Contents lists available at ScienceDirect

Journal of Pediatric Nursing

journal homepage: www.pediatricnursing.org

ELSEVIER

A pilot study to improve provider adherence to NAEPP guidelines

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ARTICLE INFO

Keywords:
Asthma
Adherence
Providers
Guidelines
Pediatric
Children
Registry
Electronic medical record

ABSTRACT

The prevalence and morbidity of Asthma in the United States has increased since the 1991 National Asthma Education and Prevention Program (NAEPP) and updated Expert Panel Report −3 (EPR-3) guidelines in 2007 were published. To improve provider adherence to the NAEPP EPR-3 guidelines Children's Hospital of Orange County (CHOC) in California integrated the HealtheIntent[SM] Pediatric Asthma Registry (PAR) into the electronic medical record (EMR) in 2015.

Methods: A serial cross-sectional design was used to compare provider management of CHOC MediCal asthma patients before 2014 ($N = 6606$) and after 2018 ($N = 6945$) integration of the Registry with NAEPP guidelines into the EMR. Four provider adherence measures (Asthma Control Test [ACT], Asthma Action Plan [AAP], inhaled corticosteroids [ICS] and spacers) were evaluated using General Linear Mixed Models and Chi square.

Findings: In 2018, patients were more likely to receive an ACT, (OR = 14.95, 95% CI 12.67, 17.65, $p < .001$), AAP (OR = 12.70, 95% CI 11.10, 14.54, $p < .001$), ICS (OR = 1.85, 95% CI 8.52, 14.54, $p < .001$) and spacer (OR = 1.45, 95% CI 1.31, 1.6, $p < .001$) compared to those in 2014.

Discussion: The pilot study showed integration of the Pediatric Asthma Registry into the EMR, as a computer decision support tool that was an effective intervention to increase provider adherence to NAEPP guidelines. Ongoing monitoring and education are needed to promote and sustain provider behavioral change. Additional research to include multi-sites and decreased time between evaluation years is recommended.

Application to practice: Can be used for excellent health policy decision making as a direct impact on patient care and outcomes, by improving provider adherence to the NAEPP guidelines.

Background

Asthma, a major noncommunicable disease, the most common chronic disease among children has no known cure, but can be controlled with medication and monitoring. Inflammation and bronchospasm in the respiratory system are the two pathophysiological components of asthma, causing symptoms which may be daily or intermittent (World Health Organization, 2023). Similar findings were found by Seibert et al. (2019) and Cardet et al. (2022) who identified associations between poverty, unemployment, and education and asthma morbidity outcomes (asthma control test scores and hospitalizations) due to stress in a cohort of Hispanics and African Americans. Stress may be from behavior, psychological, or environmental factors. Nurmagambetov et al. (2018) reported missed school days of 2.3 per person per year, with a significant economic burden of $1.1 billion; and a total cost of Asthma to society of $81.9 billion. The Centers for Disease Control and Prevention (2022) reported a prevalence of asthma in the population in 2020 of 5.8%, affecting 4.2 million Americans under 18 years of age. In 2020, there were 64,525 hospital inpatient stays (rate 8.8 per 10,000), and 790,478 Emergency Department (ED) visits for asthma exacerbations (rate 25.4 per 10,000) for children under 18 years of age with asthma.

In 1988, the National Heart, Lung, and Blood Institute held a workshop, which lead to the National Asthma Education and Prevention Program (NAEPP) committee which developed and published the first Expert Panel Report (EPR): Guidelines for the Diagnosis and Management of Asthma in 1991 (National Heart Lung and Blood Institute, 2016). Since the initial publication, updates have been made with the latest in December 2020 (U.S. Department of Health and Human Services, 2020). Despite the implementation of NAEPP guidelines in 1991,

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https://doi.org/10.1016/j.pedn.2023.07.016
Received 5 November 2022; Received in revised form 17 July 2023; Accepted 17 July 2023
Available online 25 July 2023

sequelae of asthma continue to increase as measured by ED visits, hospital admissions, and deaths. After >25 years, the prevalence of asthma has increased from 4.3% in 1992 to 7.8% in 2019 (Centers for Disease Control and Prevention, 2022; Morbidity and Mortality Weekly Report, 1998). ED visits, hospital visits, and death rates have decreased since 1992, but the incidence remains high (U.S. Department of Health and Human Services, 2020).

In 2013, The Agency for Healthcare Research and Quality (AHRQ) published a comprehensive systematic review of the literature that included 73 studies with eight types of interventions; however, only a few were randomized control trials (RCTs), with the majority pre-post designs which reported a beneficial effect (Okelo et al., 2013). The research focused most on improving health care processes, and less on clinical outcomes. The AHRQ authors concluded, due to the lack of sufficient RCTs they were not able to comment on the effectiveness of the interventions. There were 10 studies utilizing computerized decision support (CDS) tools with low to moderate evidence to support their use. Since the AHRQ review, two additional data sets describe the use of CDS tools in the electronic medical record (EMR) that remind and prompt providers to utilize NAEPP EPR-3 guidelines at the time of care to improve patient care and outcomes (Gupta et al., 2019; Kercsmar et al., 2019).

