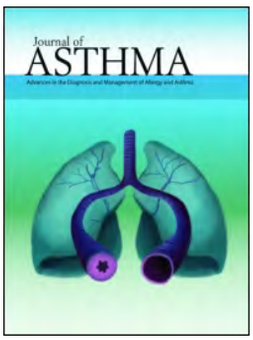

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Enhancing guideline-based asthma care processes through a multi-state, multi-center quality improvement program

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ABSTRACT

Objective: This study investigated the effectiveness of Enhancing Care for Patients with Asthma (ECPA)—a collaborative quality improvement program implemented in 65 community health centers that serve asthma patients in four states—on clinic-based asthma performance measures consistent with national guidelines. *Methods:* This study utilized a pretest-posttest quasi-experimental design. Six clinic-based performance measures of each center were collected from a retrospective chart review at time points: before the ECPA implementation; at the end of the 12-month long ECPA program; and 6 months after program completion. The effectiveness of the ECPA was assessed using generalized linear mixed models with a Poisson distribution and log link by evaluating the change in each measure from baseline to program completion, from baseline to 6-month post-program completion and from program completion to 6-month post-program completion. *Results:* The ECPA implementation was positively associated with improvement in all measures from baseline to program completion: documentation of asthma severity (rate ratio (RR) 1.314; 95% confidence interval (CI) 1.206, 1.432); Asthma Control Test (RR 3.625; 95% CI 3.185, 4.124); pulmonary function testing (RR 1.771; 95% CI 1.527, 2.054), asthma education (RR 2.246; 95% CI 2.018, 2.501), asthma action plan (RR 2.335; 95% CI 2.070, 2.634) and controller medication (RR 1.961; 95% CI 1.504, 2.556). Improvement was sustained for all six measures at the 6-month post-program completion time point. *Conclusion:* This study demonstrated the favorable effect of the ECPA program on evidence-based asthma quality measures. This program could be considered a model worth replication on a broader scale.

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Asthma; guideline-based measures; quality improvement program; quality measures; real-world analysis

Introduction

Evidence-based asthma guidelines have been developed and put into practice, but achieving asthma management goals in practice remains challenging. Expert Panel Report 3 (EPR-3): Guidelines for the Diagnosis and Management of Asthma, a well-accepted asthma guideline published in 2007 (1), stresses the importance of maintaining asthma control by reducing impairment and future risk, such as asthma exacerbation and the need for ER visits and hospitalizations. The guidelines underline four components in long-term asthma management (2). Component 1 focuses on assessing and monitoring asthma through appropriate severity and control evaluation. Component 2 emphasizes the importance of asthma self-management that includes provision of a written asthma action plan and development of a provider-patient partnership. Component 3 stresses the need for evaluating patients' triggers and minimizing exposure to them. Component 4 highlights two categories of asthma medications: long-term controllers and short-term relievers. Despite the four comprehensive asthma components the difficulties in achieving control of asthma, with issues such as misdiagnosis, poor inhaler technique, and poor adherence to treatment, have been well documented (3). Regardless of the barriers, previous research suggests that asthma control could be optimized through the implementation of EPR-3 guidelines in primary care practices (4).

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Although the implementation of asthma guidelines may result in improved asthma control, the guidelines remain underutilized in practice (5–8). Wisnivesky et al. have reported that less than half of primary care providers have used these guidelines to manage their patients, and only 9% adhere to asthma action plan provision (8), a specific EPR-3 guidelines component. Prior research has also reported that physicians indicated that they appropriately utilized asthma guidelines in their practice when they actually did not (9). Due to the gaps in asthma care quality, several interventions have been put forth to enhance asthma guideline usage (10). For instance, Cloutier et al. implemented a previous version of the EPR-3 guidelines in 20 private practices in Connecticut to improve care for children with asthma since 2001 (11). Despite these numerous and long-standing efforts, the replicability and sustainability of interventions remain somewhat questionable. There is a need for effective efforts that could be replicated in a broader sense to improve evidence-based practice among providers of patients with asthma.

Quality improvement approaches have been employed in healthcare to generate effective care in real-world settings (12). The approaches aim at bridging the gap between the current practice and what is considered best practice (13). While asthma quality improvement efforts have commenced, the goal of optimal asthma care across the country demands an effective, sustainable, and replicable quality improvement program. To enhance guideline-based asthma care processes in health centers serving patients with asthma, in 2012 the American Lung Association of the Upper Midwest (ALAUM) launched Enhancing Care for Patients with Asthma (ECPA).

