Quality Improvement–Driven Reduction in Countywide Medicaid Acute Asthma Health Care Utilization

Elizabeth D. Allen, MD; Tricia Montgomery, MPH; Gloria Ayres, BS; Jennifer Cooper, PhD; Joshua Gillespie, MAEd; Sean P. Gleeson, MD; Judith Groner, MD; Stephen Hersey, MD; Gerd McGwire, MD; Courtney Rowe, CPNP-AC; Dane Snyder, MD; David Stukus, MD; Kristin S. Stukus, MD; Christopher Timan, MD; Neal Wegener, BS; Richard J. Brilli, MD

From Pediatric Pulmonology (ED Allen), Respiratory Therapy (G Ayres), The Center for Surgical Outcomes Research (J Cooper), Ambulatory Pediatrics (J Groner, S Hersey, and D Snyder), Hospital Pediatrics (G McGwire), Pediatric Allergy/Immunology (D Stukus), Pediatric Emergency Medicine (KS Stukus), Neonatology (C Timan), Data Resource Center (N Wegener), Chief Medical Officer (RJ Brilli), Nationwide Children's Hospital; Quality Improvement Services (T Montgomery), The Ohio State University Wexner Medical Center; Operations (J Gillispie), President (SP Gleeson), Children's Community Practices (C Rowe), Partners for Kids, Columbus, Ohio

The authors have no conflicts of interest to disclose.

Address correspondence to Elizabeth D. Allen, MD, Division of Pediatric Pulmonology, Nationwide Children's Hospital, 700 Children's Dr, Columbus, OH 43205 (e-mail: beth.allen@nationwidechildrens.org).

Received for publication June 25, 2018; accepted December 27, 2018.

ABSTRACT

OBJECTIVE: This study evaluates the impact of a coordinated effort by an urban pediatric hospital and its associated accountable care organization to reduce asthma-related emergency department (ED) and inpatient utilization by a large, countywide Medicaid patient population.

METHODS: Multiple evidence-based interventions targeting general pediatric asthma care and high health care utilizers were implemented using standardized quality improvement methodologies. Annual asthma ED and inpatient utilization rates by 2- to 18-year-old members of an accountable care organization living in the surrounding county (>140,000 eligible members in 2016), adjusted per 1000 children from 2008 through 2016, were analyzed using Poisson regression. We compared these ED utilization rates to national rates from 2006 to 2014.

RESULTS: Asthma ED utilization fell from 18.1 to 12.9 visits/1000 children from 2008 to 2016, representing a 28.7% reduction, with an average annual decrease of 3.9% ($P < .001$), during a time when national utilization was increasing. Asthma inpatient utilization did not change significantly during the study period.

CONCLUSIONS: Asthma-related ED utilization was significantly reduced in a large population of primarily urban, minority, Medicaid-insured children by implementing a multimodal asthma quality improvement program. With adequate support, a similar approach could be successful in other communities.

KEYWORDS: accountable care organization; inpatient asthma; outpatient asthma; pediatric asthma; population health

ACADEMIC PEDIATRICS 2019;19:216–226

WHAT'S NEW

Quality improvement strategies improve asthma outcomes in studies; however, translating these successes to large populations is challenging. We demonstrate that improving asthma outcomes for large Medicaid-insured urban populations is possible via coordinated, multifaceted interventions spanning hospital, primary care, and community settings.

ASTHMA IS A highly prevalent pediatric illness responsible for significant morbidity and mortality. In 2016, 8.3% of US children had a current asthma diagnosis, with over half having experienced an attack.[1] Racial differences in prevalence and severity are intensified by poverty-related hardships[2] and contribute to increased health care utilization by inner-city children with asthma. At Nationwide Children's Hospital (NCH), children with asthma utilize a significant portion of emergency department (ED) and inpatient (IP) care. Responding to the community's needs and the desire to improve the quality and the value of care provided,[3,4] our hospital identified reducing asthma morbidity as a quality strategic focus area in 2010.

Copyright © 2018 by Academic Pediatric Association

Inconsistent provision of guideline-based asthma care contributes to poor asthma outcomes.[5] Multiple interventions, directed at provider care and/or home management, have successfully improved outcomes within specific intervention groups[6–8]; however, to our knowledge, there has been only a single report[9] of improvement in asthma outcomes across a large, urban, high-risk, Medicaid-insured pediatric population. Exemplified by the Controlling Asthma in American Cities Project,[10] it has become increasingly recognized that, to successfully impact asthma on a large scale, multiple interventions via multilevel, multigroup collaboration is required.

Our implementation strategy utilized a multipronged approach to achieve a positive impact on countywide asthma morbidity. We recruited multidisciplinary teams from multiple departments to identify and implement evidence-based asthma care practices utilizing quality improvement (QI) methodology.[11,12] Our projects intentionally mixed interventions aimed at improving the care of all our asthma patients with programs targeting those children noted to have particularly high asthma morbidity. The specific aim of our asthma QI project was to reduce hospital asthma-related ED and IP visit use by patients 2 to 18 years old who lived in Franklin County, Ohio, and were members of its accountable care organization (ACO) by 3% per year.

METHODS

CONTEXT

Nationwide Children's Hospital is a large, freestanding quaternary children's hospital centrally located in Franklin County, an urban area with a metropolitan population exceeding 2 million.[13] In Franklin County, 23.4% of the population is under 18 years of age; 67.9%, 23.3%, and 5.5% of the population are white, black, or Hispanic/Latino, respectively; and 16.6% live in poverty.[14] In 2016, NCH managed greater than 90,000 ED visits and more than 27,000 inpatient stays in its 616 beds. Asthma was the fourth most common reason for both ED care (2927 visits) and inpatient stays (greater than 1000 stays). NCH is associated with one of the nation's oldest and largest pediatric ACOs, Partners for Kids (PFK). In 2016, PFK was responsible for the health care of approximately 320,000 Medicaid managed care patients. Franklin County ACO children constituted 46% of the statewide ACO population and generated 64% of ACO asthma-related ED and urgent care visits. NCH's 11 primary care clinics provide care for nearly half of the Franklin County ACO population. Eighty-three percent of the NCH-primary care asthma population is Medicaid insured; this population is 65% black, 17% white, and 9% Hispanic, and 10% have limited English proficiency.[15]

INTERVENTIONS

TEAM DEVELOPMENT

A multidisciplinary asthma oversight committee led by a pediatric pulmonologist acted as a central planning and communication hub for inpatient and outpatient asthma QI activities. This committee included multidisciplinary leadership representing IP care, ED, NCH-primary care, home-based asthma education, general pediatrics, pediatric hospitalists, pediatric pulmonary and allergy specialists, community providers, and school outreach programs, along with representatives from pharmacy, pediatric residency, respiratory therapy, nursing, and quality improvement services. The asthma oversight committee created a key driver diagram (Fig. 1) to illustrate the rationale behind the overall QI program. The committee then coordinated focus teams to execute interventions based on National Heart, Lung, and Blood Institute Expert Panel guidelines,[16] published reports of effective pediatric asthma tools and programs,[6–8,17–20] and local experience with previous asthma activities.