In 2015, the leadership at Children's Hospital of Orange County (CHOC) decided to utilize a CDS tool, Pediatric Asthma Registry (PAR) and NAEPP EPR-3 guidelines, which was integrated into the outpatient Cerner EMR. The PAR utilizes information from HealtheIntent[SM], a database where data was imported from many different sources including clinical data from the Cerner EMR, claims data, and lab data from Quest and LabCorp. CHOC is continuing to expand data imports into the database.

There was little research on an asthma CDS in the EMR. The objective of this pilot study was to evaluate if the CDS tool, CHOC Clinical HealtheIntent[SM] PAR and NAEPP EPR-3 guidelines, integrated into the EMR improved provider adherence and treatment in a Medi-Cal population of children. Evidence based practices can utilize this study to assist in developing asthma programs using a CDS tool in their EMR.

Methods

This pilot study was conducted at Children's Hospital of Orange County (CHOC), a 334-bed hospital including primary and specialty care clinics in Orange; and a 54-bed hospital in Mission Viejo. These hospitals and clinics serve a population base in Orange County of over 699,000 children under the age of 21 years (Children's Hospital of Orange County, 2020a). The CHOC hospitals and clinics use Cerner as their EMR. The pilot study data collection and analyses were conducted between 2018 and 2020.

For this study, a serial cross-sectional design was used to compare change in provider management of asthma patients using the year 2014, prior to embedding the CDS tool into the CHOC Cerner EMR, and the year 2018 after embedding the CDS tool into the EMR. The measurement periods were calendar years 2014 and 2018. The Medi-Cal asthma population was age birth to 21 years with a sample of 6606 children in 2014 and 6945 children in 2018. The following variables were

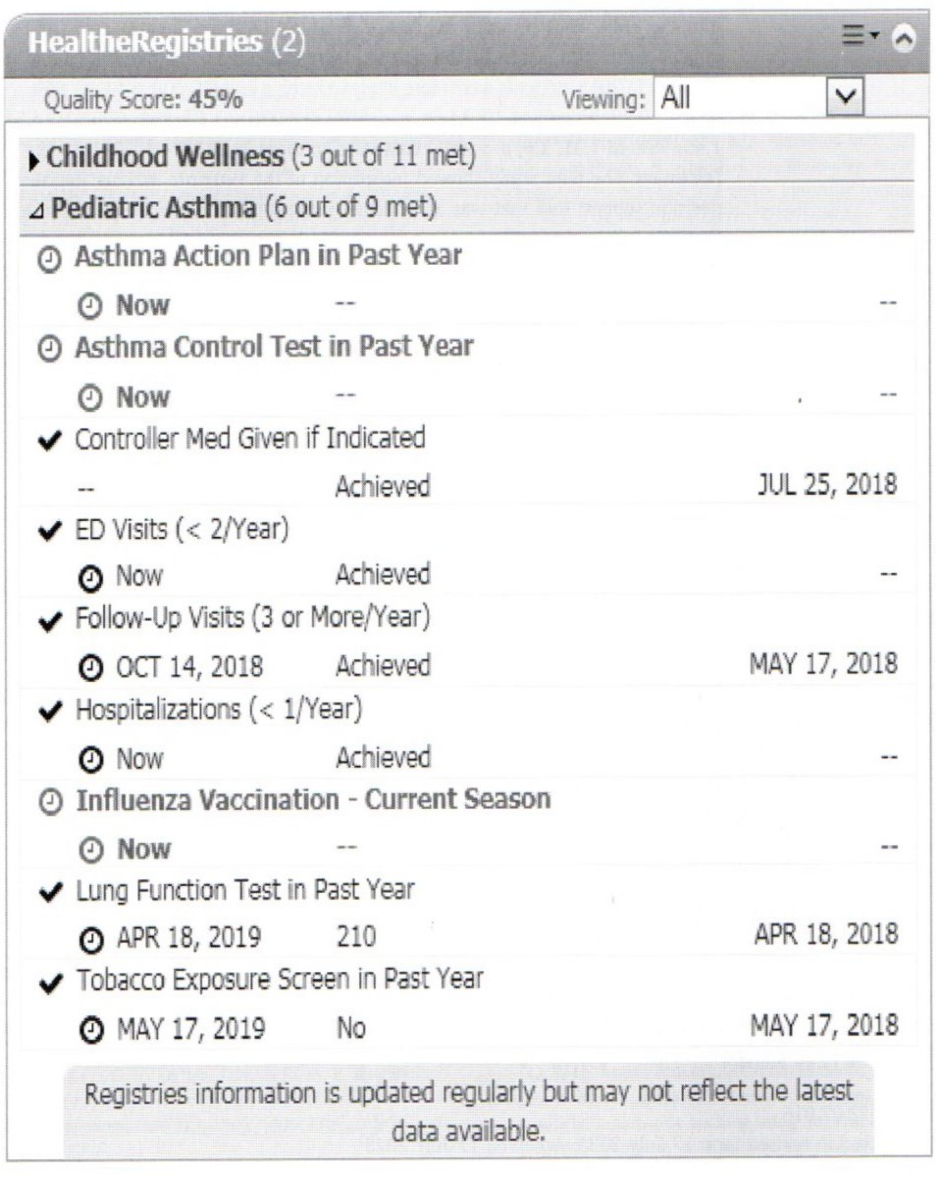

Fig. 1. Display of the measures when provider accesses the PAR after entering the patient's EMR. 9 measures are identified with the date of meeting the measure, or in red and bold if not met. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

