

Effectiveness of Pediatric Asthma Pathways for Hospitalized Children: A Multicenter, National Analysis

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Objective To determine if clinical pathways affect care and outcomes for children hospitalized with asthma using a multicenter study.

Study design This was a retrospective, multicenter cohort study using an administrative database, the Pediatric Health Information System. We evaluated the impact of inpatient pediatric asthma pathways on children age 2-17 years admitted for asthma from 2006 to 2015 in 42 children's hospitals. Date of pathway implementation for each hospital was collected via survey. Using generalized estimating equations with an interrupted time series approach (to account for secular trends), we determined the association of pathway implementation with length of stay (LOS), 30-day readmission, chest radiograph utilization, ipratropium administration >24 hours, and administration of bronchodilators, systemic steroids, and antibiotics. All analyses were risk-adjusted for patient and hospital characteristics.

Results Clinical pathway implementation was associated with an 8.8% decrease in LOS (95% CI 6.7%-10.9%), 3.1% decrease in hospital costs (95% CI 1.9%-4.3%), increased odds of bronchodilator administration (OR 1.53[1.21-1.95]) and decreased odds of antibiotic administration (OR 0.93[0.87-0.99]) (n = 189 331). We found no associations between pathway implementation and systemic steroid administration, ipratropium administration for >24 hours, chest radiograph utilization, or 30-day readmission.

Conclusions Clinical pathways can decrease LOS, costs, and unnecessary antibiotic use without increasing rates of readmissions, leading to higher value care. (*J Pediatr* 2018;■■■:■■■-■■■).

Asthma is a leading cause of pediatric hospitalizations,¹ at a cost of nearly \$1 billion annually in the US.² Inconsistent adoption of evidence-based guidelines by healthcare providers contributes to variability in quality of care and outcomes for children hospitalized for asthma, including rates of transfer to intensive care units, hospital readmissions, hospital length of stay (LOS), and healthcare expenditures.³⁻⁸ Clinical pathways are operational versions of practice guidelines, aimed at inpatient management of common illnesses.⁹ Pathways hold promise as a means to increase clinicians' adoption of evidence-based guidelines and to improve quality of care.

The number of hospitals implementing inpatient pediatric asthma pathways has grown substantially in recent years,¹⁰ possibly driven by factors including the development of inpatient pediatric asthma performance metrics by the Joint Commission in 2007,¹¹ increasing pressures to publicly report quality metrics,¹² and/or changes in insurance reimbursement policies intended to incentivize higher value care.¹³

Studies of inpatient pediatric asthma pathways have demonstrated improvements in quality of care and reductions in LOS.¹⁴⁻²⁴ However, current evidence is limited to single-center or single health-system studies with limited duration of follow-up. Concluding that pathways are effective based on these studies alone could be subject to biases, including publication bias (ie, only successful pathway interventions are reported) and failure to account for secular trends (ie, LOS is

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APR-DRG	All Patient Refined Diagnosis Risk Group
EMR	Electronic medical record
GEE	Generalized estimating equation
ITS	Interrupted time series
LOS	Length of stay
PHIS	Pediatric Health Information System

declining in general). Our objective was to determine if clinical pathways affect care and outcomes for children hospitalized with asthma in a large national sample, accounting for secular trends.

Methods

This retrospective, multicenter cohort study used an administrative database, the Pediatric Health Information System (PHIS).²⁵ PHIS includes approximately 30% of pediatric hospitalizations in the US. It contains data from 48 tertiary children's hospitals (including 26 states and the District of Columbia). The Children's Hospital Association and participating hospitals collaborate to ensure data reliability and quality. Data elements for each hospital discharge include patient demographics, dates of admission and discharge, discharge diagnoses, tests used, medications prescribed, and procedures performed. Patient identifiers are removed from the database, but each patient is assigned a unique identifier that permits capture of readmissions at the same hospital as the index admission.⁵

Selection of our study population is outlined in **Figure 1**. The 42 (88%) PHIS hospitals where pathway status was known were included for this analysis. We included children ages 2-17 years admitted for a primary diagnosis of asthma from January 1, 2006 to December 1, 2015. Asthma was defined using *International Classification of Diseases-Clinical Modification, Ninth Revision*, and *Tenth Revision* codes²⁶ as specified in the **Appendix** (available at www.jpeds.com) and All Patient

Refined Diagnosis Risk Group (APR-DRG, 3M) of 141: Asthma. Children transferred into or out of the hospital were excluded due to inability to accurately determine LOS.²⁷ Children were excluded if they were discharged against medical advice, transferred to the intensive care unit, or died during the admission. This study was approved by the Institutional Review Board of the University of California, San Francisco, California.

