

# Asthma Intervention Program Prevents Readmissions in High Healthcare Users

Mario Castro, Nina A. Zimmermann, Sue Crocker, Joseph Bradley, Charles Leven, and Kenneth B. Schechtman

Departments of Medicine and Biostatistics, Washington University School of Medicine and Barnes-Jewish Hospital, St. Louis, Missouri

The largest portion of the cost for asthma healthcare is due to hospitalizations. Improved methods of healthcare delivery for patients with asthma are needed to prevent readmissions. From 1996 to 1999, 96 adult subjects (predominantly young African American women) hospitalized with an asthma exacerbation, who had a history of frequent healthcare use, were randomized to an asthma nurse specialist intervention ( $n = 50$ ) or a usual care group ( $n = 46$ ) for 6 months. Our aim was to decrease rates of readmissions within 6 months of hospital discharge, to reduce cost, and to improve health-related quality of life. Our results demonstrate a 60% reduction in total hospitalizations (31 readmissions in the intervention group and 71 in the control group,  $p = 0.04$ ), with no significant change in emergency department visits. Readmissions for asthma were reduced by 54% (21 vs. 42 in the control group;  $p = 0.04$ ). We found a marked reduction in lost work or school days: 246 versus 1,040 days in the control group ( $p = 0.02$ ). The intervention resulted in a substantial reduction in direct and indirect healthcare costs, saving \$6,462 per patient ( $p = 0.03$ ). A brief intervention program focusing on high healthcare users with asthma can result in improved asthma control and reduced hospital use with substantial cost savings.

**Keywords:** asthma education; healthcare costs; hospitalizations

Asthma is a common chronic disease that affects 15 million people in the United States (1, 2). The economic impact of this disease has been estimated to be 11.3 billion dollars in 1998 (2). Hospitalizations account for almost half of annual direct healthcare expenditures for asthma (3). Hospitalizations for asthma disproportionately affect African Americans, who are more than three times as likely as whites to be hospitalized (1, 4). More than 80% of the resources used for asthma are consumed by 20% of the population, who are frequent users of the healthcare system (3). Interventions directed at reducing costs for this group are needed. We hypothesized that patients with a history of frequent healthcare use would benefit from a limited nurse-focused intervention. We proposed to study the effect of this intervention on the rate of readmission, lost work/school days, asthma-specific quality of life, and overall cost of healthcare.

## METHODS

### Patients

The extended version of the methods is available in the online data supplement. All patients admitted to Barnes-Jewish Hospital with the primary admitting diagnosis of asthma were screened for participation

(Received in original form August 15, 2002; accepted in final form May 30, 2003)

Supported by the Barnes-Jewish Hospital Foundation.

Correspondence and requests for reprints should be addressed to Mario Castro, M.D., M.P.H., Washington University School of Medicine, Box 8052, 660 South Euclid Avenue, St. Louis, MO 63110-1093. E-mail: castrom@msnotes.wustl.edu

This article has an online supplement, which is accessible from this issue's table of contents online at [www.atsjournals.org](http://www.atsjournals.org)

Am J Respir Crit Care Med Vol 168, pp 1095-1099, 2003

Originally Published in Press as DOI: 10.1164/rccm.200208-877OC on June 13, 2003

Internet address: [www.atsjournals.org](http://www.atsjournals.org)

from September 1996 to July 1999. From a total of 828 hospitalized patients, 96 were eligible for randomization based on the following criteria: physician diagnosis of asthma of at least 12 months duration, 18-65 years of age, FEV<sub>1</sub> to FVC ratio of less than 80%, and had a history of one or more hospitalizations in the previous 12 months. The study was approved by the Human Studies Committee of Washington University School of Medicine. All patients gave informed consent before entry into the study.

### Study Design and Intervention

The study consisted of a randomized, controlled, prospective trial investigating the use of an asthma nurse specialist to provide a multifaceted approach to asthma care for "high-risk" inpatients who met the study criteria. The study patients were randomly assigned to the intervention or "usual care" group in a blind selection procedure. The usual care group received the normal care provided by their private primary care physician.