OVERALL INTERVENTION STRATEGY

Each focus team utilized Institute for Healthcare Improvement QI methodologies, including brainstorming, key driver diagram development, plan–do–study–act cycles, data collection evaluated through control charts, and regular feedback to clinical teams and individual providers that focused on clinical outcome- or process-related aims. Multiple interventions were intentionally launched simultaneously during our project. Impacting health outcomes at a population level requires multidimensional changes; sustaining program support requires demonstrating impact on a timely basis.

INDIVIDUAL FOCUS TEAM INTERVENTIONS

Inpatient focus team interventions.—The inpatient team originally convened to implement routine provision of a home care management plan compliant with Joint Commission Children's Asthma Care measures,[18] known locally as an Asthma Action Plan (AAP), to children admitted for asthma. Team focus subsequently shifted to developing standardized note templates[17] and admission order sets that guided care and supported control assessment with adjustment of controller therapies prior to discharge. Controller medication in-hand at discharge[18] and multiplatform (group, one-on-one, video) education were also provided (Table 1).

NCH-primary care focus team interventions.—The earliest formal primary care asthma QI work was done in conjunction with the American Academy of Pediatrics Chapter Quality Network programs.[20] These programs utilized the Institute for Healthcare Improvement Collaborative Model for Achieving Breakthrough Improvement. Participants attended group learning sessions and then returned to their practices to implement evidence-based asthma care via QI techniques. Subsequently, NCH-primary care activities shifted to internally generated interventions. After implementing routine provision of AAPs at asthma visits, NCH-primary care asthma patients were targeted for Asthma Control Test[21,22] screening[23] and standardized note-driven assessment (initially during asthma-specific visits and subsequently during all clinic visits). Finally, goals were established for guideline-adherent medication escalation or step-up therapy for poor control. Additionally, asthma

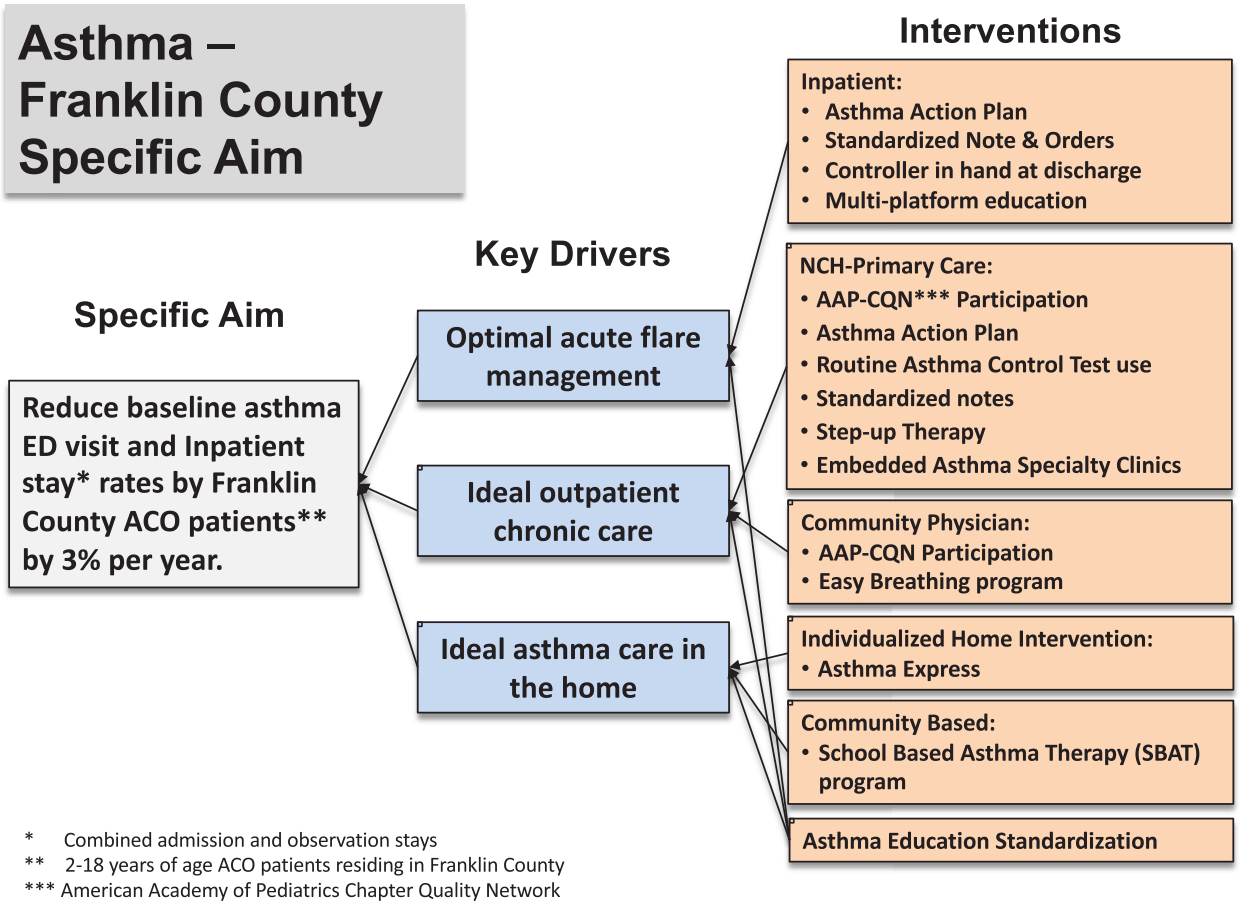

Figure 1. *Key driver diagram.*

Table 1. Interventions, Time Course of Implementation, Process Measures Achieved, and Outcome Measures Listed by Focus Team