Defining Exposure to Pathways

As described previously, we contacted all PHIS hospitals via survey to determine whether the hospital had an inpatient asthma pathway, its date of initial implementation, and dates of any pathway improvements (quarter, year).¹⁰ Our study team used an established definition of clinical pathways; to be classified as a pathway, the intervention had to satisfy 4 criteria: (1) be a structured multidisciplinary plan of care, (2) be used to translate guidelines or evidence into local structures, (3) detail the steps in a course of treatment or care in a plan, pathway, algorithm, guideline, protocol or other "inventory of actions," and (4) aim to standardize care for a specific population.²⁸ The **Appendix** provides an example of a pediatric inpatient asthma pathway.

Each asthma hospitalization was assigned an exposure status to pathways based on hospital and date of hospitalization, using the information we had gathered via survey. We assumed that the impact of pathway implementation would not be immediate. As a result, in our analysis, we allowed a 1-year wash-in period,²⁹ during which we excluded all records to account for the time taken for full pathway implementation (1 quarter

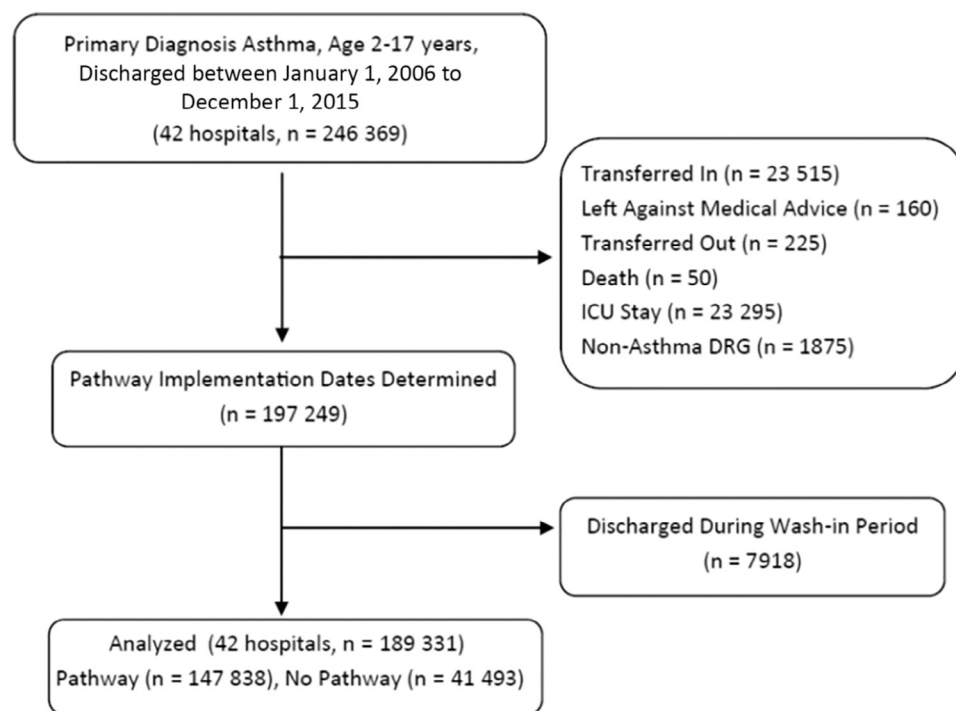


Figure 1. Flow diagram of selection of pediatric asthma admissions for analysis. *ICU*, intensive care unit.

before implementation, quarter of implementation, and 2 quarters after implementation).

Outcomes

Our primary outcome was hospital LOS in days. Our secondary outcomes included administration of bronchodilators, administration of systemic steroids, administration of antibiotics, administration of ipratropium for >24 hours, utilization of chest radiography, 30-day hospital readmission, and total hospital costs. All outcomes were analyzed at the patient level.

Statistical Analyses

We used generalized estimating equations (GEEs, cluster = hospital) with an interrupted time series (ITS) approach to determine the influence of pathway implementation on our primary and secondary outcomes. The ITS approach assesses the effects of pathways correcting for overall secular/time trends.

