Original Research

Translational Effect of Provider-Focused, Multi-State, Multi-Clinic Asthma Care Quality Improvement Program on Patient-Level Health Care Costs

Journal of Primary Care & Community Health
Volume 12: 1–8

DOI: 10.1177/21501327211000246
journals.sagepub.com/home/jpc
SAGE

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Abstract

Introduction/Objectives: Enhancing Care for Patients with Asthma (ECPA), a year-long provider-focused, multi-state, multi-clinic quality improvement program, decreased avoidable utilizations among patients with asthma, but its effects on health care expenditures were not determined. This study examined the translational and sustainable effects of improved care through ECPA on individual-level total health care costs due to asthma. **Methods:** We conducted a retrospective pretest-posttest quasi-experimental study in which attributed 1683 patients in a 12-month pre-ECPA implementation period served as their own control. We constructed the total annual asthma-related health care costs per patient occurred during pre-ECPA implementation, ECPA implementation, and post-ECPA completion. We used 3-level generalized linear mixed models (GLMMs) to estimate the ECPA effect on the annual health care costs and account for correlation between the repeated outcome measures for each patient and nested clinic. All costs were adjusted for inflation to 2014 U.S. dollars, the last year of program observation. **Results:** Total asthma-related health care costs among the 1683 included patients decreased from an average of $7033 to $3237 per person-year (pre-ECPA implementation vs implementation). Using the cost data from the 12-month pre-ECPA implementation period as a reference, GLMMs found that the ECPA implementation was associated with a reduction in total annual asthma-related health care costs by 56.4% (95% CI −60.7%, −51.8%). During the 12-months after ECPA completion period, health care costs were also found to be significantly lower, experiencing a 57.3% reduction. **Conclusions:** The economic benefits of ECPA provide a justification to adopt this quality improvement initiative to more primary care clinics at a national level.

Keywords

Primary care, Asthma, health care costs, quality improvement, health care utilization, patient care, guideline adherence, pediatrics, quasi experimental design, administrative claims data

Dates received: 26 October 2020; revised: 24 November 2020; accepted: 27 November 2020.

Introduction

Asthma, a chronic inflammatory disease of the airways,[1] is prevalent and economically burdensome for the U.S. health care system. According to the National Center for Health Statistics, asthma prevalence has risen from 7.3% in 2001 among all people[2] to 12.1% among children and 14.1% among adults in 2017.[3] This chronic condition is a significant contributor to the high costs of health care. In a single year, asthma costs the health care system a staggering $80 billion, or at least $3266 per patient, in direct health care expenditures.[4] These costs include office-based

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medical provider visits, prescription drugs, and outpatient, inpatient, and emergency room (ER) visits. Nevertheless, the expenditures associated with these health services are preventable and could be minimized through proper asthma management.

Despite the availability of comprehensive asthma management guidelines, patients with asthma are at a higher risk of visiting the ER visits and experiencing hospitalization. The Expert Panel Report 3 (EPR-3) Guidelines for the Diagnosis and Management of Asthma has detailed essential components of asthma care for optimal asthma management that could reduce the need for ER and inpatient hospital use.[5] Despite the availability of the guidelines, in 2017 alone asthma still accounted for approximately 1.5 million ER visits.[6] The statistics reported by the Centers for Disease Control and Prevention (CDC) indicated that U.S. patients with asthma are prone to avoidable hospital inpatient utilization of as high as 200 000 episodes yearly.[7] Since hospital admissions are the main cost contributor due to their high overall costs[8,9] and ER use is very prevalent in patients with asthma,[10] an intervention that reduces the number of these events may contribute to a reduction in total direct costs due to asthma.

Enhancing Care for Patients with Asthma (ECPA) is a quality improvement program attempting to enhance asthma care processes in participating primary care clinics in Illinois, New Mexico, and Oklahoma, and Texas. During the 12-month active improvement period, this program enriched guideline-based asthma care processes among health care providers in participating clinics. ECPA utilized the Wagner Chronic Care Model to identify 6 elements that are necessary to create a sustainable system for high-quality asthma care management in participating clinics. The 6 elements include "an integrated health system, delivery system design promoting efficient workflow, clinical care decision support, clinical information systems supporting the use of electronic medical records, patient self-management support tools, and community resources."[11] ECPA then used the Plan-Do-Study-Act (PDSA) approach to accelerate quality improvement actions in the clinic settings.[11] As a complementary mechanism to the within-clinic activities, staff from each setting engaged in a bi-monthly learning consortium to exchange ideas on improvement processes. Previous analyses revealed that the implementation of ECPA was associated with reducing patient-level ER visits and hospitalizations by 37.7% and 47.1%, respectively.[12] Moreover, this midstream intervention has a long-term, sustainable effect on preventable use of health services since the rates of ER visits and hospital admissions at 12-months post-ECPA completion were 55.2% and 45.8% lower than the pre-ECPA implementation period, respectively.[12] By improving the quality of asthma care via primary care providers, the program demonstrated its translational effect on decreasing asthma-related ER visits and hospital admissions measured at the individual patient level.

