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Sibylle H. Lob, Jennifer Holloman Boer, Patricia G. Porter, David Núñez and Patrick Fox

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Promoting Best-Care Practices in Childhood Asthma: Quality Improvement in Community Health Centers



WHAT'S KNOWN ON THIS SUBJECT: Clinical asthma management is suboptimal. Asthma morbidity continues to be a substantial contributor to pediatric health disparities. The authors combined continuous quality improvement and care coordination to significantly reduce asthma morbidity and improve the quality of life of children and adolescents.



WHAT THIS STUDY ADDS: Targeting a much larger population of children than the previous study, a more focused, but less intensive, technical-assistance approach resulted in major improvements in care and health outcomes for a large group of primarily low-income, minority children with asthma.

abstract

OBJECTIVE: Outpatient asthma management remains suboptimal. We previously reported significant improvements in asthma guideline adherence and outcomes in children by using quality-improvement processes and community health workers. We hypothesized that a larger project could achieve comparable outcome improvements with streamlined quality-improvement processes and decreased technical assistance.

METHODS: Seventeen clinics treating 12 000 children with asthma were evaluated through interviews of a subset of patients with persistent or high-risk asthma ($n = 761$) at baseline and at 12 and 21 months and chart reviews randomly selected from all patients with asthma at baseline and 12 and 24 months ($n = 2040$). Multidisciplinary teams developed data-driven continuous quality-improvement activities. Asthma coordinators provided patient education and were active team members.

RESULTS: Study children were predominantly Hispanic (77%) and black (11%); 60% were enrolled in Medicaid, and 9% were uninsured. Comparing results between baseline and the 21-month follow-up, significantly fewer families reported emergency-department visits (29.6% vs 9.3%), hospitalizations (10.9% vs 3.4%), frequent daytime symptoms (44.0% vs 11.7%), and missed school days (28.7% vs 13.6%); significantly more reported confidence in asthma management (70.6% vs 95.5%); and quality-of-life scores increased significantly for both children and caregivers (all $P < .05$). Cross-sectional data revealed significant clinic-wide improvements in symptom documentation, health care use, and review of action plans.

CONCLUSIONS: On a larger scale, this approach realized impressive changes in provider clinical practice associated with major improvements in health outcomes. It holds great potential for significantly reducing asthma-related morbidity among low-income children. *Pediatrics* 2011;128:20–28

AUTHORS: Sibylle H. Lob, MD, MPH,^{a,b} Jennifer Holloman Boer, MS,^{a,b} Patricia G. Porter, RN, MPH,^{a,b} David Núñez, MD, MPH,^{a,b} and Patrick Fox, PhD^a

^aInstitute for Health and Aging, School of Nursing, University of California, San Francisco, California; and ^bCalifornia Asthma Public Health Initiative, California Department of Public Health, Sacramento, California

KEY WORDS

asthma, quality of care, continuous quality improvement, care coordination, pediatrics, evidence-based practice, guideline adherence, quality of life, health disparities

ABBREVIATIONS

NAEPP—National Asthma Education and Prevention Program
CQI—continuous quality improvement
RTTM—regression to the mean

All authors contributed substantially to the conception and design of the study and to the evaluation plan. Dr Lob performed the majority of the data analysis, and all authors were closely involved in the interpretation of the data. All the authors participated in drafting or revising the article, each adding important intellectual content. All authors approved the final version of the manuscript.

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Address correspondence to Patrick Fox, PhD, Institute for Health and Aging, University of California, San Francisco, 3333 California St, San Francisco, CA 94143-0646. E-mail: pat.fox@ucsf.edu

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Despite the availability of National Asthma Education and Prevention Program (NAEPP) guidelines, the quality of asthma care in the United States remains suboptimal.¹ Adherence to 17 NAEPP asthma care quality indicators is only 45.5%.² Compared with white children, black and Hispanic children are less likely to receive anti-inflammatory medications and timely follow-up care after an asthma emergency-department visit and have a 2.6- and 2-times-higher emergency-department visit rate, respectively.^{1,3–8} Only 14% of community health center patients had documentation of an asthma-management plan.⁹ Much remains to be done to improve pediatric asthma care, especially in low-income and minority groups.

From 2001 to 2004, we conducted a demonstration, the California Asthma Among the School-aged Project, to improve asthma care for largely low-income, minority, school-aged children. Community health workers were combined with continuous quality-improvement (CQI) strategies to increase NAEPP guideline compliance. Care processes and clinical outcomes improved dramatically.¹⁰ To increase dissemination, we streamlined the CQI process by preselecting tools and topic areas for action. We streamlined reporting, feedback, and teleconferences and used a similar program-staffing pattern while increasing the program from 7 to 17 clinics and adding children ages 0 to 5 years. The asthma coordinator function was retained, but we did not require home visits for all patients. We hypothesized that this “scaled-down” intervention would improve compliance with NAEPP guideline-based care and improve asthma-related outcomes for children and caregivers.