We included several covariates in the model to correct for confounding that might be related to case-mix differences across hospitals or seasonality of asthma admissions. The patient characteristics included in the model were age, sex, race, payer, median household income for the patient's zip code, APR-DRG severity, number of complex chronic conditions, presence of mental health comorbidities, discharge disposition, season of hospital admission, and number of hospital admissions in the prior year. We also included hospital-level characteristics in the model, including geographic region and hospital size. These variables were chosen based on previous studies showing potential associations with LOS.³⁰⁻³² We used GEE models with logit link to analyze binary outcomes and GEE models with a log link to analyze LOS and costs (point estimates were back-transformed to be rate ratios). Costs were calculated from charges using year- and hospital-specific cost to charge ratios, and we adjusted for inflation using the Consumer Price Index for Hospital Services. Given that prior studies have documented very high rates of bronchodilator administration for children admitted for asthma,⁵ we also conducted a sensitivity analysis excluding all children who did not receive bronchodilators to confirm the findings of our primary analysis. We used a *P* value of <.05 as a threshold for statistical significance. All analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina).

Additional Analyses

We performed a subgroup analysis limited to admissions to hospitals that implemented pathways during our study interval from 2006 to 2015 (15 of the 42 hospitals in the primary analysis). The goal of this analysis was to better control for potential unmeasured hospital-level confounders, such as quality improvement resources and hospital culture.

Several hospitals reported improvements to pre-existing pathways during our study interval. To better understand the impact and importance of continued improvement on existing pathways, we conducted an analysis comparing hospital admissions occurring after initial pathway implementation to admissions occurring after improvements to existing pathways. Improvements commonly involved revising and updating

pathway content and integrating pathway tools into the hospital's electronic medical record (EMR).

These additional analyses were completed using the same covariates and multivariable models as our primary analysis (GEE with an ITS approach).

Results

Of the 42 hospitals in our primary analysis, 25 had pathways in place throughout the study interval, 2 had no pathways during the study interval, and 15 implemented pathways during the study interval. Twenty hospitals reported improvements to existing pathways during the study interval (Figure 2).

The Appendix includes a table comparing patient- and hospital-level characteristics for admissions during periods with or without inpatient pediatric asthma pathways (42 hospitals, *n* = 189 331). Admissions occurring during periods when hospitals did not have pathways were more likely to involve Hispanic children and children with higher APR-DRG severity level. These admissions were also more likely to occur in smaller hospitals and those in the Western region of the US.

The majority of children were male (62%), median age of 5 years, which reflects the epidemiology of asthma for this population.

Primary Analysis Comparing Admissions with Vs without Pathway at Hospital

Our primary analysis compared admissions during periods with or without inpatient pediatric asthma pathways (42 hospitals, *n* = 189 331). In our unadjusted analysis, we found pathways were associated with a 14.5% decrease in LOS soon after implementation (unadjusted mean LOS 1.87 days before implementation versus 1.60 days soon after implementation). After model adjustment, we found an 8.8% decrease in LOS soon after implementation (*P* < .001, adjusted mean LOS 1.78 days before implementation vs 1.63 days after implementation).

Secondary Outcomes

Table I describes our secondary outcomes. Pathways were associated with a 3.3% decrease in hospital costs, from an adjusted mean of \$3735-\$3611. Pathways were also associated with increased odds of bronchodilator administration (OR 1.53, 95% CI 1.21, 1.95), and decreased odds of antibiotic administration (OR 0.93, 95% CI 0.87, 0.99). During the entire study interval (2006-2015), pathway implementation was associated with total reductions of ≈22 000 hospital days, ≈\$18 000 000 in hospital costs, and ≈4000 instances of antibiotic utilization. Pathways were not associated with any significant changes in administration of systemic steroids, chest radiograph utilization, ipratropium use >24 hours, or 30-day hospital readmissions.

Our sensitivity analysis excluding children who did not receive bronchodilators found an 8.4% decrease in LOS (*P* < .001), 3% decrease in hospital costs (*P* < .001), and decreased odds of antibiotic administration (OR 0.91, 95% CI 0.86, 0.98), closely aligned with the findings of our of our primary analysis.

