

Cost-effectiveness of self-management in asthmatics: a 1-yr follow-up randomized, controlled trial

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ABSTRACT: Patient education in asthma can improve outcome but cost-effectiveness has not been widely assessed. The aim of the present study was to carry out a cost-effectiveness analysis of patient education in asthmatics in a 12-month follow-up.

The authors randomly allocated 78 asthmatics to a control or intervention group after they had received ordinary outpatient consultation care. Intervention consisted of two 2-h group sessions followed by 1–2 individual sessions administered by a nurse and a physiotherapist. Self-management was emphasized. Effectiveness was expressed in terms of quality of life and forced expiratory volume in one second (FEV₁). Doctor visits, days off work, dispensed pharmaceuticals, hospital admissions, travel costs, time costs and educational costs were recorded.

The control and intervention groups induced mean total costs of Norwegian Krone (NOK) 16,000 and 10,500 per patient, respectively. A 10-unit improvement in St. George's Respiratory Questionnaire total score and a 5% improvement in FEV₁ in the intervention group were associated with a saving of NOK 3,400 and 4,500, respectively, compared to the control group. The number needed to educate (NNE) to make one person symptom free was associated with a saving of NOK 12,200. The results were robust to realistic changes in the assumptions upon which they were based.

It could be concluded from this study that patient education in asthmatics in a 12-month follow-up improved patient outcomes and reduced costs.
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The prevalence of asthma in North-America and Europe is about 5% of the adult population with strong evidence for increasing incidence [1]. Asthma results in a significant burden being placed on public health budgets in these countries [2–6], and the potential for public savings is high. Health economical evaluations are therefore, strongly warranted [7, 8].

Patient education in asthmatics can improve patient outcome and has been recommended in several clinical guidelines for asthma [9–12]. However, previous cost-effectiveness assessments after asthma education are rare and of limited applicability to clinical practice. KAUPPINEN *et al.* [13] reported an improvement in the forced expiratory volume in one second (FEV₁) at higher costs without performing a sensitivity analysis and NERI *et al.* [14] described the cost of one day of admission being prevented.

The present asthma education programme has been shown, in a 12 month follow-up, to improve quality of life, level of lung function [15] and compliance to inhaled corticosteroids [16] as well as reducing GP consultation rates and absenteeism from work [17] due to asthma. Based on these data, estimated the cost-effectiveness ratios of patient education choosing St. George's Respiratory Questionnaire (SGRQ) total score, FEV₁ and number needed to educate (NNE) to make one person symptom free as clinically important effectiveness measures were calculated.

To the best of the authors' knowledge no previous

report on patient education in asthmatics has evaluated how many patients need to be educated in order to obtain a given effect. NNE is equivalent to the number needed to treat (NNT), that has been strongly advocated in clinical trials [18].

The study was conducted in the societal perspective, implying that all costs are accounted for, irrespective of who pays.

Subjects and methods

The study design and educational programme have recently been described in detail [15–17].

Study design

Seventy-eight consecutive symptomatic asthmatics were included in the study May 1994–December 1995, after having received ordinary consultation care at the outpatient chest clinic at a medium sized somatic hospital in Southern Norway. At inclusion, they gave written signed consent and were then randomly allocated to an intervention group or a control group using random number tables received from an external statistician in sealed envelopes. The patients in the intervention group first received an education programme, and were then followed by their general practitioners (GPs), while the patients in the control group were transferred directly to their GPs (fig. 1).

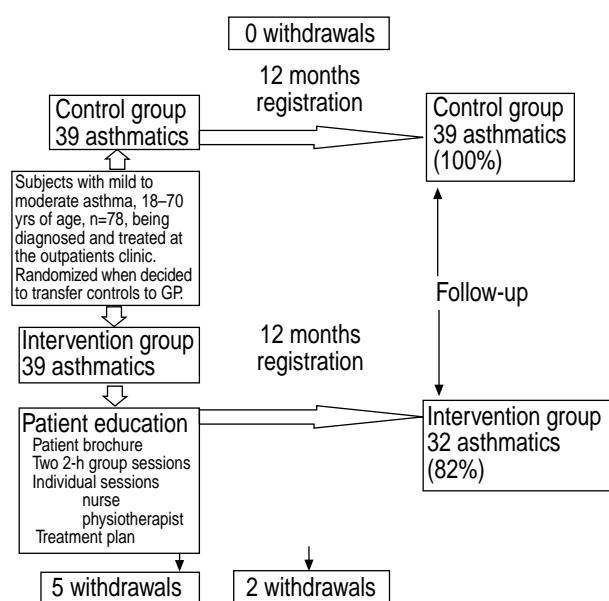


Fig. 1. – Scheme of study design and withdrawals.

