

Economic Evaluation of a Community-Based Pulmonary Rehabilitation Program for Chronic Obstructive Pulmonary Disease

Kamran Golmohammadi,¹ Philip Jacobs,^{1,2} and Don D. Sin^{1,3,4}

¹The Institute of Health Economics, Edmonton, Alberta, Canada; ²The Department of Public Health Sciences, University of Alberta, Edmonton, Alberta, Canada; ³The James Hogg iCAPTURE Center for Cardiovascular and Pulmonary Research, Vancouver, British Columbia, Canada;

⁴The Department of Medicine (Pulmonary Division), University of British Columbia, Vancouver, British Columbia, Canada

Abstract. Pulmonary rehabilitation has been demonstrated to be efficacious in chronic obstructive pulmonary disease (COPD), however, its cost-effectiveness is largely unknown. The present study determined the cost-effectiveness of a community-based pulmonary rehabilitation program for COPD patients with mild, moderate, and severe disease. We compared the direct costs (in Canadian dollars) and disease-specific quality of life (measured by the St. George's Respiratory Questionnaire, SGRQ) of patients with COPD (N = 210) who enrolled in the rehabilitation program in Edmonton, Canada one year before and after completion of the program. To determine temporal trends in health service utilization between 2000 and 2002 we used similar data from 592 COPD patients from the same region who did not participate in the rehabilitation program. We found that the health status of patients enrolled in the program improved significantly following pulmonary rehabilitation, irrespective of the severity of disease (total SGRQ score improved by 4.85%, $p = 0.001$). The total direct cost per 100 person-years of follow-up before the program was \$122,071 (SE = 29,566); after the program it was \$87,704 (SE = 26,146). The average reduction of total costs before and after the program was \$34,367 per 100 person-years or ~\$344 per person per year ($p = 0.02$). Over one-year, pulmonary rehabilitation was associated with decreased health service utilization, reduced direct costs and improved health status of COPD patients.

This suggests that pulmonary rehabilitation is cost-effective for patients with relatively high utilization of emergency and hospital-based services.

Key words: Pulmonary rehabilitation—Cost-effectiveness—Economic analysis—COPD.

Introduction

Chronic obstructive pulmonary disease (COPD) is a disorder characterized by progressive and irreversible decline in lung function [16]. Most patients with COPD complain of cough, sputum production, and dyspnea, which impair their functional status and quality of life [16]. In the late 1960s, Petty and coworkers [17] showed that exercise and breathing retraining can improve patients' ability to perform various activities. Since then, many studies have demonstrated the effectiveness of pulmonary rehabilitation therapy for improving quality of life and health status in COPD [2, 3, 5, 7, 8, 14].

Although there is a large body of evidence for the effectiveness of pulmonary rehabilitation, its economic value in a real world setting is largely unknown. One study suggested that outpatient pulmonary rehabilitation programs are cost-saving [10]. However, because this study was conducted on patients enrolled in a clinical trial, the generalizability of their findings to community-based patients is uncertain. Moreover, there is little information on the economic value of pulmonary rehabilitation on patients with mild disease, as previous studies have largely concentrated on patients with moderate-to-severe disease [9, 10]. We therefore conducted an economic evaluation of a community-based pulmonary rehabilitation program for COPD patients, focusing on both health outcomes and costs across different levels of disease severity.

Methods

Rehabilitation Program

The Caritas Centre for Lung Health is the only center that delivers a comprehensive, multidisciplinary outpatient pulmonary rehabilitation program for COPD patients residing in the Edmonton and surrounding areas (total population ~900,000 persons). Similar to other pulmonary rehabilitation centers across Canada, The Caritas Program is grounded on 10 key components of rehabilitation: breathing exercises, education, endurance training, upper extremity conditioning, psychosocial support, adaptations in activities of daily living, relaxation techniques, nutritional counseling, inspiratory muscle conditioning, and interval training [6]. Smoking cessation programs are provided elsewhere in the region.

Respiratory therapists perform the major role with contributions by physiotherapists, recreation therapists, dieticians, pharmacists and pulmonary physicians. Once enrolled, each participant completes a program over 6 weeks (3 days a week) or 8 weeks (2 days a week). Each class has 12 enrollees and lasts ~2 1/2 hours. The classes are designed so that one-third of the time is spent on education through both group lectures and one-on-one teaching sessions. The remainder of time is spent exercising and practicing breathing techniques.