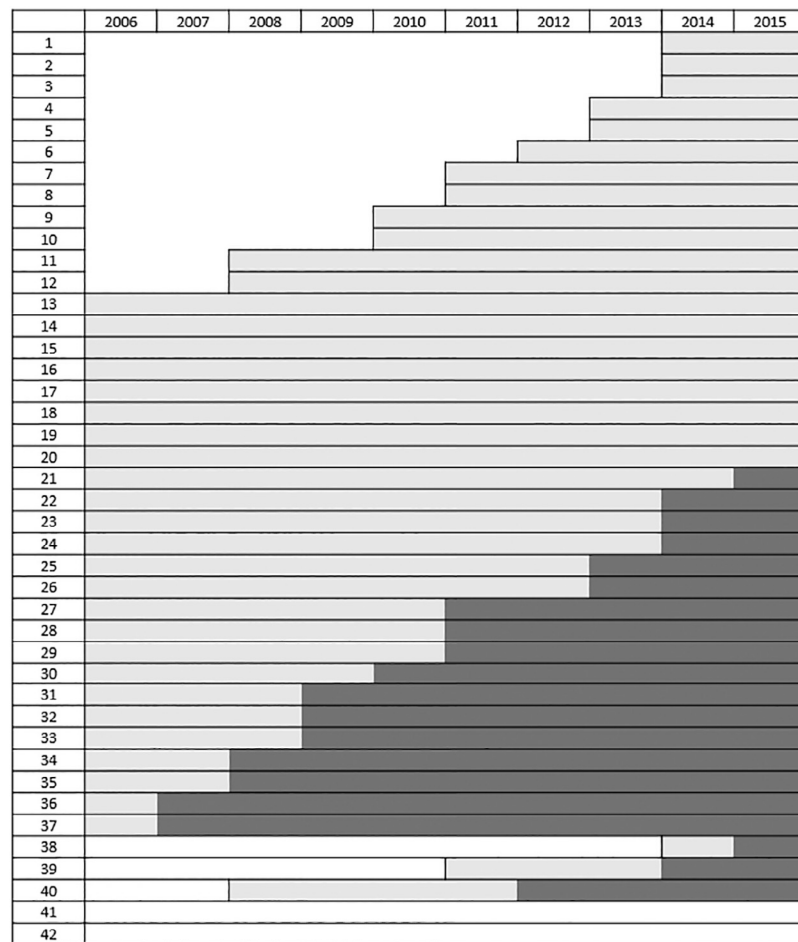


Figure 2. Timing of pathway implementation for hospitals included in analysis. White bars represent times during which there was no pathway in place. Light gray bars represent times during which pathways were implemented. Dark gray bars represent times during which improvements were made to existing pathways.

Table I. Effects of pediatric asthma pathways for hospitalized children comparing children cared for during periods with or without a pathway

Outcomes	Improvement (↓ or ↑)	Pathway vs no pathway: all hospitals (42 hospitals, N = 189 331)
Length of hospital stay (rate ratio, 95% CI)	↓	0.91 (0.89, 0.93)
Administration of bronchodilators (OR, 95% CI)	↑	1.53 (1.21, 1.95)
Administration of systemic steroids (OR, 95% CI)	↑	1.14 (0.77, 1.70)
Administration of antibiotics (OR, 95% CI)	↓	0.93 (0.87, 0.99)
Chest radiograph utilization (OR, 95% CI)	↓	1.04 (0.99, 1.10)
Ipratropium use >24 h (OR, 95% CI)	↓	0.97 (0.89-1.07)
30-d hospital readmission (OR, 95% CI)	↓	1.03 (0.92-1.15)
Cost (Rate ratio, 95% CI)	↓	0.97 (0.96-0.98)

Statistically significant results indicated in bold print.

Additional Analyses

In the analysis of hospitals implementing pathways during the study interval (**Table II**), effects across the primary and secondary outcomes were greater (15 hospitals, n = 55 909). We found pathways were associated with a 14% decrease in LOS soon after implementation (from an adjusted mean of 1.84-1.58 days) and an 11% decrease in costs (from an adjusted mean of \$3890-\$3462). We found that pathway implementation was also associated with increased odds of bronchodilator administration (OR 2.69, 95% CI 1.83, 3.96) and systemic steroid administration (OR 3.06, 95% CI 1.67, 5.61), and decreased odds of chest radiograph utilization (OR 0.92, 95% CI 0.86, 0.99) and antibiotic administration (OR 0.91, 95% CI 0.83, 0.99).

Table II also describes the analysis of the effects of secondary pathway improvements (39 hospitals, n = 140 303). These improvements commonly involved EMR integration of pathways. Improvements also sometimes involved revisions of pathway content and educational efforts with healthcare providers. Pathway improvements were associated with a 23% decrease in LOS ($P < .001$) and 12% decrease in hospital costs ($P < .001$) soon after the improvement. Improvements were also