After 1 yr, all the patients were invited to a follow-up examination. The availability and organization of GP care was similar in the two groups.

Eligible asthmatics were 18–70 yrs of age, and did not suffer from any other serious disease. The primary inclusion criterion for asthmatics was a prebronchodilator FEV₁ \geq 80% of predicted (% pred) value [19]. Furthermore, either a positive reversibility test [19], a documented 20% spontaneous variability (peak expiratory flow (PEF) or FEV₁) or a positive methacholine test (PD₂₀). A positive reversibility test was defined as \geq 20% increase (FEV₁ or PEF) from baseline after inhalation of 400 ng salbutamol. The inclusion rate amongst the eligible patients was 92% (78 out of 85).

Educational programme

None of the randomized patients had earlier received organized asthma education. The education programme consisted of two 2-h group sessions and 1–2 h of individual counselling administered both by a nurse and a physiotherapist (fig. 1). Elementary pathophysiology of asthma, asthma drug mechanisms, how to cope with asthma and principles for self-management were covered. An individual self-management plan aimed at encouraging early change of medication during episodes of asthma attacks was issued. The intervention group also received a specially-made 19-page booklet co-ordinating the information given during the educational sessions.

Outcome variables

Effectiveness measures. Both Health Related Quality of Life (HRQoL) and symptom data have been recommended as important effectiveness measures in the management of asthma and have been found to correlate well with pulmonary function measures [5]. Other less important alternatives of comparison, as

previously published [16, 17], could have been tested, but recommendations for cost-effectiveness analyses advise unidimensional designs [20].

Health Related Quality of Life. Both HRQoL and symptom free days have also been advocated in cost-effectiveness analyses [5, 21]. HRQoL was assessed at baseline applying four simple questions translated from the Omnibus interviews [22]. The answers were dichotomized at the signs "▼" shown later, to reveal outcomes of clinical importance [5, 20]. Wording of the questions and the preprinted alternatives for answering were: 1) The last year my chest trouble has become: Worse, unchanged or ▼ better; 2) The last two weeks I have had asthma symptoms during the day: All the time, 2–4 times a day, every day, 2–3 times a week or ▼ more seldom; 3) The last two weeks I have had asthma symptoms during the night: Waken 3 times or more, waken 1–2 times or ▼ do not wake up; 4) My asthma has the last two weeks restricted me from doing what I want: To a great extent, medium extent or ▼ little or no extent. Regarding the responses to these questions, the two groups were comparable at baseline [15]. The same four questions were repeated at the 1-yr follow-up.

At the 1-yr follow-up, patients completed the SGRQ [23], a validated and disease-specific quality of life instrument consisting of 76 weighted items. A "Total" score is calculated, providing a global estimation of the patients' respiratory health. The total scores ranges 0–100, a score of 100 indicating maximum disability. A difference of four units indicates a slight clinical effect, while a difference of eight or twelve units indicates moderate or very good clinical effects, respectively. Thus, a difference of 10 units in SGRQ total score between treatment groups at the 1-yr follow-up, is of clinical significance.

Spirometry. Spirometry was performed prior to randomization and at 12 months follow-up by standard methods [19] using a Jaeger MasterLab Body Box (Würzburg, Germany). The patients were told to abstain from bronchodilators for 6 h before testing.

Costs. The costing was based on utilization of care and unit costs (IUS\$ = 7 Norwegian Krone (NOK), 1994). Costs, as presented, were rounded to the nearest NOK 100 unless the original cost was <100. Exact costs were used when statistical tests were performed. Patient co-payments were included in the costs. Direct costs in this study are defined as costs borne by the healthcare system, community and family. Indirect costs are defined as productivity loss and time costs borne by the individual, family, society or by the employer.