The ECPA is a partnership between ALAUM and a private health insurer with the purpose of leveraging a 12-month collaborative, continuous quality improvement approach in community health centers that serve asthma patients in Illinois, New Mexico, Oklahoma, and Texas. The ECPA's overall goal was to improve asthma-related health outcomes by supporting the implementation of EPR-3 asthma-care guidelines in participating health centers: primary care clinics, pediatric clinics, multispecialty health centers, school-based and mobile clinics. The ECPA embraced the Wagner Chronic Care Model, a broadly adopted strategy for quality improvement initiatives (14), that characterizes a method for restructuring health care (15). Specifically, the ECPA adapted the six elements identified in the model as necessary to form a system with high-quality chronic disease management for asthma: 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. To create effective, standardized asthma care that complied with the EPR-3 guidelines, the Plan-Do-Study-Act (PDSA) cycle guided action-oriented learning in each center.

The ECPA has demonstrated its replicability since the program was successfully re-implemented in multiple health centers in four states within a 3-year period. Nevertheless, effectiveness and sustainability of ECPA on clinic-based performance measures have not been evaluated. The objective of this study was to evaluate the effectiveness of the ECPA on asthma performance measures in multiple health centers in four states during a recent 3-year period.

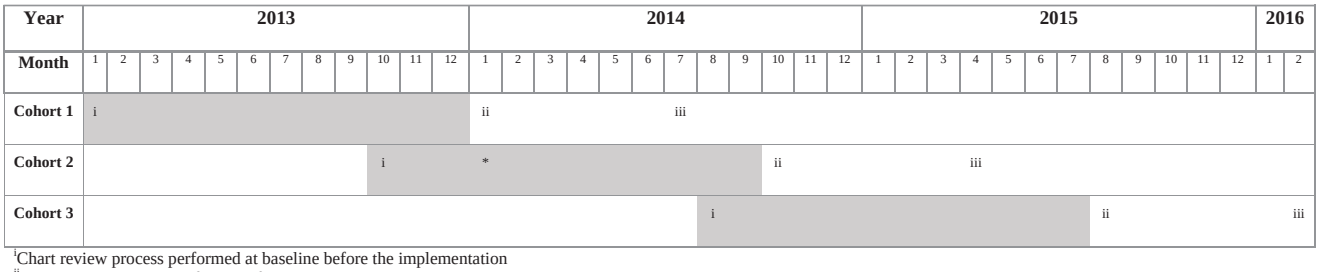
Methods

Centers were invited to participate in the ECPA through personal phone calls and face-to-face meetings with ALAUM state managers to facilitate a successful partnership. The centers that agreed to participate in the ECPA were formally assessed to ensure they had a provider and staff champion who were willing to commit to the 12-month program, had support from the various levels of administration, and did not have other organizational initiatives that would compete with the ECPA, such as recent administrative turnover, new medical directors, implementation in progress of electronic medical record systems. To effectively manage the improvement effort, the ECPA divided center recruitment and participation into three chronological cohorts: each cohort contained at least one center from each state. Figure 1 summarizes the implementation timeline of each cohort.

ECPA quality improvement efforts

Quality improvement efforts through the ECPA contain two main components: (1) improvement activities within each participating center using the PDSA cycle and (2) learning collaboratives with other centers within the same cohort. The PDSA cycle was chosen because it is an easily understood rubric for testing a quality improvement initiative that utilizes a four-step approach—create a plan to assess the initiative (P), carry out the plan (D), measure outcomes identified in the plan (S), and determine modifications needed based on the findings (A) (16,17).

Each center formed a multidisciplinary quality improvement team to champion the initiative and established asthma guideline-based objectives to accomplish goals. Within each center, the PDSA cycle was used as a strategy for improvement activities. ALAUM provided step-by-step, training, research, and technical assistance



[i]Chart review process performed at baseline before the implementation
[ii]Chart review process performed after the 12-month long program was completely implemented
[iii]Chart review process performed 6 months after the program's completion
*Participating health centers in Cohort 2 from New Mexico, Oklahoma, and Texas joined the program in October 2013. The 8 Illinois centers joined the program in January 2014.

Figure 1. The implementation timeline of each participating cohort in the Enhancing Care for Patients with Asthma Program (ECPA).

that centers used to improve the asthma care process. Every other month, the ALAUM state manager conferred with clinic staff about steps in the improvement process. In addition to meetings, monthly technical assistance calls from ALAUM were made to address individual, unique implementation problems at each center.