Given the translational, sustainable effect of ECPA on the patient-level preventable health care utilization, this study hypothesized that the ECPA implementation was also associated with alleviating total asthma-related direct health care costs among patients receiving asthma care from participating clinics. The objective of this study was to determine the effect of ECPA on the total asthma-related health care costs among patients receiving asthma care from primary care clinics participating in the ECPA initiative.

Methods

This retrospective study utilized a quasi-experimental, pretest-posttest design to evaluate the effect of ECPA on asthma-related health care costs. The study design addressed internal validity issues by comparing the same patient group both before and after the implementation of ECPA; a randomization process in this real-world setting was not possible.[13]

Source of Data

The study was conducted using administrative claims data from a private insurer that provided coverage to a majority of patients in Illinois, New Mexico, and Oklahoma and provided health care benefits to patients who received care in ECPA-participating clinics. The private insurer provided coverage to patients through commercial insurance, employer-sponsored insurance, and Medicaid managed care. The administrative claims data from January 1, 2012 to December 31, 2014 were utilized. Over this period, the study was segmented into 3 parts: (1) 12-month pre-ECPA implementation (January-December 2012); (2) 12-month ECPA implementation (January-December 2013); and (3) 12-month post-ECPA completion (January-December 2014). A 12-month measurement period is recommended by the National Institutes of Health (NIH) to avoid a seasonality effect among patients with asthma for cost and utilization analyses.[14]

Source of Participants

The provider identification number of each clinic was used to attribute patients to each clinic. Patients were included in this study if they had both: continuous enrollment from January 1, 2012, to December 31, 2014 and presence of at least one claim at a participating clinic during the 12-month pre-ECPA implementation period with a primary or secondary diagnosis of asthma (ICD-9-CM code of 493.xx). Patients were excluded if they disenrolled from their insurance plans between January 2012 and December 2014.

Outcomes

The primary outcomes of this study were the total costs of asthma-related health care over 3 study periods (12 months per period). The total asthma-related health care costs were defined as the sum of amounts paid by the insurer and patient cost-sharing across use of 6 asthma-related resource use categories: ER visits, hospital admissions, physician office or outpatient visits, prescriptions, DMEs, and other services with the ICD-9-CM code of 493.xx as primary or related reasons. The costs of each resource use were computed in each 12-month study period and then summed to determine total annual asthma health care costs.

ER visit costs were computed as the sum of costs for all events with CPT code 99281-99285. The costs for hospital admissions were calculated from claims with Place of Service (POS) code 21: Inpatient Hospital. The costs for physician office and outpatient visits were calculated from claims with POS code 11: Office, POS code 22: Outpatient Hospital, and POS code 24: Ambulatory Surgical Center. Asthma-related prescriptions costs were identified using the national drug code (NDC) lists from the Healthcare Effectiveness Data and Information Set (HEDIS).[15] The costs for DME supplies were computed using POS code 12: Home and Healthcare Common Procedure Coding System (HCPCS) code Axxxx-Zxxxx. Other service costs included anything outside of the 5 resource use categories. All costs were inflated to 2014 U.S. dollar values using Medical Care Services of the Consumer Price Index (CPI) retrieved from U.S. Bureau of Labor Statistics.[16] The 2014 U.S. dollar values were selected as it was the last year of program observation to ensure that the costs incurred in each study period were reported the same way.

Data Analytic Approach

Descriptive statistics. The age and gender of included patients were reported as demographic characteristics. Asthma-related health care costs (mean, SD) per patient-year were computed according to study periods and heath resource use categories. The differences between each cost element—(1) pre-ECPA implementation and ECPA implementation; (2) pre-ECPA implementation and post-ECPA completion; and (3) ECPA implementation and post-ECPA completion—were computed as means and SDs and then assessed by the Wilcoxon Signed Rank Test.[17]

To display changes in total asthma-related health care costs within a 12-month period, scatter plots of the costs per month were presented and stratified by study period. Bar graphs were included to represent cost changes from the same month of the pre-ECPA implementation and ECPA implementation periods; the pre-ECPA implementation and post-ECPA completion periods; and the ECPA implementation and post-ECPA completion periods.