The study intervention consisted of the following multifaceted approach: (1) suggestions by the nurse to the primary physician regarding potential simplification or consolidation of current regimen in accordance with the National Asthma Education and Prevention Program II (5); (2) completion of a daily "Asthma Care" flow sheet while in the hospital; (3) provision of asthma education appropriate to the patient's education, motivation, and cultural beliefs; (4) provision of psychosocial support and screening patients for professional counseling; (5) establishment of an individualized asthma self-management plan; (6) consultation with social service professionals to facilitate discharge planning; and (7) the provision of outpatient follow-up through telephone contact, home visits, and follow-up appointments with the primary physician, as necessary. Three consecutive nurses provided the intervention and collected the data for the study.

All analysis was conducted with the intention-to-treat principle with the primary endpoint being readmission due to asthma within 360 days. Secondary endpoints included total readmissions, emergency department visits, quality of life, direct and indirect healthcare costs, lost school or work days, and cumulative number of days of hospitalization. Costs were estimated using cost logs that were collected contemporaneously by all patients during the 180-day enrollment period. Quality of life was measured using a disease-specific measure, the Asthma Quality of Life Questionnaire, at entry into the study and at 6 months (9, 10).

### Statistical Analysis

*T* tests and chi-square tests were used to compare variables between groups. However, because of the skewed nature of variables such as the number of days in the hospital and the number of emergency department visits, the Wilcoxon's test was sometimes used. Stepwise logistic regression was used to identify variables that had an independent association with being readmitted at least two times within a year of the initial hospitalization. A log-rank test was used to perform between group comparisons of the survival curves measuring time to the first readmission. Summary data on continuous variables are expressed as mean  $\pm$  SD. All data analyses were performed using SAS software (SAS Institute, Cary, NC).

## RESULTS

### Baseline Characteristics

Baseline characteristics of study patients, including demographics, asthma history, healthcare use, and pulmonary functions, are

TABLE 1. BASELINE CHARACTERISTICS OF STUDY PATIENTS\*

Characteristics	Control Group (n = 46)	Intervention Group (n = 50)
Age, yr	38 ± 12	35 ± 11
Female, %	39 (85)	40 (80)
African American, %	36 (78)	43 (86)
Median annual household income, U.S. \$	29,284 ± 8,777	25,442 ± 7,582
Education of 12th grade or less, %	30 (65)	30 (60)
Payer, %	18 (40)	29 (58)
Medicaid	7 (15)	5 (10)
Medicare	15 (33)	8 (16)
Private insurer	5 (11)	8 (16)
Uninsured/self-pay		
Onset of asthma, yr	16 ± 17	15 ± 14
Diagnosis of asthma, yr	18 ± 18	16 ± 14
Asthma worse during certain seasons, %	36 (78)	40 (80)
Asthma worse due to exposure to pets/pests, %	22 (48)	25 (50)
Hospitalizations previous 12 months	2.4 ± 2.5	2.4 ± 2.6
Emergency department visits previous 12 months	4.8 ± 5.0	5.6 ± 5.5
FEV <sub>1</sub> , L	1.55 ± 0.64	1.58 ± 0.55
Percent predicted	58 ± 22	57 ± 18
Range of percent predicted	14–113	15–87

\* Values are means ± SD followed by percentages of the group. All variables were not significantly different between groups (p > 0.05).

shown in Table 1. In general, the patients were young, African American women with a high school education or less with a history of frequent healthcare use. There were slightly more patients in the intervention group who had Medicaid and slightly more in the control group who had private insurance. In general, patients had moderate to severe airflow obstruction at entry into the study. Both groups were well balanced with respect to all baseline characteristics, and there were no significant differences between the groups.

