

COST-BENEFIT ANALYSIS OF POSTERIOR FUSION OF THE LUMBOSACRAL SPINE

T. TUNTURI, P. NIEMELÄ, J. LAURINKARI, H. PÄTIÄLÄ & P. ROKKANEN

Institute of Clinical Sciences, University of Tampere and Central Hospital, Tampere; Department of Social Policy, University of Helsinki; Department of Public Health Science, University of Kuopio, Finland

In this study the cost-benefit ratio of posterior fusion of the lumbosacral spine was assessed. The calculations were based on 118 operated patients, followed up for an average of 4.8 years.

Costs were calculated using the average costs of treatment at central hospitals, visits to the outpatient department and travelling. The costs for one patient exceeded on average 5,569 US dollars.

The economic benefits derived from the operations were estimated by the work output of those 36 patients who postoperatively returned to their previous or a corresponding occupation. The postoperative work output was estimated using the coefficients for known causes of retirement (emigration, mortality, disability). The benefits of one lumbosacral fusion amounted on average to 16,075 US dollars.

Fusion of the lumbosacral spine proved to be profitable at a cost-benefit ratio of 1 : 2.9. If the selection of patients for operation could be made so as to guarantee that working capacity is restored by operative treatment, the cost-benefit ratio might be improved to 1 : 9.5.

It is emphasized that cost-benefit analyses of surgical procedures are important from the standpoint of principles of treatment and priority of operations. This study deals with economic aspects only. The medical aspects of the present material have been presented in two previous papers.

Key words: cost-benefit analysis; medical economics; spinal fusion

Accepted 28.ii.79

The amount of money allocated to health services in the USA constituted 8.3 per cent (119 billion US dollars) of the gross national product in 1975 (Knowles 1977). The corresponding figure for Finland was 6.8 per cent (2.0 billion US dollars) in 1976 (Lääkintöhallitus 1978). These enormous sums emphasize the importance of quantitative measurements of health benefits produced in the different sectors of the medical service (Talousseuvosto 1972, Grant 1974).

Health political measures are to an increasing extent evaluated by cost-benefit analysis (Kocher 1972, Second Symposium on the Efficiency of Medical Care 1972, Elo et al. 1974, Niemelä et al. 1975, Dahlberg & Nachemson 1976, Schoenbaum et al. 1976). Although measurements of the economic value of health are open to criticism (Laurinkari et al. 1974), even rough systematic estimates are useful in health-political decision making (Elo et al. 1974). The economic benefits from surgical pro-

cedures have previously been evaluated by cost-benefit analysis in only a few studies (Pätiälä et al. 1976).

The aim of this study was to assess the cost-benefit ratio of operative fusion of the lumbosacral spine by means of cost-benefit analysis. In the present study purely economic aspects are considered.

PATIENTS AND METHODS

The material consisted of 133 patients subjected in 1968–1975 to posterior fusion of the lumbosacral spine at the Central Hospital of Tampere, Finland (Tunturi et al. 1979b) or the Central Hospital of Middle Finland (Tunturi et al. 1979a). Of these patients 116 attended follow-up examinations in 1976–1977. The average period of follow-up was 4.8 years. Two patients died of pulmonary embolism on the seventh to eighth postoperative day. The analysis was thus based on 118 patients.

The following set of data, derived from the results of follow-up examination and other sources, was used in the cost-benefit analysis:

- A Preoperatively, conservative treatment had failed to restore working capacity and the patients were disabled as regards their own occupation.
- B The average duration of hospital treatment for these patients was 58 days, including treatment for late complications. In 1976, the daily cost of treatment at a central hospital amounted to 92.49 US dollars (Sairaalaliitto 1977).
- C The average number of postoperative visits made by these patients to a central hospital outpatient department was 5.8. In 1976, the cost per visit was 28.04 US dollars (Sairaalaliitto 1977).
- D Journeys to the hospital for treatment or for outpatient department visits were assumed to have taken place half by public transport, and half by taxi (expert's opinion on the appropriate means of transport required). Forty kilometers was accepted as the average distance to a central hospital (Niemelä et al. 1974). The average fare for a return journey was 2.86 US dollars by public transport (train) and 33.90 US dollars by taxi.
- E The economic benefits derived from the operations were calculated on the basis of the patients' postoperative work output.