Representatives (minimally a clinician champion and a staff champion) from participating health centers attended learning collaboratives, facilitated by the ALAUM. In-person meetings were organized every other month to allow attendees to (1) share ideas, challenges, and successes in their ongoing improvement efforts, (2) to participate in a continuing education topic related to asthma care and guidelines, and (3) to strategize the next step of participating health centers' PDSA cycle. Representatives who could not attend the meetings in person, they participated by remote options. The learning collaboratives were meant to create a learning environment to exchange successes, troubleshoot challenges, provide continuing asthma education, and develop concrete quality improvement plans for each center once the representatives returned to their settings.

Data collection process

Since the ECPA's goal was to support the implementation of EPR-3 guidelines in practice, the ECPA employed a retrospective chart review to obtain six clinic-based performance measures at three different time points. A team member from each center, usually a nurse or a health center manager, conducted a review of approximately 30 randomly selected charts of patients with asthma seen within the previous 2 months at each of the three time points: baseline before the ECPA implementation (time = 0); at the end of the 12-month long program of ECPA activities (time = 12); and 6 months after program completion with no structural support from ECPA (time = 18). All charts were reviewed in centers that had fewer than 30 patients at any of the three time points. Centers could also elect to report the measures from all patients with asthma they served in the previous 2 months. To ensure the consistency of chart extraction, a standardized chart audit tool with key data collection for the six measures was provided to all centers, and ALAUM state program managers worked closely with each participating center during the data collection process to ensure its completeness.

ECPA outcomes

Six clinic-based performance measures consistent with the EPR-3 guideline recommendations were the outcomes of interest. The clinic-based measures included documentation of asthma severity, asthma control, and pulmonary function testing as measures of asthma assessment and monitoring; documentation of asthma education and an asthma action plan as measures of education and provider/patient partnership in asthma care; and controller medication prescription as a measure of medication use. Performance measures were reported as the number of patient charts that documented the asthma care element and the total number of charts reviewed at that time point.

In the chart review process, asthma severity was assessed as documentation of the asthma severity rating (intermittent, mild persistent, moderate persistent, and severe persistent) in patient medical record as defined in the EPR-3 guidelines. Asthma control was evaluated as documentation of the Asthma Control Test (ACT) completed by the patient or caregiver. Pulmonary function testing was a spirometry test, using a laptop-based spirometer, within the past 12 months. Asthma education was assessed as documentation of assessment and teaching on the use of the patient's medication delivery device. Asthma action plan (Appendix 1) was defined as a personalized written plan, including the patients' asthma severity classification, their asthma triggers, and the green, yellow, and red zones for medication therapy based on either personal best for peak flow measurement or symptoms. Lastly, controller medication was reported as documentation of a prescription issued for a controller medication, such as inhaled corticosteroids, to patients with persistent asthma.

Statistical analyses

For data analysis, this quasi-experimental study employed a one-group pretest-posttest design (18), in which each cohort center served as its own control before the ECPA implementation. Characteristics of participating centers from each state were reported using descriptive statistics. Characteristics included participating cohort number, specialty, number of providers, and geographic area. Participating cohorts were assigned a number from one to three based on date of ECPA initiation. Specialty refers to how the participating centers described their specialties (stand-alone primary care, including designation of family medicine and internal medicine, stand-alone pediatric clinic, multi-specialty health center, and school-based clinic and/or mobile clinic). Number of providers was defined as the number of providers with qualifications to prescribe medication. Providers were medical or osteopathic physicians, physician assistants, and nurse practitioners. Geographic area defined by the Centers for Medicare & Medicaid Services was used to classify the zip code of each participating center into urban and rural/super-rural areas. These definitions of geographic areas were selected because they were used for billing and payment purposes (19).

This study calculated the proportions of each clinic-based performance measure at baseline, program completion, and 6 months after program completion. Descriptive statistics were reported using the mean and standard deviation; median, interquartile range, minimum, and maximum values. A Wilcoxon Signed Rank Test (20) was computed to compare the performance measure: (1) at baseline with program completion and (2) at program completion with 6-month post-program completion. The null hypothesis of the test was that the median difference between pairs of time = 12 and baseline (or time = 18 and time = 12) equals zero.

The effectiveness of the ECPA was assessed in three ways: (1) the change in each clinic-based performance measure from baseline to program completion, (2) the change in each clinic-based performance measure from baseline to 6-month post-program completion, and (3) the change in each clinic-based performance measure from program completion to 6-month post-program completion. To determine implementation effects, this study adopted a generalized linear mixed model (GLMM) to account for repeated within-center measures. Since the clinic-based performance measures were collected as the number of patient charts documenting the asthma care element and the total number of charts reviewed, which could be different by centers and time points, a Poisson distribution with an offset (21) and its canonical log link were selected to model the outcomes. Cohort, state, specialty, number of providers, and geographic area were used as adjusting covariates in the model. The adjusted rate ratios (RRs), 95% confidence intervals (CIs), and corresponding p values were computed.