measured: use of asthma control test (ACT), asthma action plan (AAP), inhaled corticosteroids (ICS), and spacers.

At the time of implementation two measures (ACT and AAP) were chosen to focus on provider adherence. The provider signs into the EMR, enters the patient chart and the PAR section was selected which immediately displays nine (9) measures in real time: AAP, ACT, controller med given, ED visits (< 2/year), follow-up visits (3 or more/year), hospitalizations (<1/year), influenza vaccine, lung function test, tobacco exposure screen (Fig. 1); and if they have been met. Asthma order sets, based on asthma classification, have been designed within the EMR which gives ease of order entry. When the patient's diagnosis was classified, the disease classification definition was displayed with the NAEPP recommendations to the right.

Inclusion criteria used for this pilot study was from Cerner Standard 2017 Pediatric Asthma Registry Requirements. Only patients in the registry were included in the study:

- Medi-Cal as payer source;
- Age < 21 years as of the last day of the measurement period;
- Patient had dx of asthma (prior to 2015, International Classification of Diseases [ICD], 9th Revision diagnosis codes 493.2 asthma [chronic], 493.9 asthma [acute], 493.91 status asthmaticus, and 493.92 acute exacerbation; OR after October 2015, patients with ICD, 10th Revision diagnosis codes J45.*);
- Had a problem of asthma (not in a resolved status) at any time prior to the end of the measurement period, and
- Had an outpatient visit during the measurement period or in the two previous measurement periods (Cerner, 2018).

For this study exclusion criteria from Cerner Standard 2017 Pediatric Asthma Registry Requirements were used. Patients having at least one of the following during the measurement period or in the two previous measurement periods were excluded: Cystic Fibrosis, tracheostomy, chronic respiratory disease arising in the perinatal period, bronchiectasis, chronic respiratory failure, deceased, or manually excluded (Cerner, 2018).

Not all patients diagnosed with asthma require an ICS, which was given based on the patient's asthma classification. At CHOC, the asthma classification was documented on the AAP. Unfortunately, this field was not retrievable for data analysis. Without this field, not all patients with ICS recommendation were included in the study. Providers do not regularly provide an ICD-10 diagnosis code, which includes the asthma classification, therefore it was not possible to capture accurate classification of all asthma patients at CHOC. To evaluate for the use of ICS which was defined as two ICS prescriptions within the same year, a subset of asthma patients who had an ED visit, hospital admission, or outpatient clinic visit with the diagnosis of asthma exacerbation within the designated measurement period was used.

Also, a separate subset of the initial identified population was used for the evaluation of spacer prescriptions because all asthma patients do not require a spacer. Patients were excluded from the subset if all aerosol medications were given by nebulizer or a dry powder inhaler, which do not require a spacer. Dry powder inhalers are easier to use, breath activated and recommended for children over 5 years of age (Geller, 2005). A patient was included if there was a prescription written for a metered dose inhaler (MDI).

Statistical analysis for the primary question was done using a General Linear Mixed Model for binary responses. The models included a random intercept for subjects (random factor was "Subjects"), thus accounting for the possibility of clustering of non-independent observations within subjects (repeated measures at 2014 and 2018). The dependent variables included ACT, AAP, ICS, and spacer. Confounding variables of the patient included: age, gender, race/ethnicity, and language. There was an assumption made that normality of distribution was not needed for categorical dependent variables, and the statistical model selected was specialized for this binomial distribution. Chi square was used to compare the differences between years within each age stratum, as well as differences between age strata in 2014 and 2018.

Ethical considerations

Approval was received by the CHOC Institutional Review Board prior to the start of the study. The data was secured on the CHOC cloud based HealtheIntent^{SM} database. Only CHOC employees had access to the data. The researchers evaluated de-identified aggregate data. No protected health information was given to the researchers.

Results

Patient demographics

Demographics of the samples for each year (2014 and 2018) were similar except in terms of age grouping (stratified according to NAEPP guidelines) and race/ethnicity (Table 1). The age strata had significant differences between 2014 and 2018: the number and percentage of patients in the 0–4 year stratum was lower, whereas the 5–11 year stratum and the ≥12 year stratum were higher. In 2018 all patients in the 0–4 years stratum would be new patients but the other groups are a mix of new and existing patients. The genders were similar in both years, 2014 (56.7% males) and 2018 (57.3% males).