### Hospital Readmissions

As shown in Table 2, there was a 60% reduction in total readmissions in the intervention group compared with the control group

over 12 months (31 vs. 71 readmissions, respectively, p = 0.04). The majority of readmissions were due to asthma (21 vs. 42 [intervention vs. control group], p = 0.04). There was a 68% reduction in hospitalizations not due to asthma (10 vs. 29 [intervention versus control group], p = 0.19). Multiple readmissions (two or more) were more frequent in the control group (15 vs. 7 in the intervention group, p = 0.03). Time to the first readmission was not significantly different between groups (Figure 1). There was a 69% reduction in total hospital days in the intervention group compared with the control group over 12 months (p = 0.04), mostly driven by the reduction in hospital days for asthma (129 vs. 53 days, respectively, p = 0.04). There were no significant differences in the number of healthcare provider visits. There

TABLE 2. HEALTHCARE USE WITHIN 1 YEAR OF INITIAL HOSPITALIZATION\*

Variable	Control Group (n = 46)	Intervention Group (n = 50)	Difference† (%)	p Value‡
Number of readmissions	71	31	−60	0.04
For asthma	42	21	−54	0.04
Per patient	0.9 ± 1.5	0.4 ± 0.9		
Not for asthma	29	10	−68	0.19
Per patient	0.6 ± 1.5	0.2 ± 0.5		
Number of times patients readmitted, %				
0	21 (46)	30 (60)	−30	0.16
1 <sup>  </sup>	10 (22)	13 (26)	18	0.63 <sup>§</sup>
2 or more <sup>  </sup>	15 (33)	7 (14)	−57	0.03
Hospital days	244	82	−69	0.04
For asthma	129	53	−62	0.04
Per patient	2.8 ± 5.9	1.1 ± 2.4		
Not for asthma	115	29	−77	0.21
Per patient	2.5 ± 7.2	0.6 ± 1.5		
Emergency department visits	64	93	34	0.52
Per patient	1.4 ± 1.5	1.9 ± 4.3		
Healthcare provider visits	157	166	3	0.82
Per patient	3.4 ± 3.9	3.3 ± 4.2		

\* Values are means ± SD followed by percentages of the group.

† Percent differences were calculated by dividing the absolute percent difference between groups by the control group percentage.

‡ All reported p values are by Wilcoxon Rank Sums test for continuous measures and chi-square test for dichotomous ones.

§ Kaplan-Meier survival curves measuring time to first readmission were compared using log rank test and the results were similar (p = 0.18) (Figure 1).

<sup>||</sup> Number of times patients were readmitted zero, one, and two or more times, mutually exclusive categories.

**TABLE 3. INDEPENDENT PREDICTORS OF READMISSIONS\***

Variable	Odds Ratio	95% Confidence Interval	p Value
Assignment to the control group	3.6	1.2–10.9	0.02
Previous hospitalizations	1.3	1.0–1.5	0.01
Duration of asthma, per 10 yr	1.4	1.0–2.0	0.04

\* Logistic regression analysis of predictors of two or more hospitalizations within 1 year of initial hospitalization compared with those with one or less hospitalization.

was a slightly higher number of emergency department (ED) visits in the intervention group (n = 93) than the control group (n = 64), although it was not statistically significant. However, we found one individual in the intervention group with 30 ED visits who was a clear outlier. When we recomputed the average ED visits without this one outlier in the intervention group, we found, on average, 1.3 ± 1.5 ED visits in the intervention group compared with 1.4 ± 1.5 in the control group.

To determine whether readmission rates differed during the first 6 months as compared with the second 6 months (when no intervention was being provided by the nurse), we evaluated when each of the subsequent 98 readmissions occurred. A total of 46% of readmissions in the control group and 48% of the intervention group occurred during the second 6 months (p = 0.85). This suggests that the effect of the intervention on readmissions was sustained for at least an additional 6 months.

We then analyzed whether the assignment to the intervention group was associated with a decreased number of readmissions after adjusting for baseline demographic factors, lung function, and quality of life. As Table 3 shows, the strongest independent predictors of readmission were the number of previous hospitalizations and the duration of asthma. After adjusting for these variables and other univariate predictors of readmission, assignment to the control group remained a significant independent predictor of readmission. Those patients in the control group were 3.6 times more likely to be readmitted two or more times in 12 months after the index hospitalization than those patients receiving the intervention.

