Reducing Albuterol Use in Children With Bronchiolitis

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abstract

OBJECTIVES: In 2014, the American Academy of Pediatrics published bronchiolitis guidelines recommending against the use of bronchodilators. For the winter of 2015 to 2016, we aimed to reduce the proportion of emergency department patients with bronchiolitis receiving albuterol from 43% (previous winter rate) to <35% and from 18% (previous winter rate) to <10% in the inpatient setting.

METHODS: A team identified key drivers of albuterol use and potential interventions. We implemented changes to our pathway and the associated order set recommending against routine albuterol use and designed education to accompany the pathway changes. We monitored albuterol use through weekly automated data extraction and reported results back to clinicians. We measured admission rate, length of stay, and revisit rate as balancing measures for the intervention.

RESULTS: The study period included 3834 emergency department visits and 1119 inpatient hospitalizations. In the emergency department, albuterol use in children with bronchiolitis declined from 43% to 20% and was <3 SD control limits established in the previous year, meeting statistical thresholds for special cause variation. Inpatient albuterol use decreased from 18% to 11% of patients, also achieving special cause variation and approaching our goal. The changes in both departments were sustained through the entire bronchiolitis season, and admission rate, length of stay, and revisit rates remained unchanged.

CONCLUSIONS: Using a multidisciplinary group that redesigned a clinical pathway and order sets for bronchiolitis, we substantially reduced albuterol use at a large children's hospital without impacting other outcome measures.

Bronchiolitis is 1 of the most common reasons for hospitalization in young children, accounting for 18% of hospital admissions for children younger than age 1 and $1.73 billion in hospital charges in the United States in 2009.[1] Bronchodilators are commonly used to treat children with bronchiolitis, although research has shown no benefit in respiratory status of inpatients, admission rate, or hospital length of stay.[2,3] In 2014, the American Academy of Pediatrics (AAP) updated their guidelines on bronchiolitis, recommending against treatment with bronchodilators.[3,4] One of the Society of Hospital Medicine's 5 opportunities for increasing value in health care is not using bronchodilators in bronchiolitis.[5] Despite the AAP guideline and meta-analyses recommending against the use of bronchodilators, this practice is common throughout pediatric institutions.[6,7]

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In 2013 our institution updated its bronchiolitis clinical pathway and mirrored the existing AAP guidelines at that time, suggesting an option for a trial of albuterol for patients with bronchiolitis, with documentation of a respiratory assessment before and after the intervention.[4] Although the pathway specified that albuterol was more likely to be effective in older infants with personal and/or family history of wheeze, even very young infants were receiving trials of albuterol. Before the 2015 to 2016 bronchiolitis season, 43% of bronchiolitis patients in the emergency department (ED) and 18% of inpatients received albuterol. Thus, almost half of all patients were exposed to a likely unnecessary therapy with potential side effects.

Given the baseline frequency of albuterol usage, we wanted to improve the value of the care of children with bronchiolitis by reducing albuterol use. We set out to revise our clinical pathway to reflect the 2014 AAP guidelines and educate clinicians about the recommended changes in practice. The use of a clinical pathway has previously been shown to be effective in reducing unnecessary interventions in bronchiolitis.[8] We also wanted to use clinical decision support within our electronic health record (EHR) to help guide providers not to use albuterol. On the basis of albuterol use seen in the period after release of the AAP guidelines, we aimed to reduce rates of albuterol use to 35% of patients in the ED and to 10% of inpatients during the 2015 to 2016 bronchiolitis season.

METHODS

Context

This quality improvement project was performed at an urban academic pediatric hospital with an annual ED census of >95 000 visits and an annual inpatient census of 29 000 patients. On average, ~3600 patient visits to the ED and 1500 inpatient admissions each year at the institution are coded with the primary diagnosis of acute bronchiolitis.

Study Population

All patients seen in the ED or inpatient setting between the ages of 29 days and 1 year with a discharge diagnosis of acute bronchiolitis were included in the study. Discharge diagnoses were defined by using *International Classification of Diseases, Ninth Revision* and *International Classification of Diseases, 10th Revision* codes. To focus on a population of infants with a typical presentation of bronchiolitis, as defined in our pathway and the AAP guidelines, we excluded patients who required ICU admission and those with comorbid discharge diagnoses of asthma, pertussis, laryngitis, tracheitis, foreign body, or complex chronic conditions, as defined previously.[9]

Study Period

The study period from October 2014 to March 2017 involved 3 winter seasons (when bronchiolitis is of highest prevalence), with the 1-year preintervention period beginning with the winter of 2014 serving as the historical control (October 2014 to September 2015), the 6 months around the winter of 2015 serving as the intervention period (October 2015 to March 2016), and then 1 year of follow-up postintervention (April 2016 to March 2017).

