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Cost-effectiveness of self-management in asthma: A systematic review of peak flow monitoring interventions

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Objectives: It is generally accepted that home peak flow monitoring increases patients' self-management and could lead to cost savings. The aim of this review was to analyze costs and the cost-effectiveness of self-management based on peak flow monitoring interventions in asthma.
Methods: Twenty-one studies were included in this review. Data were extracted, and methodological and economic quality were assessed. These studies presented economic information regarding self-management interventions based on peak flow monitoring in asthmatics. The mean methodological quality was 4.6 (maximum 8), and the mean economic quality was 12.0 (maximum 15).
Results: In eighteen studies, the interventions led to net savings compared with usual care or less intensive intervention. Only three studies found the total costs to be higher in the intervention group. In thirteen of the seventeen studies that analyzed health outcomes, at least one of the reported health outcomes improved statistically significantly after the intervention. However, the methods of economic evaluation differed among the studies and were not always in line with the standard methodology.
Conclusions: The interventions, costs, and outcomes were very diverse. The results emphasize the need for guidelines to increase the comparability of cost-effectiveness evaluations relating to asthma. Only then will it be possible to conclude whether interventions for asthmatics, such as self-management based on peak flow monitoring interventions, are cost-effective.

Keywords: Review, Cost-effectiveness, Asthma, Peak expiratory flow rate, Self-management

Asthma is a chronic inflammatory disorder of the airways, which causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing (34). Approximately 300 million people worldwide suffer from asthma (24). Despite the continuous improvements in treatment and prevention, and the increase of knowledge resulting from research, its prevalence is increasing in the Western community (24). The human and economic burden associated with asthma is severe (34).

Because asthma is a chronic disorder, which cannot be cured, self-management and education are crucial to ensure effective control of asthma. Peak flow monitoring in self-management and education interventions are particularly useful for controlling asthma by demonstrating the variable airflow limitations that characterize the disorder. A peak flow monitor registers airway obstruction by measuring the rate of the peak expiratory flow (PEFR). The PEFR shows the

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maximum rate of airflow attained during forced vital capacity determination. Increasingly, electronic peak flow monitors with transfer possibilities are replacing standard peak flow monitors, as information communication technology is improving. Self-management including peak flow monitoring seems to increase patient awareness of their disease status and control (12). It also enables substitution of care, possibly saving costs. The effectiveness and cost-effectiveness of self-management and education programs in asthma have been reviewed several times (6;8–10;14;21;33). However, a structured review of costs and the cost-effectiveness of asthma self-management purely based on peak flow monitoring interventions is lacking. The main objective of this review was "What is the cost-effectiveness of self-management based on peak flow monitoring interventions in asthma?"

METHODS

Literature Selection

The aim of the search strategy was to identify all studies presenting economic information about self-management interventions based on peak flow monitoring in asthmatics. Search engines used to extract relevant studies were Medline, Pubmed, OHEE-HEED, and PsycINFO. Searches were performed up until December 1, 2004, and were restricted to studies in English, German, and Dutch. The search string used was: (['asthma'] and ['self-management' or 'monitoring'] and ['cost*' or 'economic' or 'effectiveness']).

To be included, peak flow monitoring had to be the main intervention and separate cost data had to be presented. Studies in which no original empirical outcomes were presented were excluded. Because only a limited number of studies in this field were full economic evaluations, other types of economic evaluations such as cost-outcome analyses, cost analyses, cost-outcome descriptions, and cost-descriptions (5) were also suitable for inclusion. The search strategy identified 342 potentially relevant articles. Selection took place by reading the abstracts, and, when in doubt, the whole article. Four additional relevant articles were identified from the references of other relevant studies.

The main reason for exclusion was that peak flow monitoring was not the primary intervention (34 percent). See Table 1 for more details. In the end, twenty-one studies were included in this review. The collected studies were summarized by D. Willems and checked by M. Joore using a data extraction form (available on request) based on the Centre for Reviews and Dissemination Report (3). Methodological and economic quality assessment took place using a checklist from the Cochrane Collaboration (1). Thirteen studies were published in the 1990s, and eight were published after the year 2000. Twelve of the articles originated from Europe, seven from the United States, and two from Canada.