PATIENTS AND METHODS

Study Population and Design

Seventeen community health centers in California participated in the 28-month translational research project

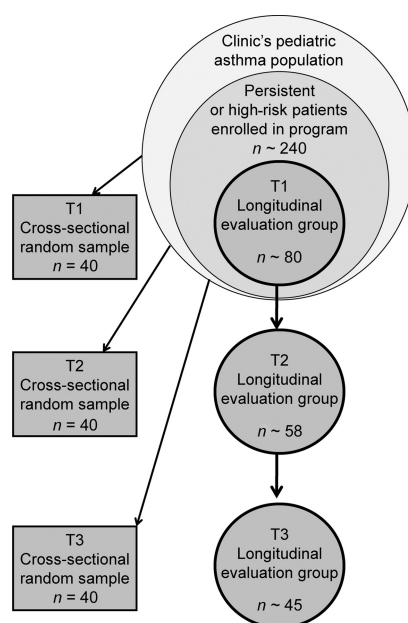


FIGURE 1

Clinic chart review (left) and patient interview sampling and follow-up evaluation (right) designs. *T_n* indicates time *n*.

(2006–2008), with 2 centers having participated in our previous CQI project in the same clinic or provider setting. Small to very large clinics served between 140 and 2100 predominantly low-income and minority children with asthma annually. A quasi-experimental design was used to examine patient-level (longitudinal) and clinic-level (cross-sectional) outcomes over time (see Fig 1). For the former, ~80 children per site with persistent or high-risk asthma (on the basis of the risk criteria below) were enrolled consecutively by site physicians at clinic visits. They were identified during visits or through claims data or asthma registries. These children were interviewed at baseline and annually thereafter to assess the impacts on care processes and patient outcomes. On average, another 160 children were subsequently enrolled and received care coordination by the asthma coordinator but were not interviewed. This ensured that ~240 children per clinic were enrolled in the program. The following were the eligibility criteria: age

0 to 18 years; seen by a primary care provider for asthma in the 6 months before referral; and English- or Spanish-speaking (for the initial 80 children). Diagnostic criteria included asthma (*International Classification of Diseases, Ninth Revision* [ICD-9] codes 493.00–493.92) and an asthma clinical risk index¹¹ for children aged 5 years or younger. A negative index did not automatically exclude children from being enrolled. Children aged 5 years or younger with a diagnosis of bronchitis, bronchiolitis, or wheezing were eligible if providers still suspected asthma (on the basis of the referring providers' clinical judgment). Only 11 of 1350 children who were enrolled at baseline did not have an asthma ICD-9 code (all aged 5 years or younger). Additional inclusion criteria were having 1 of the following asthma risk criteria in the 6 months before referral: use of 2 or more asthma medicines; 1 or more asthma hospitalizations or 1 or more unscheduled asthma clinic or emergency-department visits; or symptoms consistent with persistent asthma severity classifications at referral (as judged by the referring providers). Per the study protocol, providers received training in diagnosis and severity classification of asthma according to NAEPP guidelines. The clinic-level, cross-sectional evaluation assessed whether care improvements extended beyond the children who were followed longitudinally. Forty charts were selected annually from each site's entire pediatric asthma population using a different random sample each time. Eligibility criteria included the following: age 0 to 18 years; asthma diagnosis (ICD-9 codes 493.00–493.92); and at least 1 primary care provider visit for asthma in the previous 12 months. The Committee on Human Research at the University of California, San Francisco, approved the study.

Intervention

Multidisciplinary CQI teams were formed at each site with a “clinician champion” (physician or nurse practitioner), an asthma coordinator, and other clinical and nonclinical staff. Each clinic used a team-based, systematic, data-driven CQI process to implement changes in patient education and at least 2 of 3 additional core components (asthma visit flow sheet, asthma action plan, and home trigger assessment). The asthma coordinator ensured that information collected through patient interactions was incorporated into CQI planning and provided coordination of CQI interventions and program activities, care management, and linkages among providers, home, school, and community. Asthma coordinators were health educators, community health workers, medical assistants, or respiratory therapists. A central technical-assistance team provided each site with (1) NAEPP guideline–derived (2002 update¹²) care standards agreed to by each CQI team and target goals determined by the technical-assistance team (eg, 90% of patients receive trigger education) (see Table 2); (2) assistance and oversight for consistent application of the CQI model; (3) training for asthma coordinators to work with patients and families; and (4) data collection and reporting procedures. Technical assistance and training on asthma assessment and management (partly by external experts) was provided through annual program-wide meetings and site visits; tailored site training opportunities; monthly clinician champion and bimonthly all-site teleconferences; individualized written and verbal feedback on monthly or bimonthly progress reports; and an asthma resources Web site. Updated tools used in the CQI process (eg, flow sheet and the asthma action plan) are available at betterasthmacare.org.