The cost of asthma education included patient co-payments and reimbursement costs according to the fee schedule of the National Health Insurance (NHI) covering both group sessions and individual sessions. Market prices were applied for the Peak Flow meter, the cost of premises and the patient brochure.

The cost of hospital care for asthma was based on the Norwegian Diagnosis Related Groups (DRG)

reimbursement rates [24], assuming that all admissions fell in diagnosis group 4 [24], rate number 97 (NOK 10,880 per stay).

The patients reported monthly GP visits due to asthma [17], using standardized registration forms and self-addressed, stamped envelopes. Detailed information on date, time and duration of consultation, name of the doctor, pulmonary function tests and personal costs by the patient was received, and the costs set according to the NHI fee schedule [25]. The public block grant for GP clinics was included, at the time NOK 365 100·yr⁻¹, which with an average consultation rate of 4,010 consultations·yr⁻¹ [26], assuming each patient consultation amounted to NOK 91. Pulmonary consultant visits were costed according to the NHI fee schedule [25]. The cost of pharmaceuticals according to the Anatomical Therapeutic Chemical (ATC) Classification Index, group R03 and H02A B [27], was based on monthly reports from the local pharmacies recording current market prices for dispensed medication.

The cost of time for those employed was set equal to the national hourly wage rate (NOK 106.2) [28]. Time costs were applied for both seeking healthcare and asthma education, assuming 2 and 2.5 h (including waiting and travel time) for GP and pulmonary physician visits, respectively. The individual educational sessions at the same day were assumed to last for 1 h (plus 1.5 h travel time) including 40 min individual nurse and physiotherapist sessions, thereby adjusting for 20 min waiting time per session. The cost of lost leisure for those not employed was assumed to be zero, but alternative assumptions were explored in the sensitivity analyses.

The number of days absent from work due to asthma were reported monthly, and valued according to the national average daily wage rate (NOK 567) [28].

Patients' travel costs in relation to medical care and asthma medication were calculated on the basis of bus fares from the patients' residence.

No discounting was undertaken since the costs and consequences were contained within 1 yr.

Cost-effectiveness analysis. Cost-effectiveness analyses relate monetary costs to a measure of clinical effectiveness. A cost-effectiveness ratio is the difference in costs between two alternatives to the difference in effectiveness between the same two alternatives (δ costs/ δ effects). A positive ratio implies a positive effect at a certain cost. A negative numerator and a positive denominator imply a positive effect at a lower cost, a so-called dominant strategy [29]. An adjusted cost-effectiveness ratio relates to the cost per outcome of clinical significance, for example the cost per 10-unit improvement in SGRQ total score or 5% improvement in FEV₁.

Sensitivity analyses

One-way sensitivity analyses were undertaken to explore how robust the results were to changes in the basic case assumptions, *i.e.* the assumptions upon which they were based. The low estimate for production loss was calculated to be hourly wage-rate times 70% and the

high estimate times 130% [30], thereby accounting for example, for social costs (employer tax *etc.*).

A threshold analysis on the most important cost assumption (production loss) was undertaken in order to identify the "break even" point, *i.e.* the value that made the total costs in the two groups equal [31].

Statistics

Regarding the binary outcomes from the four quality of life questions, the concept of NNT which is the estimated number of patients who need to be treated with a new treatment rather than the standard treatment, for one additional patient to benefit was applied [18]. In this study this expression was changed to NNE. NNE is the reciprocal value of Absolute Risk Reduction (ARR) *i.e.* 1/ARR. $ARR = P_i - P_c$, where P_i is the proportion with the desirable outcome in the intervention group and P_c is the proportion in the control group. For example the NNE to make one person experience "A better year" is calculated as follows: $NNE = 1/(0.81 - 0.43) = 1/0.38 = 2.63$.

The 95% confidence interval (CI) for the difference between two population proportions (ARR) were constructed around the difference between the observed proportions P_i and P_c in the two samples of sizes n_i and n_c . The standard error of this difference = square root [$(P_i/n_i) + (P_c/n_c)$] where $q_i = 1 - p_i$ and $q_c = 1 - p_c$ [18].