Statistical inferences. Three-level generalized linear mixed models (GLMMs) were used to estimate the effects of ECPA on asthma-related ER visits, hospital admissions, and total asthma-related health care costs per study period. GLMMs were selected because within-patient effects were of interest (change in the annual cost data of each patient from pre-ECPA implementation to ECPA implementation phases, from pre-ECPA implementation to post-ECPA completion phases, and from ECPA implementation to post-ECPA completion phases). GLMMs also account for multi-level data of ECPA as costs per period of each patient are nested within that patient. Patients who were attributed to the same clinic are also nested in that clinic.

Due to the right-skew of the health care cost data, the distribution of the costs was assessed to determine an appropriate distribution assumption. Following recommendations by Canes,[18] both non-transformed and log-transformed scales of the cost data were reviewed. We then assessed the histogram, quantile measurements[18] and the Anderson-Darling statistics of the 2 scale values with different distributions (i.e., exponential, gamma, normal, and lognormal) along with their *P*-values.[19] Lognormal distribution was chosen because its *P*-value for the Anderson-Darling test was the largest, suggesting the optimal match. In addition, the observed and estimated quantiles of the log-transformed data were most similar to the normal distribution.

The association between the ECPA effect and health care costs were analyzed using GLMMs with lognormal distribution and identity link.[18] All models allowed random-effects for patients and participating clinics. All statistical analyses were completed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). The PROC GLIMMIX procedure was utilized for statistical modeling. Regression coefficients from GLMMs were expressed as the percentage change in the cost outcome when the study period changed from a reference period (i.e., $100(e^{\beta_1}-1)$). A significance level of less than 0.05 (2-tailed) was adopted for all analyses. This study was determined to be exempt from Institutional Review Board (IRB) review by the University of Minnesota IRB due to use of existing administrative claims data.

Results

Patients were attributed to 1 of the 9 clinics from Illinois (4 clinics), New Mexico (3 clinics), and Oklahoma (2 clinics). Of 1683 included patients, 1121 (67%) received asthma care from clinics in Illinois. Clinics in New Mexico included oldest group of patients (mean=45.6 years). Most patients were female. Table 1 summarizes the demographics of the included patients with asthma. Participating clinics in Texas were excluded from analysis due to a lack of claims data availability.

Table 1. Baseline Demographic Characteristics of Patients Receiving Asthma Care from Participating Primary Care Clinics.

Characteristics	Total	Illinois	New Mexico	Oklahoma
Health centers (%)	9 (100.0)	4 (44.4)	3 (33.3)	2 (22.2)
Patients (%)	1683 (100.0)	1121 (66.6)	498 (29.6)	64 (3.8)
Age in 2012, years				
Mean (SD)	31.2 (24.0)	25.5 (22.9)	45.6 (20.5)	29.2 (21.7)
Median	22	15	51	25
Minimum-Maximum	1-93	1-93	1-90	1-81
Patients aged less than 18 years (%)	44.6	58.0	15.3	39.1
Gender				
Female	929 (55.2%)	574 (51.2%)	322 (64.6%)	33 (51.6%)
Male	754 (45.8%)	547 (48.8%)	176 (35.3%)	31 (48.4%)

Due to rounding, percentages may not always add up to 100%.
Abbreviations: SD, standard deviation.

Table 2 summarizes annual asthma-related costs stratified by study period according to the 6 resource use categories. The total annual asthma-related health care costs in the ECPA implementation and post-ECPA completion were $6 387 773 (54.0%) and $6 934 036 (58.6%) lower than the pre-ECPA implementation period, respectively. Costs due to hospital admissions and physician office and outpatient visits were the 2 highest asthma-related direct expenditures across all 3 study periods. All cost categories demonstrated a reduction when comparing pre-ECPA implementation to ECPA implementation costs and pre-ECPA implementation to post-ECPA completion costs. ER visit and hospital admission costs showed a 46.0% reduction at minimum, using the pre-ECPA implementation phase as a reference.

