHAB study received and completed the EQ-5D questionnaire: a total of 137 patients distributed evenly between the two groups completed the questionnaire. The sample is representative of the entire project population. Single-measure HRQL is computed by both methods and for cases as well as for controls. An HRQL gain for cases would be interpreted as an effect of CCR.

Sensitivity Analysis

The components selected for sensitivity analysis are wages, currents costs other than wages, and number of treatment sequences. In the cost analysis, the wage item is drawn from the hospital accounts and there is no uncertainty concerning the number of employees or the amount of their actual remuneration. However, major uncertainty is related to the use of expenditure instead of costs. On these grounds, the wage component is included in the sensitivity analysis. For other current costs, some assumptions were applied in the development of allocation keys; therefore, this item is included for sensitivity analysis. In analyzing the number of sequences, cases were treated differently from controls, as the number of rehabilitation sequences was based on interviews and assumptions, whereas the number of usual care sequences was drawn from the patient administrative system. It makes sense, therefore, to attribute a greater uncertainty to the number of sequences for cases than to the number of sequences for controls. In addition, substituting expenditure for costs due to the top-down approach renders the number of treatment sequences quite important. The high estimate for number of sequences is the one used above, 250 patients per year completing, whereas the low estimate is those 130 patients who actually completed the treatment.

A linear, one-way sensitivity analysis was performed. There seems to be no theoretical rationale of combining the three items (wages, current costs other than wages, and number of sequences) in an *n*-way sensitivity analysis, as they are not related.

RESULTS

Table 1 concerns the control group share of all outpatients. As mentioned, the nature of the visits was examined to verify the share of 3.1 percent. The difference between controls and all other patients does not seem large from these figures; therefore, the assumption that controls constituted not only 3.1 percent of patients but also 3.1 percent of resources spent in the outpatient department seems to hold. Table 2 shows the costs of a cardiac rehabilitation treatment sequence.

From Table 2, it appears that the rehabilitation ward at Bispebjerg Hospital in the study period had total current costs at around €242,000 per year. Included in this figure is also the ward's share of current costs mutual for the department or hospital but not investments or other capital costs. It is estimated that, at full capacity, the ward can launch treatment of between 250 and 300 patients a year. Thus, the cost of one treatment sequence embarked upon would be slightly less than €940. However, as not all treatments are completed although patients are found eligible, a dropout rate of approximately 20 percent remains. The cost per completed treatment is consequently higher, in the case with 300 patients embarking and 17 percent dropping out, the cost per completed sequence is around €976. During the study period, the capacity was not fully exploited, as several eligible patients did not want to participate in a randomized study. The cost per sequence in the study period is compared with the cost per sequence in 2004, where CCR is offered to heart patients as standard procedure and the department capacity is fully used.

The cost per sequence for cardiac rehabilitation, thus, is estimated to be approximately €976. This value refers to the study period. However, after the completion of the

Table 2. Cardiac Rehabilitation, Costs in Euros

Year	2000	2001	2002	Average 2001–02	2004
Current costs apart from wages	29.261	37.755	36.642	37.199	66.023
Wages total [numbers in parentheses indicate no. of employees during the project period]	196,451	205,576	208,021	206,799	374,816
Physician (1)	63,356	65,823	65,067	65,445	129,973
Nurse (1)	42,081	45,230	46,240	45,735	87,285
Physiotherapist (1)	37,722	39,164	40,020	39,592	61,579
Others (1 secretary, 1/2 dietician)	53,293	55,360	56,694	56,027	95,980
Total current costs	**225,712**	**243,331**	**244,664**	**243,998**	**440,839**
Costs per patient sequence					
No. of patient sequences per year	97	130	130	130	420
Cost per actual sequence	2,327	1,873	1,882	1,877	1,050
Costs per sequence when 250 sequences per year	903	973	979	976	

Note. Costs in 2003 are not included, as the project ended in March 2003. The department's share of mutual expenditure at the hospital is included in current costs. No capital costs are included. 2000 and 2004 figures are included for comparison purposes but are not part of the analysis.