The Chi-squared test or Fisher's exact test was applied for binary outcomes, while the Mann-Whitney U-test was applied for the cost data due to skewedness.

A cost/concentration curve shows the cumulative costs plotted against the cumulative number of patients, starting with the patient with the highest costs and ending with the patient with the lowest cost.

All analyses were performed using the SPSS version 8.0 (SPSS Inc, Chicago, USA). The Norwegian Data Inspectorate and the regional ethical committee approved the study.

Results

Effectiveness measures

The study groups were comparable at baseline (table 1), including use of medication as previously

Table 1. – Baseline characteristics of the asthmatics included in the study

	Control group	Intervention group
Subjects n	39	39
Sex, Male	8 (21)	15 (39)
Age yrs	44 ± 12	41 ± 12
Smoking habits		
current smokers	13 (33)	9 (23)
Employed	24 (62)	29 (74)
FEV ₁ % pred	95 ± 17	93 ± 13
FVC % pred	105 ± 15	104 ± 12
FEV ₁ %	78 ± 9	75 ± 8

Data are presented as n (%) or mean ± SD. FEV₁: forced expiratory volume in one second; FVC: forced vital capacity; % pred: per cent predicted. FEV₁ % was calculated according to the following, $(FEV_1/FVC) \times 100$.

Table 2. – Health related quality of life according to St. George's Respiratory Questionnaire (SGRQ), change in forced expiratory volume in one second (FEV₁) and response to four quality of life questions at 12 month follow-up

	Control group	Intervention group	Difference	95% CI for the difference	OR	p-value
Subjects n	39	32				
SGRQ total scores at the one year follow-up	36.5 ± 18	20.2 ± 15	16.3	8.2–24.4		0.0002*
FEV ₁ change in mL	-83 ± 38	112 ± 39	195	11–377		0.038*
FEV ₁ change in %	-2.7 ± 12	3.4 ± 13	6.1	0.2–12.1		0.043*
Percentage answering that they had						
A better year	43	81		1.8–16.5	5.5	0.002 [#]
Symptom free days	36	81		2.4–22.7	7.4	0.001 [#]
Symptom free nights	60	94		2.0–47.8	9.9	0.001 [#]
No impact on daily life	62	88		1.2–14.7	4.3	0.02 [#]

Data are presented as mean ± SD. CI: confidence interval; *: independent-samples t-test; [#]: Chi-squared test; OR: odds ratio.

reported [16], 96% were on inhalation steroids at randomization and two-thirds of the asthmatics were employed. At follow-up, the SGRQ total score was 16.3 units lower (HRQoL was better) in the educated group, compared to controls ($p < 0.001$). The lung function (FEV₁) improved by 6.1% in the intervention group compared to the noneducated ($p < 0.05$, table 2). There was a need to educate 2.6, 2.2, 2.9 and 3.9 persons for one person to experience a better year with regards to the chest condition, symptom free days, symptom free nights and to have no impact in daily life, respectively (all p -values ≤ 0.02 , fig. 2).

Costs

The mean direct cost in the educated group was NOK 5,900, the indirect costs NOK 4,600, in total NOK 10,500 (table 3). The corresponding costs for the control group were NOK 4,000, 11,900 and 16,000. Reduced absenteeism from work in the educated group explained most of the difference in total costs. The production loss accounted for 75% and 32% of the total

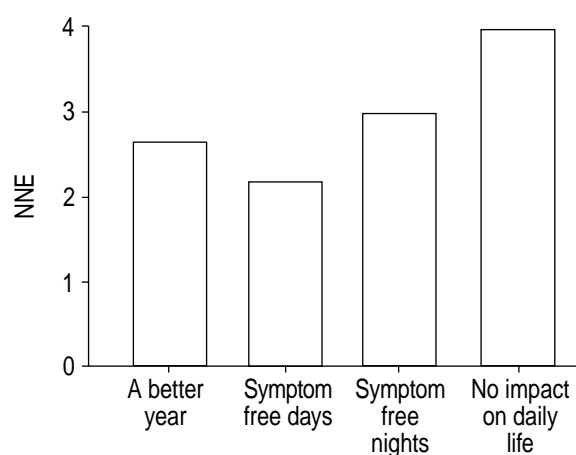


Fig. 2. – Number needed to educate (NNE) to make one person have 4 types of outcome. 95% confidence intervals: a better year: 1.7–5.9; symptom free days: 2–22; symptom free nights 1.9–6.3; no impact on daily life: 2.1–20.