Data Collection

Patient-level data were collected using closed fixed-response interviews conducted by the asthma coordinators at baseline (time 1), 12 months (time 2), and 21 months (time 3). To control for seasonality, only time 2 interviews conducted within 4 weeks of the baseline interview anniversary were analyzed. The time 3 follow-up had to be conducted at 21 months because the study start was delayed and enrollment took longer than expected. Chart reviews were conducted by clinic staff at baseline (time 1), 12 months (time 2), and 24 months (time 3), reviewing the most recent visit in the previous 12 months. Although we were using a previous version of the NAEPP guidelines, many of our measures are consistent with asthma control and risk assessment in the Expert Panel Report 3.¹³ Quality-of-life information was collected from patients aged older than 7 years and all caregivers using validated instruments.^{14,15} Interviewers and chart reviewers were provided extensive training. Details on outcome measures are shown in [Supplemental Text](#).

We combined interview and chart review measures to create several aggregate site-level effect measures averaging out each site’s variation between indicators. We calculated relative improvement scores for each outcome measure and ranked the sites.¹⁰ A mean overall outcome rank was calculated across care-process indicators for the chart review data, as were mean overall, clinical, symptom, and process outcome ranks for the interview data.

We refined our previous model adherence assessment tool to measure the relationship between the degree of adherence to the intervention model and outcomes.¹⁰ The tool included 17 objectives within 4 categories: CQI application; clinician champion performance; asthma coordinator performance; and

responsiveness to technical assistance (see [Supplemental Appendix](#)). Each objective described optimal systems and processes. Before site follow-up data were available, the project director and coordinator independently scored the items and developed consensus scores for each item. Site adherence ranks were calculated by ranking the sum of the 17 scores.

Statistical Analysis

In the final analysis, ordinal variables were dichotomized. For patient-level data, the Obuchowski method extending the McNemar test to clustered matched-pair data and the test of symmetry were used.¹⁶ Bivariate analyses for clinic-level data used Pearson χ^2 , Fisher’s exact, and 2-sample *t* tests.

In initial models, stepwise logistic regression for clinic-level data used the intervention effect, the site effect, and all demographic variables. Final models included intervention effects as well as covariates and interaction terms with $P < .05$. To examine correlations between outcomes and model adherence, we performed linear regression analyses, regressing mean outcome ranks against the model adherence rank. Initial models included (and retained if $P < .05$) the size of the clinics’ pediatric asthma population, as well as proportions of black patients, uninsured patients, children younger than 5 years of age, and patients with moderate or severe persistent asthma. These variables were included because some population subgroups have worse clinical outcomes and are potentially more likely to have better chart documentation or receive guideline-recommended care. Statistical analyses were performed with SAS 9.2 (SAS Institute, Cary, NC).

RESULTS

The sites served a population of ~12 000 children with asthma annu-

TABLE 1 Demographic and Clinical Characteristics

Indicator	Clinic-Level Chart Review Samples						Patient-Level Interview Sample			
	Time 1		Time 2		Time 3		<i>P</i> ^a	Time 1		<i>P</i> ^b
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%		<i>n</i>	%	
Gender, male	680	59.6	680	57.9	680	59.4	.95	761	58.7	.75
Race/ethnicity	631		633		638			761		
Black		10.9		11.4		10.3	.67		6.7	.001
Hispanic		76.9		75.8		77.1			85.3	
White		5.9		7.1		7.2			3.9	
Other		6.3		5.7		5.3			4.1	
Health care coverage	662		672		676			759		
None		9.2		7.7		8.6			7.5	
Medi-Cal MC		51.7		61.6		58.4	.002		60.5	<.0001
Medi-Cal FFS		8.0		6.4		10.5			6.6	
Other government programs		16.9		12.1		11.2			19.1	
Private		13.6		10.7		9.9			5.5	
Other		0.6		1.5		1.3			0.8	
Severity classification ^c	392		537		600			561		
Intermittent		43.9		42.3		36.3			22.6	
Mild persistent		36.0		34.1		44.5	.014		49.2	<.0001
Mod persistent		19.9		22.0		18.0			25.8	
Severe persistent		0.3		1.7		1.2			2.3	
Age ^d	680	7.6 (7.0)	680	8.0 (7.5)		8.1 (7.7)	.07	761	7.4 (6.9)	.47

^a Comparing time 1 with time 3.^b Comparing time 1 between clinic-level chart review and patient-level interview samples.^c *n* is low at time 1 because of poor documentation (that improved over time).^d Data are mean (median).

ally. A total of 4049 children were enrolled in the study; the first 1350 patients were enrolled in the patient-level evaluation group and interviewed at baseline. Of these, 761 (56%) patients were available for interviews at both time 2 and time 3.