Average total asthma-related costs per patient-year decreased from $7033 per patient in the pre-ECPA implementation period to $3237 and $2913 in the ECPA implementation period and post-ECPA completion period, respectively. Costs per year across the 6 health resource use categories were significantly reduced from pre-ECPA implementation to implementation phases and from pre-ECPA implementation to post-ECPA completion phases (all *P*-values for the Wilcoxon Signed Ranks Test were $<.0001$). Average annual ER visit costs reduced from $268 per patient during the 12-month pre-ECPA implementation to $99 and $82 in the ECPA implementation period and post-ECPA completion period, respectively. Similar declining trends were found for the average annual hospital admission ($3463 vs $1870 vs $1659 for pre-ECPA, implementation, and post-ECPA completion periods, respectively).

To better understand how total asthma-related health care costs varied between calendar months, the costs per month were stratified and plotted (Figure 1). Monthly health care costs of the pre-ECPA implementation period were greater than the cost in the implementation and post-ECPA completion periods. During the pre-ECPA implementation period, the month of February had the highest total asthma-related health care costs. The total asthma-related health care costs of the 3 study periods formed a trough from April to August.

The GLMM analyses demonstrated that the 12-month ECPA implementation was associated with a 56.4% reduction in total annual asthma-related health care costs compared to 12-month pre-ECPA implementation (95% CI −60.7%, −51.8%; *P*-value $<.0001$). In addition, the 12-month post-ECPA completion period was also significantly associated with a 57.3% reduction in total annual asthma-related health care costs compared to the 12-month pre-ECPA implementation period (95% CI −61.7%, −52.3%; *P*-value $<.0001$). No statistically significant difference was found when comparing the total asthma-related health care costs between the 12-month implementation and post-ECPA completion periods (percent change −2.2%; 95% CI −12.0%, 8.6%; *P*-value .6754).

Discussion

This study revealed the positive, translational effect of ECPA on health care costs among patients with asthma. After ECPA introduced asthma care improvement processes among providers at the clinic level, asthma-related health care costs among 1683 patients decreased by 54.0% (from $11 836 254 in pre-ECPA implementation to $5 448 481 in implementation phases). ECPA was significantly associated with decreased total asthma-related costs during the 12-month implementation and 12-month post-ECPA completion phases compared to pre-ECPA implementation phase. The effects of the ECPA program appeared to be sustainable because GLMMs revealed a 57.3% reduction in the total asthma-related health care costs, incurred during the 12-month post-ECPA completion period. These results indicate that ECPA is an effective real-world quality improvement program that reduces asthma-related health care costs among patients who received asthma care from participating clinics.

Table 2. Asthma-Related Costs by Types of Health Resource Use in 1683 Patients with Asthma Participating in Enhancing Care for Patients with Asthma (ECPA) Program

	Costs of the attributed 1683 patients (% of the total cost)			% cost difference		
Health resource use	Pre-implementation year 2012	Implementation year 2013	Post-completion year 2014	Δ Pre to Imp	Δ Pre to Post	Δ Imp to Post
Emergency room visit	$450,439 (3.8%)	$166,077 (3.0%)	$137,743 (2.8%)	−63.1%	−69.4%	−17.1%
Hospital admission	$5,828,720 (49.2%)	$3,146,847 (57.8%)	$2,791,507 (56.9%)	−46.0%	−52.1%	−11.3%
Physician office and outpatient visits	$4,380,885 (37.0%)	$1,495,675 (27.5%)	$1,417,547 (28.9%)	−65.9%	−67.6%	−5.2%
Asthma medications	$661,344 (5.6%)	$543,869 (10.0%)	$489,785 (10.0%)	−17.8%	−25.9%	−9.9%
Durable medical equipment	$176,357 (1.5%)	$85,795 (1.6%)	$49,420 (1.0%)	−51.4%	−72.0%	−42.4%
Other	$338,509 (2.9%)	$10,217 (0.2%)	$16,215 (0.3%)	−97.0%	−95.2%	58.7%
Total	$11,836,254 (100.0%)	$5,448,481 (100.0%)	$4,902,218 (100.0%)	−54.0%	−58.6%	−10.0%

All cost components were inflated to 2014 U.S. dollars using Medical Care Services of the Consumer Price Index (CPI) retrieved from U.S. Bureau of Labor Statistics.
Abbreiviations: Δ, cost difference; Imp, 12-month implementation period; Post, 12-month post-program completion period; Pre, 12-month pre-implementation period.