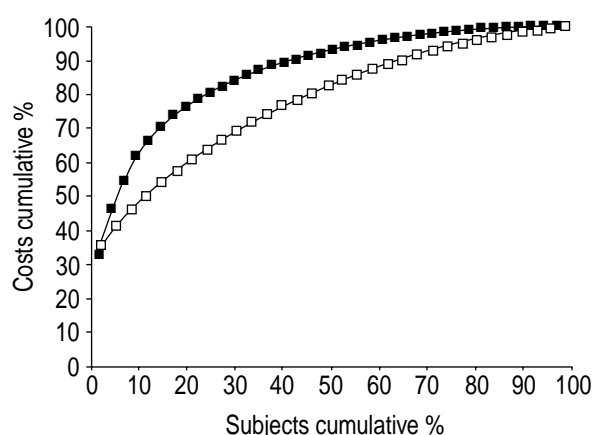


Fig. 3. – The cost/concentration curve showing the cumulative costs plotted against the cumulative number of patients. ■: control; □: intervention.

costs in the control and intervention groups, respectively.

There was an uneven distribution of costs. According to the cost/concentration curve (fig. 3), the most costly patient in each group accounted for more than 30% of the total group costs. For the educated group, 20% of the most resource intensive patients accounted for about 60% of the total costs compared to about 75% in the control group. Nine and 23% induced costs higher than NOK 15,000 ($p = 0.11$, Fisher's exact test) in the education and control group, respectively.

Cost-effectiveness analyses

According to the baseline case assumptions, the total costs were lower in the educated group than in the control group. This implies that asthma education incurred lower costs and better outcomes. If indirect costs were disregarded, the costs were higher in the educated group (table 3). With all costs included, the cost-effectiveness ratios were NOK -3,400 per 10 unit improvement in SGRQ total score, NOK -4,500 per 5% improvement in FEV₁ and NOK -12,200 per symptom free patient (table 4).

Table 3. – Direct, indirect and total costs (NOK) per patient during a 12 month follow-up for the intervention and control groups

	Control		Intervention		p-value*
	Mean ± SD	Median 25/75 P [#]	Mean ± SD	Median 25/75 P [#]	
Cost items					
Patient education programme	0	0	900 ± 50	900 (900/1000)	<0.001
Peak flow meter	0	0	200	200	<0.001
Pharmaceuticals/drugs	3300 ± 3100	2400 (1900/4500)	3700 ± 3400	2400 (1000/5600)	0.703
GP visits [†]	600 ± 900	200 (0/800)	200 ± 500	0 (0/200)	0.001
Pulmonary physician visits [†]	55 ± 200	0 (0/0)	52 ± 200	0 (0/0)	0.555
Hospital admissions	0	0	700 ± 2700	0 (0/0)	0.116
Travel costs doctor visits	63 ± 89	22 (0/88)	21 ± 55	0 (0/22)	0.001
Travel costs educational programme	0	0	100 ± 34	100 (100/100)	<0.001
Total direct costs	4000 ± 3800	3400 (1100/5500)	5900 ± 4800	4100 (2500/8800)	0.054
Patient time cost for education programme	0	0	1200 ± 600	1400 (1100/1400)	<0.001
Patient time cost for doctor visits	300 ± 700	0 (0/200)	100 ± 500	0 (0/0)	0.044
Production loss [†]	11600 ± 33100	0 (0/5100)	3400 ± 16700	0 (0/0)	0.038
Total indirect costs	11900 ± 33500	200 (0/6400)	4600 ± 17300	1400 (1100/1500)	0.302
Total costs	16000 ± 35400	5400 (1500/11100)	10500 ± 20500	5800 (4000/10100)	0.510

*: Both cost items and sums are, if NOK >100, rounded off to nearest NOK 100. *Mann-Whitney U-test; [#]: 25/75 P=25th and 75th percentiles; [†]: The mean number of GP visits, pulmonary physician visits and days off work in the control group were 2.6, 0.2 and 20.5, respectively. The corresponding figures for the intervention group were 0.7, 0.2 and 6.0 [17]. Median values with 25th and 75th percentiles are shown due to the skewed distribution of data. Time costs include travel time and are only calculated for those being employed, but alternative assumptions are explored through sensitivity analysis. Control: n = 39; Intervention: n = 32.