Focus Team	Initial Year	Year Peak Level Reached	Intervention/Process	Impact/Outcome Assessment
Inpatient	2009	2012	Asthma Action Plan (90%)	30-d asthma-related ED return rate
	2011	2012	Standardized history and physical template (80%)	
	2011	2016	Asthma order set (90% of non-ICU inpatient stays)	
NCH-primary care	2009	2011	AAP-CQN participation (5 clinics)	Asthma ED utilization rate per 1000 NCH-primary care patients
	2011	2012	Asthma Action Plan given for asthma-specific visits (80%)	
	2012	2015	Asthma assessment note—any PCN visit, regardless of reason for visit (65%)	
	2013	2014	Asthma Control Test—any PCN visit (75%)	
	2015	2016	Step-up therapy for uncontrolled asthma (50%)	
	2011	2016	Embedded asthma specialty clinics (250 visits/mo)	
Community physician	2009	2011	AAP-CQN Chapter 2 (6 sites)	(No direct outcome measure established)
	2013	2016	Easy Breathing (>3000 asthma patients enrolled, >1800 from Franklin County)	
Asthma Express	2012	2014	Standardized asthma curriculum: hospitalized patients prioritized for enrollment (474 patients)	90-day asthma ED use post completion of Asthma Express participation
	2015	2015	Addition of home assessment, high-efficiency particulate air vacuum + allergen-resistant bedding (253 patients)	
	2016	2016	Return to educational focus; motivational interviewing techniques added (214 patients)	
School-Based Asthma Therapy	2013	2016	Student enrollment: 367 student participants by December 2016	Pre-enrollment vs post-enrollment asthma ED and inpatient visits[25]

ED indicates emergency department; NCH, Nationwide Children's Hospital; ICU, intensive care unit; AAP-CQN, American Academy of Pediatrics Chapter Quality Network; and PCN, primary care network.

specialty clinics were established throughout the network. These clinics were staffed by NCH-primary care providers who employed intensified education and case management techniques for a proven reduction of asthma-related ED utilization (Table 1).[24]

Community provider focus team.—Community asthma QI work also initially involved American Academy of Pediatrics Chapter Quality Network programs. Subsequently, Easy Breathing, a validated, primary-care-focused asthma management program[6] offering maintenance of certification credits, was sponsored for this setting. Some community provider groups launched their own internal asthma QI projects in parallel with NCH'S asthma QI activity. Monitoring program impact in the community setting was challenging due to the multitude of medical record systems employed (Table 1).

Asthma Express focus team.—Asthma Express, modeled on Boston's Community Asthma Initiative[7] and provided by NCH's home care services, typically enrolled children referred during asthma hospitalizations but also accepted referrals from outpatient providers. Providers often referred patients whose caregivers appeared to have suboptimal understanding of asthma and its treatment despite previous asthma education. The program's educational content, teaching techniques, and approach to the home environment were adjusted over time in an effort to reduce post-program enrollment ED returns. The program, which included 2 to 3 home visits per enrollee, initially focused on standardized asthma education. Environmental assessments and mitigation supplies were later added, but when minimal additional impact was seen the program shifted back to a more educationally focused program augmented by motivational interviewing techniques (Table 1).

School-Based Asthma Therapy focus team.—A School-Based Asthma Therapy program based on the Rochester model[8] targeted students referred by school nurses or providers due to frequent symptoms, repeated asthma-related absences at school, or repeated asthma-related ED or IP utilization (often with suspected poor medication compliance). This program facilitated family, provider, and school nurse communication and arranged for directly observed controller therapy administration at school with subsequent reduction in ED and IP utilization (Table 1).[25]

Asthma Education Standardization

Family education provided at NCH facilities was standardized via a shared electronic medical record-based AAP template, educational materials, and use of uniform terminology. In early 2014, the AAP was revised to include orange and red zones to distinguish symptoms that should trigger contacting a provider (orange) from those requiring urgent (ED) evaluation (red).

Analysis

Measurement of Focus Team Intervention Implementation (Process) and Impact (Outcomes)

All focus team evaluations were limited to children 2 to 18 years old, included patients irrespective of insurance status, and were based on NCH's ED and IP data (Table 2). Statistical process control charts were used to graphically display process (or outcome) data in a time-ordered sequence. Three types of charts were used: *c*-charts, *u*-charts, and *p*-charts. After establishing a baseline, upper and lower control limits were calculated to determine whether future data variation was "in control" (without statistically significant change) or had changed significantly, implying influence by new interventions or circumstances. Statistical process control chart centerlines reflect the mean of a sequential series of data, and subsequent shifts were computed using standard statistical process control rules.[12] Significant change is graphically reflected by a shift in the centerline. (In some charts, if single point variation was unusually extreme, centerline and control limit calculations excluded these outlier data points; major seasonal swings were accounted for by seasonally adjusting the analysis.) Provided the *u*-charts followed a Poisson statistical distribution, the 2-sample Poisson rate test was employed to detect statistically significant changes. In turn, *p*-charts track proportions or the number of nonconformities per item; therefore, 2-proportion *z*-tests were used to detect statistically significant changes for those metrics.

Focus team process measures.—Process charts reflected how rapidly interventions were implemented and whether they were sustained. Representative process charts are provided in Figure 2: inpatient focus team asthma action plan use (Fig. 2A); NCH-primary care focus team asthma assessment notes (Fig. 2B); asthma specialty clinic appointments (Fig. 2C); and School-Based Asthma Therapy program enrollment (Fig. 2D).

Focus team outcome measures.—Outcome charts reflecting alterations in clinical markers were utilized to assess the impact of focus team activities. Representative outcome charts are provided in Figure 3:

- *Inpatient focus team*—For the 30-day asthma ED return rate (Fig. 3A), a significant change was confirmed using a 2-proportion *z*-test.
- *NCH-primary care focus team*—Change in the asthma ED utilization rate per 1000 NCH-primary care patients (Fig. 3B) was confirmed with a 2-sample Poisson rate test.
- *Asthma Express focus team*—The change in the 90-day post-completion ED return rate (Fig. 3C) was confirmed with a 2-sample Poisson rate test. Additionally, 90-day ED utilization by patients who were referred to the program but did not enroll (starting 4 weeks post-discharge, the average program enrollment length) were compared to participant outcomes during each phase of the program using a 2-sample Poisson rate test (enrollees who did not complete the program were excluded from this analysis). Statistical testing was performed using Minitab 17 (Minitab Inc.; State College, Penn).