Due to the real-world nature of the ECPA, missing data on the six clinic-based performance measures was expected. Patient care demands relative to staff workload could hinder completion of all chart extractions, resulting in missing data. For transparency, this study reported the percentage of missing data for each measure. Review of the missing data patterns showed no monotonic patterns, meaning that the ECPA's missing data could be defined as an arbitrary missing pattern (22). Thus, this study conducted multiple imputation with a fully conditional specification (FCS) method (22–24). Cohort, state, specialty, number of providers, and indicators for geographic area were included as predictors in the imputation procedure. PROC MI, a SAS analysis procedure, was used to impute the missing values of the 6 clinic-based performance measures, with five sets of imputations for each measure. After obtaining the imputed datasets, an analysis of each dataset using GLMM was performed. PROC MIANALYZE was used to combine the analytical results and form a single inference.

All analyses were conducted using SAS software, version 9.3 of SAS System for Windows (SAS Institute, Inc., Cary, NC, USA). A two-sided alpha level set at 0.05 was used for hypothesis testing. The use of the data for the analyses was determined to be exempt from the University of Minnesota's Institutional Review Board (IRB) review.

Results

Eighty centers were invited to participate in the ECPA. Of those, 65 agreed to join the improvement program (participation rate = 81.25%). At the end of program implementation (time = 12), none of the 65 centers had dropped out of program participation (100% retention rate). Table 1 summarizes the characteristics of the participating centers overall and by the four states. Illinois had the highest number of participating centers (22 centers representing 23 distinct physical locations); Oklahoma had the lowest number of participating centers (eight centers representing 16 distinct physical locations). The majority of participating centers were stand-alone primary care clinics and were located in urban areas. The median number of providers in participating centers was ≤ 13 in each state.

Table 2 shows descriptive statistics for the six clinic-based performance measures at three different time points. In total, 1,616 charts before the ECPA implementation, 1,409 charts at the end of the 12-month long ECPA

Table 1. Characteristics of participating centers in the Enhancing Care for Patients with Asthma Program (ECPA).

Characteristics	4 States 65 Centers 75 Locations	IL 22 Centers 23 Locations	NM 18 Centers 19 Locations	OK 8 Centers 16 Locations	TX 17 Centers 17 Locations
Participating cohort (number of centers)					
Cohort 1 (January 2013)	23 (35.4%)	8 (36.4%)	7 (38.9%)	3 (37.5%)	5 (29.4%)
Cohort 2 (October 2013)	23 (35.4%)	8 (36.4%)	4 (22.2%)	4 (50.0%)	7 (41.2%)
Cohort 3 (August 2014)	19 (29.2%)	6 (27.3%)	7 (38.9%)	1 (12.5%)	5 (29.4%)
Specialty					
Stand-alone primary care clinic	24 (36.9%)	5 (22.7%)	8 (44.4%)	2 (25.0%)	9 (52.9%)
Stand-alone pediatric clinic	12 (18.5%)	3 (13.6%)	4 (22.2%)	3 (37.5%)	2 (11.8%)
Multi-specialty health center	15 (23.1%)	2 (9.1%)	5 (27.8%)	3 (37.5%)	5 (29.4%)
School-based or mobile clinic	14 (21.5%)	12 (54.5%)	1 (5.6%)	0	1 (5.9%)
Number of providers					
Mean (SD)	23.63 (40.2)	18.18 (46.7)	20.89 (26.0)	25.71 (40.6)	40.38 (49.1)
Median	6	2	11	9	13
Interquartile range	2–21	2–11	4–19	3.5-80	4–17
Minimum-Maximum	1–219	1–219	1–73	2–156	3–127
Geographic area					
Urban	49 (75.0%)	22 (100.0%)	3 (16.7%)	7 (87.5%)	17 (100.0%)
Rural and super rural	16 (25.0%)	0	15 (83.3%)	1 (12.5%)	0

IL = Illinois; NM = New Mexico; OK = Oklahoma; TX = Texas; SD = Standard deviation.

program, and 1,368 charts at 6 months after program completion were reviewed. Before the ECPA implementation, at least three-fourths of the participating centers reported less than half of patients having documentation for the following guideline-based components: ACT, pulmonary function testing, asthma education, and asthma action plan. At baseline, median asthma severity reporting and pulmonary function testing was zero, meaning that, before the ECPA implementation, patients attributed to at least 50% of participating centers did not have ACT or pulmonary function testing documented.