Out of 60 men, 18 (30 per cent) had returned postoperatively to their previous or

a corresponding occupation after an average disability period of 10 months. The interval between operation and follow-up was on average 54 months. Thus, economic benefits could be calculated on the basis of a period of 44 months for each of the 18 men.

Out of 56 women, 18 (32 per cent) had returned postoperatively to their previous or a corresponding occupation (14 employees, four housewives) after an average disability period of 6 months. The average interval between operation and follow-up was 58 months. Benefits could thus be calculated on the basis of a period of 52 months for each of the 18 women.

- F Postoperative capacity for lighter work was not regarded as a benefit derived from operation.
- G For the rest of life (i.e. work output after follow-up) economic benefits were estimated using various coefficients of retirement. 4.2 per cent was accepted as the annual ratio of postoperative retirement from work due to spinal disease (on the basis of follow-up). Inevitable retirement was taken into account using available statistical data (emigration and mortality, Tilastokeskus 1978; disability, Eläketurvakeskus 1977 and Kansaneläkelaitos 1978).
- H The mean age at the time of operation was 36 years; after the inevitable postoperative sick-leave period the potential future duration of work performance was thus on average 28 years for each patient (pensionable age in Finland: 65 years).
- I Ten per cent was accepted as the rate of discount.
- J Costs and benefits were calculated according to the index for 1976. It was assumed that 118 operations were performed in 1976. In addition, the mean costs and benefits per patient were calculated by dividing the total sums by the total number of patients.
- K The mean industrial wages per hour in 1976 were used as a basis for calculation (men: 3.91 US dollars; women: 2.87 US dollars). For housewives, the mean wage per hour of domestic assistants in 1976 was used (1.93 US dollars). Thus, the mean annual income amounted to 8,032 US dollars for men, 5,896 US dollars for employed women, and 3,956 US dollars for housewives.

RESULTS

Costs

The costs of the operations consisted of the sum of the costs of hospital treatment, visits

Table 1. Costs of 118 operations (for principles of calculation, see text)

Sources of costs		US dollars	
Costs of hospital treatment:			623,730.70
Patients who died	$2 \times 8 \times 92.49 =$	1,479.79	
Patients attending follow-up	$116 \times 58 \times 92.49 =$	622,250.91	
Costs of visits to the outpatient department	$116 \times 5.8 \times 28.04 =$	18,865.48	18,865.48
Travelling costs			14,497.54
Train	$116 \times 3.4 \times 2.86 =$	1,128.05	
Taxi	$116 \times 3.4 \times 33.90 =$	13,369.49	
Total			657,093.72

to the outpatient department and travelling (Table 1).

The overall cost of the 118 operations amounted to some 657,000 US dollars and the cost for one operation to an average of 5,569 US dollars. The costs of hospital treatment constituted 95 per cent of the total costs, while visits to the outpatient department and travelling accounted for about half each of the remaining 5 per cent.

Benefits

The overall benefits derived from the operations calculated according to items A and E–K amounted to 1.10 million US dollars for the men, 0.67 million for the employed women, and 0.13 million for the housewives. The economic benefits derived from 118 operations thus totalled 1,896,870 US dollars

(Table 2); the benefit derived from one operation amounted to an average of 16,075 US dollars.

Summary of costs and benefits and the cost-benefit ratio

The difference between the benefits and costs of 118 operations was 1,239,776 US dollars; the corresponding figure for one operation was 10,507 US dollars. The cost-benefit ratio was 1 : 2.9.