Specific Aims and Overall Program Outcome Assessment

Franklin County ACO total asthma ED utilization rate, NCH asthma ED utilization rate, and NCH asthma

Table 2. Measure Definitions

Measure Name	Numerator	Denominator	Participation Definition
Focus Team Process Measures			
Inpatient Focus Team			
Asthma Action Plan	Patients receiving an Asthma Action Plan prior to discharge	NCH asthma inpatient discharges	
Standardized history and physical template	Patients with history and physical documentation using standardized templates	NCH asthma inpatient discharges	
Asthma order set	Patients admitted using standardized asthma order set	NCH asthma inpatients admitted to regular (non-intensive care) unit	
NCH-Primary Care Focus Team			
AAP-CQN participation			Clinics completing AAP-CQN program
Asthma Action Plan	Patients receiving an Asthma Action Plan at visit	NCH-primary care clinic visits with a primary diagnosis of asthma	
Asthma assessment note	Standardized asthma notes documented	NCH-primary care clinic visits by patients with diagnosis of asthma identified at any NCH encounter within the preceding 24 mo	
Asthma control test	Patients with documented total asthma control test score	NCH-primary care clinic visits by patients with diagnosis of asthma identified at any NCH encounter within the preceding 24 mo	
Step-up therapy	Patients prescribed added (newly prescribed or step-up) asthma controller medications	Patients with poor asthma control identified by provider in their asthma assessment note	
Specialty clinic appointments			Number of patient visits to an NCH-primary care asthma specialty clinic
Community Physician Focus Team			
AAP-CQN participation			Franklin County sites completing AAP-CQN program
Patients enrolled in Easy Breathing			Cumulative total number of asthma patients who were registered in the Easy Breathing program
Asthma Express Focus Team			
Asthma Express participation			Total Asthma Express (with described modifications) program completions
School-Based Asthma Therapy Focus Team			
Student enrollment			Students receiving controller medication at school or re-enrolled to participate in a School-Based Asthma Therapy program during the upcoming school year
Focus Team Outcome Measures			
Inpatient Focus Team			
Inpatient post-discharge 30-d ED return rate	NCH asthma ED visits within 30 d of inpatient discharge	NCH asthma inpatient discharges	
NCH-Primary Care Focus Team			
NCH-primary care asthma ED utilization rate	NCH asthma ED visits	1000 patients with NCH-primary care visit within previous 13 mo	
Asthma Express Focus Team			
Asthma Express post-completion 90-d ED return rate	NCH asthma ED visits within 90 d of completing Asthma Express program	Patients completing Asthma Express program	

(*continued*)

Table 2 (*Continued*)

Measure Name	Numerator	Denominator	Participation Definition
Specific Aims/Overall Impact Measures			
Franklin County ACO total asthma ED utilization rate	ACO member asthma ED visits,* NCH and non-NCH facilities	ACO members living in Franklin County (total monthly enrollment during 1 yr/12)	
Franklin County ACO NCH asthma ED utilization rate	ACO member asthma ED visits, NCH facilities only	ACO members living in Franklin County (total monthly enrollment during 1 yr/12)	
Franklin County ACO NCH asthma inpatient utilization rate	ACO member inpatient stays,† NCH facilities only	ACO members living in Franklin County (total monthly enrollment during 1 yr/12)	
National ED utilization rate‡	ED visits with a primary asthma code diagnosis in the nationwide emergency department sample	Annual US resident age-specific population estimates from the US Census	

NCH indicates Nationwide Children's Hospital; AAP-CQN, American Academy of Pediatrics Chapter Quality Network; ED, emergency department; and ACO, accountable care organization.

All patients were ages 2 to 18 years with International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes 493.xx.

*ED visit includes an emergency room visit with a primary diagnosis of asthma, whether discharged or hospitalized.

†Inpatient stay includes a primary diagnosis of asthma, as well as either observation or admission stays.

‡See text for additional details regarding sources.

inpatient utilization rates.—ACO billing data were used to identify ED visits and IP stays by 2- to 18-year-old ACO participants residing in Franklin County who had a primary diagnosis of asthma. The utilization rate reflects events per 1000 children covered by the ACO. Numbers of ACO children were calculated by dividing total monthly enrollment (the cumulative total of children participating in the ACO each month) by 12, a methodology