Patient demographics for ICS

The subset to analyze patients with ICS totaled 2593 in 2014 and 2772 in 2018. Demographics including gender, race/ethnicity and primary language were similar in both study-year groups, ($p > .05$) (Table 2). However, age differed between the 2014 and 2018 groups. The number and percentage of patients in the 0–4 year stratum decreased ($p < .001$), whereas the 5–11 year stratum increased ($p = .005$), and the >12 year stratum increased ($p < .001$) (Table 2).

Patient demographics for spacer

The subset to analyze patients with spacer totaled 3472 in 2014 and

Table 1
Patient Demographics.

	2014 n (%)	2018 n (%)	p^1
Gender			
Male	3745 (56.7)	3977 (57.3)	0.724
Female	2861 (43.3)	2968 (42.7)	0.671
Age			
0–4 years	2396(36.3)	1399(20.1)	<0.001***
5–11 years	2828(42.8)	3223 (46.4)	0.009**
≥ 12 years	1382(20.9)	2323(33.4)	<0.001***
Race/ethnicity			
Hispanic	5099 (77.2)	5089 (73.3)	0.047*
Caucasian	740 (11.2)	888 (12.3)	0.012*
African American	111 (1.7)	144 (2.1)	0.098
Asian	136 (2.1)	167 (2.4)	0.183
Native American (AI/AN)	4(<0.1)	5 (<0.1)	0.796
Native Hawaiian/Other Pacific Islander	25(<0.1)	27 (0.4)	0.923
Other/Unknown	491 (7.5)	625 (9.0)	0.002**
Primary Language			
English	3774 (57.1)	3754 (54.1)	0.542
Spanish	2821 (42.7)	3178 (45.8)	0.026*
Vietnamese	5(<0.1)	5 (<0.1)	0.937
Chinese	1 (<0.1)	2 (<0.1)	0.593
Other	5(<0.1)	6 (<0.1)	0.827

Note. 2014 N = 6606, 2018 N = 6945, AI/AN = American Indian/Alaskan Native.

* $p < .05$. ** $p < .01$. *** $p < .001$.

[1] From chi square comparing 2014 to 2018 for the specific characteristic.

Table 2
Inhaled Corticosteroid and Spacer Subset Patient Demographics.

	Inhaled Corticosteroids			Spacer		
	2014 n (%)	2018 n (%)	p^1	2014 n (%)	2018 n (%)	p^1
Gender						
Male	1578 (60.6)	1699 (61.3)	0.872	2056 (59.2)	2213 (59.4)	0.927
Female	1015 (39.1)	1073 (38.7)	0.828	1416 (40.7)	1511 (40.6)	0.907
Age						
0–4 years	1119 (43.2)	657 (23.7)	<0.001***	1140 (32.8)	584 (15.7)	<0.001***
5–11 years	1131 (43.6)	1385 (50.0)	0.005**	1700 (49.0)	1867 (50.1)	0.564
≥ 12 years	343 (13.2)	730 (26.3)	<0.001***	632 (18.2)	1273 (34.2)	<0.001***
Race/ethnicity						
Hispanic	1883 (72.6)	1891 (68.2)	0.141	2622 (75.5)	2726 (73.2)	0.388
Caucasian	262 (10.1)	322 (11.6)	0.111	408 (11.8)	477 (12.8)	0.228
African American	47 (1.8)	57 (2.1)	0.526	78 (2.2)	80 (2.1)	0.781
Asian	48 (1.9)	62 (2.2)	0.329	75 (2.1)	89 (2.3)	0.524
Native American (AI/AN)	0	0		3 (0.09)	2 (0.05)	0.599
Native Hawaiian/Other Pacific Islander	10 (0.4)	11 (0.4)	0.948	14 (0.4)	16 (0.4)	0.863
Other/Unknown	343 (13.2)	429 (15.5)	0.042*	272 (7.8)	334 (9.0)	0.111
Primary Language						
English	1460 (56.3)	1460 (52.7)	0.147	1944 (56.0)	2036 (54.7)	0.547
Spanish	1129 (43.5)	1309 (47.2)	0.097	1520 (43.8)	1679 (45.0)	0.489
Vietnamese	2 (0.08)	2 (0.07)	0.947	3 (0.09)	3 (0.08)	0.932
Chinese	1 (0.04)	2 (0.07)	0.603	1 (0.03)	1 (0.03)	0.960
Other	1 (0.04)	0		4 (0.12)	5 (0.13)	0.819

Note. Inhaled Corticosteroid 2014 $N = 2593$, 2018 = 2772, Spacer 2014 $N = 3472$, 2018 $N = 3724$, AI/AN = American Indian/Alaskan Native.
* $p < .05$. ** $p < .01$. *** $p < .001$.
[1] From chi square comparing 2014 to 2018 for the specific characteristic.

3724 in 2018. Demographics including gender, race/ethnicity and primary language were similar in both study-year groups, ($p > .05$) (Table 2). However, age differed between the 2014 and 2018 groups. The number and percentage of patients in the 0–4 year stratum decreased ($p < .001$), whereas the 5–11 year stratum non-significantly increased ($p = .564$), and the >12 year stratum increased ($p < .001$) (Table 2).