Demographic and Clinical Characteristics

Table 1 displays demographic and clinical characteristics of the clinic-level chart review and patient-level interview samples. In the chart samples, a significant difference exists for health care coverage between time 1 and time 3 with an increase in Medicaid patients. Asthma severity changed significantly, and it is noteworthy that the documentation itself of asthma severity increased (58% of patient charts had a documented severity classification at time 1 and 88% at time 3). Comparing patient-level and clinic-level samples at time 1, we found expected differences in asthma severity because the patient-level sample was designed to include

persistent or high-risk asthma patients. Furthermore, the patient-level sample included more Hispanic patients, more Medicaid managed care, and fewer privately insured patients.

Loss to Follow-up

In the patient-level evaluation group, 27% of patients were lost to follow-up or did not complete the time 2 interview within 4 weeks of their baseline anniversary. By time 3, another 17% were lost. The group lost to follow-up included fewer Medicaid managed care (52% vs 60%; *P* = .003), more privately insured (15% vs 6%; *P* < .0001), and fewer Hispanic (75% vs 85%; *P* < .0001) patients but showed no significant difference in asthma severity, clinical outcomes, or care processes at baseline, except for slightly more children with frequent nighttime symptoms (51% vs 45%; *P* = .03).

Clinic-Level Analysis

Aggregated chart reviews showed a highly significant time 1 to time 2 and

time 2 to time 3 increase (Pearson χ^2 *P* < .0001) in all care-process outcomes except prescribed controller medications (already 93% at baseline). Because logistic regression models revealed significant variations in the degree of change across clinics, we describe in detail the changes between time 1 and time 3.

Overall, documentation of day or nighttime symptoms increased from 32% and 26% at time 1 to 71% and 67% at time 3, respectively. In 13 and 14 clinics, respectively, the change was significant (*P* < .05) or the clinics met the 90% target goal. Acute care visits were documented in 4% of charts at time 1 and increased to 50% at time 3 (12 of 17 clinics improved significantly). Documentation of emergency-department visits and hospitalizations increased from ~17% to ~60%, with a significant change in 11 and 12 clinics, respectively. Documentation of asthma-related missed school days increased from 6.5% at time 1 to 59% at time 3,

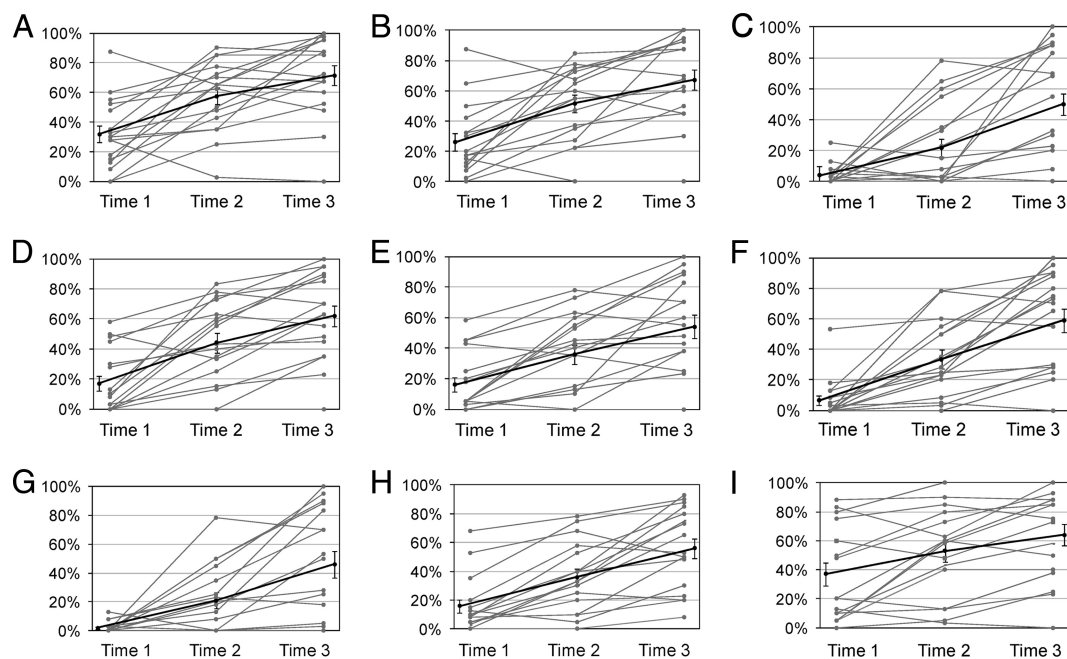


FIGURE 2

Care-process outcomes (documentation at the last visit) for chart review samples. Each community health center is represented by a gray line connecting the outcome at times 1, 2, and 3. The overall (program-level) mean $\pm$ SE is represented by a black line, with the ends slightly displaced from the individual clinic data for clarity. A, Day symptoms documented; B, night symptoms documented; C, acute visits documented; D, emergency-department visits documented; E, hospitalizations documented; F, missed school documented; G, missed work documented; H, Asthma Action Plan created, updated, or reviewed; I, environmental tobacco smoke exposure assessment.