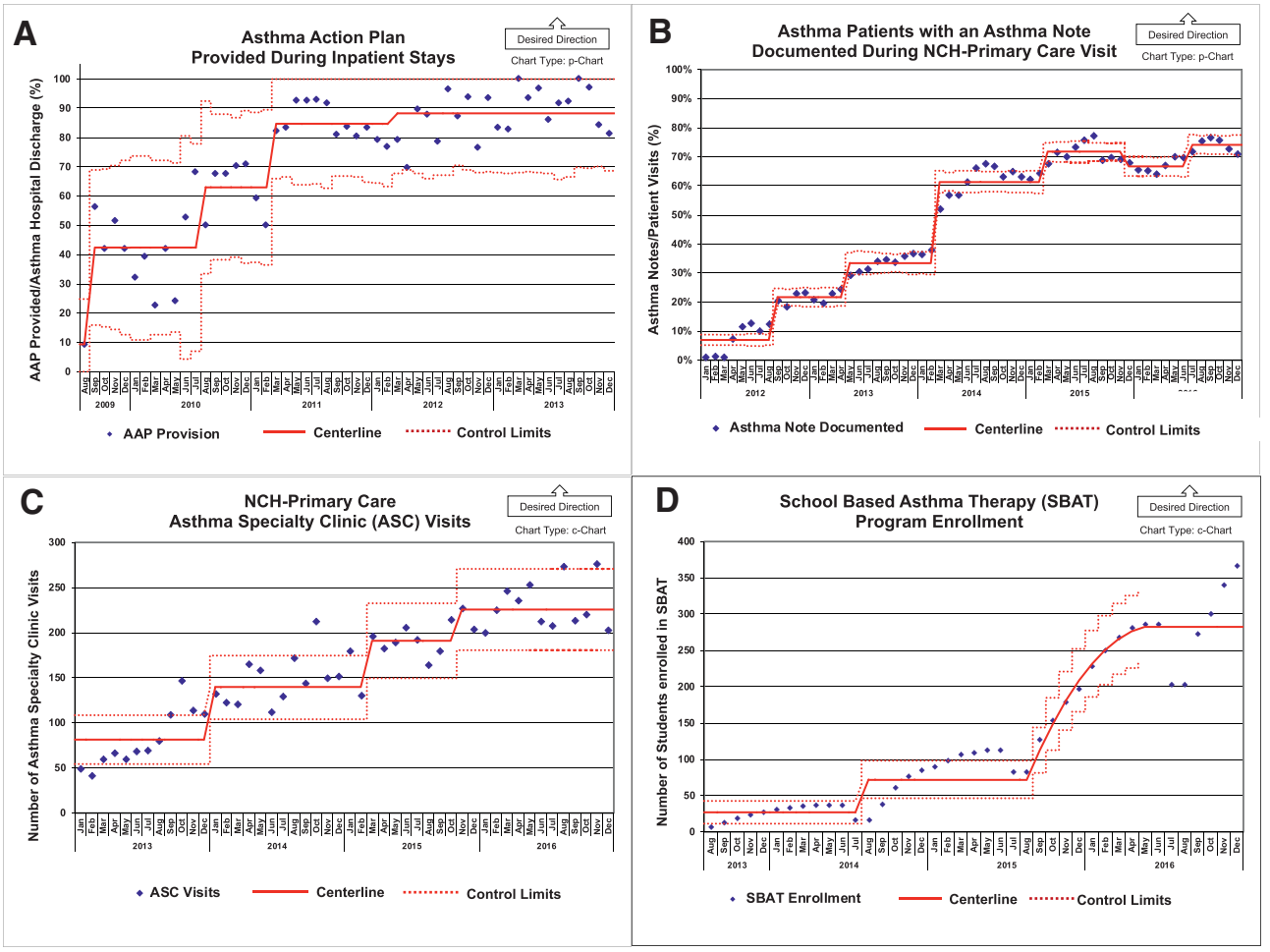

Figure 2. *Focus team process measures.*

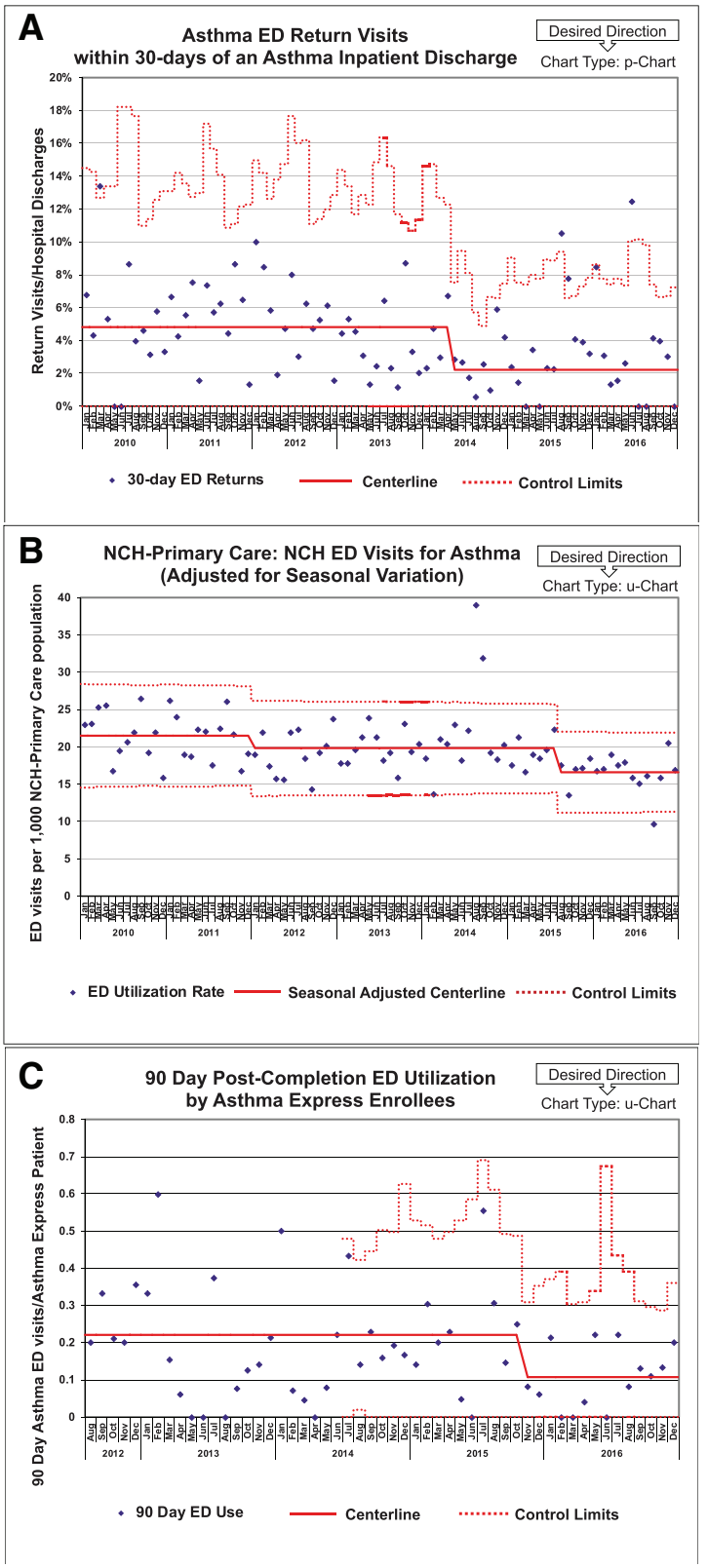

Figure 3. *Focus team outcome measures.*

used by insurers to measure their covered populations.[26] The numerator for ED visit rates included patients discharged from the ED and those transferred to an inpatient bed. The numerator for IP stay rates included both hospital admission and hospital observation stays. We combined these events because they reflected an inability to safely discharge a patient from the ED. To test whether changes in NCH's ED utilization were due to shifts in care to outside institutions, total Franklin County ACO ED utilization rates (including ED visits at outside

facilities) were measured using ACO billing information. We evaluated change in annual rates of asthma ED and IP utilization from 2008 through 2016 using Poisson regression (Table 2).

National ED utilization rate.—To investigate whether reductions in ACO asthma ED utilization simply reflected widespread asthma patterns, we evaluated national pediatric ED use rates. ED visits with a primary asthma code diagnosis in the Nationwide Emergency Department Sample (NEDS)[27] and annual US resident age-specific population estimates from the US Census[28,29] were used to estimate asthma ED utilization rates (visits per 1000 children) for children 2 to 18 years old from 2006 to 2014 (most recent years available). Annual estimates and their standard errors were calculated accounting for the complex survey design of the NEDS, and a weighted least squares linear regression model was used to test for a linear alteration in rates over time. Each annual estimate was given a weight proportional to the inverse of its estimated variance. Analyses were performed using SAS Enterprise Guide 7.1 (SAS Institute Inc.; Cary, NC) (Table 2).

