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ORIGINAL ARTICLE

An Economic Evaluation of Asthma Action Plans for Children with Asthma

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The costs and effectiveness of asthma action plans for children were evaluated in a cross-sectional economic analysis. Direct health care and indirect costs, nights with symptoms, and asthma attacks were measured in 879 Ontario children with asthma. From a societal perspective, the total annual costs of the asthma action plan and the control groups were CDN$6,948 and CDN$6,140 per patient, respectively. Health outcomes were similar. The difference in cost was attributable to greater medication and health services use in the intervention group. Prospective randomized trials are necessary to measure potential improvements in control of asthma using asthma action plans.

Keywords action plans, asthma, child, cost-effectiveness, disease management, health services utilization

INTRODUCTION

In Canada, the prevalence of asthma in children under the age of 14 years is 11% (1). Asthma is the leading cause of school absences in Canada, and evidence suggests that asthma care for children is inadequate, resulting in less than optimal control (2, 3). In the last two decades, asthma has become a major cause of increased morbidity and mortality in children in various global regions due to the under-treatment of the disease (4, 5). It has been hypothesized that much of the burden of pediatric asthma morbidity may be prevented with proper asthma education and disease management.

In addition to the burden of morbidity due to disease, asthma poses a significant economic burden. Direct and indirect expenditures for care of children with asthma in the U.S. in 1996 were estimated to be close to US$2 billion, with direct medical expenditures related to prescription medication, hospital inpatient stay, hospital outpatient care, emergency department (ED) visits, and office-based visits accounting for approximately half (6). Parents' loss of productivity from asthma-related school absence days was US$719 million, and 211 school-age children died from asthma in 1996, representing US$265 million in lost potential lifetime earnings (6).

Asthma education and action plans are recognized as important elements for the optimal management of asthma and to avoid an acute asthma attack in adults, but evidence is inconclusive regarding their effectiveness and cost-effectiveness in children (7). Studies have demonstrated the short-term benefits of asthma disease management programs, such as improved outcomes, efficient use of resources and decreased costs (8, 9). However, evidence on their long-term benefits is lacking. This evidence is critical since the severity of asthma in a patient may vary from year to year (8). A Cochrane Systematic Review (2004) on educational interventions for asthma in children stated that limited evidence existed to conclude whether self-management education is effective for children with more severe asthma compared with those with a less severe form of the disease (9).

What constitutes asthma education for children may vary from sessions with a qualified asthma educator to simple written materials and resources. Health care providers often consider a written asthma action plan accompanied by education sessions as the gold-standard in asthma self-management. An asthma action plan typically consists of written instructions that are customized for the patient. The plan includes (1) a list of the patient's asthma triggers and how they should be avoided; (2) a list of symptoms to be aware of and actions to take should they occur; and (3) the names and doses of medications that the patient requires and when to use them. The objective is to regularly update the plan and follow it closely to prevent or effectively treat asthma symptoms and exacerbations (10).

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Previous research has suggested that the success of an asthma action plan in preventing exacerbation and for day-to-day asthma control may depend on factors such as age, gender, ethnicity, parental education, immigrant status, language, and financial constraints on the family (11–13). The main reasons cited for failure of an asthma action plan implementation are insufficient time provided by physicians to explain the plan to caregivers or inadequate monitoring by physicians (14, 15). If effective, asthma action plans may be expected to increase costs related to medication use and regular physician follow-up but reduce costly inpatient admissions and emergency room visits. Although three economic evaluations on education and self-management programs related to pediatric asthma were identified, none explicitly measured the cost-effectiveness of asthma action plans (16). The primary research objective of this study was to evaluate the economic benefit of asthma action plans for children by comparing the direct and indirect costs and health outcomes between children receiving an asthma action plan and those without such a plan.