Table 1. Overview of Inclusion of Studies

Exclusion criteria	No. of studies (%)
Self-management based on peak flow monitoring not as main intervention	116 (34)
No costs presented	87 (25)
Review article	24 (7)
No original empirical outcomes presented (other than review articles)	65 (19)
Asthma was not one of the main diseases or no separate data on asthma presented	33 (10)
Total number of studies excluded	325 (95)
Number of studies included	17 (5)
Reference check	4
Total number of studies included	21

Interventions

The frequency of peak flow measurements was specified in seven of the twenty-one studies. The frequency as stated varied from "regularly" (25), to "once daily" (11;19), to "twice daily for one day per week" (27), or "if symptoms occurred, and at least twice daily in the two weeks before the follow-up visits" (15–17). Self-treatment by medication at home based on peak flow monitoring, was explicitly mentioned in fourteen studies (2;4;7;11;13;19;20;22;23;25;27;28;30;31). In seven studies, it was unclear whether self-treatment was applied. In all studies, the self-management intervention based on peak flow monitoring also included some form of health education.

In most studies, a full detailed description of the content of the intervention was lacking. In four studies (7;20;28;32), the intervention contained a combination of individual sessions and group sessions, whereas in seven studies (2;4;13;19;22;23;25), only individual sessions took place. In nine studies (11;15–18;23;26;29;31), only group sessions took place, and in one study, this feature was unclear (31).

It was notable that, in one study, the intervention was carried out during hospital admission (30), whereas in another study, sessions were also given at home (28), and in one study during an 1-week asthma camp. In Cowie et al. (2), the intervention consisted of one single session (2). Eleven studies described multiple sessions (range, 2 to 8). The duration of a single session varied from 30 minutes to 4 hours.

Health Outcomes

No health outcomes were described in four studies (4;13;20;29). Clinical outcomes, such as lung function rates, asthma symptoms, and asthma-free days were measured in thirteen studies (2;4;7;15–19;22;25–27;30). Lung function parameters most frequently reported included the peak expiratory flow (PEF), the forced expiratory volume in 1 second (FEV_1), and the forced expiratory volume expressed as a percentage of that predicted (FEV percent). Changes in behavior, knowledge, attitude, and compliance were assessed in five studies (18;22;23;25;32). Quality of life was an outcome parameter in ten studies (7;15–17;22;23;25;27;28;31). The following specific questionnaires were used to measure patient outcomes: the St. George's Respiratory Questionnaire (7;15–17), the Asthma Quality of Life Questionnaire (25;27;28), the Asthma Quality of Life Scale (28), four asthma questions from the Omnibus interviews (7), and the Psychosomatic Discomfort Scale (28). Generic quality of life was measured using the 15D (15–17), the Short Form 36 (23), the EQ-5D (22), and daily quality of life readings on a five-point scale (25).

Direct and Indirect Costs

In this study, costs have been divided into three categories: direct medical costs, direct nonmedical costs, and indirect costs. Direct medical costs such as intervention costs and hospital costs were directly assigned to health care regardless of who was paying. Direct nonmedical costs such as time and travel costs were not directly assigned to health care. Indirect costs refer to productivity losses. All the studies described direct medical costs. Data on direct costs were gathered using a variety of measures: telephone interviews, self-administered patient questionnaires, diaries, surveys, medical records, pharmacy reports, claims, and sickness fund records.

However, five studies did not report the total intervention costs as part of the direct medical costs (4;13;22;25;31), whereas in one study (32), the intervention costs were the only direct medical costs reported. In Tschopp et al. (31), the only direct medical costs considered were hospitalization costs. The remaining nineteen studies calculated at least two types of direct medical costs, one of which (2) only calculated the intervention costs, and the number of visits to the emergency department with an estimated range of the costs of one visit to the emergency department. In two studies, in addition to the intervention costs, hospitalization costs, and costs for emergency care were the only direct costs mentioned (18;20). Hospital costs were analyzed in eighteen of the twenty-one studies and the cost of emergency care (including urgent medical examinations) in sixteen studies. Outpatient visits and/or physician visits were included in twelve studies. Drug costs were calculated in twelve studies.

Six studies misclassified direct nonmedical costs as indirect costs (productivity loss). In five studies, the time costs of participating in the intervention or seeking health care were incorrectly regarded as indirect costs (7;11;15–17). In another study, travel costs to healthcare facilities and miscellaneous expenses were misclassified as indirect costs (29). A total of fourteen studies analyzed indirect costs. To measure indirect costs, all studies used patient registration such as diaries, questionnaires, and records. In two studies, data about sick leave days were retrieved from sickness fund records (26;30).