with 14 of 17 clinics showing significant improvement. Documentation that an asthma action plan was created, updated, or reviewed at the last visit tripled from 16% to 56%. In 13 clinics, the increase was significant or the 90% goal was reached. At time 1, 37% of patients were asked about environmental tobacco smoke exposure increasing to 64% at time 3 (significant improvement in 11 clinics). Figure 2 shows variation across clinics over time.

Patient-Level Analysis

Table 2 lists patient-level outcomes at time 1, time 2, and time 3, with significant improvements in clinical outcomes, care processes, correct use of medications, patient confidence, and quality-of-care ratings. Results were not homogeneous across clinics either. On average, 70% of clinics showed significant improvement between time 1 and time 3 or reached the target goal for each indicator. Most im-

provement occurred in the first year. Of 761 children, 44% were 5 years of age or younger and 77% of these had a positive clinical risk index. When children with a negative index ($n = 79$) were excluded from the analyses, results were unchanged. Outcomes at all 3 time points were within 2 percentage points of the results for the full group. Subgroup analyses according to age (0–5, 6–11 or ≥ 12 years) showed that generally, 0- to 5-year-old children experienced higher health care use at baseline with greater absolute reduction in percentage points but not necessarily greater relative improvement. In all 3 age categories, improvements were statistically significant for all indicators except hospitalizations in children aged 6 to 11 years and those aged 12 years or older, caregivers missing work for children aged 12 years or older, and spacer use for children aged 6 to 11 years. Another subgroup analysis ac-

cording to size of pediatric asthma population (0–399, 400–799, or ≥ 800 patients) showed no consistent differences between subgroups. A final subset analysis excluded the 2 clinics that had participated in our previous CQI project with results within 2 percentage points of the full group for almost all indicators.

Model Adherence

As shown in Fig 3, model adherence scores attained by the clinics ranged between 31 and 75 (of a possible 85), with a mean score of 55. Because intervention effects on care-process and clinical outcomes differed among the clinics, we were able to compare each site's outcomes to its adherence to the intervention model by linear regression. For the clinic-level data, a significant linear relationship ($R^2 = 0.29$; $P = .026$) existed between the sites' model-adherence ranks and mean overall outcome ranks (calculated across chart review care-process indi-

TABLE 2 Care Process and Clinical Outcomes: Patient-Level (Interview) Sample

Indicator	<i>n</i>	Time 1, <i>n</i> (%)	Time 2, <i>n</i> (%)	Time 3, <i>n</i> (%)	<i>P</i> ^a	No. of clinics with <i>P</i> < .05 and/or reached goal
Patients who experienced daytime symptoms more than twice a week in the past 2 weeks	761	335 (44.0)	112 (14.7)	89 (11.7)	.002	13/17 ⁱ
Patients who experienced nighttime symptoms more than twice a month in the past 2 weeks	761	341 (44.8)	145 (19.1)	113 (14.8)	.003	11/17 ⁱ
Patients who used rescue medications frequently in the last 2 weeks (more than 2 times per week) ^a	484	149 (30.8)	49 (10.1)	38 (7.9)	.002	12/16 ⁱ
Patients with any acute office or clinic visit attributed to asthma in the past 6 months	760	378 (49.7)	200 (26.3)	156 (20.5)	.006	11/17 ^j
Patients with any emergency-department visits attributed to asthma in the past 6 months	761	225 (29.6)	57 (7.5)	71 (9.3)	.009	8/17 ^j
Patients with any hospitalization attributed to asthma in the past 6 months	761	83 (10.9)	10 (1.3)	26 (3.4)	.008	6/17 ^j
Patients who missed any school in the past month because of asthma ^b	537	154 (28.7)	78 (14.5)	73 (13.6)	.019	5/16 ^j
Caregivers who missed any work in the past month because of the child's asthma ^c	400	87 (21.8)	39 (9.8)	24 (6.0)	.009	10/16 ^j
Patient's provider reviewed written asthma action plan with the patient at the last visit	761	307 (40.3)	512 (67.3)	571 (75.0)	.011	11/17 ^k
Any health care provider ever asked about exposure to asthma triggers ^d	725	415 (57.2)	688 (94.9)	698 (96.3)	.002	15/17 ^k
Any health care provider ever provided trigger education ^d	713	376 (52.7)	689 (96.6)	699 (98.0)	.001	16/17 ^k
Patients who have rescue medications, know they are rescue medications, and use them correctly	761	470 (61.8)	661 (86.9)	695 (91.3)	.002	14/17 ^k
Patients with PERSISTENT asthma who take controller medications, know they are controller medications, and take them correctly ^e	278	169 (60.8)	220 (79.1)	236 (84.9)	.029	10/16 ^k
Patients who always use spacers ^f	632	454 (71.8)	554 (87.7)	560 (88.6)	.040	10/17 ^k
Patients who rate asthma care as excellent or very good	761	519 (68.2)	660 (86.7)	685 (90.0)	.006	12/17 ^k
Patients who feel confident managing their asthma	761	537 (70.6)	705 (92.6)	727 (95.5)	.009	16/17 ^k
Patients with "very good" quality of life (defined as a mean score ≥ 6) ^g	299	127 (42.5)	230 (76.9)	252 (84.3)	.003	12/16 ^k
Caregivers with "very good" quality of life (defined as a mean score ≥ 6) ^g	680	212 (31.2)	437 (64.3)	492 (72.4)	.002	11/17 ^k