**Healthcare Costs**

The healthcare costs, including direct and indirect costs, for the patients in the control and intervention groups for the 180 days after the initial hospitalization are shown in Table 4. The average total healthcare costs per patient in the control group was \$12,188 ± \$19,352 compared with \$5,726 ± \$5,679 in the intervention group (p = 0.03), resulting in an overall savings of \$6,462 per patient attributable to the intervention. The majority of savings came from a decrease in the direct healthcare costs (69% or \$4,430 per patient, p = 0.07). These were primarily due to lower costs for hospitalizations for asthma in the intervention group, accounting for a cost savings of \$2,955 per patient for hospitalizations (p = 0.01).

The savings in direct healthcare costs in the intervention group was not due to differences in medication refills. The total number of medication refills that occurred during the 180 days after the initial hospitalization included (control vs. intervention) inhaled corticosteroids (174 vs. 214), leukotriene modifier (39 vs. 10), long-acting β-agonist (69 vs. 134), and theophylline (46 vs. 64) (all p > 0.05). Thirty-seven percent of all patients were on an inhaled corticosteroid on admission, and this increased to 83% at discharge. Furthermore, we found that the mean number of refills for antiinflammatory medications was 5.1 ± 4.5 in those with one or more readmission compared with 4.2 ± 4.5 in those with no readmissions (p = 0.34). Therefore, there were no significant differences between the groups in the provision of antiinflammatory treatment at discharge or at the 180-day follow-up.

Indirect healthcare costs, including lost workdays and non-professional/caregiver help, were lower in the intervention group resulting in a cost savings of \$2,220 per patient (p = 0.03). The lower indirect healthcare costs were primarily due to a 76% less lost work days. The next largest portion of indirect healthcare cost savings was due to less unpaid caregiver cost in the intervention group.

**Quality of Life**

Changes in quality of life as measured by the Asthma Quality of Life Questionnaire at baseline and 6 months are shown in Table 5. The overall asthma-specific quality of life in the control group improved significantly from 2.74 at baseline to 3.90 6 months

**TABLE 4. HEALTHCARE COSTS FOR STUDY PATIENTS\***

Component of Healthcare	Control Group (n = 46)	Intervention Group (n = 50)	Difference	p Value
Intervention cost	NA	186 ± 100	186	NA
Direct costs	8,079 ± 15,685	3,650 ± 4,178	-4,430	0.07
Hospitalizations				
For asthma	4,413 ± 9,592	1,458 ± 3,301	-2,955	0.01
Not for asthma	2,157 ± 6,225	724 ± 1,862	-1,433	0.14
Emergency department	505 ± 1,046	593 ± 973	88	0.67
Healthcare provider visits	140 ± 160	136 ± 173	-4	0.90
Nurse/Paid caregiver	244 ± 1,351	151 ± 919	-93	0.69
Tests†	30 ± 103	8 ± 57	-22	0.26
Asthma medications‡	566 ± 593	579 ± 473	13	0.80
Indirect costs	4,108 ± 6,142	1,888 ± 3,181	-2,220	0.03
Lost work/school days by patient	1,040	246	-794	
Cost of lost work days	1,743 ± 3,247	378 ± 753	-1,366	0.02
Lost work days by family	328	96	-232	0.34
Cost of lost work days	546 ± 2,750	149 ± 546	-397	
Nonprofessional/other paid help	217 ± 931	270 ± 1,014	63	0.79
Unpaid caregiver cost	1,601 ± 3,882	1,096 ± 2,659	-505	0.46
Total healthcare costs	12,188 ± 19,352	5,726 ± 5,679	6,462	0.03

Definition of abbreviation: NA = not applicable.

\* All values (except for number of lost school/work days) are mean dollars per patient ± SD (adjusted to 1999 dollars).

† Tests include only allergy skin testing/immunotherapy.

‡ Medication costs calculated based on 1999 average wholesale cost.