Comparison of outcomes 2014 to 2018

Data were available for a total of 13,551 patients (6606 in 2014, and 5945 in 2018). Clustering of visits within patients was accounted for in the model; denoting a patient as "yes" met the specified criteria for the outcome measures with one or more visit. Using the General Linear Mixed Model, each outcome increased significantly between 2014 and 2018 ($p < .001$) (Table 3). Results for ACT showed patients in 2018 were 15 times more likely than patients in 2014 to receive an ACT (odds ratio [OR] = 14.95; 95% confidence interval [CI] 12.67, 17.65; $p < .001$). Patients in 2018 were 13 times greater than patients in 2014 to receive an AAP (OR = 12.70; 95% CI 11.10, 14.54, $p < .001$). Patients in 2018 were 1.9 times greater than patients in 2014 to receive an ICS (OR = 1.85; 95% CI 1.61, 2.13, $p < .001$). Patients receiving spacers in 2018 were 1.5 times greater than patients in 2014 (OR = 1.45; 95% CI 1.31, 1.60, $p < .001$).

Further analysis examined change between years for each age stratum and among age strata within the same year using Chi square. These analyses did not control for gender, race/ethnicity, or language.

Asthma control test

Administration of ACT across the total of all ages increased from 237 (3.5%) in 2014 to 2286 (32.9%) in 2018 ($p < .001$) (Fig. 2). Between 2014 and 2018 ACT in each of the three age strata increased, with the greatest improvement in the 5–11 year stratum 136 (4.8%) to 1249 (38.8%) ($p < .001$) (Fig. 2). In 2014 there was a significant difference in ACT administration between the 0–4 year stratum (2.0%) and the other two age strata: 5–11 years (4.8%) ($p < .001$), and ≥ 12 years (3.9%) ($p < .001$) (Table 4). In 2018, all three strata significantly differed from each other: between the 0–4 year stratum (2.0%) and the 5–11 year stratum (4.8%) ($p < .001$), and the ≥12 years (3.9%) ($p < .001$); and the smallest change between the between the 5–11 year stratum (4.8%) and the ≥12 years (3.9%) ($p = .017$) (Table 4).

Table 3
Comparison from 2014 to 2018 for asthma control test, asthma action plan, inhaled corticosteroid, and spacer prescription—results from general linear mixed models.

	2014 N n (%)	2018 N n (%)	OR	SE	CI Lower	CI Upper	p
Asthma Control Test	6606 237 (3.5)	6945 2286 (32.9)	14.95	0.085	12.674	17.653	<0.001***
Asthma ActionPlan	6606 371 (5.6)	6945 2770 (39.9)	12.70	0.069	11.102	14.537	<0.001***
InhaledCorticosteroid	2593 540 (20.8)	2772 863 (31.1)	1.85	0.072	1.61	2.13	<0.001***
Spacer	3472 1303 (37.5)	3724 1642 (44.1)	1.45	0.052	1.310	1.603	<0.001***

Note. SE = standard error; OR = odds ratio; CI = confidence interval.
*$p < .05$. **$p < .01$. ***$p < .001$ after controlling for age, gender, race/ethnicity and language.