^a Includes only children who had rescue medications and knew they were rescue medications at all 3 time points.^b Includes only children who attended school, preschool, and daycare at all 3 time points.^c Includes only children whose parents or guardians worked at all 3 time points.^d Excludes children and families who answered "not sure" at any time point.^e Includes only children who had documentation of persistent asthma at all 3 time points.^f Includes only children with metered dose inhaler medication at all 3 time points.^g Includes only children and caregivers who completed a quality-of-life interview at all 3 time points. Children were only asked to complete quality-of-life interviews if they were 7 years of age or older (49% of all patients at baseline). One clinic did not collect any child quality-of-life data.^h Adjusted McNemar test for clustered matched-pair data comparing times 1 and 3.ⁱ Target goal is 10%.^j Target goal is 0%.^k Target goal is 90%.

cators) with no other significant covariates in the model. This finding demonstrates that care-process indicators measuring compliance with NAEPP guidelines improved in direct proportion to compliance with the components of the intervention model. No correlation between model adherence and care processes was found comparing time 3 outcomes to either time 1 or time 2. Likewise, for patient outcomes in the longitudinal interview

sample, no simple linear relationship existed between model adherence and summary outcomes.

DISCUSSION

This multifaceted CQI and care-coordination intervention was associated with significantly improved care processes, clinical outcomes, and quality of life. Care processes improved not only for the children followed longitudinally but also clinic

wide. Even with the streamlined model serving more clinics, we were able to achieve similar improvements as in our previous efforts.¹⁰

Because we were unable to include a control group in this translational research study, it is impossible to know exactly how much improvement was a result of regression to the mean (RTTM) or other secular trends. RTTM is likely if patients are selected for a

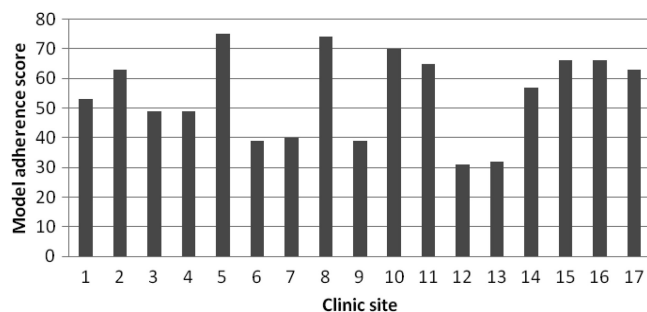


FIGURE 3

Model adherence score (of a possible 85) according to clinic site.

study because of recent urgent health care use or acute symptoms. Our eligibility criteria included recent acute visits or hospitalizations. However, this was 1 of 3 criteria, and only 1 had to be fulfilled. As a result, about half of the participants were selected because of the other 2 criteria (2 or more asthma medications or persistent asthma). Furthermore, at baseline our patients were not as acutely ill as those in many asthma studies we reviewed.^{17–29}

To assess the size of the potential RTTM for clinical outcomes, we examined control groups of trials in the pediatric asthma literature that reported equivalent utilization measures to ours at the 1-year follow-up. Our improvements were always greater, usually substantially so, than those found in any usual care control groups that were roughly similar in baseline use to our patients (ie, between half and twice the mean number of urgent clinic visits, emergency-department visits, or hospitalizations).^{19–22,30} This is especially significant because the control group patients tended to be more acutely ill at baseline, predisposing them to more RTTM. The sample size weighted average across utilization outcomes showed a relative improvement for these controls of 40% in mean urgent clinic visits, emergency-department visits, and hospitalizations, presumably as a result of RTTM and other secular trends. Because we found an average reduction of 75%

across the same variables (data not shown), the remaining 35% reduction was likely a result of program impacts, a substantial and clinically significant change. Even when we did subset analyses modifying our sample to better match the age range of the published comparison control groups, our average reduction only dropped 2% (from 75% to 73%, data not shown). Furthermore, our reductions in mean urgent clinic visits, emergency-department visits, and hospitalizations were greater than those found in the intervention groups of these trials.