https://doi.org/10.1017/S0266462306051403

Table 3. Usual Care Costs, Costs in Euros

Year	2000	2001	2002	Average 2001–02
Current costs apart from wages, outpatient ward	56,055	59,740	59,566	59,653
Wages total [numbers in parentheses indicate no. of employees during the project period]	784,666	827,669	846,866	837,268
Physicians (4)	282,434	305,050	310,435	307,743
Nurses (8)	260,328	270,956	280,758	275,857
Others (8 secretaries)	241,903	251,663	255,673	253,668
Total current costs, outpatient ward	840,721	887,409	906,433	896,921
Control group share (3,1 percent)	26,146	27,598	28,190	27,894
Costs per sequence (95 per annum)	275	290	297	294

randomized study, the capacity of the rehabilitation ward has been extended and the budget is correspondingly higher. In 2004–05, all current costs amount to €440,000 per annum, computed by the same principles as in Table 2. Almost 500 patients embark on rehabilitation per annum, and 420 complete the sequence. These figures render an average cost per treatment of €1,050.

The total costs for the outpatient ward and the derived costs for usual care patients are displayed in Table 3. In the top of the table, current costs are computed, using the exact same method as for the intervention costs in Table 3. Below the total current cost results in the table, these are sized to fit the small share of patients participating in the study. Only 3.1 percent of outpatients were part of the control group in the randomized study. Included in this figure are only contacts by controls during the 12 months following randomization.

Table 4 presents the results of the HRQL assessment for both approaches. It appears that there is a clear and almost significant difference in HRQL in favor of CCR when measured on the VAS scale, whereas cases and controls have approximately the same HRQL when using the preference-weighted method, any visible difference being in favor of controls, as cases have an average HRQL of .817 and controls have an average HRQL of .822.

The sensitivity analysis did not alter results considerably with regard to wage costs or other current costs. The largest uncertainty in the cost computation remains the number of patient sequences in the rehabilitation group. The low estimate is 130 patients completing per year, whereas the high estimate is the one applied above. Applying the low estimate renders the cost per sequence for cases €1,877, or close to twice the cost per sequence under the high estimate of 250 completed sequences per year.

DISCUSSION

Cardiac rehabilitation is found to be more costly than usual care, with an additional cost of €682 per sequence. The total cost per sequence is found to be €976. The quality of life gain is uncertain, as CCR results in a minor HRQL gain or no gain at all, depending on the applied measure. On the basis of the intervention costs, therefore, it is likely that CCR is not cost-effective. Although the estimated cost of usual care is rather reliable, this reliability does not apply to the estimated cost of CCR. Therefore, the actual magnitude of the additional cost of CCR compared with usual care is uncertain; however, it can be safely concluded that CCR is more costly than usual care.

The costs of CCR and usual care are established by means of a top-down approach, taking into account any information with relevance for the two types of treatment. An alternative approach would be the application of DRG prices to the value of CCR visits and usual care visits. The Danish DRG system applies a set of prices to somatic treatment, based on bottom-up cost studies. However, in the field of CCR and usual care, the applicable DRG price would be the same, that is, the standard price per visit, approximately €180. The only difference between CCR and usual care is consequently the number of visits, which, again renders CCR more costly than usual care.

The overall finding regarding the costs of CCR corresponds well with the British health technology assessment

Table 4. Health-Related Quality of Life

	Cases ($N = 68$)	Controls ($N = 69$)	Difference	t-test of equality (p)
Average VAS score	.710	.657	.057	.06
Average preference-weighted EuroQol score	.817	.822	−.005	.44

VAS, visual analogue scale.

(3); however, the Hong Kong study (14) rendered more agreeable results from a CCR point of view. It is likely that the present setting is more comparable with a British setting than a Chinese one. Regarding effects, no comparable results exist.