Table II. Additional analyses of effects of inpatient pediatric asthma pathways*

Outcomes	Improvement (↓ or ↑)	Additional Analysis 1 - Pathway vs no pathway: hospitals implementing pathways during study interval (2006-2015) (15 hospitals, N = 55 909)	Additional Analysis 2 - Secondary pathway improvement vs initial pathway implementation (39 hospitals, N = 140 303)
Length of hospital stay (RR, 95% CI)	↓	0.86 (0.83,0.89)	0.77 (0.75-0.79)
Administration of bronchodilators (OR, 95% CI)	↑	2.69 (1.83,3.96)	1.06 (0.87-1.30)
Administration of systemic steroids (OR, 95% CI)	↑	3.06 (1.67,5.61)	2.20 (1.83-2.64)
Administration of antibiotics (OR, 95% CI)	↓	0.91 (0.83,0.99)	1.00 (0.94-1.06)
Chest radiograph utilization (OR, 95% CI)	↓	0.92 (0.86,0.99)	1.04 (0.99-1.10)
Ipratropium use >24 h (OR, 95% CI)	↓	1.13 (0.99, 1.30)	0.68 (0.63-0.74)
30-d hospital readmission (OR, 95% CI)	↓	1.17 (0.96, 1.43)	1.13 (1.02-1.26)
Cost (Rate ratio, 95% CI)	↓	0.89 (0.87,0.91)	0.88 (0.87-0.89)

*Statistically significant results indicated in bold print.

associated with increased odds of systemic steroid administration (OR 2.20, 95% CI 1.83, 2.64) and decreased odds of ipratropium use >24 hours (OR 0.68, 95% CI 0.63, 0.74). In this analysis, we found an increase in odds of 30-day readmissions (OR 1.13, 95% CI 1.02, 1.26).

Discussion

In this national, multicenter analysis, inpatient pediatric asthma pathways were associated with significant decreases in LOS, costs, and unnecessary antibiotic use without increases in rates of readmissions, leading to higher value care. These findings support widespread efforts to improve care and outcomes by investing resources into pathway implementation.¹⁰ Modifications to existing pathways following initial implementation were associated with significant benefits and may be a means of enhancing the sustainability of the initial gains achieved from clinical pathways.

Our results show slightly smaller effects than previous studies of inpatient pediatric asthma pathways, which report LOS decreases of 10%-50% and costs decreases of 7%-23%.¹⁵⁻¹⁹ The larger effects in prior studies may have been due to several factors. First, most of these studies used limited methods for correcting for confounding bias because of secular trends or patient case-mix. Second, most prior studies have analyzed outcomes over a shorter time period of 6-12 months after implementation. Our analysis excludes data from the first 9 months of implementation and focuses on longer-term sustained effects. In addition, studies showing improvements after pathway implementation are more likely to be published than negative studies (publication bias). Our larger, multicenter design was less susceptible to biases from selective reporting of institutional experience. Lastly, the aggregate smaller effect size we found may be a reflection of the hospital-level variability in pathway effects.

Our analysis demonstrates the potential of clinical pathways to create significant gains in healthcare value. Because asthma is a leading cause of pediatric hospitalizations,¹ small effects on LOS and costs at the patient level have potentially important effects at the healthcare system level. During our study interval, pathways were associated with total reductions of ≈22 000 hospital days and ≈\$18 000 000 in hospital costs. Given our analysis only represents approximately 30% of pediatric hospitalizations nationally,³³ the potential value gains with more widespread pathway implementation could be significant.

We conducted an additional analysis limited to hospitals that implemented pathways during our study interval (15 hospitals). This analysis provided advantages over our primary analysis and prior studies. First, because hospitals provided their own control data, we could better account for potential unmeasurable factors that may have affected the success of pathway implementation (eg, quality improvement resources, hospital culture) than we could in our primary analysis. In addition, unlike prior studies, this analysis accounted for secular trends. In this analysis, we found pathways had even greater and broader effects in increasing value. These findings suggest pathways have the potential to create even larger gains in value than those suggested by our primary analysis (42 hospitals), which could not control for potential unmeasurable confounders.

Ongoing local pathway improvement efforts may represent a means to sustain continued gains after initial implementation. We found the largest reductions in LOS (23%) and cost (12%) when analyzing the effects of improvements to existing pathways (pathways initially implemented either before or during our study interval). Among hospitals that reported pathway improvements, the majority cited integration of pre-existing pathways into the EMR. Some also reported revisions to pathway content and educational efforts with healthcare

providers. Centers of clinical pathway research, such as Seattle Children's Hospital, have made electronic integration using electronic order sets a core principle/component of implementation,³⁴ and more recent analyses of pathway implementation have demonstrated quality gains when pathway implementation was supported by order set creation.^{14,23,24} However, integrating pathways into the EMR requires time and resources, and it is not yet clear what impact EMR integration has on the success of pathway implementation. A recent systematic review evaluated interventions to increase the use of electronic health information by healthcare practitioners to improve clinical practice and patient outcomes. They found no differences in guideline use comparing electronic vs printed guidelines but reported increased use of electronic guidelines when accompanied by training or delivered via mobile device rather than a stationary, desktop computer. Authors found no evidence that the use of electronic guidelines translated into improved patient outcomes.³⁵ Future health informatics research should determine how electronic integration of pathways can be optimized to improve patient outcomes, and whether centralized development and dissemination of electronic resources (eg, order sets) can improve the cost-effectiveness of the implementation process.