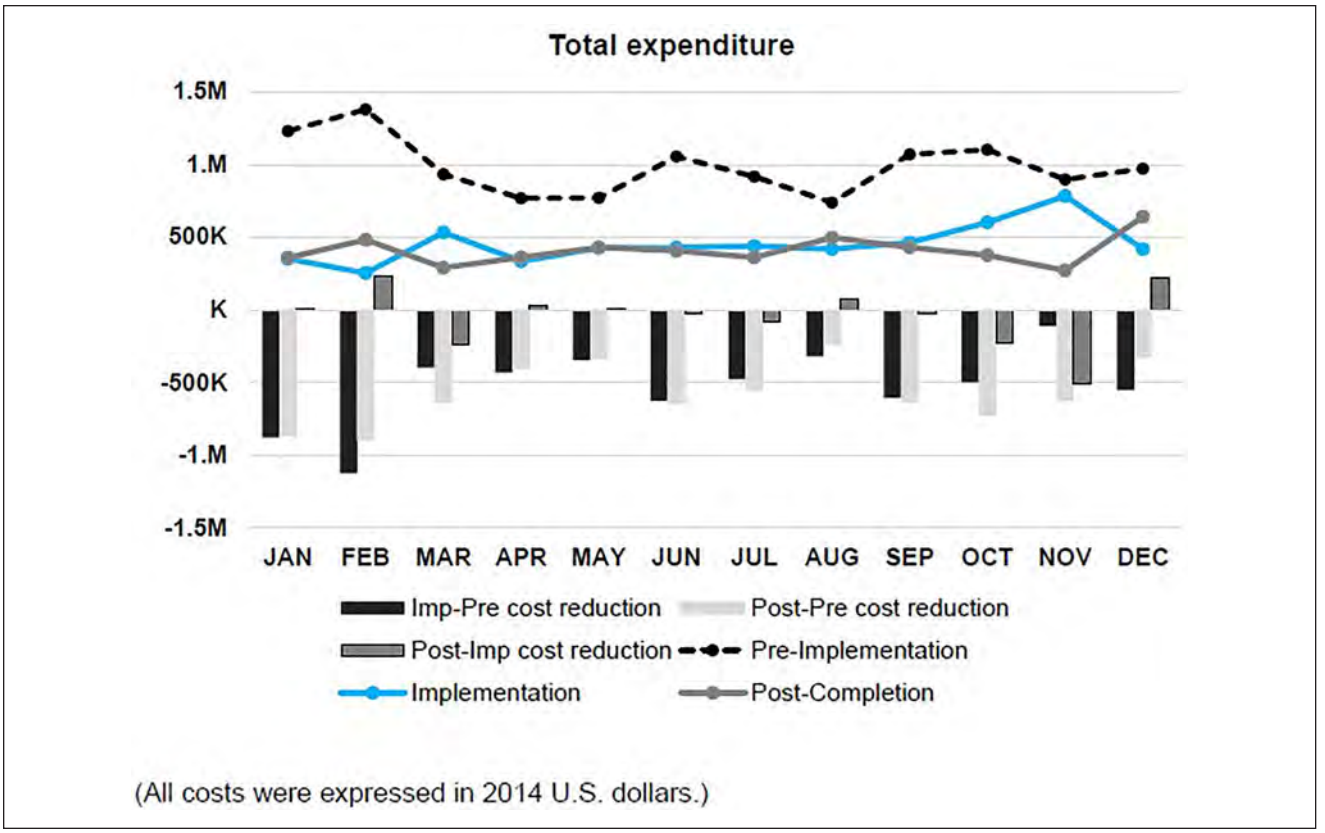

Figure 1. Costs for emergency room visits and inpatient stays per month and cost reduction using pre-implementation period as a reference.

ER visits and office and outpatient visit costs were reduced at least 60%. ER cost reduction could result from a 37.7% reduction in the rate of ER visits from the pre-ECPA implementation to ECPA-implementation phases.[12] The large reduction in physician office and outpatient visit costs may be attributable to improvements in asthma self-management among the clinic patients as learned and developed through appropriate asthma education and asthma action plan creation.[11] These self-management components are necessary for optimizing asthma control.[20,21] The EPR-3 guidelines for scheduling follow-up care depend on how well patients control their symptoms.[5] An office visit should be scheduled every 2 to 6 weeks when asthma symptoms are not well controlled. Follow-up care could then be reduced to only 2 times per year when asthma symptoms are well maintained.