METHODS

Study Population and Data Collection

A stratified sampling plan was used to recruit 879 children with asthma from seven urban and suburban sites in the greater Toronto area, including primary care practices, respiratory specialist offices, asthma clinics, and EDs. While the sampling was not random, the stratified design allowed for recruitment of children with a wide spectrum of asthma severity. Children who were between 1 and 18 years of age with a charted clinical diagnosis of asthma or reactive airway disease and a prescription for at least one asthma medication, such as inhaled corticosteroids or bronchodilators, within the past year were eligible. Detailed information regarding family demographics, asthma history, asthma medication use, asthma symptoms and exacerbations, use of health services, and receipt of asthma education and actions plans was collected by personal interviews with older children and with the parents of infants and young children between November 2000 and March 2003. Complete data were available from 217 subjects who responded affirmatively to the question, "Has your child ever been given a personal asthma self-management or action plan?" (intervention group) and from 618 subjects who responded negatively (control group). The direct and indirect costs, the number of nights with symptoms, and the number of asthma attacks were compared between the intervention and control groups. The study was approved by the Hospital for Sick Children and the University of Toronto Research Ethics Boards, and all participants provided written informed consent.

Asthma Action Plan Intervention

In addition to determining whether participants received an asthma action plan, all subjects were asked whether they received any asthma information or education in the previous 6 months. Those who responded affirmatively reported receiving information from various sources, including physicians, asthma educators or nurses, pharmacists, respiratory therapists, community organizations, or others. As asthma action plans are ideally provided alongside asthma education, those who indicated receiving an asthma action plan were assumed to have also received asthma education that included two information sessions given by an asthma educator and written materials. According to the Canadian Asthma Consensus Guidelines, patient education and asthma action plan implementation are two basic components of asthma management (17).

Cost Measurement

Respiratory-related direct and indirect costs were assessed from a societal perspective to provide the most comprehensive assessment of costs associated with asthma management. Societal costs included all items in the public and private health care sectors and the indirect productivity cost associated with caregiver time losses due to caring for children with asthma. The time horizon for the analysis was one year to facilitate comparison with other studies.

The cost of each item or service was calculated by multiplying the volume of use by its unit price. Direct health care costs consisted of asthma-related health care resource use including ambulatory visits to family doctors, pediatricians and specialists, ED visits, hospital admissions, prescriptions for asthma medications, and medical equipment (e.g., nebulizer, spacer, and peak flow meter). Health care utilization was recalled over periods that have been documented to be reliable (18). Thus, uncommon events such as ED visits and hospital admissions were recalled over one year while shorter recall intervals were used for more frequent events, such as physician visits (6 months) and use of medications (current). All health care resource use was extrapolated to one year for the analysis. Indirect costs consisted of the productivity losses of parents or caregivers to provide care related to their child's asthma illness, including travel and wait time associated with accessing respiratory health care services. Unit prices for all items were derived from the provincial physician fee schedule, provincial drug formulary, inpatient case costing database (19), Statistics Canada wage database (20), and self-reported responses. Table 1 lists the direct and indirect cost items and the unit price sources. All prices are reported in 2003 Canadian dollars. Some unit prices for earlier years were adjusted to 2003 dollars using the consumer price index provided by the Bank of Canada.

An inpatient case cost was retrieved from the Ontario Case Costing Initiative (OCCI) using ICD10 code J45 for asthma as the most responsible diagnosis during the admission (21). For each inpatient admission, the OCCI average daily cost for Ontario children was multiplied by the average length of stay (LOS). The physician cost for inpatient care consisted of one full consultation assessment fee with a subsequent general assessment fee assigned to each remaining day of the LOS. Medication costs were based on the Ontario Drug Benefit Program formulary prices in 2002. Asthma medication is typically prescribed in 1-month supply inhalers. As some medications were used intermittently and to allow for less than optimal compliance, it was conservatively assumed that each drug prescription reported by study participants would last 6 weeks. The total annual medication cost per child was estimated by multiplying the cost of each prescription by eight for an annual cost and summing all medication costs.