After program implementation, the median of all measures increased from baseline to program completion and from baseline to 6-month post-program completion. ACT documentation had the highest absolute median improvement from 0% at baseline to 79% at time = 12 and 88% at time = 18. Moreover, at least 50% of participating centers had 100% of patients with documentation of a prescribed controller medication at program completion and at 6 months after program completion. Asthma severity and ACT performance measures revealed a slight uptrend from month 12 to month 18, and no performance measures returned to baseline levels. There

Table 2. Overall performance on clinic-based performance measures.

Measures	Time points[a]	Median	Interquartile range	Minimum-Maximum	Wilcoxon Signed Ranks Test (*p* value)[b]	% Missing
Asthma severity	Baseline	67%	20–95%	0–100%	NA	0%
	Program completion	94%	71–100%	20–100%	402.5 (<.0001)*	14%
	6-month post-completion	96%	68–100%	0–100%	43 (0.5400)	11%
Asthma Control Test	Baseline	0%	0–24%	0–100%	NA	0%
	Program completion	79%	60–97%	70–100%	599 (<.0001)*	17%
	6-month post-completion	88%	53–100%	0–100%	29.5 (0.6357)	28%
Pulmonary function testing	Baseline	0%	0–30%	0–100%	NA	0%
	Program completion	29%	40–55%	0–100%	363 (0.0001)*	8%
	6-month post-completion	17%	0–30%	0–100%	−184 (0.0362)*	6%
Asthma education	Baseline	23%	0–46%	0–100%	NA	0%
	Program completion	72%	42–95%	0–100%	690.5 (<.0001)*	6%
	6-month post-completion	57%	30–90%	0–100%	−219.5 (0.0326)*	6%
Asthma action plan	Baseline	12%	0–40%	0–95%	NA	0%
	Program completion	57%	27–85%	0–100%	717 (<.0001)*	6%
	6-month post-completion	50%	16–87%	0–100%	−72 (0.4520)	6%
Controller medication	Baseline	80%	0–100%	0–100%	NA	0%
	Program completion	100%	89–100%	0–100%	342 (<.0001)*	17%
	6-month post-completion	100%	86–100%	39–100%	−19 (0.6732)	20%

Note. NA = Not applicable.

[a] Chart review was completed to collect the 6 clinic-based performance measures at three time points: baseline (time = 0), program completion (time = 12), and 6-month post-completion (time = 18).

[b] A Wilcoxon Signed Ranks Test compared the clinic-based performance measures at baseline to program completion and at program completion to 6-month post-completion.

* Asterisks indicate statistical significance of a Wilcoxon Signed Ranks Test at $\alpha = .05$.

Table 3. Estimates from a complete case analysis of implementation effects on clinic-based performance measures.

Measures	Change from reference	Rate ratio	95% Confidence interval		*p* value
Asthma severity	Baseline	Ref	N/A	N/A	N/A
	Program completion	1.314	1.206	1.432	<.0001*
	6-month post-program completion	1.368	1.256	1.490	<.0001*
Asthma Control Test	Baseline	Ref	N/A	N/A	N/A
	Program completion	3.625	3.185	4.124	<.0001*
	6-month post-program completion	3.048	2.678	3.469	<.0001*
Pulmonary function testing[†]	Baseline	Ref	N/A	N/A	N/A
	Program completion	1.771	1.527	2.054	<.0001*
	6-month post-program completion	1.575	1.343	1.847	<.0001*
Asthma education	Baseline	Ref	N/A	N/A	N/A
	Program completion	2.246	2.018	2.501	<.0001*
	6-month post-program completion	2.006	1.794	2.243	<.0001*
Asthma action plan	Baseline	Ref	N/A	N/A	N/A
	Program completion	2.335	2.070	2.634	<.0001*
	6-month post-program completion	2.219	1.967	2.503	<.0001*
Controller medication[‡]	Baseline	Ref	N/A	N/A	N/A
	Program completion	1.961	1.504	2.556	<.0001*
	6-month post-program completion	2.186	1.691	2.826	<.0001*

Note. Ref = Reference; N/A = Not applicable.

*Asterisks indicate statistical significance at $\alpha = .05$.

Complete case analyses of generalized linear mixed regression assuming Poisson distribution with an offset and its canonical log link were used to estimate the implementation effects of ECPA on clinic-based performance measures, accounting for cohort, state, specialty, number of providers, and geographic area.