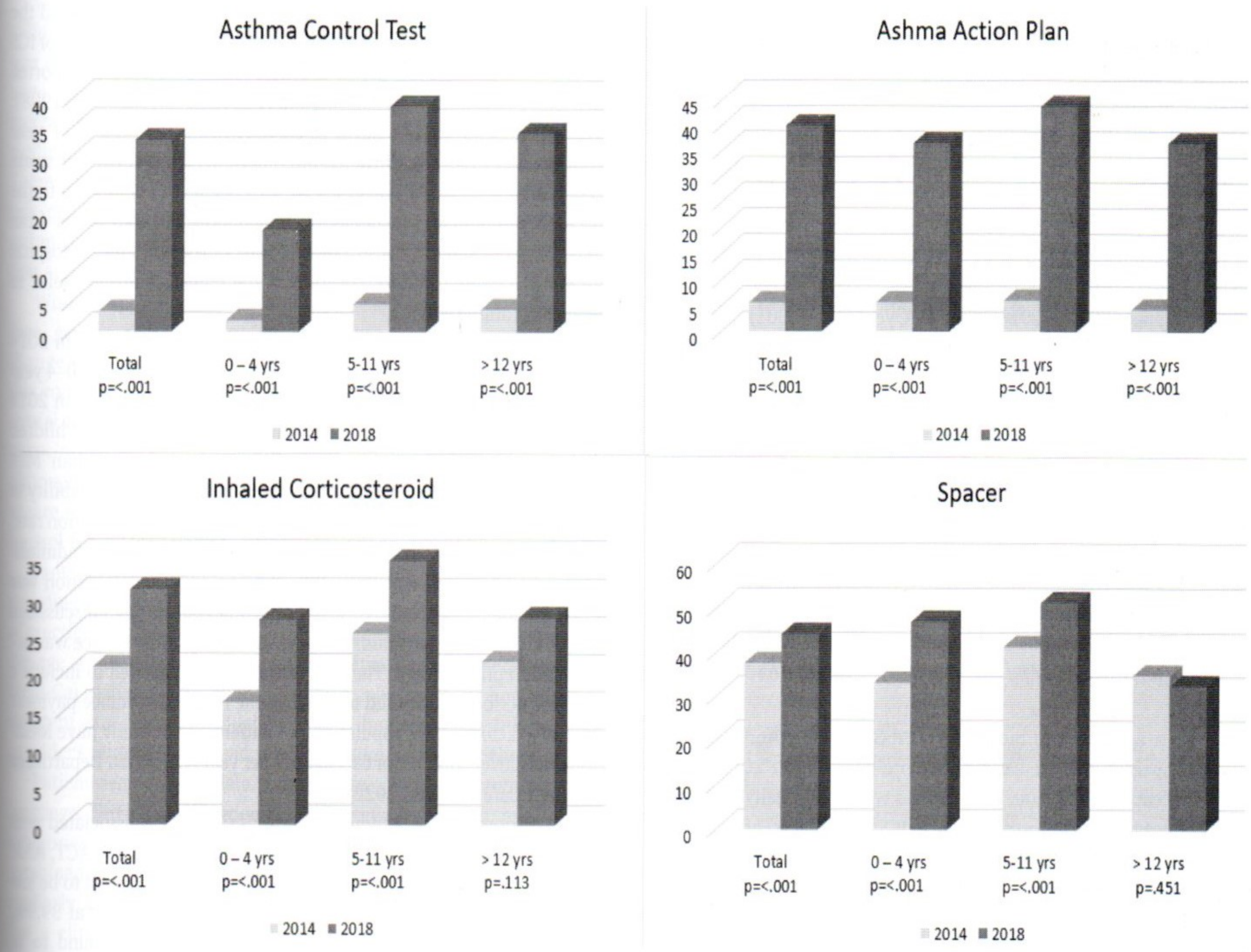

Fig. 2. Differences between 2014 and 2018 within age strata for Asthma Control Test, Asthma Action Plan, Inhaled Corticosteroid, and Spacer Prescription.
Note. Percent of patients in measurement period with data for outcome variable, by total and age stratum.

Table 4
Results of comparison of age strata within the same year.

	2014				2018			
	5–11 years		> 12 years		5–11 years		> 12 years	
	Chi-Square	*p*	Chi-Square	*p*	Chi-Square	*p*	Chi-Square	*p*
Asthma Control Test								
0–4 years	29.08	<0.001***	12.03	<0.001***	111.37	<0.001***	70.91	<0.001***
5–11 years			1.60	0.205			5.74	0.017*
Asthma Action Plan								
0–4 years	0.45	0.501	3.38	0.066	8.83	0.003**	<0.001	0.993
5–11 years			5.86	0.015*			12.32	<0.001***
Inhaled Corticosteroid								
0–4 years	19.09	<0.001***	3.79	0.052	6.28	0.012*	0.002	0.96
5–11 years			1.21	0.270			6.48	0.01**
Spacer								
0–4 years	8.44	0.004**	0.20	0.659	1.10	0.294	16.16	<0.001***
5–11 years			3.65	0.056			44.24	<0.001***

Note. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Asthma action plan

Analysis of AAP receipt across the total of all three age strata increased from 371 (5.6%) in 2014 to 2770 (39.9%) in 2018 ($p < .001$), where the 5–11 year stratum had the largest increase from 175 (6.1%) to [illegible] (43.7%) ($p < .001$) (Fig. 2). Table 4 shows in 2014, when each age stratum was compared to each of the other age strata in the same year, only the 5–11 year (6.1%) and ≥ 12 year (4.3%) strata were significantly different ($p = .015$). In 2018, the 5–11 year (43.7%) stratum was significantly different from the other two strata, which coincides with the 5–11 year old stratum having the largest increase: 0–4 years (36.5%) ($p = .003$), and ≥ 12 years (36.5%) ($p < .001$).

Inhaled corticosteroids

Chi-Square calculations showed a statistically significant difference for the total of all ages from 540 (20.8%) in 2014 to 863 (31.1%) in 2018 ($p \leq 0.001$) (Fig. 2). There was a significant change between the years 2014 and 2018 for the 0–4 year stratum, ($p < .001$) and 5–11 year stratum ($p < .001$) (Fig. 2), but no significant change for the ≥12 year stratum ($p = .113$). When comparing the age strata within the same year, in 2014 only the 0–4 year (33.3%) and the 5–11 year (41.3%) age strata showed a statistically significant difference ($p \leq 0.001$) (Table 4). Whereas, in 2018 the 5–11 year stratum was significantly different from both the 0–4 year ($p = .01$) and ≥ 12 year ($p = .01$) strata.