TABLE 1.—Direct and indirect cost item prices and sources.

Item	Unit price*	Cost source
Emergency department physician consult	80.75	Ontario Schedule of Benefits & Fees
Primary care physician visit	29.95	Ontario Schedule of Benefits & Fees
Respiratory specialist visit	57.10	Ontario Schedule of Benefits & Fees
Pediatrician visit	53.15	Ontario Schedule of Benefits & Fees
Family practice visit	54.10	Ontario Schedule of Benefits & Fees
In-patient physician assessment	125.00 first day; 23.00/day for remaining days	Ontario Schedule of Benefits & Fees
Emergency department visit	141.21	Chedoke-Mc Master Hospital
Asthma in-patient case cost	1 to ≤4 years 836.90 >4 to ≤11 years 860.60 >11 to ≤18 years 803.40	Ontario Case Costing Initiative
Dispensing fee—public plan	6.54	Ontario College of Pharmacists
Dispensing fee—private plan	11.99	Community chain pharmacy
Asthma prescription	4.64–204.47	Ontario Drug Benefits Plan
Asthma educator	26.00	Asthma Clinic at the Hospital for Sick Children
Asthma education brochures	5.00	Ontario Lung Association
Asthma action plan	0.25	Ontario Lung Association
Productivity time loss (hourly wage=)	0–31.76	Chedoke-Mc Master Hospital
Spacer	19.99	Community chain pharmacy
Nebulizer	129.99	Community chain pharmacy
Peak flow meter	43.00	Community chain pharmacy
Homemaker time loss (hourly wage=)	9.13	Statistics Canada

*All prices reported in 2003 Canadian dollars.
= Hourly wage based on a 37.5–hour work week.

Intervention Cost

The model used to estimate the unit cost of an asthma action plan assumed two information sessions with an Asthma Educator and written materials. A certified Asthma Educator/Nurse Practitioner usually conducts two sessions of 10 to 15 minutes each. Based on nurses' hourly wages and associated benefits at the Hospital for Sick Children in Toronto, the total cost of education was estimated to be $26.00. Written materials provided to the individual patient or caregiver consisted of booklets published by the Ontario Lung Association. The value of reading materials was estimated to be $5.00 and the cost of the printed asthma action plan itself was only $0.25 per copy. The total assigned cost for the intervention was $31.00 per patient.

While children in the control group did not receive an asthma action plan, many reported receiving other forms of asthma education. Different unit costs were assigned for asthma education based on the reported source of education. If parents reported receiving education from respiratory specialists, asthma educators, and respiratory therapists, they were allotted the full intervention cost even if they did not receive an action plan. If they reported receiving information from family physicians, pediatricians, school or community health nurses, pharmacists, community organizations, teachers, or the Internet, they were assigned a partial asthma education cost that consisted only of the cost of written education material ($5.00). Thus, the control group included participants who reported that they did not receive an asthma action plan but who may have received partial or full asthma education.

Indirect Costs

As parental productivity losses were not ascertained directly, the volumes of time losses were estimated based on the frequency of various types of health care visits. For the productivity cost for the parent or caregiver of children with asthma, we assumed a school day loss was equivalent to the productivity loss of one day of work by one parent (22). Based on Krahn et al.'s study, we assumed that one third of outpatient physician and ED visits occurred during work hours (23). An ED visit was conservatively assumed to be 3 hours (23). Family physician and pediatrician visits were assumed to last one hour, whereas specialist visits were assumed to be 1.5 hours to account for extra travel time required to visit a specialist.

A daily wage was calculated by dividing the reported annual income by 239 total working days per year. This number was derived by subtracting weekend days (104), statutory holidays (12), and vacation days (10) from 365 days. An hourly wage was derived by dividing this value by 8 hours. For parents who were students, homemakers, on social assistance, or on disability, 100% of the average Ontario homemaker's 2001 salary reported in the CENSUS was used and adjusted for inflation to 2003 (20). The total time loss in hours associated with each child was multiplied by the hourly wage.