DISCUSSION

Evaluation of costs and benefits

In studies such as the present one the principal problems relate to the estimation of

Table 2. Economic benefits from 118 operations (for principles of calculation, see text)

Working capacity	Number of patients	Benefits (US dollars)	
		Period before follow-up	Period after follow-up
Died postoperatively	2	–	–
Shifted to lighter work or pensioned	80	– ¹	– ¹
In previous or a corresponding occupation	36	770,094 ²	1,126,776 ³
Total	118		1,896,870

¹ see item F

² see items E, I–K

³ see items G–K

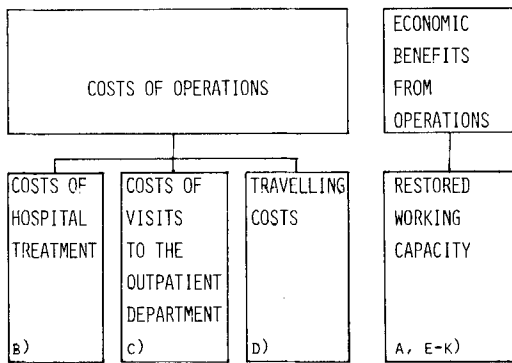


Figure 1. Costs of and benefits due to fusion of the lumbosacral spine; systemic delimitation (for explanation of the letters A–K, see text.)

benefits. The cost-benefit analysis here employed (Pitkänen 1970, Dasgupta & Pearce 1972, Valtiovarainministeriö 1975), is well suited for this purpose. Systemic delimitation (Figure 1) was considered a necessary basis for the analysis.

Only those operations which restored the patient's capacity to work in his previous or a corresponding occupation were considered a source of economic benefit. Postoperative capacity for lighter work was not considered a benefit derived from operation, since the patients concerned might have been able to perform such work without any treatment. It was difficult to calculate the benefits, because working capacity was known only during the follow-up period, not afterwards. If inability to work in the future is less than calculated, benefits increase; in the opposite case, they decrease.

The discount rate (10 per cent) applied agrees well with those previously used (Mattson 1970, Elo et al. 1974, Päätiälä et al. 1976).

The mean industrial wages per hour may be considered an appropriate basis for calculation in this study, because most of our patients had been labourers in heavy or moderately heavy manual work.

As the average daily cost of treatment at a central hospital was known, this was used as a basis for calculating the costs incurred by

operation, although the hospital costs of surgical patients may differ from this mean value. More exact calculations would require a detailed estimate of the distribution of the total costs among the various contributing factors.

Cost-benefit ratio and methods of treatment

In the present series, fusion of the lumbosacral spine proved to be an economically profitable procedure (cost-benefit ratio 1 : 2.9), even though only 31 per cent of the operations restored the patient's capacity to work in his previous or a corresponding occupation. However, lumbosacral fusion proved less profitable than knee synovectomy, for instance (Päätiälä et al. 1976, cost-benefit ratio 1 : 5.2–6.2). Had every operation restored the patient's working capacity to match his previous or a corresponding occupation, the cost-benefit ratio would have risen to 1 : 9.5. Hence, if the aim were to improve the economic benefit derived from lumbosacral spine fusion, only those patients whose prognosis with regard to the restoration of working capacity is optimal should be selected for operation. This would presuppose recognition of those factors that are of prognostic value in respect of the operative results. Some relevant data may be extracted from previous reports (Eriksen 1960, Harmon 1963, Wiltberger 1964, Rombold 1966, Kokan et al. 1974, Thompson et al. 1974, Weber & Peyer 1974). In two recent papers the present authors have directed attention to some prognostic factors and discussed the conclusions drawn by other investigators (Tunturi et al. 1979a,b).

On the other hand, problems will also arise if patients are selected for operation on very strict criteria, and exclusively with a view to improving the cost-benefit ratio of the treatment in question. If operative fusion is not regarded as indicated because of a poor prognosis, another method of treatment must be chosen, which represents an economically better alternative.