Human Subjects Protection

Based on the QI nature of this work, it was deemed exempt from review by our institutional review board.

Results

Focus Team Process Charts

The inpatient focus team increased provision of an AAP from 9.4% to 88.3% of discharged patients (Fig. 2A). The NCH-primary care team increased use of a standardized asthma note during the clinic visits of patients with asthma from 0.7% to 74.0% (Fig. 2B). Visits to the primary-care based asthma specialty clinics rose from a mean of 81.4 per month to 222.6 per month (maximum 270 visits) (Fig. 2C). School-Based Asthma Therapy enrollment rose from a mean of 27 to 282 (maximum 367) over its first 4 years of operation (Fig. 2D).

Focus Team Outcome Charts

The inpatient focus team achieved a 54% decrease in the 30-day post-asthma inpatient stay asthma-related ED return rate from 4.8% to 2.2% ($P = .001$) (Fig. 3A). The NCH-primary care focus team's ED utilization decreased from 21.5 to 16.6 per 1000 children ($P < .001$) (Fig. 3B). The Asthma Express focus team reduced 90-day post-program completion asthma ED use from 0.22 to 0.11 visits per participant per 90 days ($P < .001$) (Fig. 3C). Over 3.5 years, 2092 children were referred to Asthma Express; 45%, 1%, and 54% completed, enrolled without completing, and did not enroll, respectively. Return rates for non-enrollees versus enrollees did not differ until the 2016 modification (educational focus with motivational interviewing techniques), when 254 enrollees had a 0.11 90-day ED utilization rate versus a 0.22 utilization rate for 357 non-enrollees ($P < .001$)

Specific Aims and Overall Impact

Countywide asthma-related ED utilization (Fig. 4) by Franklin County ACO members decreased from a baseline rate of 18.1 visits/1000 children in 2008 to 12.9 visits/1000 children in 2016, representing a 28.7% total reduction and an average annual decrease of 3.9% ($P < .001$). This decrease occurred during a period when yearly national asthma-related ED utilization (NEDS data; Fig. 4) increased by an average of 0.15 visits/1000 children ($P = .03$). No shifts in asthma care to outside institutions occurred. Asthma care visits to NCH's ED accounted for a stable 75 ± 1.5% (mean ± standard deviation) of total Franklin County ED utilization. Asthma-related NCH IP stay rates for children in the ACO did not change significantly from 2008 to 2016, with an average annual change of 1.0% (95% confidence interval = −0.4, 2.5; $P = .15$).

Discussion

Implementation of NCH asthma communitywide QI initiatives was associated with a substantial, significant 28.7% reduction in asthma-related ED visits by ACO patients living in Franklin County from 2008 to 2016. This improvement occurred in a countywide Medicaid-insured asthma population exceeding 14,000 children. Most patients lived in an urban area surrounding the 15th largest city in the United States. Our asthma ED utilization fell despite rising national rates in pediatric asthma ED utilization observed from 2001 to 2010, as reported by Nath and Hsia[30] and echoed in our analysis of 2006 to 2014 (Fig. 4).

Nationally, pediatric asthma morbidity has remained high despite widespread publicity and advocacy for the use of standardized evidence-based care guidelines targeting patients with poorly controlled asthma. Previous work has recognized that guideline knowledge alone does not reliably change providers' or caregivers' practice.[31,32] Multiple published interventions have demonstrated good results in their specific study cohorts; however, movement from asthma efficacy studies (intensive interventions by expert study staff on relatively homogeneous patient cohorts) to effectiveness studies (non-expert implementation of feasible changes across multiple settings directed at a broad, heterogeneous group)[33] has been limited.

Our work began by establishing multi-stakeholder consensus regarding the value of addressing pediatric asthma morbidity and benefited from strong institutional support. Institute for Healthcare Improvement QI methodology helped teams concentrate on measureable interventions and utilize small tests of change with serial adjustments to foster accountability for process and outcome metrics. We intentionally selected a mix of evidence-based interventions to improve care for all asthma patients as well as to provide intensive interventions for struggling patients and families. Our program promoted partnerships across the health care system, the community, and the home.

Improvement in PFK asthma ED utilization rates was relatively gradual after establishing the asthma oversight