Outcome Measurement

Clinical guidelines state that night-time awakening due to asthma symptoms and frequency of asthma exacerbations are both important measures of asthma control in children (17). In this study, the two outcome measures were the number of nights with symptoms in the prior month and the number of attacks in the prior 6 months. A night-time symptom was defined as any wheezing or whistling in the chest, shortness of breath, chest tightness, and cough that awakened the child from his or her sleep. An attack was defined as a sudden worsening of symptoms that required action such as taking additional medicine to relieve symptoms or an unscheduled visit to an ED or doctor. The frequency reported for each outcome measure was linearly extrapolated to determine the number of annual occurrences.

Statistical Analysis

A cost-consequence analysis was used to measure the total costs and the health outcomes associated with the asthma action plan and control groups. The mean cost per patient per year and the mean number of nights with symptoms and number of attacks per patient per year were calculated and

reported separately for each group. Initially, costs and outcome variables were compared using parametric and nonparametric univariate statistics. The chi-square test was applied to categorical variables and the Wilcoxon rank sum test was used for continuous variables. Incremental mean annual costs per patient and increments in the mean annual number of nights with symptoms and the number of attacks per patient were calculated between the intervention and control groups. Health service utilization was compared between groups using a chi-square test of proportions. For each variable in this category, the mean number of annual visits per patient was calculated.

As total annual cost per patient was the major dependent variable, a generalized linear model multiple regression was performed to explain the effect of independent variables on the total cost per patient and to control for potential selection bias due to the nonrandomized design. In addition to the binary exposure variable of receipt of an asthma action plan, explanatory variables included in the regression model were ethnicity, income, employment status, asthma duration, season of study participation, and number of nights with symptoms. An important potential confounder, disease severity was incorporated into the regression model using the previous use of oral systemic steroids (prednisone) as a surrogate marker for more severe disease. Because the cost data were positively skewed, a log transformation for each patient's cost was conducted to normalize the data. Most cost predictors in the regression model were statistically significant at the 0.05 level. Total costs were retransformed using a smearing estimator to ensure that the retransformed costs were unbiased and consistent (24).

Sensitivity Analysis

Three one-way sensitivity analyses were performed to test the robustness of our findings to variations in underlying assumptions. The selection of these three analyses was based on assumptions made regarding the average daily cost of inpatient care and the productivity time loss in terms of hours. The base-case inpatient case cost assumed an average daily cost for hospital admission multiplied by the average length of stay. Physicians' fees were added. In the first sensitivity analysis, the inpatient case costs were varied in accordance with the minimum and maximum inpatient daily cost. In the second sensitivity analysis, alternative durations of parental time losses for physician, specialist, and ED visits were tested (23). This included a sensitivity analysis that assumed a constant time loss of 1.5 hours for all types of physician and ED visits. The final sensitivity analysis assumed that all physician and ED visits occurred entirely during working hours rather than one third of working hours.

RESULTS

Sample Characteristics

Table 2 presents the sample characteristics by action plan status. The intervention group was on average one year older than the control group. As well, a significantly greater proportion of parent respondents in the action plan group were either born in Canada or were of Canadian/North American background or spoke English at home compared to the control group. A significantly higher proportion of children in the action plan group displayed a history of allergies. In the control group, 15% received asthma education in the last 6 months from sources comparable to the intervention group, 22% received written materials only, and 63% of the control group did not receive any asthma education. There were no differences in household income, parent education, or marital status between groups.

TABLE 2.—Sample characteristics by group.