Quality Assessment

Most of the studies clearly described the inclusion and exclusion criteria and the population and specified the primary outcome measures. In twelve studies, the analysis did not include intention-to-treat analyses (2;4;7;11;16–18;22;23;25;28;29), and in three studies, the use of this strategy was unclear.

The study designs were randomized controlled trials ($n = 13$), cohort studies ($n = 3$), and before and after studies ($n = 5$). The mean methodological quality was 4.6 out of a maximum of 15 (SD 2.0; range, 1 to 8). Of the twenty-one studies, seventeen studies were full economic evaluations, suggesting that both the costs and outcomes of at least two alternatives were analyzed in these economic evaluations. It was notable that, in one study, although it was a full economic evaluation according to the terminology, only intervention costs were included (32). One full economic evaluation was a cost-utility analysis (27), and the sixteen remaining full economic evaluations were cost-effectiveness analyses. The remaining four studies were cost analyses, in which only the costs of at least two alternatives were analyzed (4;13;20;29).

Common perspectives of an economic evaluation were the societal perspective (all costs and outcomes experienced by all those who are significantly affected by the intervention) and the healthcare perspective (only health costs and outcomes). Only four studies (all full economic evaluations) mentioned the perspective (all societal) of the economic evaluation (7;26;27;30). In addition, two of these studies also adopted the healthcare perspective (26;27). Among the remaining studies, ten studies calculated both direct and indirect costs, which suggests, although not explicitly mentioned, that these studies also adopted a societal perspective. The remaining seven studies only calculated direct medical costs and, therefore, adopted a healthcare perspective.

Three studies (7;15;27) calculated an incremental cost-effectiveness ratio (ICER) in line with the standard methodology of economic evaluation (5). Kauppinen et al. (15) and Gallefoss and Bakke (7) calculated ICERs for clinical and quality of life outcomes. Schermer et al. (27) presented the incremental costs per quality-adjusted life-year (QALY) gained and successfully treated week gained. In one cost-effectiveness study, no ICER was calculated because the groups were equivalent in terms of their health outcomes (17). In the remaining thirteen cost-effectiveness studies, no ICERs were calculated (2;11;16;18;19;22;23;25;28;31;32), or at least not in line with the standard methodology (26;30). The uncertainty of the outcomes was presented in sensitivity analyses in two studies (7;30), whereas only Schermer et al. (27) presented the uncertainty surrounding the ICER, using bootstrap results of the incremental costs and effects. Furthermore, twelve studies did not present measures of variability for the point estimates of primary outcome measures (2;4;18;20;22;23;25;26;28–30;32). The heterogeneity of the studies aggravated the transferability of costs. For that reason, the costs were only presented in their local currency. The mean score of the quality assessment regarding the economic evaluation was 12.0 of a maximum of 18 (SD 2.1; range, 9 to 15).

RESULTS

In Gallefoss and Bakke (7) and Schermer et al. (27) the intervention was dominant compared with regular care. The between-group difference in total costs in Schermer et al. (27) was only statistically significantly lower in the intervention group during the second year. According to the Dutch informal ceiling ratio of €18,000/QALY, the probability that the intervention was cost-effective compared with regular care was 52 percent (27). In Kauppinnen et al. (15), the cost-effectiveness ratios were all positive, which indicates that an extra unit of effect comes at a price.

Of the eighteen studies that did not calculate ICERs, only two studies found the total costs to be higher in the intervention group (28;32). However, in Søndergaard et al. (28), the difference was not tested, and in Windsor et al. (32), only the intervention costs were calculated.

Although the symptom plan program in Cowie et al. (2) yielded savings compared with no action plan, the savings from the peak flow based program were even higher. In the remaining fifteen studies, the interventions led to net savings compared with usual care or a less intensive intervention (4;11;13;16–20;22;23;25;26;29–31). The statistically significant net savings differed in two studies (11;19) and were not statistically significant in four studies (16–18;20). In the other nine studies, this finding was unclear.