Planning the Intervention

We assembled a multidisciplinary quality improvement team of physicians, nurses, and respiratory therapists to implement the project. Before the 2015 winter season, the team met and discussed opportunities for improvement in bronchiolitis care. The team identified the reduction of unnecessary albuterol use in both the ED and inpatient settings as the focus of intervention and reviewed a process map and potential drivers of unnecessary albuterol use. Drivers were derived from team discussion and review of the process map. The primary driver for unnecessary albuterol use was hypothesized to be providers continuing to use albuterol despite knowing its ineffectiveness in patients with a typical presentation of bronchiolitis. Other key drivers included a lack of knowledge of the bronchiolitis clinical practice guidelines by nurses and respiratory therapists, which might be contributing to the continued use of albuterol. The team chose to focus on patients <12 months old because this age group was considered to be least likely to benefit from albuterol therapy. Similarly, patients admitted to the ICU were excluded from the interventions given their severity of illness. The lower limit of 29 days was used given the higher likelihood of heart defects, metabolic diseases, and other congenital anomalies in neonates presenting with respiratory distress, making clinical diagnosis of bronchiolitis more difficult. The team considered a number of interventions to address the gap and achieved consensus around the following 3 steps: (1) update an existing clinical pathway addressing bronchiolitis care; (2) provide educational interventions to physicians, nurses, and respiratory therapists; and (3) provide explicit clinical decision support to physicians against albuterol use in order sets for bronchiolitis care (termed the “do not order set” by the pathway team). The team continued to monitor albuterol use over subsequent winter seasons and reported summary results back to clinicians through in-person and electronic communication as well as computer screensavers.

Interventions

A clinical pathway was previously developed for bronchiolitis in the ED setting in November 2005 and for inpatients in November 2013. On the

basis of the 2014 AAP guideline update, the ED and inpatient clinical pathways were modified to explicitly state that bronchodilators were not recommended for typical patients with bronchiolitis (accessible at http://www.chop.edu/pathways). The quality improvement team felt that the evidence base for the AAP guideline was strongest in infants with a typical presentation of bronchiolitis: symptoms of a viral upper respiratory infection (rhinorrhea, congestion, and cough) in an infant (<1 year old) progressing to lower respiratory involvement evidenced by a constellation of 1 or more of the following findings: wheeze, coarse rales, increased work of breathing, and tachypnea. Therefore, the pathway also specified atypical features suggestive of possible asthma that may warrant an individualized consideration of albuterol, such as recurrent wheezing, previous inhaled corticosteroid use, age >12 months, or previous strong response to albuterol.

The education component was conducted during the intervention period and consisted of didactic sessions for nurses, respiratory therapists, and physicians conducted by team members in those roles as well as informal review of changes during unit safety huddles, informational "tip sheets" distributed via e-mails, and computer screensavers. The education sessions and materials noted that albuterol is not recommended for an infant with a typical presentation of bronchiolitis. No further educational interventions were conducted after the intervention period.

Finally, we provided clinical decision support in existing EHR order sets. Previous order sets for bronchiolitis did not include albuterol. Rather than excluding albuterol from the order set, on the basis of previous experience with clinical decision support for reducing unnecessary testing, the team decided to include an (opt-in) option for physicians to order an albuterol trial while at the same time providing "do not order" decision support stating that bronchodilators were not recommended for routine use (Fig 1). To encourage order set adoption, the bronchiolitis order set was shown as 1 of the suggested order sets for all infants seen in the ED with a respiratory chief complaint and included in the standard pediatric admission order set for all inpatients.

Study of the Intervention

A quasi-experimental design was used to study the impact of the 6-month intervention period. The primary outcome was albuterol use, as defined by any administration of inhaled albuterol during the ED or inpatient visit of a patient with bronchiolitis. For the ED, we reviewed admission rate (proportion of infants who required hospitalization), length of stay, and revisits within 72 hours of discharge as balancing measures to determine if there was a negative impact on patient care outcomes. Similarly,