TABLE 5. CHANGES IN ASTHMA QUALITY OF LIFE FOR STUDY PATIENTS\*

Domain	Control Group (n = 33)				Intervention Group (n = 33)				Between-Group p Value
	Baseline	180 Days	Change	P Value	Baseline	180 Days	Change	p Value	
Activity	3.1 ± 1.1	4.2 ± 1.6	1.1 ± 1.3	< 0.001	3.1 ± 0.8	4.2 ± 1.4	1.2 ± 1.2	< 0.001	0.73
Symptom	2.4 ± 0.9	3.9 ± 1.6	1.5 ± 1.5	< 0.001	2.3 ± 0.8	4.0 ± 1.4	1.7 ± 1.3	< 0.001	0.49
Emotional	2.4 ± 1.1	3.8 ± 1.6	1.4 ± 1.5	< 0.001	2.2 ± 0.9	3.7 ± 1.5	1.5 ± 1.4	< 0.001	0.85
Environmental	3.3 ± 1.3	3.8 ± 1.6	0.6 ± 1.4	0.05	3.3 ± 1.3	3.9 ± 1.4	0.6 ± 1.8	0.02	0.86
Overall	2.7 ± 0.9	3.9 ± 1.5	1.2 ± 1.3	< 0.001	2.7 ± 0.7	4.0 ± 1.3	1.4 ± 1.2	< 0.001	0.55

Definition of abbreviation: NS = not significant.

\* Change in asthma-specific quality of life scores from baseline to 180 days from initial hospitalization. A positive score indicates an improvement in quality of life.

later ( $\Delta 1.18$ ,  $p < 0.001$ ) and also improved significantly in the intervention group from 2.70 at baseline to 4.02 ( $\Delta 1.35$ ,  $p < 0.001$ ), with no significant difference in the improvement of quality of life between the two groups. Quality of life improved significantly in all four domains within each group, although there was no significant difference in any domain between the groups.

## DISCUSSION

Our study demonstrates that a brief nurse-directed intervention in hospitalized asthma patients with a frequent history of healthcare use results in a significant reduction in subsequent readmissions, lost work or school days, and direct and indirect healthcare costs. Previous studies have had relatively small sample sizes, selected cohorts, use of historical control subjects, or ignored the impact of such a program on healthcare costs (8–16). Some of these studies, but not all, have demonstrated a beneficial effect on healthcare use and asthma knowledge.

Few studies have performed a prospective, randomized controlled trial of an asthma education program in a hospital setting (13, 17). George and colleagues studied 77 patients with asthma randomized to a nurse-directed intervention, including education and outpatient follow-up in an asthma program (13). In those patients for which information was available, they demonstrated a significant reduction in hospitalizations and emergency department visits. In a similar study, 201 children admitted to the hospital with acute asthma were provided a nurse-directed teaching program focusing on asthma home management. Subsequent follow-up demonstrated a significant reduction in readmissions (17). Finally, a study in 160 children admitted to the hospital with acute asthma provided discharge planning, which included a focused

education program and self-management plan (22). Six-month follow-up demonstrated a significant reduction in readmissions and emergency department visits. Healthcare costs, the impact on school or work days, and quality of life were not available in these studies.

An interesting finding in our study was a trend toward a reduction in hospitalizations not due to asthma (68% reduction) similar to that seen due to asthma (54%), although not statistically significant. This potential effect of the intervention on hospitalizations for causes other than asthma is similar to that seen in a program conducted in patients with congestive heart failure (18). This suggests that access to nursing and psychosocial support may provide benefits to healthcare problems other than those intended by the intervention.

Furthermore, findings from this study suggest that a short-term intervention targeted at high healthcare users may have longer term effects. The study nurse provided asthma education and support during the initial hospitalization and only for the subsequent 6 months. However, we found no significant difference in readmission rates between the groups in the subsequent 6 months when no intervention was being provided. This effect may be due to greater asthma knowledge and self-management skills, the positive impact of the nurse-patient relationship on accessing future healthcare needs, and improving sense of control over one's health care needs (19, 20).

A potential limitation of our study is the lack of generalizability of the results. Our study focused on high healthcare users in an urban academic medical center. The majority of these patients were young, African American women with asthma from lower socioeconomic strata. Only 12% of those patients admitted to our hospital with a primary diagnosis of asthma were enrolled. However, we did show a significant impact on healthcare use and days lost from work or school without compromising the patient's health or quality of life. Therefore, the potential application of this intervention to other patients with asthma should have a similar positive benefit.