In thirteen of the seventeen studies that analyzed health outcomes, at least one of the reported health outcomes improved statistically significantly after the intervention (7;11;15;16;18;19;22;23;25;27;30–32). In three studies (16;17;26), the difference between groups was not statistically significant, and in one study this difference was unclear (28). The incremental costs, outcomes, and cost-effectiveness ratios are presented in Table 2. If the author stated no statistically significant difference in outcome, the outcome scores were assumed to be zero in this table.

CONCLUSION

This review summarized and compared the results of costs and cost-effectiveness of asthma self-management based on peak flow monitoring. A considerable number of eligible studies were found on this subject (21). Nevertheless, the interventions studied were very diverse and specific details were often not presented. In addition, asthma quality of life outcomes were measured in only ten studies and generic quality of life outcomes in only six studies. Only one study expressed the health outcomes as utilities and calculated QALYs.

It was noticeable that the studies calculated a variable range of types of costs, which made it difficult to compare the total costs of the studies. Because many studies chose to take a limited perspective, not all the relevant costs were included. Furthermore, misclassification of nonmedical costs appeared in six studies. The methods of economic evaluation differed in many studies and were not always in line with the standard methodology. Incremental cost-effectiveness ratios were only calculated in three studies. A cost-effectiveness plane, a scatter plot of the uncertainty, and a cost-effectiveness acceptability curve were only presented in the study by Schermer et al. (27). Even after our own calculation of cost-effectiveness ratios from the data presented, it was almost impossible to compare the results because of the large heterogeneity in study methods.

In thirteen of the seventeen full economic evaluations, at least one of the reported health outcomes improved statistically significantly after the intervention. These outcomes related especially to clinical symptoms. Of the seventeen full economic evaluations, the intervention (or more intensive intervention) was dominant in no less than fourteen studies, four of which described the difference as statistically significant. In Windsor et al. (32), Kauppinen et al. (15), and Søndergaard et al. (28), an extra unit of effect came at a price. In all four cost-analyses the intervention led to net savings.

Given the results of the studies, the use of self-management programs based on peak flow monitoring in asthmatics seems to be cost-effective or even cost saving. However, one should bear in mind that these results were obtained in trial settings and may be an overestimation of cost-effectiveness in day-to-day practice. In addition to this idea, the relatively poor methodological quality of the studies and the difference in methods mean that the conclusions of this review should be interpreted with caution. First, the methodological quality of cost and cost-effectiveness studies in asthmatics should be improved. Second, uniform guidelines for economic evaluations of asthmatics are needed to compare cost-effectiveness evaluations of self-management based on peak flow monitoring interventions. Moreover, until the societal perspective is applied in economic evaluations, resulting in a cost-utility analysis, it is almost impossible to fully synthesize the evidence of self-management based on peak flow monitoring interventions. As a result, based on the available evidence reviewed in this study, we cannot conclude whether self-management based on peak flow monitoring interventions in asthmatics is cost-effective.