Study Patients

Although the Caritas Program enrolls patients with advanced interstitial lung disease and asthma, the major focus is on COPD rehabilitation: >70% of the enrollees have COPD. For analytic purposes of this study, we included only those COPD patients who participated in the Caritas Program for the year 2001. The inclusion criteria were physician diagnosis of COPD, age greater than 45 years, a significant history of smoking (>10 pack-years), and persistent symptoms of cough, sputum production and/or dyspnea at rest or upon exertion even with optimal medical therapy. We excluded patients with severe cardiac dysfunction (congestive heart failure on chest radiograph or clinical history) and those with pulmonary disorders other than COPD.

We divided the eligible COPD patients into 4 groups based on modified recommendations from the Global Initiative for Chronic Obstructive Lung Disease (GOLD) Committee: Stage 1 ($FEV_1 \geq 80\%$ of predicted), Stage 2A (FEV_1 of 50–79% of predicted), Stage 2B (FEV_1 of 35–49% of predicted), and Stage 3 ($FEV_1 < 35\%$ of predicted). The FEV_1 cutoff thresholds for Stage 3 disease were slightly altered from the original GOLD criteria to ensure reasonable balance in the number of patients across the severity groups.

Outcomes

The economic impact of the program was measured in terms of changes in health-related quality of life (HRQOL) of study participants and changes in direct costs associated with the program. The HRQOL of participants was measured at baseline and at the end of the six (or eight) week program, using the St. George's Respiratory Questionnaire (SGRQ) [11]. SGRQ is a disease-specific instrument, which was originally designed to measure, in a valid and reproducible manner, the health status of patients with COPD. The SGRQ contains three domains: "Symptoms" (frequency and severity of COPD symptoms), "Activity" (activities that cause or are limited by breathlessness), and "Impacts" (social functioning, psychological disturbances resulting from airways disease). Scores range from 0 to 100, with higher scores indicating poor health [13].

Total direct costs included expenditures related to the operations of the rehabilitation program as well as the incremental costs associated with hospital and emergency events for patients one year before and following their participation in the rehabilitation program. Hospital and emergency events for only respiratory causes were included in the cost. To objectively ascertain these events, we searched the regional health care databases for all respiratory-related emergency visits and inpatient admissions that occurred between January 1, 2000 and September 30, 2002, using *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* codes 306.1, 415.19, 465.9, 466.0, 481, 482, 485, 486, 487.1, 490, 491, 492, 494, 496, 502, 511–516, 518, 519, 786, and 799. The costs of the program were calculated based on the portion of total expenditures allocated to the rehabilitation program by the Center for Lung Health. These included costs for administration, respiratory therapists, aides, supplies, rental fee for space, and physician services. Since the rehabilitation program provides services to persons with respiratory conditions other than COPD, we prorated the total costs based on the proportion of COPD patients enrolled in the program. Inpatient hospital admissions were valued based on Case Mix Grouping for Alberta hospitals [15] and a physician fee schedule from Alberta Health and Wellness [1]. Emergency visit costs were valued based on the Alberta Ambulatory Care Classification scheme and physician fee schedule from Alberta Health and Wellness [15].

To evaluate the temporal trends for respiratory hospitalizations and emergency visits over the study period, we examined health service utilization for patients with COPD who did not participate in the program during the same period of time. The control group consisted of patients older than 45 years of age, residing in Edmonton and surrounding region, who had at least one health service encounter during the study period for COPD ($N = 592$ COPD patients). This study was approved by the Health Research Ethics Board-Capital Health.

Table 1. Demographic characteristics of the study population

Total number of participants (210)		
Age (year)	Mean (standard deviation)	68.5 (8.5)
Sex		
Female	Number (%)	106 (50.5)
Male	Number (%)	104 (49.5)
Smoking history (pack-years)	Mean (SD)	37.6 (22.3)
FEV ₁ predicted (%)	Mean (SD)	55.1 (21.9)
Disease severity stages		
S 1*	Number (%)	31 (14.8)
S 2A	Number (%)	78 (37.1)
S 2B	Number (%)	51 (24.3)
S 3	Number (%)	41 (19.5)

* Severity of disease was unidentified in 9 patients.

Abbreviation: FEV₁, forced expiratory volume in one second.