Sensitivity analyses

The direct and total cost differences did not vary overtly when choosing the most unfavourable assumptions for the variables (table 5). Since production loss had the largest impact on the total cost difference, the corresponding low and high production loss estimates also had the greatest influence on the sensitivity analyses, varying, the total cost difference between NOK 3,000 and 8,000 (table 5). If the cost of production loss was set to 25% of what was assumed in the baseline case analysis, the two patient groups would have the same average costs per patient (NOK 7,000).

Discussion

The present study indicates that patient education in mild to moderate asthmatics improved health, and at the same time saved costs. A 10-unit improvement in SGRQ total score and a 5% improvement in FEV₁ in the intervention group were associated with a saving of NOK 3,400 and 4,500, respectively, compared to the control group during a 12 month follow-up. The NNE to make one person symptom free was 2.2 and for each patient becoming symptom free after patient education there was a concomitant saving of NOK 12,200. A one-way sensitivity analyses indicated satisfactory robustness of the main conclusions.

To the best of the authors' knowledge the present study is the first to assess cost-effectiveness ratios of patient education in asthmatics referring to HRQoL, lung function and NNE and to report better outcomes at lower costs; a negative cost-effectiveness ratio. Generally in medicine, there is a tendency to be accustomed to positive cost-effectiveness ratios; better outcomes at higher costs. Previously, KAUPPINEN *et al.*

[13] reported a 5.5% improvement in FEV₁ at 17% higher costs in the intervention group 12 months after patient education, compared to controls.

The assumption that the last three specific quality of life questions reflect an average of the study period may be opposed, since the authors asked for the occurrence of asthma symptoms and impact on daily life during the last two weeks. However, in the SGRQ, several of the subscore components also relate to the patient's current state. It is likely that the last two weeks represent a typical average for the study period. Furthermore, no differentiation was carried out in the questionnaire between those reporting symptoms <2–3 times per week and those being symptom free. In figure 2 these were all interpreted as being "symptom free". Thus, the data presented on daily symptoms, might be an overestimate with regard to symptom control, but in clinical practice many physicians would argue that having symptoms <2–3 times per week is a satisfactory symptomatic relief in asthmatics.

A limitation of the present study is that the SGRQ scores were only obtained at the 12-month follow-up as opposed to FEV₁ and the four asthma symptoms, which were also recorded at baseline. Hence, it was not known whether there was a drop or increase in SGRQ scores in the control group from baseline to follow-up. The difference in SGRQ scores is reported as an improvement, assuming comparable quality of life at baseline. This assumption is supported by the fact that the intervention and control groups were comparable at baseline for all variables recorded [15–17]. Nevertheless, the cost-effectiveness analysis of the SGRQ scores should be interpreted with caution.

Other methodological issues concerning bias and confounding have been thoroughly discussed and statistically tested, when possible, in previous reports from the same study [15–17]. The skewed distribution

Table 4. – Cost-effectiveness ratios

	Direct costs	Total costs
Cost-effectiveness ratios*		
Difference in SGRQ total scores at 1-yr follow-up	1839/16.3 = 113	-5493/16.3 = -337
FEV ₁ , change in mL	1839/195 = 9.4	-5493/195 = -28
FEV ₁ , change in %	1839/6.1 = 301	-5493/6.1 = -901
Adjusted cost-effectiveness ratios* ^{#,+}		
Difference in SGRQ total score at 1-yr follow-up	1110/10	-3400/10
FEV ₁ , change in mL	900/100	-2800/100
FEV ₁ , change in %	1500/5	-4500/5
Cost-effectiveness ratio/per % of patients having:		
A better year	1839/38 = 48	-5493/38 = -145
Symptom free days	1839/45 = 41	-5493/45 = -122
Symptom free nights	1839/34 = 54	-5493/34 = -162
No impact on daily life	1839/26 = 71	-5493/26 = -211
The cost of making one person have ^{‡, #}		
A better year	4800	-14400
Symptom free days	4100	-12200
Symptom free nights	5400	-16100
No impact on daily life	7100	-21100