Characteristics	Action plan $n=217$		No action plan $n=618$		p value*
	n	%	n	%	
Child's sex					
Male	132	60.8	378	61.2	0.93
Female	85	39.2	240	38.8	
Child's age*					
4 years and under	53	24.4	217	35.1	0.001
5 to 9 years	94	43.3	269	43.5	
10 years or more	70	32.3	132	21.4	
Mean age, standard deviation	7.73, 4.29		6.57, 4.10		
Mean household income, standard deviation	$63,804, $23,683		$61,903, $24,467		
Parent respondent born in Canada*					
Yes	146	62.8	338	54.6	0.001
No	71	32.7	280	45.3	
Family ethnicity*					
Canadian/North American	125	57.6	276	44.7	0.004
European/East European	40	18.4	135	21.8	
Other	52	24.0	207	33.5	
Drug plan					
Yes	189	87.1	533	86.3	0.75
No	28	12.9	85	13.8	
Child history of allergies*					
Yes	144	66.4	326	52.8	<0.001
No	73	33.6	292	47.2	

*Chi-square p value ≤ 0.005.

Health service utilization by subgroups of patients with one or more visits is displayed in Table 3. A significantly higher proportion of the action plan group was followed by a respiratory specialist compared with the control group. In addition, the intervention group had, on average, fewer routine family doctor visits. Although not statistically significant, lower proportions of the action plan group had experienced all three measures of urgent care, including asthma ED visits, hospital admissions, and unscheduled clinic visits for asthma, compared to the no asthma action plan group. However, among the subgroup of children who did require urgent care, the action plan group demonstrated higher rates of use, suggesting that they may represent a population with more severe asthma or asthma that is more difficult to treat.

Comparison of Costs

Table 4 reports the unadjusted mean direct and indirect costs for the two study groups. The asthma action plan group had a total annual cost of $6,948 per patient while costs for the control group were $6,145 per patient. Direct costs accounted for 37% and 36% of the total for the intervention and control groups, respectively, while indirect costs due to parental productivity losses accounted for 63% and 64%, respectively. The largest direct cost component was inpatient costs which accounted for 13% and 14% of the total cost for the intervention and control groups, respectively. The asthma action plan group incurred higher costs for respiratory specialists. There was also a difference in the asthma medication costs

TABLE 3.—Health services utilization by group for patients reporting one or more visits.

Asthma-related health service	Action plan $n=217$		No action plan $n=618$	
	n	%	*n*	%
Family physician visits*	91	42.0	334	54.1
Mean visits per year; median; interquartile range	1.31; 0.00; 2.00		1.73; 1.00; 2.00	
Pediatrician visits	57	26.3	192	31.1
Mean visits per year; median; interquartile range	0.91; 0.00; 1.00		0.87; 0.00; 1.00	
Respiratory specialist visits*	173	79.7	329	53.2
Mean visits per year; median; interquartile range	2.09; 2.00; 2.00		1.16; 1.00; 2.00	
Hospital admissions	51	23.5	169	27.4
Mean per year; median; interquartile range	0.49; 0.00; 0.00		0.43; 0.00; 1.00	
Emergency department visits	111	51.1	351	56.8
Mean visits per year; median; interquartile range	1.44; 1.00; 2.00		1.29; 1.00; 2.00	

*Chi-square p value <0.01.

(including dispensing fees) between the two groups, with the intervention group spending an average of $166 more per child per year.

Table 5 presents the regression analysis for the adjusted total cost per patient. Costs were controlled for asthma severity (previous use of an oral steroid), frequency of night-time symptoms, and demographics characteristics, such as ethnicity, income, and employment status. The results demonstrated that higher total costs per patient were associated with more severe disease, higher household income, more nights with symptoms, and longer asthma duration. Children of parents of European or other non-North American ethnicity or who were employed also demonstrated higher costs. In addition, higher costs were associated with intermediate or peak asthma season.

Comparison of Outcomes

The cost-consequence analysis in Table 6 indicates that the intervention group was more costly and no more effective

TABLE 4.—Unadjusted annual cost per patient by group.