Table 2. Incremental Costs, Effects, and Cost-Effectiveness Ratios per Patient

Study Author	Description Interventions	Months	Incremental costs per patient (mean)			Total	Incremental outcomes (mean)		ICER
			Currency	Direct	Indirect		Outcome	Score	
Cowie et al. (2)	Peak flow plan versus symptom plan	6	$	−122†	n.c.	−122*†	Waking with asthma	0	Dominant
							ß$_2$-agonist utilization	0	Dominant
							Self-rating severity	0	Dominant
	Peak flow plan versus no plan	6	$	−146†	n.c.	−146†*	Waking with asthma	0	Dominant
							ß$_2$-agonist utilization	0	Dominant
							Self-rating severity	0	Dominant
	Symptom plan versus no plan	6	$	−24†	n.c.	−24†	Waking with asthma	0	Dominant
							ß$_2$-agonist utilization	0	Dominant
							Self-rating severity	0	Dominant
Dinelli and Higgins (4)	Health treatment plan versus UC	6	$	−653	n.c.	−653	n.a.	n.a.	n.a.
	No health treatment plan versus UC	6	$	−115	n.c.	−115	n.a.	n.a.	n.a.
Gallefoss and Bakke (7)	Intervention versus UC	12	NOK	−1,900	−7,300	−5,500	SGRQ	16.3*	Dominant
							FEV$_1$ in %	6.1*	Dominant
							Symptom free days	45*†	Dominant
Ghosh et al. (11)	Intervention versus UC	12	IR	−668†	−825*†	−1,493*†	PEF	14.5*	Dominant
Greineder et al. (13)	Education and follow-up versus education	12	$	−1,166†	n.c.	−1,166†	n.a.	n.a.	n.a.
Kauppinen et al. (15)§	Intensive versus conventional education	12	FIM	+674*†	−238†	+406*	SGRQ	4†	FIM 102/ SGRQ
							15D	.02†	FIM 20,300/ 15D
							PEF	7.3†	FIM 56/ % PEF
							FEV$_1$	7.6*†	FIM 53/ % FEV$_1$
Kauppinen et al. (16)§	Intensive versus conventional education	36	£	+66†	−78†	−12	SGRQ	1.3	Dominant
							15D	0	Dominant
							PEF	4.4	Dominant
							FEV$_1$	5.3*	Dominant
Kauppinen et al. (17)§	Intensive versus conventional education	60	£	+49†	−167†	−117†	SGRQ	2.1	Dominant
							15D	0	Dominant
							PEF	2.6	Dominant
							FEV$_1$	1.5	Dominant
Kelly et al. (18)	Intervention versus UC	12	$	−2,014	n.c.	−2,014	PEF	2.9*†	Dominant
Lahdensuo et al. (19)	Intervention versus UC	12	FIM	+656*	−1,607	−950*	healthy days	14.6*	Dominant
Lawrence (20)	Full program versus UC	12	$	−1,691†	n.c.	−1,691†	n.a.	n.a.	n.a.
	Partial program versus UC	12	$	−1,096†	n.c.	−1,096†	n.a.	n.a.	n.a.

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Table 2. (Continued)

Study Author	Description Interventions	Months	Incremental costs per patient (mean) Currency	Direct	Indirect	Total	Incremental outcomes (mean) Outcome	Score	ICER
Lindberg et al. (22)	Intervention versus UC	12	SEK	−736	+106	−630	EQ-5D	0	Dominant
							% limitation in physical activities	11*†	Dominant
							% more than 2 attacks	6*†	Dominant
							% nighttime wakening	16*†	Dominant
Lucas et al. (23)	Intervention versus UC	24	$	−1,592†	n.c.	−1,592†	SF-36 physical	5.5*†	dominant
							SF-36 mental	1.7*†	Dominant
							Nights woken	.8*†	Dominant
McLean et al. (25)	Intervention versus UC	12	$	−80†	−121†	−201†	AQLQ	.8*†	Dominant
							Symptom total	.4*†	Dominant
Neri et al. (26)	Complete versus reduced program	12	$	−167†	−225†	−392†	Asthma attacks	3.2†	Dominant
Schermer et al. (27)	Intervention versus UC	24	€	+200	−213	−13	QALY	.015†	Dominant
							AQLQ	.1†	Dominant
							FEV_1	0	Dominant
							successfully treated week	6*†	Dominant
Søndergaard et al. (28)	Intervention versus UC	6	£	+555†	−188†	+366†	AQLQ	in 7 items	Calculation impossible
							PDS	3.2	£114 / PDS
Taitel et al. (29)	Intervention versus UC	12	$	−332†	−143†*	−475	n.a.	n.a.	n.a.
Trautner et al. (30)	Intervention versus UC	12	DM	−931†	−3,352†	−4,283†	Severe asthma attacks	3.8*	Dominant
Tschopp et al. (31)	Intervention versus UC	12	CHF	−3,068†	−1,988†	−5,056	AQLQ	.7*†	Dominant
Windsor et al. (32)	Peak flow versus no peak flow guidance	12	$	+28†	n.c.	+28†	Adherence	42%*†	$.7/% adherence

Note. Numbers were rounded off upward. Symbols denote the following: + = positive; − = negative; * = statistically significant difference; † = own calculation; § = without drug costs.
ICER, incremental cost-effectiveness ratio; UC, usual care; n.c., not calculated; n.a., not applicable; NOK, Norwegian kroner; IR, Indian rupees; FIM, Finnish marks; SEK, Swedish kronor; DM, German marks; CHF, Swiss francs; AQLQ, Asthma Quality of Life Questionnaire; PDS, Psychosomatic Discomfort Scale; FEV_1, forced expiratory volume in 1 second; PEF, peak expiratory flow; SGRQ, St. George's Respiratory Questionnaire; SF-36, Short Form 36; QALY, quality-adjusted life-year.

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