*: incremental cost (NOK)/unit of improvement; #: the main outcome cost-effectiveness ratios are rounded off to the nearest NOK 100; †: the cost of making one person have = (direct or total costs difference × number needed to educate); +: an adjusted cost-effectiveness ratio relates to the cost per outcome of clinical significance. SGRQ: St. George's Respiratory Questionnaire; FEV₁: forced expiratory volume in one second; NOK: Norwegian Krone.

of costs implies that few persons accounted for a large impact on average costs (fig. 3). This observation seems common when considering cost evaluations for asthma [13, 14, 32, 33]. For example, within the USA, 10% of asthmatic patients accounted for 44% of the total medical costs of treating the condition [34].

Regarding cost-effectiveness analyses in patient education, an interesting topic would be how to maintain effectiveness while reducing educational costs. The authors were not able to pinpoint which

part of the educational package could be excluded in order to obtain this. With more knowledge on how to educate asthmatics in relation to age, asthma severity, intellectual capacity, educational status, personality *etc* cost-effectiveness ratios of personally designed education programmes, for example based on pre-intervention testing, should become an important topic for future research.

The authors believe the introduction of the concept NNE is quite reasonable and beneficial. NNE has the

Table 5. – One-way sensitivity analyses on costs

Variables	Range of values	Total costs		Mean difference
		Control mean	Intervention mean	
Time cost for those employed				
Base case	NOK·h ⁻¹ 106.2	16000	10500	5500
Low	106.2 × 70%	15900	10100	5800
High	106.2 × 130%	16100	10800	5200
Time cost for those not employed				
Base case	NOK·h ⁻¹ 0	16000	10500	5500
Low	106.2 × 70%	16200	10700	5400
High	106.2 × 130%	16300	11000	5400
Cost of educational programme				
Base case	NOK 916	16000	10500	5500
Low	Teaching costs	16000	10100	5900
High	Teach costs × 2	16000	10600	5400
Production loss				
Base case	NOK·h ⁻¹ 106.2	16000	10500	5500
Low	106.2 × 70%	12500	9500	3000
High	106.2 × 130%	19500	11500	8000
Travel costs				
Base case	NOK Bus fares	16000	10500	5500
Low	0	15900	10300	5600
High	Bus fares × 4	16200	10900	5300

Cost items and differences are rounded off to nearest NOK 100. "Base case" is the assumption for the main conclusion. "Low" and "High" means low and high estimates for the assumptions. Regarding the patient education programme, the amount paid and reimbursed is exchanged with the cost of teaching when the scale of pay is used as a basis.

advantage of conveying both statistical and clinical significance and it identifies the clinical effort required to attain a beneficial outcome. In comparison, the much used odds ratio is not helpful in clinical decision-making. The low NNE-figures reported here are powerful, especially compared to high NNT-figures often reported in trials testing the effects of medication.

Statistically significant differences in costs regarding GP visits and absenteeism from work, but not for the summed cost items (table 3) were found. A possible explanation for this could be that the statistical assumptions for nonparametric tests of comparable distributions of costs in the two groups, were not met. Besides this, statistical power could of course have been better with larger study populations. However, in cost analyses, statistically significant differences are not critical, as the most important factor is whether the precision around the estimates of costs is sufficient for the decision in hand [35]. Thus, sensitivity analyses were performed, testing reasonable low and high estimates for the assumptions without overt changes in the main conclusions. The robustness of the results are supported by the threshold analysis, revealing the low cost estimates for absenteeism from work needed (25%), to make total costs comparable in the treatment groups. There is no simple answer as to why the present asthma education study is the first to demonstrate a dominant strategy. The most likely explanation is that the treatment plan, aimed at immediate change of medication at early symptoms/signs of exacerbation, might well influence the difference in production loss.

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