Cost category	Action plan $n=217$		No action plan $n=618$	
	Average annual cost per patient ($)	% of Total	Average annual cost per patient ($)	% of Total
Direct costs				
Inpatient care	937	13.5	832	13.6
Emergency visits	320	4.6	286	4.7
Family physician services	142	2.1	188	3.1
Respiratory specialist services	239	3.4	133	2.2
Pediatrician services	97	1.4	92	1.5
Asthma medication costs	505	7.3	374	6.1
Dispensing fees	272	3.9	238	3.9
Nebulizers	35	0.5	38	0.6
Spacers	13	0.2	13	0.2
Peak flow meters	12	0.2	5	0.1
Asthma education	27	0.4	6	0.1
Subtotal direct costs	2,599	37.4	2,205	35.8
Indirect costs				
Parent's productivity loss	4,350	62.6	3,940	64.2
Total unadjusted costs	6,948		6,145	

All costs reported in 2003 Canadian dollars.

TABLE 5.—Regression analysis of log of total cost per patient.

Independent variable	Regression coefficient	Standard error	p value
Asthma action plan—No (reference: yes)	−0.0991	0.0834	0.24
Oral steroids—no (reference: yes)	−0.7756	0.0864	<0.0001
Ethnicity(reference: Canadian/North American)			
European/ East European	0.0143	0.0949	0.88
Other	0.3040	0.0867	<0.01
Income	0.0422	0.0142	<0.01
Asthma duration	0.5303	0.1764	<0.01
Employment (reference: full- or part-time)			
Social Assistance or Disability	−0.3113	0.1804	0.085
Homemaker or unemployed	−0.3899	0.0911	<.0001
Allergy season of participation (reference: low season)			
Intermediate	0.3031	0.1174	0.01
Peak	0.3666	0.1192	0.002
Number of nights with symptoms	0.0250	0.0048	<0.0001

Model R-Square = 0.1867, F-value = 17.18, Model p value <0.0001.

than the control group. An asthma action plan alone may not be a cost-effective means to control the number of nights with symptoms and attacks in children with asthma. The median annual number of nights with symptoms was higher for the control group but the interquartile range was equal for both groups. The median and interquartile ranges for the number of attacks per year were equal for the asthma action plan and no asthma action plan groups. Overall, the health outcomes were not statistically significantly different between groups.

Sensitivity Analysis

Three one-way sensitivity analyses were performed on cost items with the most uncertainty, including inpatient care and productivity time loss (Figure 1). The incremental costs did not vary significantly from the base case for each sensitivity analysis. When the inpatient daily case cost was varied between the minimum and maximum, the incremental mean total cost per patient varied from CDN$811 to CDN$917 (95% confidence interval, CDN$449, CDN$1384). Adjustments for both sensitivity analyses in time loss values resulted in an incremental cost of CDN $853 (95% confidence interval, CDN$484, CDN$1221). In all sensitivity analyses, the total cost per patient remained greater in the intervention group compared with the control group.

DISCUSSION

The recommended management strategy for asthma consists of medications to control symptoms and underlying airway inflammation and a comprehensive education plan that promotes self-management through the control of environmental exposures to asthma triggers and through self-monitoring of symptoms (17). It has been recommended by the Canadian Consensus guidelines that a comprehensive asthma education program include an asthma action plan to help an individual monitor symptoms for adequate control (17). However, asthma action plans are often inadequately implemented by health practitioners owing to time constraints (14, 15).

The overall results for the cost-consequence analysis found no significant difference in effectiveness of an asthma action plan between the two groups. This finding is supported by a 2002 Cochrane Review on the effectiveness of written management instructions on asthma outcome measurements (25).

TABLE 6.—Cost-consequence analysis.

Health outcomes	Action plan $n = 217$		No action plan $n = 618$		Increment
Adjusted total annual cost per patient (mean, 95% confidence interval)	$7,186	$6,491–$7,882	$6,326	$5,999–6,652	$860
Number of nights with symptoms per year (median, interquartile range)	0.00	1.71	0.60	1.71	−0.60
Number of attacks per year (median, interquartile range)	4.00	6.00	4.00	6.00	0

All costs reported in 2003 Canadian dollars.