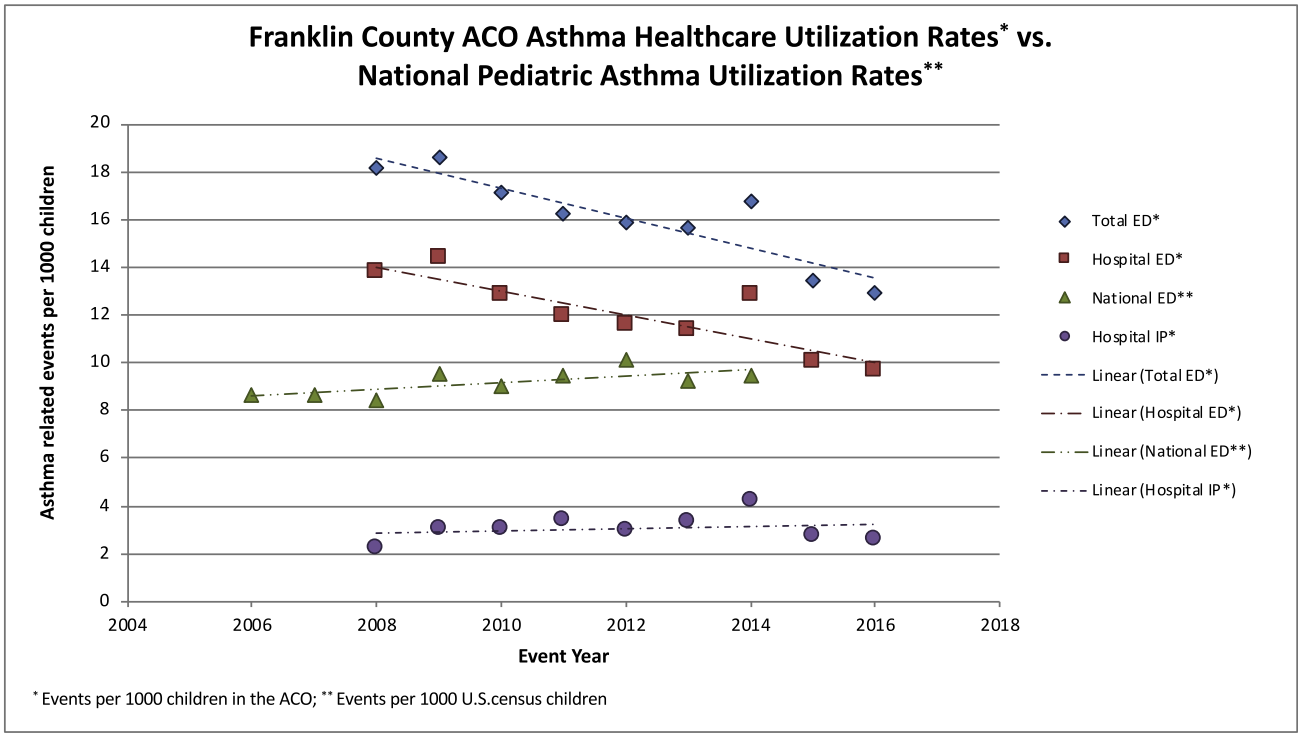

Figure 4. *Franklin County asthma emergency department and inpatient utilization rates (events/1000 children covered by accountable care organizations) from 2008 to 2016 versus national pediatric asthma emergency department utilization rates (events/1000 children in US census) from 2006 to 2014.*

committee in 2011 but has accelerated in recent years. The slow progress during the initial years likely reflects progressive intervention uptake and trials. Some interventions were also abandoned, delaying progress; for example, efforts to establish peer counseling for parents[34] and an attempt to organize independent pharmacy-based education[35] were unsuccessful. We believe increasing adherence to more effective processes, such as Asthma Control Test use in NCH-primary care clinics,[23] spread of asthma specialty clinics[24] within the NCH-primary care system, and growth of the School-Based Asthma Therapy program,[25] as well as networking between teams, fueled gains. The impact of enterovirus D68 in mid-2014[36] markedly increased the overall 2014 yearly rate, temporarily masking progress.

Although we observed significant improvements in asthma-related ED utilization, inpatient utilization remained unchanged for the group as a whole. Broader reductions in hospitalization rates should be possible with more timely administration of oral steroids upon arrival to the ED[37] and more consistent adherence with inhaled corticosteroid therapy at home.[38] These factors were not successfully addressed by our current efforts (asthma ED patients receiving oral steroids within 1 hour of arrival actually fell from 73% to 65% from 2013 to 2016; data not shown), and ongoing QI efforts will target these issues.

The relative impact of individual projects cannot be determined because of the contemporaneous launch of multiple QI interventions, exposure of some patients to multiple interventions, and limited data availability (eg, community physician-related interventions). However, the aggregate effects of multiple focus team projects over years is apparent. For example, the improvement in NCH-primary care asthma ED utilization rates over time implies efficacy of at least some of the multiple interventions by that focus team (Fig. 3B). Emergency department return rates 30 days after asthma inpatient discharge (Fig. 3A), as well as 90 days after completion of the Asthma Express program (Fig. 3C), improved significantly over time as these teams adjusted their interventions.

Our study has several limitations. First, some data that typically would be collected in a prospective study, such as tallies of total referrals versus enrollments in the newly launched School-Based Asthma Therapy program, were not maintained. Second, we did not utilize control charts to analyze specific aims of our countywide outcomes. ACO claims data prior to 2008 were unavailable, preventing us from estimating a baseline rate for countywide asthma-related ED and IP utilization before the start of our QI project. Further, we elected to analyze yearly utilization rates to ameliorate the significant impact of seasonality on asthma outcomes, but this strategy reduced data points below thresholds required for control chart analysis. We therefore relied on historic comparison of the population's health utilization, as well as comparison to national rates, to substantiate the program's impact. Third, our specific aim measures were tied to billing data, and billing practices are influenced by external, insurer forces; for example, we noted a substantial shift in billing practices regarding inpatient stay insurer-defined qualification for admission versus observation status beginning in 2012. Our definition of "inpatient stay" as a combination

of these events prevented this change from falsely suggesting a decline in our hospitalization rates. Fourth, if patients chose to obtain care at competing local institutions, the resulting decrease in single hospital-based utilization rates could lead to inaccurate claims of program efficacy. Our analysis indicated that NCH asthma ED utilization remained a steady proportion of total Franklin County ACO asthma ED utilization; improvements were not due to health care market shift. Fifth, with regard to generalizability, the interventions and QI strategies implemented during our work are not unique and can be implemented in other communities; however, doing so will require identification of support such as we received from our hospital and ACO to sponsor and incentivize change. Finally, we did not collect balancing measure data reflecting the impact of the asthma QI program resource utilization on the success of other institutional QI initiatives.

In conclusion, using standard improvement strategies and focused hospital support, we successfully implemented a constellation of practice improvements and patient-targeted community-based programs that reduced asthma ED utilization by 28.7% in a countywide, largely urban, Medicaid-insured population. This work involved real-world application of evidence-based guidelines and programs. We believe that coordinated, multidimensional programs driven by QI strategies could yield similar results in other communities.

ACKNOWLEDGMENTS

The quality improvement work described in this manuscript was supported by Nationwide Children's Hospital and its affiliated accountable care organization, Partners for Kids. These institutions did not direct (1) study design; (2) the collection, analysis, and interpretation of data; (3) the writing of the report; or (4) the decision to submit the paper for publication.

We thank J. Terrance Davis, MD, for his invaluable assistance with manuscript preparation; Linda Stoverock, RN, DNP, NEA-BC, and Laura Evans, MBA, RRT-NPS, RCP, for their leadership and support of nursing and respiratory therapy-based initiatives; and leaders and staff throughout our organization for their dedication to improving the lives of children with asthma.