Spacers

A significant change was seen between 2014 (37.5%) and 2018 (44.1%) for the total of all the age groups ($p \leq 0.001$). There was a significant change 2014 to 2018 in the 0–4 year ($p \leq 0.001$) and in the 5–11 year ($p \leq 0.001$) strata. There was no significant change in the ≥12 year stratum ($p = .451$) (Fig. 2). In 2018, the 0–4 year and 5–11 year strata had increased by 13.6% and 9.9%, but the ≥12 years had decreased by 2.4% from 2014. When comparing the three age strata within 2014: the 0–4 year stratum differed significantly from the 5–11 year stratum ($p = .004$). The ≥12 year stratum was not significantly different from the other two age strata: 0–4 years ($p = .66$), and 5–11 years ($p = .056$). Whereas in 2018 the ≥12 year stratum was significantly different from the other two strata: 0–4 years ($p \leq 0.001$), and 5–11 years ($p \leq 0.001$) (Table 4).

Discussion

Provider adherence to the NAEPP EPR-3 guidelines for ACT, AAP, ICS, and spacers improved comparing pre-intervention 2014 data to post-intervention 2018 data. The changes were statistically significant for each measure of interest (ACT, AAP, ICS and spacers) after controlling for age, gender, race/ethnicity, and language. Although all changes were statistically significant, ACT (OR = 14.96) and AAP (OR = 12.70) were greater than ICS (OR = 1.85) and spacers (OR = 1.45). This may be attributed to provider training and monitoring (provided at implementation and new hire training) when the ACT and AAP were implemented as the initial measures for the CDS tool. No change in monitoring or additional measures have been added after the integration in 2015. This gives support to measures improving when providers are aware they are monitored.

From 2014 to 2018 ACT (one per year) had a significant increase across all age strata and the total of all ages. The smallest increase was in the 0–4 year age strata. The increased findings in 2018 are higher than those reported by Yawn et al. (2016) where a validated tool to evaluate asthma was documented in 7.5% of the medical records. There are ACTs for the different age strata, and these may not be distributed in all clinics. A clinic location and provider variable would be helpful to further analyze the change in ACT use.

The AAP documentation (initial or one update per year) increased across all age strata and total for all ages was significant. AAP documentation findings in 2014 and 2018 are higher than those reported by Yawn et al. (2016), who reported 3.1% of participants had an AAP documented. Like the ACT, providers were aware of the AAP adherence being measured.

ACT and AAP had the greatest increase for the 5–11 year age stratum between 2014 and 2018. This increase may be due to the care provided via the CHOC Breathmobile; an asthma clinic van with 2 exam rooms, pulmonary function testing (spirometry and oscillometry), and asthma specialty staff (Children's Hospital of Orange County, 2020b). The Breathmobile utilizes the same Cerner EMR system with the PAR integration and provides comprehensive asthma care, visiting 22 elementary schools in Orange County every four to six weeks. The visit includes a comprehensive history, utilizing an ACT to develop an AAP with the team and family. The Breathmobile has decreased hospital admissions from 16.0% to 4.6% and ED visits from 40.9% to 17.0% (Children's Hospital of Orange County, 2020b). The Breathmobile preschool and school-aged children are included in the 5–11 year stratum.

ICS use had the largest increase in the 0–4 year stratum. This increase was most likely related to the CDS tool in the EMR and establishment of the PAR. Providers had easy access to NAEPP EPR-3 guidelines and the admission and ED visit history. Compared to the literature, the use of ICS for the Children's Medical Group patients in 2018 was less than reported by Diette et al. (2001); Janson-Bjerklie (2004); Legorreta et al. (1998); O'Laughlen et al. (2013); Yawn et al. (2016). In 2018 the 5–11 year stratum (34.9%) was significantly different from the other two age strata (0–4 years 27.2%, ≥ 12 years 27.4%). This result may be related to the CHOC Breathmobile which has decreased hospital admissions from 16.0% to 4.6% and ED visits from 40.9% to 17.0% (Children's Hospital of Orange County, 2020b). Location of the clinic would be useful to include in future research.

Spacer use for the age stratum 0–4 years was 380 (33.3%) in 2014 and 274 (46.9%) in 2018. Of note, in 2014, 1140 (32.8%) of the 0–4 year stratum had an MDI prescribed, this decreased to 584 (15.7%) in 2018 ($p < .0001$), which was a decrease by more than half (52.2%). Children at this age may be receiving more nebulized treatments than MDI (excluded from the study), which was appropriate due to the inability to use an MDI unless a spacer was used. With a low spacer prescription rate, the question was raised as to how the medication was being administered to the children with a prescription for an MDI. A question was raised if patients received free spacers in clinic, but through discussions with clinic staff and respiratory therapists at CHOC, this service was not provided in primary care. The data retrieval was expanded to include a two-year period, but this did not change the results. Insurance payment was not a factor for this population. All patients in the study have Medi-Cal which covers the cost of two spacers per year (California Department of Health Care Services, 2022).