The results from the 3-level GLMMs show that the quality improvement efforts among asthma care providers at the clinic level substantially and sustainably improve patient-level cost outcomes. ECPA was significantly associated with a 56.4% decrease in total annual asthma-related health care costs during the 12-month implementation period when using the costs from the pre-ECPA implementation period as a reference. The program was also explicit in its sustainable effect on the asthma-related expenditures since the total asthma-related health care costs occurred 12 months after the program completion was also significantly reduced. As per prior research stressed, most public health policy research has focused on a downstream intervention (e.g., interventions that are directly provided to patients to encourage behavioral change).[22] Moreover, those upper-level quality improvement initiatives have not emphasized patient-level health outcomes as their evaluation goals.[23] The patient-level cost reduction findings of this current study along with the demonstrated ECPA effect on minimizing rates of potentially preventable health events[12] have built empirical evidence for the development of patient-level measures derived from real-world, upper-level quality improvement interventions.

The cost patterns of total asthma-related health care due to asthma were in accordance with previous studies. For example, among Illinois patients, the observable peak was evident in February of the pre-ECPA implementation period, consistent with the published literature for that state. A majority of included patients were from ECPA-clinics located in Illinois. The health report from Illinois state[24] found that asthma-related hospital admissions in Illinois peak during January, February and March. Therefore, the

included Illinois patients might be the main contributors to the cost peak. Moreover, the total asthma-related health care costs due to asthma reached a nadir between April and August. This finding may reflect lower hospital admission expenditure during that period since the number of asthma-related hospitalizations among U.S. patients were at their lowest from June to August.[25]

There were approximately 25 million US patients with asthma in 2017.[7] Assuming that the ECPA was implemented in one-tenth clinics that treated patients with asthma, the implementation of the quality improvement program could potentially contribute to the reduction of as nearly as 5 billion US dollars to the health care system in a given year. Although the effect of the ECPA implementation in clinics with different characteristics may vary depending on how effective the program was executed among health care personnel who provided asthma care, the potential cost saving demonstrated in this study should be considered by decision makers in adopting the program with an aim to reduce financial burdens to health insurers.

This study has several strengths. First, this study used 3 years of cost data on all patients. Data from the 12-month post-ECPA completion allowed the evaluation of the program's potentially sustainable effects on the cost outcomes. Second, this study allowed a unique random intercept of each patient and clinic in the GLMM analyses to account for within-patient and within-clinic variation, resulting in precise estimates of the model parameters. Third, ECPA was implemented in different geographical states, so the results of this study reflected the effect of the initiative that was successfully executed in primary care clinics with diverse settings.

Three limitations should be considered. First, this study used administrative claims data which were subject to coding errors and potential bias derived from providers' payment maximization effort.[26] Second, this study used the same group of patients before the program was implemented as a comparison group. While all non-time dependent variables—gender, race, and ethnicity—remained stable during the three-year study period, this study could not account for time-dependent variables, such as patient age. This time-varying confounder might have biased our implementation and post-implementation modeled results toward the mean because asthma costs increase as patients age.[27] Nevertheless, the results from this study, in conjunction with the alleviation of the asthma-related ER visits and hospital admission rates,[12] could support administrative decision-making in adopting the clinic-based quality improvement approach of ECPA in other settings.

Conclusion

This study provides evidence that quality improvement efforts at the clinic level through ECPA are associated with substantially reduced patient-level, asthma-related health care costs. Implementation of ECPA contributed to more $6 million reduction in total asthma-related health care costs among the 1683 included patients of a single health insurer. The results from generalized linear mixed models revealed that ECPA was significantly associated with the reduction in total asthma-related health care costs during the 12-month ECPA implementation and 12-month post-ECPA completion periods. Given the favorable effect of ECPA on short-term and relatively long-term asthma expenditures, ECPA was an effective quality improvement program that enhanced asthma care processes at the practice-level and resulted in cost savings at the patient-level.

Acknowledgments

Enhancing Care for Patients with Asthma (ECPA) was funded by Health Care Service Corporation (HCSC)'s Healthy Kids, Healthy Families initiative to the American Lung Association. The authors would like to acknowledge the American Lung Association and HCSC for assistance in data acquisition.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Sirikan Rojanasarot was a PhD candidate during the study period in the Social and Administrative Pharmacy Program, Department of Pharmaceutical Care & Health Systems, College of Pharmacy, University of Minnesota, Minneapolis, MN. Dr. Rojanasarot is a full-time employee of Boston Scientific. Boston Scientific was not involved in this study. Dr. Karaca-Mandic provides consulting services to Precision Health Economics and Tactile Medical. These consulting activities do not have a relation to the manuscript. The other authors have no conflict of interest.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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