This systematic review reported that none of the outcomes measured (e.g., hospitalization, ED visits, oral systemic corticosteroid use, lung function, days lost from school or work, unscheduled doctor visits, and respiratory tract infections) were statistically different when compared to no written plans for adults (25). However, a systematic review of several studies showed that asthma education strategies stressing self-efficacy strategies were effective in reducing the cost of health care utilization, improving physiological function, reducing morbidity, and increasing functional status compared to usual care in children (9).

Children with allergies have greater disease morbidity and a higher incidence of asthma attacks (26, 27). This was a consistent finding in the present study. The results showed that the intervention group reported a higher rate of allergies. After controlling for differences in disease severity, asthma control, season, and demographics, the annual total cost for the asthma action plan group remained greater than the control group by an average of CDN$860 per patient, primarily due to greater medication costs, more respiratory specialist visits, and higher inpatient care costs. It is possible that the intervention group was more adherent with medication regimens due to the use of the asthma action plan and hence, received better care and was more closely followed by a specialist compared to the control group.

Cost savings have been reported for educational intervention strategies that used peak-flow measurements for self-management compared with a symptom-based

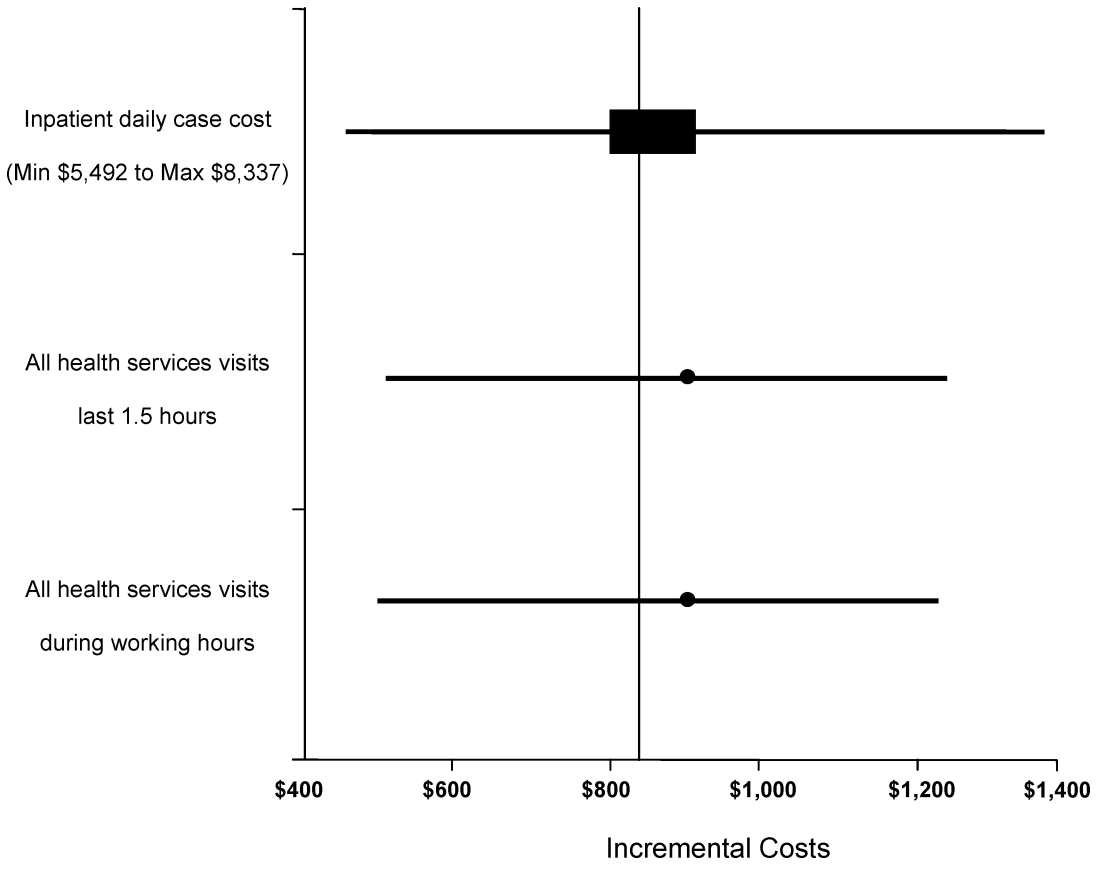

FIGURE 1.—**One-way sensitivity analysis**
Vertical bar represents the base case incremental cost of $860. Points and box represent the incremental cost or range of costs under the assumption of the sensitivity analysis. Horizontal lines indicate 95% confidence intervals. All costs reported in 2003 Canadian dollars.

self-management plan in adult patients (7). A study evaluating the value of asthma action plans in children reported that 9 of 10 caretakers found the intervention to be useful in managing exacerbations (28). Moreover, Wolf et al. concluded that asthma self-management programs in children improved an array of outcome measures, but additional studies are necessary to compare morbidity and other quality indicators, such as functional status outcomes (9). Other research reported that self-management programs for children with severe asthma resulted in net savings, although their efficiency among children with mild or moderate disease was uncertain (16). Pediatric asthma self-management training and education were also medically effective and reduced costs associated with emergency room visits and hospitalizations (29). In contrast, the present study showed that the addition of an asthma action plan did not improve the rate of asthma exacerbations or frequency of nights with symptoms. Given that the cost of full asthma education was not substantial, the intervention would need to reduce other costs, such as inpatient care and parental productivity losses, to be cost-effective.