Integration of the CDS into the EMR at CHOC was associated with increased provider adherence to the NAEPP guidelines when ACT, AAP, ICS, and spacers were evaluated. But the adherence continued to be low in the post-intervention 2018 data with ACT at 32.9%, AAP at 39.9%, ICS at 31.1%, and spacers at 44.1%. Improvement was found to be higher in measures that providers knew were being monitored, demonstrated by the ACT and AAP odds ratios being higher than those of ICS and spacer. Although integration of the PAR into the EMR appears to be a successful intervention to increase provider adherence to the NAEPP guidelines, ongoing monitoring and education are needed to promote and maintain the behavioral change.

Application of this pilot study into clinical practice, integration of the PAR into the EMR as a CDS tool, can be used to improve provider adherence to the NAEPP guidelines. The use of NAEPP guidelines in clinical practice has shown improved patient outcomes (U.S. Department of Health and Human Services, 2007). This study adds to evidence-based practice by integrating best available research with clinical, and patient management, allowing for excellent health policy decision making as a direct impact on patient care and outcomes.

Limitations

Diagnosis coding changed in 2015 from ICD-9 to ICD-10 allowing for classification within the diagnosis code. This may influence the patients identified each year with asthma, and provider awareness of classification prompting the use of NAEPP guidelines. Without classification, it was difficult to determine which patients would benefit from ICS. As a surrogate for this study, a subset of patients with ED visit or hospital admits for asthma exacerbation where diagnosis of asthma exacerbation in the medical record was used for analysis: but not all patients requiring an ICS may have been included in the subset.

This study evaluated the Medi-Cal population at CHOC, excluding those with private insurance which limits the generalizability to the pediatric Medi-Cal providers who utilize Cerner as their EMR. The location of the study was one site, also reducing generalizability. There was no research with CDS in the Medi-Cal/Medicaid population. CHOC has a predominant Hispanic population, but the race and ethnicity were combined into one variable in the database, not providing separate details on each independently.

Due to the length of time (4 years), there may be a threat to internal validity, due to changes the researchers were not aware of. ICD coding was discussed, but other influences such as education and media may have impacted the outcomes. Change of providers and their experience increases over four years, education may be influenced by continuing medical education, grand round presentations, or additional education. There has been media attention given to Asthma in news segments and talk programs, as well as commercials. Social media also has many asthma groups where patients or parents can gain additional information and support.

While the primary tests controlled for selected patient characteristics (age, gender, race/ethnicity, and language), additional exploration of change within each age stratum using Chi-square tests did not include this control. Statistical models included control for a limited set of potential confounding variables. Potential confounding variables on family or sociodemographic characteristics were not included in the EMR data, although the data set was limited to Medi-Cal patients. Utilization of chi-square to analyze differences in age strata between years did not allow control for other variables.

Provider demographics were not available. There may be confounding variables by provider demographics (e.g., age, gender, location of practice, number of years in practice) that could explain differences in the age strata. Location of provider's practice would be helpful; all are Medi-Cal patients but differing clinics may be providing more or different care based on guidelines. Years in practice may influence the provider's understanding and implementation of the guidelines.

Patient demographic data included age, gender, race/ethnicity and language. CHOC has a predominant Hispanic population, but the race categories do not purely represent race due to the two variables being combined. It was unknown if a white Hispanic chose white or Hispanic, similarly a black Hispanic could choose black or Hispanic. CHOC also has a clinic in Garden Grove (a Vietnamese community) with Vietnamese providers and staff.

Recommendations

Going forward, studies might also consider additional variables of zip code, location of service, family and sociodemographic characteristics, with integration of both the EMR and claims databases to provide a more comprehensive analysis. Next steps include: a multi-site research study to increase generalizability, decreasing the time between the evaluation years to decrease the threat to internal validity, and additional research that explores the relationship of provider demographics in relation to adherence to NAEPP guidelines. Availability of these data may also identify which providers are more likely to use the guidelines. These providers can educate and train additional providers in the organization.

Promoting provider's use of the ICD-10 diagnosis code for classification of asthma and adding this as a measure of provider adherence was recommended. Use of the ACT was required to determine the patient classification of asthma. The use of the ACT may increase if the classification was being monitored. Also, with proper classification, NAEPP guidelines can be utilized appropriately giving a more accurate AAP to improve patient outcomes.

Increased monitoring has been discussed at CHOC with an added benefit of provider incentives in 2018. Monitoring would be evaluated regularly with formal feedback to the provider. It was also recommended that adding additional asthma guideline measures be included to increase adherence to the guidelines.

Conclusion

This pilot study supports the use of a CDS in the EMR for evidence-based practice to increase provider adherence to NAEPP guidelines. The study shows that after establishment of the CDS tool into the EMR at CHOC in the Medi-Cal population, provider adherence to the NAEPP EPR-3 guidelines increased. The objective was supported: ACT, AAP, ICS and spacers had significant increases from 2014 to 2018. ACT and AAP were being monitored and were higher than ICS and spacers giving strength to monitoring behavior increases adherence to the measurement.

Author credit statement

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Declaration of Competing Interest

None.

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