Statistical Analysis

We chose September 30, 2002 as the final date of evaluation because, at the time of this study, health services data from periods beyond this date were not available. To accommodate differential follow-up times among participants, rates of hospitalization and emergency visits (not resulting in hospitalization) were expressed as number per 100 person-years for the entire group and for each severity stratum. Because these values were not normally distributed, we used a Wilcoxon sign-rank test to compare rates of hospitalization and emergency visits one year before and after enrollment in the pulmonary rehabilitation program for the study participants. To determine whether there was a material difference in health service utilization (and hence total health service costs) between those who did and those who did not have a full 12 months of follow-up, we performed separate cost analysis for these two groups of participants. For analysis of SGRQ data, we used a paired t-test, as these values were normally distributed. P-values less than 0.05 were considered significant. All costs were calculated and expressed in 2003 Canadian dollars (~72 cents American dollar). For parsimony, continuous variables are shown as mean (\pm S.E.), unless otherwise indicated.

Results

We used data on 210 COPD patients who participated in the rehabilitation program. The patient characteristics are summarized in Table 1. Twenty-five patients did not complete the program; this includes 7 deaths. Decedents were excluded from the analysis. The mean FEV₁ at baseline of the study patients was 58% of predicted in women (S.D. = 22) and 52% of predicted in men (S.D. = 21). There were more women than men with Stage 1 disease ($p = 0.03$).

The total annual program costs (for COPD and other respiratory patients who participated in the program) were \$345,355 (Table 2). This figure included all personnel and overhead costs associated with the program. The average cost for each person who started the program was \$1,092. Following pulmonary rehabilitation, there was a slight but nonsignificant fall in the length of hospitalizations and in the rate of emergency visits for patients who started the program. Compared to a year prior to enrollment, the length of hospitalizations and the

Table 2. Annual expenditures for the community-based pulmonary rehabilitation program

Center costs	Itemized costs
Staffing costs	\$196,786
Professional fees (for COPD educators)	\$9,514
Rent	\$12,000
Supplies	\$15,785
Administration	\$47,373
Physician services	\$63,897
Total program costs per year	\$345,355

All values are expressed in Canadian dollars (~0.72 US dollar).

Table 3. Emergency department visits, length of hospitalization days, total direct costs one-year before and after pulmonary rehabilitation

	Before program	After program	<i>p</i> Value*
Emergency visits			
Stage 1	41.2 (13.0)	13.6 (7.9)	.085
Stage 2A	57.0 (14.7)	44.8 (11.2)	.714
Stage 2B	29.5 (12.3)	16.3 (6.7)	.346
Stage 3	41.0 (13.7)	54.4 (27.6)	.974
Hospitalization days			
Stage 1	123.9 (75.0)	12.9 (12.9)	.043
Stage 2A	232.1 (84.2)	258.9 (102.2)	.952
Stage 2B	70.2 (41.6)	74.6 (46.2)	.833
Stage 3	166.5 (77.2)	19.5 (15.3)	.063
Total cost [†]			
Stage 1	\$125,126 (80,240)	\$11,401 (10,254)	.007
Stage 2A	\$173,250 (61,528)	\$175,123 (65,267)	.715
Stage 2B	\$70,147 (45,694)	\$60,855 (34,094)	.582
Stage 3	\$110,934 (48,516)	\$22,307 (11,909)	.139

All values are expressed as mean (SE) per 100 person-years, unless otherwise specified.

**p* values are based on Wilcoxon Sign-Rank test.

[†]All values are expressed in Canadian dollars (~0.72 US dollar)

rate of emergency visits decreased by 18.6% ($p = 0.22$) and 24.8% ($p = 0.09$), respectively, one year after pulmonary rehabilitation. The total direct cost per 100 person-years of follow-up before the program was \$122,071 (SE = 29,566); after the program, it was \$87,704 (SE = 26,146). The average reduction of total costs before and after the program was \$34,367 per 100 person-years or ~\$344 per person per year ($p = 0.02$). In Table 3, we have summarized the rates of emergency visits, lengths of hospitalizations and total costs across the disease severity spectrum. In terms of cost reduction, those in Stages 1 and 3 benefited the most from the program. For the control group, the average days of hospitalization per patient-year increased from 4.6 in 2000 to 5.9 in 2001 and to 6.9 in 2002 (Fig. 1). There was no material difference in the reductions in total costs before and after pulmonary rehabilitation between those who did and did not have a full