However, a patient suffering from severe, chronic low back pain is not easily rehabilitated to his previous or a corresponding occupation by any conservative method. Hence, the only alternative to operative treatment is employment of the patient in lighter work. As long as 24 years ago, Friberg (1954) stated that shifting to lighter work is often sufficient treatment for a patient suffering from low back pain. If this can be accomplished without occupational retraining, a satisfactory result is achieved without any major economic loss for the patient and without costs for society. Retraining, on the other hand, involves considerable costs for society (e.g. half a year's retraining: 4,422 US dollars plus missed work output for the same period). Furthermore, retraining does not guarantee employment. Thus, after expensive retraining a previously disabled patient may be able to work, but is not employed.

It would have been desirable to compare the profitability of operative and conservative treatment but this was impossible owing to lack of a control material. On the other hand, conservative treatment had failed, in all the patients in this series, to restore working capacity preoperatively. Thus, it seems justified to attribute the restored working capacity of the 36 patients to the fusion operation. Furthermore, in these 36 cases operative treatment proved superior to conservative methods.

Priority sequence of surgical procedures

Because of the limited economic resources of surgery, a priority sequence should be established for various operations. Economic advantage would be one criterion of priority. A prerequisite for the application of this criterion is that the costs and benefits of various surgical procedures are known. Assessment of the cost-benefit ratios of different operations therefore seems to be an important subject of investigation.

ACKNOWLEDGEMENTS

This work had been aided by the Tampereen Kaupungin Tiederahasto.

REFERENCES

- Dahlberg, L. & Nachemson, A. L. (1976) The economic aspects of scoliosis treatment. *Scoliosis*, pp. 73–101. Academic Press, London.
- Dasgupta, A. K. & Pearse, D. W. (1972) *Cost-benefit analysis: Theory and practice*. Macmillan Press, London.
- Elo, O., Laurinkari, J. & Niemelä, P. (1974) *Cost-benefit analysis of rubella vaccination*. University of Tampere, Finland. Department of Public Health Sciences. Publication Series A. Research and Studies 4, 1–137.
- Eläketurvakeskus (1977) Tilastotietoja työeläkkeen saajista vuodelta 1976 1–147, Helsinki (The Central Pension Security Institute (1977) Statistical data of pensioners in 1976, pp. 1–147, Helsinki, Finland).
- Eriksen, B. (1960) Lumbo-sacral fusion. *J. Bone Jt Surg.* 42-B, 660–661.
- Friberg, S. (1954) Lumbar disc degeneration in the problem of lumbago sciatica. *Bull. Hosp. Jt Dis.* 15, 1–20.
- Grant, J. A. (1974) Quantitative evaluation of a screening program. *Amer. J. publ. Hlth* 64, 66–71.
- Harmon, P. H. (1963) Anterior excision and vertebral body fusion operation for intervertebral disk syndromes of the lower lumbar spine. *Clin. Orthop.* 26, 107–127.
- Kansaneläkelaitos (1978) Statistics of demographic changes for the period 1970–1976. (The Social Insurance Institution, Helsinki, Finland) (unpublished data, personal communication).
- Knowles, J. H. (1977) Doing better and feeling worse. *Health in the United States*. Ed. Knowles, J. H., p. 2, W. W. Norton & Company Inc., New York.
- Kocher, G. (1972) Kosten-Nutzen-Analysen im Gesundheitswesen. Referate und Diskussionen anlässlich eines gesundheitsökonomischen Seminars in Egerkingen (Schweiz). Pharma Information, Basel, 1–67.
- Kokan, P. J., Wing, P. C. & Thompson, W. J. (1974) Factors associated with failure of lumbar spine fusion. *Canad. J. Surg.* 17, 294–298.
- Laurinkari, J., Elo, O. & Niemelä, P. (1974) Survey of aspects of measurements of