Of note, although pathway improvement efforts were associated with several areas of performance gains, they were associated with a small increase in 30-day readmission rates (3.1% vs 3.5%; average of 2 readmissions per year per hospital). Prior studies have not shown increases in readmission rates with pathway implementation,^{15,18-21,23} and the mechanisms that drove this increase are unclear. In our prior analysis,¹⁰ many sites reported tracking of clinical outcomes, such as readmission rates, during pathway implementation. Our data would support the importance of tracking outcomes for monitoring safety and improving the pathway implementation process.

Our study has several strengths. Prior analyses of pathways were limited to single centers or single-health systems, used limited methods for controlling for secular trends in LOS or patient case-mix, and had limited duration of follow-up.¹⁵⁻¹⁹ We used an ITS analysis to account for secular trends in inpatient pediatric asthma care that were occurring simultaneously to pathway implementation. We also accounted for several potential patient- and hospital-level confounders to correct for any differences in patient case-mix that could bias our findings. However, there were several limitations to our analysis. First, because we collected pathway implementation status at the hospital-level and assigned "exposure" status, this may not be reflective of actual pathway utilization at the individual level (misclassification bias). However, prior analyses of hospital-level interventions have used this strategy,^{29,36} and because data on pathway utilization at the individual level is not routinely collected at most hospitals, this type of multicenter analysis would not have been possible without this approach. Second, we used an administrative database (PHIS), in which data for use of medications and imaging are derived from charges. Using charges as a measure of actual use has not been validated, so in some cases, a patient may have been charged for medications or imaging but not actually received

them. However, PHIS has been used extensively to study inpatient pediatric care and utilization patterns.^{5,37} Third, hospital readmission could be measured only at the hospital where the index admission occurred. Follow-up care occurring at hospitals not included in the PHIS database was not counted. This limitation could underestimate the proportion of children requiring subsequent hospital care. Fourth, our study was performed using data from large, tertiary care children's hospitals that contribute data to PHIS, and our findings may have limited generalizability outside of similar healthcare settings. Finally, this is an observational study and the selection of hospitals for implementation of pathways was not random. There may be other factors associated with pathway implementation, not accounted in our analyses, which are responsible for the effects we observed (confounding bias).

In this national, multicenter analysis, we found inpatient pediatric asthma pathways were associated with decreases in LOS, costs, and unnecessary antibiotic use without increased rates of readmissions, leading to higher value care. ■

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Appendix International Classification of Diseases-Clinical Modification, Ninth Revision, Clinical Modification and International Classification of Diseases-Clinical Modification, Tenth Revision, Clinical Modification Codes

HRQ QI™ ICD-9-CM and ICD-10-CM/PCS Specification Enhanced Version 5.0

PDI #14 Asthma Admission Rate

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PDI #14 Asthma Admission Rate

Asthma diagnosis codes: (ACSASTD)

ICD-9-CM Description

49300 EXT ASTHMA W/O STAT ASTH
49301 EXT ASTHMA W STATUS ASTH
49302 EXT ASTHMA W ACUTE EXAC
49310 INT ASTHMA W/O STAT ASTH
49311 INT ASTHMA W STATUS ASTH
49312 INT ASTHMA W ACUTE EXAC
49320 CH OB ASTH W/O STAT ASTH
49321 CH OB ASTHMA W STAT ASTH
49322 CH OBS ASTH W ACUTE EXAC
49381 EXERCISE IND BRONCHOSPASM
49382 COUGH VARIANT ASTHMA
49390 ASTHMA W/O STATUS ASTHM
49391 ASTHMA W STATUS ASTHMAT
49392 ASTHMA W ACUTE EXACERBTN

ICD-10-CM Description

J4521 Mild intermittent asthma with (acute) exacerbation
J4522 Mild intermittent asthma with status asthmaticus
J4531 Mild persistent asthma with (acute) exacerbation
J4532 Mild persistent asthma with status asthmaticus
J4541 Moderate persistent asthma with (acute) exacerbation
J4542 Moderate persistent asthma with status asthmaticus
J4551 Severe persistent asthma with (acute) exacerbation
J4552 Severe persistent asthma with status asthmaticus
J45901 Unspecified asthma with (acute) exacerbation
J45902 Unspecified asthma with status asthmaticus
J45990 Exercise induced bronchospasm
J45991 Cough variant asthma
J45998 Other asthma