Example interpretation of results:

- At program completion, participating centers were associated with 1.314 times higher improvement rate in documenting asthma severity, compared to the centers at baseline (95% CI 1.206, 1.432).
- At 6-month post-program completion, participating centers were associated with 1.368 times higher improvement rate in documenting asthma severity, compared to the centers at baseline (95% CI 1.256, 1.490).

†At 6-month post-program completion, participating centers were associated with a 25% reduction in the rate of documenting pulmonary function testing compared to the centers at program completion (RR = 0.750; 95% CI 0.655, 0.860; *p* value < .0001).

‡At 6-month post-program completion, participating centers were associated with 1.387 times higher improvement rate in documenting controller medication, compared to the centers at program completion (95% CI 1.254, 1.534; *p* value < .0001).

was a statistically significant improvement in all measures from baseline to 12-month post-implementation and from baseline to 6-month post-program completion.

The percentage of missing data for each measure at each time point is reported in Table 2. ACT and controller medication documentation at 6-month post-program completion had the highest percentage of missing data with 28% and 20%, respectively.

Tables 3 and 4 report the results of adjusted mixed-effect models from complete case and multiple imputation analyses, respectively. The findings from the two analyses are nearly identical for the changes in the six clinic-based performance measures. The adjusted rate ratios of change from baseline (time = 0) to program completion (time = 12) and to 6-month post-program completion (time = 18) of all measures were significantly greater than one, indicating that completing the ECPA implementation and 6 months after the ECPA implementation were associated with positive improvement rates in the performance measures. Specifically, centers instituting the quality improvement initiative were associated with approximately four times higher documentation of ACT at program completion, compared to before the program was implemented (adjusted RR from a complete case analysis = 3.625; 95% CI 3.185, 4.124; adjusted RR from multiple imputation = 3.852; 95% CI 3.406, 4.355).

Additionally, in terms of the change from program completion to 6-month post-program completion, quality improvement program implementation was associated with statistically significant increased improvement in documentation of a prescription issued for a controller medication (adjusted RR from a complete case analysis = 1.387; 95% CI 1.254, 1.534; adjusted RR from multiple imputation = 1.287; 95% CI 1.175, 1.411). However, at 6-month post-program completion documentation of pulmonary function testing was 25% lower as compared to at time = 12 (adjusted RR from a complete case analysis = 0.750; 95% CI 0.655, 0.860; adjusted RR from multiple imputation = 0.768; 95% CI 0.656, 0.900). The changes of other measures did not show statistically significant results. Similar results were seen when multiple imputation method was used.

Discussion

This study showed the effectiveness of a staggered, multi-state, and multi-center quality improvement program (Enhancing Care for Patients with Asthma Program or ECPA) on asthma guideline-based performance measures. The program was successfully implemented with 100% retention rate in 65 health centers from 4 states. Employing both complete case and multiple imputation

Table 4. Multiple-imputation estimates of implementation effects on clinic-based performance measures.

Measures	Change from reference	Rate ratio	95% Confidence interval		Minimum	Maximum	*p* value
Asthma severity	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	1.440	1.330	1.559	1.439	1.441	<.0001*
	6-month post-program completion	1.295	1.142	1.469	1.253	1.369	0.0005*
Asthma Control Test	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	3.852	3.406	4.355	3.812	3.954	<.0001*
	6-month post-program completion	3.781	3.193	4.479	3.653	3.966	<.0001*
Pulmonary function testing[†]	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	1.948	1.623	2.339	1.825	2.079	<.0001*
	6-month post-program completion	1.488	1.279	1.731	1.467	1.518	<.0001*
Asthma education	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	2.210	1.993	2.450	2.195	2.228	<.0001*
	6-month post-program completion	1.919	1.717	2.145	1.873	1.951	<.0001*
Asthma action plan	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	2.315	2.026	2.645	2.266	2.434	<.0001*
	6-month post-program completion	2.254	1.986	2.557	2.197	2.309	<.0001*
Controller medication[‡]	Baseline	Ref	N/A	N/A	N/A	N/A	N/A
	Program completion	1.972	1.516	2.565	1.961	1.992	<.0001*
	6-month post-program completion	2.185	1.700	2.809	2.184	2.187	<.0001*

Note. Ref = Reference; N/A = Not applicable.

*Asterisks indicate statistical significance at $\alpha = .05$.

Multiple imputation with five sets of imputations for generalized linear mixed regression assuming Poisson distribution with an offset and its canonical log link were used to estimate the implementation effects of ECPA on clinic-based performance measures, accounting for cohort, state, specialty, number of providers, and geographic area.