Another limitation of our study is possible social desirability interview bias because the patients' asthma coordinators conducted the interviews. To examine this issue, we compared the outcomes for interviews by asthma coordinators who had changed since the previous interview ($n = 83$) to those who had not changed. We found no consistent trend toward better outcomes for established asthma coordinators.

Most clinical outcome improvement occurred between time 1 and time 2, as compared with process outcomes, which improved steadily from time 1 to time 3. The clinical improvement in the first year was likely somewhat exaggerated as a result of RTTM. The change in the second year was not as dramatic, at least partly as a result of a floor/ceiling effect for some vari-

ables and to a truncated time 3 follow-up interval (only 9 months between times 2 and 3). As such, interviews were conducted much closer to the cold and flu season than the previous 2 interviews.

Twelve of 17 clinics improved significantly or reached target goals for at least half the measures. This is remarkable because small sample sizes at the clinic level made it hard to reach statistical significance, and the challenging target goals were difficult to meet. There were striking differences between clinics, with some significantly improving or meeting the goal for almost all indicators, whereas the least successful clinic improved for only one-third of the indicators. This variation could partially be explained by model adherence. We found a significant correlation between model adherence (mainly adherence to CQI principles) and improvements in care-process outcomes from time 1 to time 2. This linear relationship disappeared by time 3, possibly as a result of a ceiling effect for higher performers and because of "slower" and more reluctant clinics catching up (especially because the intensity of technical assistance by the central team was based on clinic progress). The correlation with model adherence during the first year suggests that closely following CQI processes is a forceful driver for clinic-wide improvements in care processes. On the basis of our experience, strong, collaborative leadership by a clinician champion who seeks multidisciplinary input and buy in, as well as a clinic administration that supports the CQI team and holds it accountable for CQI processes are crucial for success. Because our project was based in community health centers, which typically face many barriers implementing CQI activities, we believe that the intervention is not only replicable but actually may be easier to imple-

ment in other settings (eg, in a more resource-rich health plan setting). It is generalizable to other diseases and populations (eg, adults) because the same CQI and care-coordination techniques can be used.

We were unable to separate the effects of CQI strategies from the contribution of the asthma coordinators. The literature^{27,31–45} shows that each approach can lead to improvements in asthma care and outcomes. Research also suggests that multipronged interventions have the strongest effect, which lends support to combining both strategies.^{46–48} Several studies^{35,36,49} similar to ours used quality-improvement strategies and asthma coordinators. One project combined quality-improvement strategies like provider education and clinical process redesign with asthma coordinators who, like ours, were active in case management, coordination of quality-improvement activities, and community outreach.^{35,36} This approach

resulted in significant improvements in care processes and clinical outcomes that were slightly smaller than in our study but in a population that was less symptomatic. Similar to our experience, the authors stress the importance of the entire system joining in the goal of improving outcomes, shared learning in a collaborative group, rapid feedback and sharing results with providers, and clinician ownership through use of physician champions, as well as clinicians leading the design process. A more recent study⁴⁹ produced strong improvements in clinical outcomes (similar to ours) through quality-improvement strategies (such as flowcharts, program standards, and asthma action plans) and asthma coordinators providing patient education and program coordination. Our study differs in the use of fairly strict Plan-Do-Check-Act CQI techniques, centralized technical assistance, and more detailed care-process and quality-of-life measures.

CONCLUSIONS

Efforts such as ours, using a comprehensive approach to improving asthma care, hold great potential for reducing health disparities among disadvantaged population subgroups of children at high risk for the adverse consequences of poorly controlled asthma. It is clear that this can be accomplished and is an important component of an overall strategy for reducing the substantial burden of asthma.