Characteristics of pediatric asthma admissions during periods with or without pathways

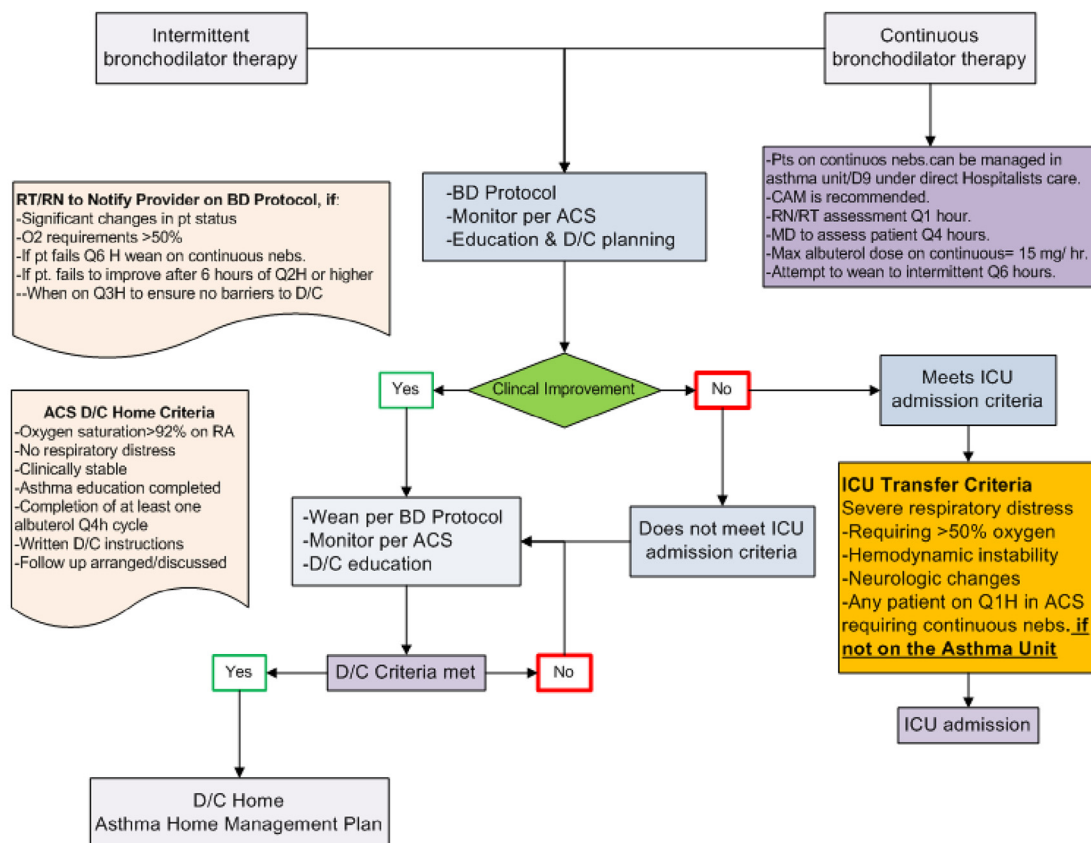
Characteristics	Total N = 189 331	Without pathway N = 41 493	With pathway N = 147 838
Age, median (IQR)	5 (3, 9)	5 (3, 9)	5 (3, 9)
Age, N (%)			
2-4 y	76221 (40.3)	16830 (40.6)	59391 (40.2)
5-7 y	49528 (26.2)	10820 (26.1)	38708 (26.2)
8-10 y	31804 (16.8)	7116 (17.1)	24688 (16.7)
11-13 y	19019 (10.0)	4127 (9.9)	14892 (10.1)
14-17 y	12759 (6.7)	2600 (6.3)	10159 (6.9)
Sex, N (%)			
Male	117676 (62.2)	26095 (62.9)	91581 (61.9)
Female	71652 (37.8)	15398 (37.1)	56254 (38.1)
Race/ethnicity, N (%)			
Non-Hispanic Black alone	48059 (25.4)	10065 (24.3)	37994 (25.7)
Non-Hispanic White alone	89652 (47.4)	17141 (41.3)	72511 (49.0)
Hispanic	33534 (17.7)	9373 (22.6)	24161 (16.3)
Asian	3648 (1.9)	909 (2.2)	2739 (1.9)
Other	14438 (7.6)	4005 (9.7)	10433 (7.1)
Payer, N (%)			
Public	116028 (61.3)	26784 (64.6)	89244 (60.4)
Private	55744 (29.4)	10658 (25.7)	45086 (30.5)
Other	14731 (7.8)	3891 (9.4)	10840 (7.3)
Missing	2828 (1.5)	160 (0.4)	2668 (1.8)
Zip median income, N (%)			
<\$34 576	50595 (26.7)	9928 (23.9)	40667 (27.5)
\$34 576-\$46 100	48421 (25.6)	10593 (25.5)	37828 (25.6)
\$46 101-\$69 150	59306 (31.3)	13395 (32.3)	45911 (31.1)
>\$69 150	29043 (15.3)	6434 (15.5)	22609 (15.3)
Missing	1966 (1.0)	1143 (2.8)	823 (0.6)
Admission season, N (%)			
Winter	43005 (22.7)	10037 (24.2)	32968 (22.3)
Spring	49941 (26.4)	11093 (26.7)	38848 (26.3)
Summer	29223 (15.4)	6262 (15.1)	22961 (15.5)
Fall	67162 (35.5)	14101 (34.0)	53061 (35.9)
APR-DRG severity, N (%)			
1	131789 (69.6)	26378 (63.6)	105411 (71.3)
2	52342 (27.6)	14095 (34.0)	38247 (25.9)
3	4963 (2.6)	968 (2.3)	3995 (2.7)
4	237 (0.1)	52 (0.1)	185 (0.1)
Complex chronic conditions, N (%)			
0	168334 (88.9)	37557 (90.5)	130777 (88.5)
1	13746 (7.3)	2571 (6.2)	11175 (7.6)
2	3240 (1.7)	546 (1.3)	2694 (1.8)
3+	4011 (2.1)	819 (2.0)	3192 (2.2)
Mental health comorbidity, N (%)			
No	178921 (94.5)	39464 (95.1)	139457 (94.3)
Yes	10410 (5.5)	2029 (4.9)	8381 (5.7)
Admissions in previous year, N (%)			
0	139946 (73.9)	30767 (74.1)	109179 (73.9)
1	33027 (17.4)	7185 (17.3)	25842 (17.5)
2-3	13012 (6.9)	2753 (6.6)	10259 (6.9)
4+	3346 (1.8)	788 (1.9)	2558 (1.7)
Census region, N (%)			
Midwest	25494 (13.5)	6517 (15.7)	18977 (12.8)
Northeast	29229 (15.4)	1186 (2.9)	28043 (19.0)
South	40520 (21.4)	5559 (13.4)	34961 (23.6)
West	94088 (49.7)	28231 (68.0)	65857 (44.5)
Hospital size, N (%)			
>150 000 bed days	42603 (22.5)	0 (0.0)	42603 (28.8)
70 000-150 000 bed days	116605 (61.6)	27652 (66.6)	88953 (60.2)
<70 000 bed days	30123 (15.9)	13841 (33.4)	16282 (11.0)