- economic value of health. *J. Soc. Med., Suppl.* **1**, 1-18.
- Lääkintöhallituksen (1978) dääkintöhallituksen vuosikirja 1971-1977, Terveystenhoito, Suomen virallinen tilasto XI: 74, Helsinki. (National Board of Health (1978) Year Book of National Board of Health 1971-1977, Health Services, Official Statistics of Finland XI: 74, Helsinki, Finland).
- Mattson, B. (1970) *Socio-economical calculations*. pp. 1-210, Akademiförlaget Stockholm.
- Niemelä, P., Laurinkari, J. & Elo, O. (1974) Economical losses due to rubella. *J. Soc. Med., Suppl.* **1**, 19-35.
- Niemelä, P., Laurinkari, J., Elo, O. & Ekblom, M. (1975) Costs due to measles vaccinations in Finland and benefits due to vaccination. *J. Soc. Med.* **5**, 605-617.
- Pitkänen, E. (1970) *Cost-benefit analysis, social and business-economical aspects in decision-making*. Business College, Kyriiri Oy, Helsinki, Finland.
- Pätiälä, H., Niemelä, P. & Laurinkari, J. (1976) Cost-benefit analysis of synovectomy of the knee. *Scand. J. Rheumat.* **5**, 227-232.
- Rombold, C. (1966) Treatment of spondylolisthesis by posterolateral fusion. Resection of the pars interarticularis and prompt mobilization of the patient. *J. Bone Jt Surg.* **48-A**, 1281-1300.
- Sairaaliitto (1977) Suomen sairaalatalous 1976 vol. 14, 1-79. (The Finnish Hospital League (1977) Hospital Economy in Finland 1976 vol. 14, 1-79).
- Schoenbaum, S. A., McNeil, B. J. & Kavet, J. K. (1976) The swine influenza decision. *New Engl. J. Med.* **295**, 759-765.
- Second Symposium on the Efficiency of Medical Care (1972) Report on a Symposium. Regional Office for Europe, WHO, Copenhagen, 1-31.
- Talousneuvosto (1972) Elämisen laatu. Tavoitteet ja mittaaminen. 1-227, Helsinki (Economic Council (1972) Quality of life. Aims and measurement. pp. 1-227, Helsinki, Finland).
- Thompson, W. A. L., Gristina, A. G. & Healy, W. A. (1974) Lumbosacral spine fusion. *J. Bone Jt Surg.* **56-A**, 1643-1647.
- Tilastokeskus (1978) Väestön muutokset syntymävuoden mukaan 1976. Helsinki (Statistical Office (1978) Population changes by date of birth 1976. Helsinki, Finland) (unpublished data, personal communication).
- Tunturi, T., Paakkala, T., Pätiälä, H., Tervo, T. & Rokkanen, P. (1979a) Lumbosacral fusion by standing H-graft technique. *Arch. Orthop. Traum. Surg.* **93**, 103-110.
- Tunturi, T., Kataja, M., Keski-Nisula, L., Lapinsuo, M., Lepistö, P., Paakkala, T., Pätiälä, H. & Rokkanen, P. (1979b) Posterior fusion of the lumbosacral spine. *Acta orthop. scand.* (In press).
- Valtiovarainministeriö (1975) Suunnittelusihiteeristö: Toimenpiteiden hyötyjä ja haittoja koskevat selvitykset. 1-128, Valtion painatuskeskus, Helsinki (Ministry of Finance (1975) Planning Secretariat: Statements of benefits and drawbacks of measures. 1-128, State Printing Center, Helsinki, Finland).
- Weber, A. & Peyer, J. (1974) Ergebnisse der dorsalen lumbosacralen Spondylodese. *Z. Orthop.* **112**, 779-781.
- Wiltberger, B. R. (1964) Intervertebral body fusion by the use of posterior bone dowel. *Clin. Orthop.* **35**, 69-79.

Correspondence to: Dr. T. Tunturi, Institute of Clinical Sciences, University of Tampere, Teiskontie 35, SF-33520 Tampere 52, Finland.