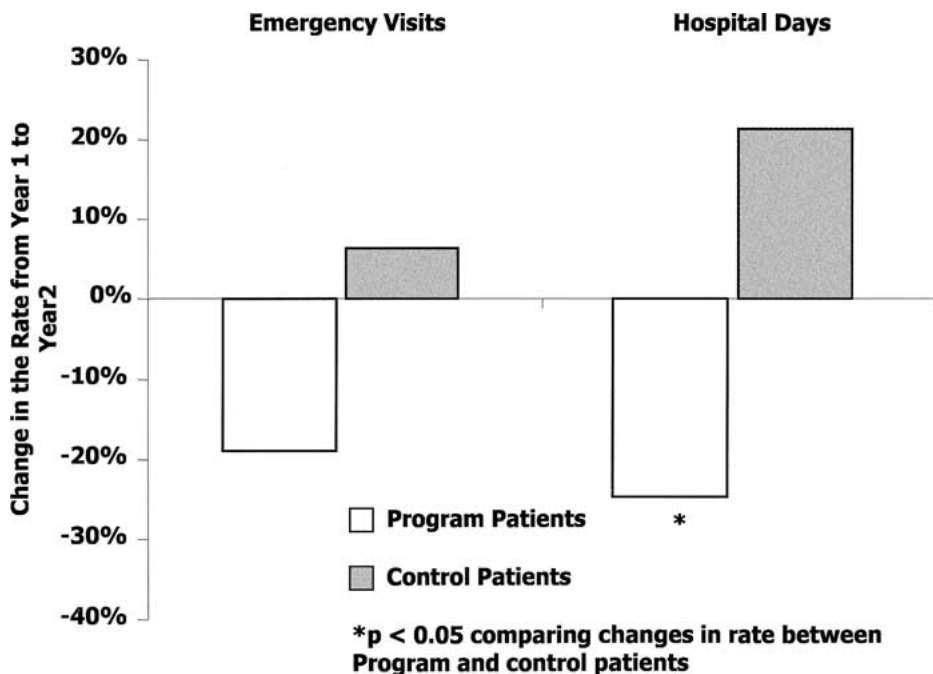


Fig. 1. Changes in rates of emergency visits and length of hospitalizations from first to second year in patients with COPD who did or did not engage in pulmonary rehabilitation. The clear bars indicate COPD patients who underwent pulmonary rehabilitation; the hatched bars indicate COPD patients who did not undergo pulmonary rehabilitation. * $p < 0.05$ comparing changes in rates between control and rehabilitation groups.

Table 4. Total direct costs one year before and after pulmonary rehabilitation among those who did and did not have 12 months of follow-up

Follow-up period after the program	Number of participants	Total Cost	
		Before the program	After the program
Full 12 months	139	\$1,049 (279)	\$903 (294)
9–12 months	71	\$1,556 (686)	\$826 (519)
All patients	210	\$1,221 (296)	\$877 (261)

All values are expressed as mean (SE) per person-year, unless otherwise specified. None of the comparisons between those who did and did not have a full 12 months of follow-up were significant at the $p = 0.05$ level (two-tailed).

12 months of follow-up after their rehabilitation, suggesting that the differential follow-up period had no significant impact on the overall findings (Table 4). HRQOL, as measured by the SGRQ, improved after the rehabilitation program for all COPD patients, regardless of severity. The overall improvement in the total SGRQ was 4.85% ($p = 0.001$) or about 193 units (total score was 3989.4 units) [Table 5].

Table 5. Quality of life (based on St. George's respiratory questionnaire) before and after pulmonary rehabilitation

Stages	Number of patients	Total % of patients	SGRQ domain scores											
			Symptoms			Activity			Impact			Average		
			Before	After	<i>p</i>	Before	After	<i>p</i>	Before	After	<i>p</i>	Before	After	<i>p</i>
1	31	14.76	48.26	42.33	0.07	55.33	48.65	0.01	30.81	22.98	0.00	41.24	34.59	0.00
2A	78	37.14	53.04	50.24	0.12	59.52	57.32	0.26	29.88	23.99	0.00	42.73	38.63	0.00
2B	51	24.29	62.53	57.02	0.03	64.20	60.37	0.01	33.75	28.75	0.01	47.77	43.21	0.00
3	41	19.52	68.01	66.55	0.59	78.28	73.80	0.01	46.86	39.66	0.00	59.90	54.47	0.00
Unknown	9	4.29	51.14	49.68	0.76	70.37	65.23	0.48	30.00	25.59	0.07	45.59	41.50	0.29
Total	210	100.00	57.48	53.88	0.00	64.17	60.34	0.00	34.28	28.13	0.00	47.21	42.36	0.00

Abbreviation: SGRQ, St. George's Respiratory Questionnaire.