ICD-CM-9; International Classification of Diseases-Clinical Modification, Ninth Revision; ICD-CM-10; International Classification of Diseases-Clinical Modification, Tenth Revision.

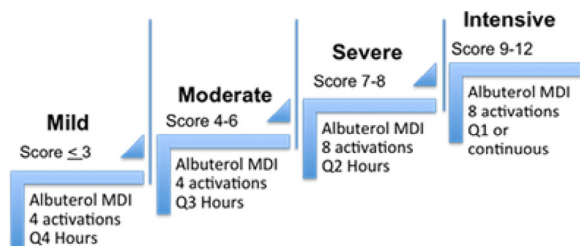
Acute Asthma Clinical Pathway Algorithm for ACS – Phase II

Otherwise Healthy Children 2 to 18 years old with Asthma

O2 should be administered if SpO2<92%



Inpatient Bronchodilator Algorithm



ASTHMA SCORE

Score	0	1	2	3
Respiratory Rate				
2-3 years	≤ 26 bpm	27-34 bpm	35-39 bpm	≥ 40 bpm
4-5 years	≤ 24 bpm	25-30 bpm	31-35 bpm	≥ 36 bpm
6-12 years	< 20 bpm	21-26 bpm	27-30 bpm	> 31 bpm
>12	≤ 18 bpm	19-23 bpm	24-27 bpm	≥ 28 bpm
Oxygen Requirement				
	≥ 98% on room air	95-97% on room air	90-94% on room air	< 90% on room air or on any oxygen
Auscultation				
	Normal with good aeration throughout	Normal to end expiratory wheezes	Expiratory wheezing	Inspiratory and expiratory wheezing to diminished breathsounds
Retraction				
	None	Intercostals	Intercostal and substernal	Intercostal, substernal, and supraclavicular

Example inpatient pediatric asthma pathway.