A second limitation of our study is the inability to identify which specific component of the intervention is most effective (21). Multiple components were delivered by the nurse during the initial hospitalization and then subsequently reinforced. We often found that the social barriers that these patients faced outweighed their ability to initially change their health behavior. Interestingly, we found no significant differences in subsequent visits to healthcare providers or in the number or type of asthma medications refilled between the groups. For example, the intervention group received 214 refills for inhaled corticosteroids compared with 174 in the "usual care" group during the 6 months of the intervention ( $p > 0.05$ ). This suggests that the enhanced patient education, provision of follow-up care and medications by the nurse, and addressing social barriers appeared to be key to the success of our program as seen in other studies (13, 17, 23).

A third limitation of our study is that all of the data from

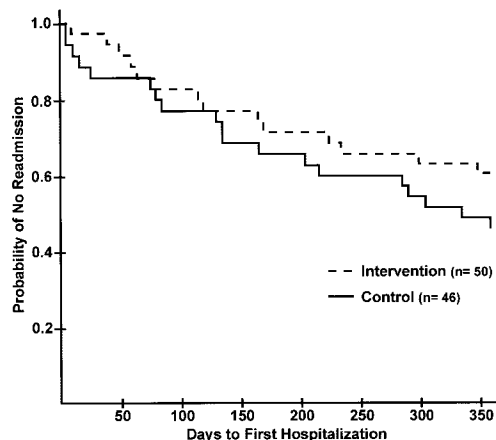


Figure 1. Probability of readmission after randomization.

our participants were collected by the asthma nurse specialist conducting the intervention. This is a potential source of bias as the interviewer may exert a qualitative influence on the participant's response. We took several measures to minimize this source of bias: (1) Each nurse specialist was trained and supervised in appropriate interviewing techniques. (2) All questions regarding the study endpoints were structured and administered in exactly the same manner among participants, and (3) responses to questions were confirmed with an external source of data when possible (e.g., hospitalization or office visit record).

In summary, this study demonstrates that a brief, nurse-directed intervention in asthmatic subjects with a history of frequent healthcare use will significantly reduce subsequent readmissions and decrease lost work or school days in a cost-effective manner. Recent efforts by the National Asthma Educator Certification Board ([www.naecb.org](http://www.naecb.org)) to improve the delivery of asthma education should increase the availability of certified asthma educators to deliver a similar program. We believe that widespread implementation of this approach in patients hospitalized with asthma with a history of high healthcare use will result in substantially improved patient satisfaction and reduce healthcare costs due to this common disease.

**Conflict of Interest:** M.C. has no declared conflict of interest; N.A.Z. has no declared conflict of interest; S.C. has no declared conflict of interest; J.B. has no declared conflict of interest; C.L. has no declared conflict of interest; K.B.S. has no declared conflict of interest.

**Acknowledgment:** The authors acknowledge the contributions of Bev Long for her expert secretarial assistance, Michael W. Rich, M.D., and Robert Strunk, M.D., for their insightful advice and comments, and the following persons and agencies without whose support this study could not have been successfully completed: Mary C. Spencer, R.N., M.S.N., Barb Gubser, R.N., M.S.N., Betty Leventhal, ED.D., L.C.W., M.N., R.N., Lee Ann Blue, R.N., M.S.N., James Crane, M.D., Philip Korenblat, M.D., Daniel L. Hamilos, M.D., Robert Senior, M.D., Michael J. Holtzman, M.D., and Barnes-Jewish Hospital and Foundation.