Example of interpretation:

- At program completion, participating centers were associated with 1.440 times higher improvement rate in documenting asthma severity, compared to the centers at baseline (95% CI 1.330, 1.559).
- At 6-month post-program completion, participating centers were associated with 1.295 times higher improvement rate in documenting asthma severity, compared to the centers at baseline (95% CI 1.142, 1.469).

[†] At 6-month post-program completion, participating centers were associated with a 23.2% reduction in the rate of documenting pulmonary function testing compared to the centers at program completion (RR = 0.768; 95% CI 0.656, 0.900; *p* value 0.0017).

[‡] At 6-month post-program completion, participating centers were associated with 1.287 times higher improvement rate in documenting controller medication, compared to the centers at program completion (95% CI 1.175, 1.411; *p* value < .0001).

analyses, this study demonstrated a significant improvement in all clinic-based performance measures before the implementation and completion of the ECPA. The study revealed an increase in controller prescription among patients attributed to the participating health centers 6-month post-program completion. The overall findings of this study suggest that the ECPA is an effective and replicable quality improvement program with positive impact on measures adhering to EPR-3 guidelines and with potential sustainability.

Prior to the ECPA implementation, there were huge needs for an effective quality improvement program that supports asthma care processes in health centers serving patients with asthma. Before the program implementation, at least three-quarters of the health centers joining the ECPA had less than 50% of their patients having documentation of ACT, pulmonary function testing, asthma education, and an asthma action plan. The apparent lack of guideline-based asthma care components is consistent with results from another quality improvement initiative implemented in 1999 in 16 health centers located in the Chicago metropolitan area (25). This initiative utilized a coordinated care approach and reported that, before its implementation, only 20% of adults and 62% of children with asthma received a treatment plan for asthma exacerbation. The coherent results illustrate a compelling and continuing need for an effective approach to improving evidence-based practice among providers of patients with asthma.

The ECPA demonstrated its effectiveness in improving clinic-based performance measures that are consistent with EPR-3 guidelines. Notably, the probability of participating centers having documented evidence for all performance measures at program completion was significantly higher than the probability at baseline. The findings are compatible with a systematic review evaluating interventions that aim at improving health care provider adherence to asthma guidelines (10). The review reported that two out of three quality improvement programs, using a learning collaborative or a team-based improvement process, increased the percentage of patients with an asthma action plan. The overall improvement in the guideline-based measure after the ECPA completion suggest an effective practical application of the ECPA quality improvement approach, consisting of improvement activities within each center via the PDSA cycle and use of learning collaboratives with other participating centers. The findings also confirm the success of the

quality improvement program in health centers with diverse characteristics and within different states.

Participating centers at 6 months after program completion had higher rates of documenting controller medication prescription compared to at program completion, revealing the sustainability of the ECPA on the measure. After health centers participated in the ECPA, it is plausible that ALAUM facilitated the provision of controller medications among health-center patients. For instance, ALAUM provided the centers with a spirometer for better assessment of asthma control and manifestations to adjust therapy. The appropriate support may enable providers at the participating centers to select proper controllers and dosing, resulting in higher documentation of controller medication prescription among patients with asthma.

Compared to program completion, pulmonary function testing measure showed a small decrease at 6-month post-program completion. This result indicates the possibility that pulmonary function testing could continue to decline without periodic reminders. Once the ECPA ended, clinic staff may have been required to engage in other new, competing priorities requiring efforts in other-disease improvement programs (26). It is also possible that, once health centers realize their declining asthma performance, they could take Step 4 (Act) of the PDSA cycle to refine what action they should take to improve the performance back to a higher stage. Anecdotally, participating health centers have applied the PDA to other priority needs, such as depression, chronic obstructive pulmonary disease, attention deficit hyperactivity disorder, and child immunization, based on the framework that has been presented by ALAUM. Since the PDSA cycle is an essential component of the ECPA and potentially contributes to the sustainability of asthma care quality improvement, clinic staff should be proficient in the PDSA mechanism. In order for health centers to maintain high performance on measures for varied conditions, they should construct a performance assessment (PDSA) calendar to review each set of measures on a regular basis. One strength of the ECPA program was 100% retention of the 65 participating health centers during a 12-month program implementation. It is likely that the relationships that developed through technical calls and participation in a learning collaborative contributed to this retention rate, although this was not evaluated in this study. The continued participation of all centers offers encouraging evidence about collaboration between the ECPA and participating centers.