The results presented should be interpreted with some caution, as major methodological problems persist. Most notably, the applied top-down setting suggests some uncertainty compared to the preferable bottom-up approach, including the use of expenditure figures as cost estimates. The costing methodology may influence the conclusion regarding the cost-effectiveness of CCR, as would the inclusion of other direct costs, notably healthcare costs outside the rehabilitation ward.

Future research ought to look into the effect of CCR on readmissions, 3- to 5-year mortality, or any morbidity-related effect measure. The most urgent need for research in the area of costs of CCR remains the bottom-up cost study.

CONCLUSION

The cost analysis showed, that cost per sequence is higher for cases than for controls. The magnitude of the difference, however, is uncertain. Whether CCR has a positive effect on life expectancy or use of the healthcare system remains to be established.

POLICY IMPLICATIONS

The results, however uncertain, point to the conclusion that cardiac rehabilitation should not be implemented in a hospital setting, as hospitals are better off providing usual care. Thus, cardiac rehabilitation, if implemented, should take place outside hospitals.

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REFERENCES

1. Ades PA, Huang D, Weaver SO. Cardiac rehabilitation participation predicts lower rehospitalization costs. *Am Heart J*. 1992;123:916-921.
2. Ades PA, Pashkow FJ, Nestor JR. Cost-effectiveness of cardiac rehabilitation after myocardial infarction. *J Cardiopulm Rehabil*. 1997;17:222-231.
3. Beswick AD, Rees K, Griebsch I, et al. Provision, Uptake and cost of cardiac rehabilitation programmes: Improving services to underrepresented groups. *Health Technol Assess*. 2004;8:1-180.
4. Certo CM. History of cardiac rehabilitation. *Phys Ther*. 1985; 65:1793-1795.
5. Giannuzzi P, Saner H, Bjornstad H, et al. Secondary prevention through cardiac rehabilitation: Position paper of the Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology. *Eur Heart J*. 2003;24:1273-1278.
6. Hambrecht R, Walther C, Möbius-Winkler S, et al. Percutaneous coronary angioplasty compared with exercise training on patients with stable coronary artery disease. *Circulation*. 2004;109:1371-1378.
7. Kupersmith J, Holmes-Rowner M, Hogan A, Rowner D, Gardiner J. Cost-effectiveness analysis in heart disease. *Prog Cardiovasc Dis*. 1995;37:243-271, 307-346.
8. Levin LÅ, Perk J, Hedbäck B. Cardiac rehabilitation – a cost analysis. *J Intern Med*. 1991;230:427-434.
9. Pashkow FJ. Cardiac rehabilitation: Not just exercise anymore. *Cleve Clin J Med*. 1996;6:116-123.
10. Pedersen KM, Wittrup-Jensen K, Brooks R, Gudex C. *Værdisætning af Sundhed*. Syddansk Universitetsforlag; 2003.
11. Pickard AS, Wang Z, Walton SM, Lee TA. Are Decisions using cost-utility analyses robust to choice of SF-36/SF-12 preference-based algorithm? *Health Qual Life Outcomes*. 2005;3:11.
12. Vanhees L, Mc Gee HM, Dugmore LD, Vuori I, Pentilla UR. *The Carinex survey. Current guidelines and practices in cardiac rehabilitation within Europe*. 1st. 1999. Leuven: Acco.
13. Vanhees L, McGee HM, Dugmore LD, Schepers D, van Daele P. A representative study of cardiac rehabilitation activities in European Union Member States: The Carinex survey. *J Cardiopulm Rehabil*. 2002;22:264-272.
14. Yu CM, Lau CP, Chau J, et al. A short course of cardiac rehabilitation programme is highly cost effective in improving long-term quality of life in patients with recent myocardial infarction or percutaneous coronary intervention. *Arch Phys Med Rehabil*. 2004;85:1915-1922.
15. Zwisler ADO, Traeden UI, Videbaek J, Madsen M. Cardiac rehabilitation services in Denmark - Still room for expansion. *Scand J Public Health*. 2005;33:376-383.