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Promoting Best-Care Practices in Childhood Asthma: Quality Improvement in Community Health Centers

Sibylle H. Lob, Jennifer Holloman Boer, Patricia G. Porter, David Núñez and Patrick Fox

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Supplemental Information

OUTCOME MEASURES

Data collected for the patient-level, longitudinal interview sample included gender, birth month and year, race/ethnicity, health care coverage, primary language spoken at home, ICD-9 diagnosis code, and clinical risk index (all only at time 1); asthma severity level; frequency of day and nighttime symptoms in the past 2 weeks; asthma-related acute clinic visits, emergency-department visits, and hospitalizations in the past 6 months; asthma-related missed school and caregiver work days in the past month; rescue and controller medications currently prescribed and whether taken correctly; spacer use with metered dose inhaler medication; environmental tobacco smoke exposure and smoking status; asthma trigger assessment and trigger education by provider; possession and understanding of asthma action plan, as well as review with the provider at the last visit; influenza vaccination in the past 12

months; confidence in managing asthma; and rating of the quality of asthma care provided. The latter 2 items were measured on a 5-point Likert scale. Responses were dichotomized in the final analysis. Patients and their families strongly agreeing or agreeing with the statement “I am confident about managing my (your child’s) asthma” were considered “confident.” Quality-of-life information was collected from patients aged 7 years or older using the validated Pediatric Asthma Quality of Life Questionnaire with Standardized Activities and from caregivers of all children using the self-administered Pediatric Caregiver’s Asthma Quality of Life Questionnaire.^{14,15} Patients and their families were considered to have reported “very good” quality of life if they had a mean score of 6 or higher (of a possible score of 7) on the quality-of-life questionnaires.

Data collected by chart review for the clinic-level, cross-sectional sample included gender, birth month and year,

race/ethnicity, and health care coverage; documentation of asthma severity at the last visit and in the 6 months prior to the last visit; prescribed rescue and controller medications; influenza vaccination in the past 12 months; and documentation of the following at the most recent asthma visit: day and nighttime symptoms; asthma-related acute clinic visits, emergency-department visits, and hospitalizations; asthma-related missed school days and caregiver missed work days; whether environmental tobacco smoke was assessed and whether there was exposure; and whether an asthma action plan was created, updated, or reviewed at the last visit or in the past 12 months. For documentation of symptoms, utilization, and asthma-related missed school or work, we also assessed whether an accompanying time frame was specified (eg, number of emergency-department visits in the past 6 months). Only if a time frame was specified did we count these items as documented.

SUPPLEMENTAL APPENDIX

Model Adherence Scoring Tool

CQI Application Section

CQI Team Performance Standard (Expectation)	Score (1–5 scale) 1 = Strongly Disagree 3 = Neither Agree or Disagree 5 = Strongly Agree
1. Utilizes a multidisciplinary Asthma CQI Team that meets at least once a month and includes appropriate representation by staff who care for children with asthma.	1 2 3 4 5
2. Uses a multidisciplinary team approach to improve the quality of asthma care with CQI activities.	1 2 3 4 5
3. Asthma CQI interventions and processes have objectively measurable indicators that will directly impact outcomes and accurately track intermediate steps toward a goal.	1 2 3 4 5
4. Applies changes to systems of care based on the information gained through specific measurable indicators of asthma CQI interventions and AC activities.	1 2 3 4 5
5. Thoroughly tests asthma CQI interventions before dissemination.	1 2 3 4 5
6. Attendance and participation by clinician champions and asthma coordinators at teleconferences, meetings and trainings.	1 2 3 4 5
7. Applies all CQI interventions to the entire pediatric asthma population. This includes all clinics involved in care for the population.	1 2 3 4 5
8. Uses a systematic method for the development, implementation and evaluation of CQI activities (this may include the description of a possible trial run before full implementation).	1 2 3 4 5
9. Has reasonable, specific and measurable outcome goal(s)	1 2 3 4 5
10. Seeks input from provider/staff outside of current members of the CQI team on the development, implementation and evaluation of CQI activities	1 2 3 4 5

SUPPLEMENTAL APPENDIX Continued

Clinician Champion Progress Section

APL Performance Standard (Expectation)	Score (1–5 scale) 1 = Never meets Expectation 5 = Always meets Expectation
1. Is an active and integrated member of the clinic-based CQI team who plans, leads, and is responsible for the coordination of all project-related CQI processes, interventions, and activities.	1 2 3 4 5
2. Supports and ensures that clinic health care providers are in compliance with National Asthma Education and Prevention Program (NAEPP) guidelines for the diagnosis, treatment and management of asthma in children.	1 2 3 4 5
3. Takes into consideration monthly/bi-monthly written feedback from the Asthma Program TA Team as evidenced in reports.	1 2 3 4 5
4. Continue to maintain clinic-wide healthcare provider and administrative buy-in to support CQI interventions and related changes in the care process for children with asthma.	1 2 3 4 5

Asthma Coordinator Progress Section

AC Performance Standard (Expectation)	Score (1–5 scale) 1 = Never meets Expectation 5 = Always meets Expectation
1. Actively and regularly participates in the asthma CQI team and during team meetings.	1 2 3 4 5
2. Information is collected at home visits, clinic visits, or through community outreach and is incorporated into a patient plan of care and/or CQI plan for all children with asthma, when applicable.	1 2 3 4 5
3. AC offers and supports asthma program-related services and is incorporated at all clinics (no more than two) during the project period.	1 2 3 4 5