A number of limitations in the study must be considered. An important limitation was the cross-sectional nature of the data. This precluded inferences about causality, permitting only the examination of an association between the presence or absence of the intervention and costs and consequences (30). Another limitation was the risk of selection bias. Although a stratified sampling plan was used to recruit children with a range of asthma severity, a large proportion of the patients were recruited from emergency departments or specialty asthma clinics and thus the sample may represent a more severe subset of children compared to the general population of children with asthma. However, this is the subset of children for whom asthma action plans would potentially demonstrate the greatest benefit and are therefore important to study. Perhaps a greater limitation was the lack of a random allocation to the intervention or control groups. A greater proportion of the control group was selected from the ED compared to the intervention group. Thus, the control group may have been more representative of children who did not receive regular follow-up care, and therefore, would not have an opportunity to receive an action plan. It is also possible that the children who received asthma action plans did so because they have more severe asthma. The regression analysis of costs attempted to control for the major confounders of asthma severity and socioeconomic status, but this may have been imperfect. If selection bias related to asthma severity was not adequately controlled for and the intervention group had more severe asthma, then the study may have underestimated the incremental effectiveness of the asthma action plan in reducing asthma exacerbations and nights with symptoms and may have overestimated the incremental costs in this group compared with the control group. Another limitation was that the information was based on recall intervals for health care resources that ranged from 1 to 6 months and were linearly extrapolated to 1 year. There was a possibility that the information collected was subject to recall bias, although recall intervals with documented validity were selected (18). Finally, parents served as proxy reporters in this study. While parents may report use of their child's health services reasonably well, it is expected that they may be less proficient at proxy reporting of symptoms and exacerbations. Guyatt et al. found only a weak correlation between a parent global symptom assessment and symptoms reported by children with asthma using a standardized quality-of-life instrument (31).

Conclusion

In this economic evaluation of asthma action plans, children in receipt of an action plan exhibited greater costs compared to a control group without demonstrating superior outcomes. Prospective, randomized controlled trials are necessary to assess the ability of written asthma action plans and personal management plans to mitigate deleterious outcomes in children with asthma and to determine if action plans should be targeted to a more severe subset of patients. In addition, research is required to establish the most cost-effective asthma education method for children, given the participation of parents as proxy reporters and educators.

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