## References

- Mannino DM, Homa DM, Pertowski CA, Ashizawa A, Nixon LL, Johnson CA, Ball LB, Jack E, Kang DS. Surveillance for asthma: United States, 1960–1995. *MMWR CDC Surveill Summ* 1998;47:1–27.
- National Institutes of Health: National Heart, Lung, and Blood Institute. Data fact sheet: asthma statistics. Washington, DC: U.S. Department of Health and Human Services; 1999.
- Smith D, Malone D, Lawson K, Okamoto L, Battista C, Saunders W. A national estimate of the economic cost of asthma. *Am J Respir Crit Care Med* 1997;156:787–793.
- Castro M, Schechtman K, Halstead J, Bloomberg G. Risk factors for asthma morbidity and mortality in a large metropolitan city. *J Asthma* 2001;38:625–636.
- National Asthma Education and Prevention Program. Expert panel report II: guidelines for the diagnosis and management of asthma. Washington, DC: National Institutes of Health; National Heart, Lung, and Blood Institute; 1997.
- Juniper E, Guyatt G, Ferrie P, Griffith L. Measuring quality of life in asthma. *Am Rev Respir Dis* 1993;147:832–838.
- Juniper E, Guyatt G, Willan A, Griffith L. Determining a minimal important change in a disease-specific quality of life questionnaire. *J Clin Epidemiol* 1994;47:81–87.
- Kelso T, Self T, Rumbak M, Stephens M, Garrett W, Arheart K. Educational and long-term intervention in the emergency department: effect on outcomes in adult indigent minority asthmatics. *Am J Emerg Med* 1995;13:632–637.
- Kelly C, Anderson C, Pestian J, Wenger AD, Finch AB, Strope GL, Luckstead EF. Improved outcomes for hospitalized asthmatic children using a clinical pathway. *Ann Allergy Asthma Immunol* 2000;84:509–516.
- Kwan-Gett T, Lozano P, Mullin K, Marcuse E. One-year experience with an inpatient asthma clinical pathway. *Arch Pediatr Adolesc Med* 1997;151:684–689.
- Mayo PH, Richman J, Harris HW. Results of a program to reduce admissions for adult asthma. *Ann Intern Med* 1990;112:864–871.
- Abdulwadud O, Abramson M, Forbes A, James A, Walters E. Evaluation of a randomised controlled trial of adult asthma education in a hospital setting. *Thorax* 1999;54:493–500.
- George M, O'Dowd L, Martin I, Lindell KO, Whitney F, Jones M, Ramondo T, Walsh L, Grissinger J, Hansen-Flaschen J, et al. A comprehensive educational program improves clinical outcome measures in inner-city patients with asthma. *Arch Intern Med* 1999;159:1710–1716.
- Doan T, Grammer L, Yarnold P, Greenberger P, Patterson R. An intervention program to reduce the hospitalization cost of asthmatic patients requiring intubation. *Ann Allergy Asthma Immunol* 1996;76:513–518.
- McDowell K, Chatburn R, Myers T, O'Riorda M, Kerckmar C. A cost-saving algorithm for children hospitalized for status asthmaticus. *Arch Pediatr Adolesc Med* 1998;152:977–984.
- Gallefoss F, Bakke P. Cost-effectiveness of self-management in asthmatics: a 1-yr follow-up randomized, controlled trial. *Eur Respir J* 2001;17:206–213.
- Madge P, McColl J, Paton J. Impact of a nurse-led home management training programme in children admitted to hospital with acute asthma: a randomized controlled study. *Thorax* 1997;52:223–228.
- Rich M, Beckham V, Wittenberg C, Leven C, Freedland K, Carney R. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. *N Engl J Med* 1995;333:1190–1195.
- Bandura A. Social learning theory. Englewood Cliffs, NJ: Prentice-Hall; 1977.
- Clark N. Social learning theory in current health education practice. *Adv Health Educ Promotion* 1987;2:251–275.
- Chapman K, Dales R, Chan-Yeung M, Côté J. Future research in asthma education. *Chest* 1994;106:270S–273S.
- Wesseldine L, McCarthy P, Silverman M. Structured discharge procedure for children admitted to hospital with acute asthma: a randomised controlled trial of nursing practice. *Arch Dis Child* 1999;80:110–114.
- Côté J, Bowie DM, Robichaud P, Parent J-G, Battisti L, Boulet L-P. Evaluation of two different educational interventions for adult patients consulting with an acute asthma exacerbation. *Am J Respir Crit Care Med* 2001;163:1415–1419.