REFERENCES

1. Centers for Disease Control and Prevention. Most Recent Asthma Data. Available at: https://www.cdc.gov/asthma/most_recent_data.htm. Accessed January 4, 2019.
2. Hughes HK, Matsui EC, Tschudy MM, et al. Pediatric asthma health disparities: race, hardship, housing, and asthma in a national survey. *Acad Pediatr*. 2017;17:127–134.
3. Brilli RJ, Allen S, Davis JT. Revisiting the quality chasm. *Pediatrics*. 2014;133:763–765.
4. Kelleher KJ, Cooper J, Deans K, et al. Cost saving and quality of care in a pediatric accountable care organization. *Pediatrics*. 2015;135:e582–e589.
5. Papadopoulos NG, Arakawa H, Carlsen KH, et al. International consensus on (ICON) pediatric asthma. *Allergy*. 2012;67:976–997.
6. Cloutier MM, Wakefield DB. Translation of a pediatric asthma-management program into a community in Connecticut. *Pediatrics*. 2011;127:11–18.
7. Woods ER, Bhaumik U, Sommer SJ, et al. Community asthma initiative: evaluation of a quality improvement program for comprehensive asthma care. *Pediatrics*. 2012;129:465–472.
8. Halterman JS, Szilagyi PG, Fisher SG, et al. Randomized controlled trial to improve care for urban children with asthma: results of the School-Based Asthma Therapy trial. *Arch Pediatr Adolesc Med*. 2011;165:262–268.
9. Kercsmar CM, Beck AF, Sauers-Ford H, et al. Association of an asthma improvement collaborative with health care utilization in Medicaid-insured pediatric patients in an urban community. *JAMA Pediatr*. 2017;171:1072–1080.
10. Herman EJ. Conceptual framework of the Controlling Asthma in American Cities Project. *J Urban Health*. 2011;88(suppl 1):7–15.
11. Langley GJ, Moen RD, Nolan KM, et al. The Improvement Guide: A Practical Approach to Enhancing Organizational Performance. 2nd ed. San Francisco, Calif: Jossey-Bass; 2009.
12. Provost LP, Murray SK. The Health Care Data Guide: Learning from Data for Improvement. San Francisco, Calif: Jossey-Bass; 2011.
13. Rowan R. Columbus metro area surpasses 2 million mark in population. *The Columbus Dispatch*. March 25, 2016.
14. US Census Bureau. QuickFacts: Franklin County, Ohio. Available at: https://www.census.gov/quickfacts/fact/table/franklincountyohio/IPE120217#viewtop. Accessed October 24, 2018.
15. Montgomery MP, Allen ED, Thomas O, et al. Association between pediatric asthma care quality and morbidity and English language proficiency in Ohio. *J Asthma*. 2018. https://doi.org/10.1080/02770903.2018.1474364.
16. National Heart, Lung, and Blood Institute. Guidelines for the Diagnosis and Management of Asthma (EPR-3). Available at: https://www.nhlbi.nih.gov/health-pro/guidelines/current/asthma-guidelines/full-report. Accessed January 4, 2019.
17. Beck AF, Sauers HS, Kahn RS, et al. Improved documentation and care planning with an asthma-specific history and physical. *Hosp Pediatr*. 2012;2:194–201.
18. Fassl BA, Nkoy FL, Stone BL, et al. The Joint Commission Children's Asthma Care quality measures and asthma readmissions. *Pediatrics*. 2012;130:482–491.
19. Hatoun J, Bair-Merritt M, Cabral H, et al. Increasing medication possession at discharge for patients with asthma: the Meds-in-Hand project. *Pediatrics*. 2016;137:e20150461.
20. Lannon CM, Peterson LE. Pediatric collaborative improvement networks: background and overview. *Pediatrics*. 2013;131(suppl 4):S189–S195.
21. Schatz M, Sorkness CA, Li JT, et al. Asthma Control Test: reliability, validity, and responsiveness in patients not previously followed by asthma specialists. *J Allergy Clin Immunol*. 2006;117:549–556.
22. Liu AH, Zeiger R, Sorkness C, et al. Development and cross-sectional validation of the Childhood Asthma Control Test. *J Allergy Clin Immunol*. 2007;119:817–825.
23. Sangvai S, Hersey SJ, Snyder DA, et al. Implementation of the Asthma Control Test in a large primary care network. *Pediatr Qual Saf*. 2017;2:1–5.
24. Snyder DA, Thomas OW, Gleeson SP, et al. Reducing emergency department visits utilizing a primary care asthma specialty clinic in a high-risk patient population. *J Asthma*. 2018;55:785–794.
25. Allen ED, Arcoleo K, Rowe C, et al. Implementation of a "real world" School-Based Asthma Therapy program targeting urban children with poorly controlled asthma. *J Asthma*. 2018;55:1122–1130.
26. Washington State Office of the Insurance Commissioner. Health Carrier Information Definitions. Available at: https://fortress.wa.gov/oic/hcis/public/InstructionDef.aspx. Accessed January 4, 2019.
27. Agency for Healthcare Research and Quality. Overview of the Nationwide Emergency Department Sample (NEDS). Available at: https://www.hcup-us.ahrq.gov/nedsoverview.jsp. Accessed January 4, 2019.
28. US Census Bureau,. National Intercensal Tables: 2000-2010. Available at: https://www.census.gov/data/tables/time-series/demo/popest/intercensal-2000-2010-national.html. Accessed January 4, 2019.
29. US Census Bureau. Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2014. Available at: http://factfinder2.census.gov/bkmk/table/1.0/en/PEP/2014/PEPSYASEXN. Accessed January 4, 2019.

30. Nath JB, Hsia RY. Children's emergency department use for asthma, 2001−2010. *Acad Pediatr*. 2015;15:225–230.
31. Cloutier MM, Tennen H, Wakefield DB, et al. Improving clinician self-efficacy does not increase asthma guideline use by primary care clinicians. *Acad Pediatr*. 2012;12:312–318.
32. Auger KA, Kahn RS, Davis MM, et al. Pediatric asthma readmission: asthma knowledge is not enough? *J Pediatr*. 2015;166:101–108.
33. Glasgow RE, Lichtenstein E, Marcus AC. Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to-effectiveness transition. *Am J Public Health*. 2003;93:1261–1267.
34. Garbutt JM, Sylvia S, Rook S, et al. Peer training to improve parenting and childhood asthma management skills: a pilot study. *Ann Allergy Asthma Immunol*. 2015;114:148–149.
35. Garcia-Cardenas V, Sabater-Hernandez D, Kenny P, et al. Effect of a pharmacist intervention on asthma control. A cluster randomised trial. *Respir Med*. 2013;107:1346–1355.
36. Midgley CM, Watson JT, Nix WA, et al. Severe respiratory illness associated with a nationwide outbreak of enterovirus D68 in the USA (2014): a descriptive epidemiological investigation. *Lancet Respir Med*. 2015;3:879–887.
37. Zemek R, Plint A, Osmond MH, et al. Triage nurse initiation of corticosteroids in pediatric asthma is associated with improved emergency department efficiency. *Pediatrics*. 2012;129:671.. −180.
38. Andrews AL, Simpson AN, Basco Jr WT, et al. Asthma medication ratio predicts emergency department visits and hospitalizations in children with asthma. *Medicare Medicaid Res Rev*. 2013;3:e1–e10.