Another strength of this study is the relatively small amount of missing data from the 6 clinic-based performance outcomes. ACT documentation at 6-month post-program completion was the only data variable with more than 20% missing data, reducing the potential for bias (27). Moreover, this study utilized both complete case and multiple imputation analyses to derive estimates of ECPA implementation effects on the clinic-based measures. The two analyses reveal complementary results that strengthen the reliability of the study. According to a systematic review investigating the effectiveness of chronic disease management programs for adults with asthma, 7 out of 14 controlled trials executed in primary care, outpatient, or health management organization settings provided inadequate information to assess missing data (28). This implies that the completeness of outcome data is often overlooked among studies focusing on improving asthma care quality.

There are two main limitations to this study. First, this study did not randomize centers into intervention and control groups. Although randomized controlled trials are known as the standard for the evaluation of healthcare interventions (29), their limited generalizability hinders their use in evaluating the effect of quality improvement efforts in real-world settings (30). This study employed a one-arm quasi-experimental design, which is suitable for use in real-life practice because each participating center served as its own control. This pre-post study design is widely used in program evaluation (31), when a clear control group cannot be established. Second, the outcomes of this study were derived from a retrospective chart review, so the quality of the outcomes depends on the accuracy and consistency of the chart review process (32). Nevertheless, formal training and a standardized chart audit tool with data collection keys were provided to all centers to ensure the consistency across all participating centers. Third, all clinic-based performance measures were intermediate, provider-focused outcomes that indicate the adoption of the asthma guidelines in practice.

Because of the clinic focus, patient outcomes were not evaluated in this study. However, previous research has revealed a positive association between the clinic-level performance measures and asthma patient outcomes, such as hospital admissions and emergency room visits (33). In addition, further understanding of the impact of the ECPA on asthma outcomes should include other patient-centered measures of satisfaction with care and improvement of quality of life. The Chronic Care Model, on which the ECPA program is based, suggests that optimal care for chronic diseases such as asthma are best achieved when there is an prepared, proactive practice team and an informed, activated patient that is highly satisfied with the care they receive (34). This study has addressed the former component, but additonal work will elucidute the patient aspect that has not been discussed in this study.

Conclusion

This study suggests the effectiveness of the ECPA program on important asthma quality measures as defined in a national asthma guideline. The ECPA implementation may serve as a model for other statewide quality improvement initiatives in enhancing guideline-based asthma care processes in health-center settings. There is a need to further examine the effect of the ECPA program on health care utilization, costs, and other patient-centered outcomes.

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Declaration of interest

Pinar Karaca-Mandic provides consulting services to Precision Health Economics and Tactile Medical. These consulting activities do not have a relation to the manuscript.

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Appendix 1: The American Lung Association Asthma Action Plan.

Asthma Action Plan

AMERICAN LUNG ASSOCIATION.

Name _____ DOB ____/____/_____

Severity Classification ☐ Intermittent ☐ Mild Persistent ☐ Moderate Persistent ☐ Severe Persistent

Asthma Triggers (list) _____

Peak Flow Meter Personal Best _____

Green Zone: Doing Well

Symptoms: Breathing is good – No cough or wheeze – Can work and play – Sleeps well at night
Peak Flow Meter _____ (more than 80% of personal best)

Control Medicine(s)	Medicine	How much to take	When and how often to take it
	_____	_____	_____
	_____	_____	_____

Physical Activity ☐ Use albuterol/levalbuterol ____ puffs, 15 minutes before activity
☐ with all activity ☐ when you feel you need it

Yellow Zone: Caution

Symptoms: Some problems breathing – Cough, wheeze, or chest tight – Problems working or playing – Wake at night
Peak Flow Meter _____ to _____ (between 50% and 79% of personal best)

Quick-relief Medicine(s) ☐ Albuterol/levalbuterol ____ puffs, every 4 hours as needed

Control Medicine(s) ☐ Continue Green Zone medicines
☐ Add _____ ☐ Change to _____

You should feel better within 20–60 minutes of the quick-relief treatment. If you are getting worse or are in the Yellow Zone for more than 24 hours, THEN follow the instructions in the RED ZONE and call the doctor right away!

Red Zone: Get Help Now!

Symptoms: Lots of problems breathing – Cannot work or play – Getting worse instead of better – Medicine is not helping
Peak Flow Meter _____ (less than 50% of personal best)

Take Quick-relief Medicine NOW! ☐ Albuterol/levalbuterol ____ puffs, _____ (how frequently)

Call 911 immediately if the following danger signs are present
- Trouble walking/talking due to shortness of breath
- Lips or fingernails are blue
- Still in the red zone after 15 minutes

Emergency Contact Name _____ Phone (_____) _____-_____

Healthcare Provider Name _____ Phone (_____) _____-_____

1-800-LUNGUSA | LUNG.org

Date ____/____/_____