Discussion

In this study we conducted an economic assessment of the everyday operations of a community-based pulmonary rehabilitation program for COPD patients. Our results indicate that pulmonary rehabilitation therapy improves the overall HRQOL of COPD patients across all disease severity categories (on average by 193 units or 4.8% between program start and finish). Since the minimally important change in the SGRQ total score is ~ 4 units, these changes are likely to have clinical relevance [12]. Importantly, there was a net reduction of $\sim \$340$ in total direct costs per patient one year after the rehabilitation program compared to a year before the program. The savings arose largely because of reductions in emergency visits and days spent in hospitals. Notably, patients in Stage 1 experienced the largest benefits from the rehabilitation program. In these patients, the total days of respiratory hospitalization fell by 89% after the program compared to a year before the program. These beneficial changes in hospitalization rates resulted in impressive reductions in the total costs for these patients (91% decrease in total costs before and after the program).

Our findings are consistent with those of Griffiths and colleagues, which also demonstrated net cost savings for COPD patients enrolled in an outpatient rehabilitation program [10]. We extend their results by demonstrating the potential cost-effectiveness of pulmonary rehabilitation programs for even Stage 1 patients (who were excluded from Griffiths' study). Moreover, because our study evaluated the impact of rehabilitation on "hard" endpoints such as length of hospitalizations and emergency visits, these findings are likely to have relevant clinical and health policy implications.

Our study's finding that Stage 1 patients benefit the most from pulmonary rehabilitation is consistent with previous studies. One recent meta-analysis of published pulmonary rehabilitation trials indicated that patients with mild COPD experienced significant relief from dyspnea and improved exercise tolerance regardless of the type or the duration of the rehabilitation program, whereas those with more severe disease were less likely to derive benefits from short rehabilitation programs such as the one we evaluated [18]. Similarly, in the report by Wedzicha and coworkers, COPD patients with moderate intensity of dyspnea benefited from pulmonary rehabilitation whereas those with severe dyspnea did not [19]. Berry and coworkers also demonstrated that patients with mild disease experienced a larger improvement in dyspnea than did those with moderate or severe disease following exercise rehabilitation [4]. These studies, as well as our own, suggest that patients with mild disease (with moderate degree of dyspnea) are likely to benefit the most from pulmonary rehabilitation, possibly because they may be able to push themselves harder during exercise training programs and achieve greater levels of cardiovascular fitness than those with more severe disease.

There are several limitations of our study that deserve attention. First, ours was an observational study and as such, confounding by measured and unmeasured factors is a concern. We did not have a control group based on random allocation. Instead, our control group was selected from a pool of patients with

COPD in the same region with similar age and other demographic characteristics as the program patients. Therefore, our control group cannot be regarded in the same way as those selected randomly. Nevertheless, it was reassuring that the rates of hospital stay and emergency visits did not materially change during the study period among these “control” patients, suggesting that the reductions in rates observed in the program patients were unlikely to be accounted for by changes in the secular trends of COPD health service utilization over the study period. Second, we did not incorporate indirect costs in our calculations. Because most patients with COPD are elderly and we retired, lost wages from work loss (which is the major determinant of indirect costs) would have been small and unlikely to have significantly altered the conclusions of this study. Third, we did not calculate costs in terms of quality-adjusted life years because we did not use a preference-based instrument to measure HRQOL. However, since pulmonary rehabilitation has salutary effects on HRQOL of COPD patients, it is very likely that, at least within the short term (one year or less), pulmonary rehabilitation would be a “dominant” (cost-effective) strategy. Finally, we did not have long-term data on health-related quality of life of these individuals. Thus, the long-term effects of pulmonary rehabilitation on health-related quality of life of our study participants remain unknown.

In summary, our analysis suggests that pulmonary rehabilitation is cost-effective for patients with COPD in the community. The economic benefits were especially pronounced for those in Stage 1. Long-term studies are needed to determine the cost-effectiveness of pulmonary rehabilitation beyond the one year time horizon.

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