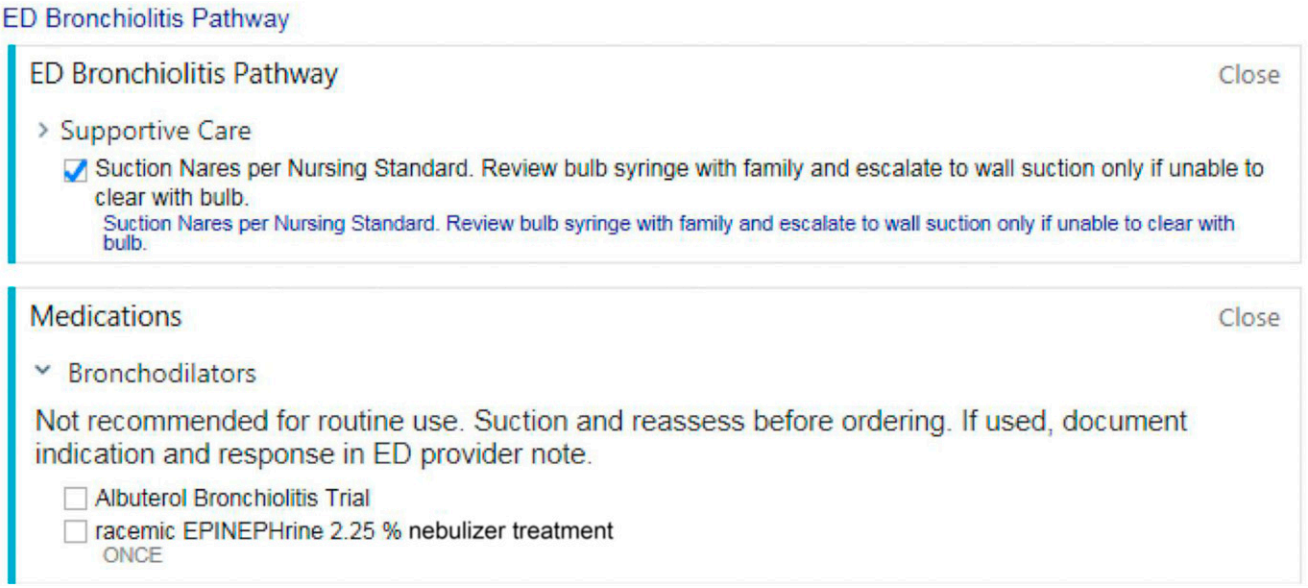

FIGURE 1
Clinical decision support in the order set for bronchiolitis. The ED (shown) and inpatient order sets for bronchiolitis were changed to explicitly recommend against ordering albuterol in patients with typical bronchiolitis. On the basis of previous experience with clinical decision support suggesting that physicians still ordered unwarranted tests excluded from order sets, an option for physicians to order an albuterol trial was included but with explicit "do not order" decision support.

length of stay and readmissions within 72 hours of discharge were used as balancing measures for inpatients.

Measures

Patients with bronchiolitis were identified by using a data warehouse that captures data from our EHR (Epic Systems, Verona, WI). A clinical application consisting of statistical process control charts for each of the metrics queried from the data warehouse was developed by using a commercial business intelligence platform (Qlik, Radnor, PA) and was made available to the quality improvement team throughout the process. We summarized data using proportions for binary variables (albuterol use, ED admission rate, ED revisit rate, and inpatient readmission rate) and means for the lengths of stay in both the ED and inpatient settings.

Analysis

The p-chart, a type of statistical process control chart using the binomial distribution, was used to assess the impact of improvement efforts, with the following criteria used to determine positive special cause variation due to changes in the process: ≥8 values in a row below the baseline mean or any value outside the 3 SD control limits.[10]

RESULTS

Outcome Measures

There were 5115 ED visits with the discharge diagnosis of bronchiolitis for infants between the ages of 29 days and 1 year in the study period and 1948 hospitalizations for infants with bronchiolitis over the same time period. Of these, 3834 ED visits and 1119 hospitalizations met inclusion criteria (Table 1). Among ED visits, 392 visits were excluded for requiring subsequent admission to the ICU, 772 visits were excluded because patients had complex chronic conditions, and 117 visits were excluded on the basis of other comorbid diagnoses. Among inpatient hospitalizations, 401 hospitalizations were excluded for requiring subsequent admission to the ICU, 358 hospitalizations were excluded because patients had complex chronic conditions, and 70 hospitalizations were excluded on the basis of other comorbid diagnoses. A total of 1355 ED visits were included in the 12-month preintervention period, 1044 visits were included during the 6-month intervention period, and 1435 were included in the 12-month postintervention period. In the inpatient setting, 413 hospitalizations were included in the preintervention period, 321 were included in the intervention period, and 385 hospitalizations were included in the postintervention period. We reviewed diagnosis codes assigned for infants presenting with respiratory complaints over the project period and observed no trends suggesting a change in coding for bronchiolitis or asthma.

The proportion of infants with bronchiolitis who received albuterol in the ED was 43% in the preintervention period, 22% during the intervention period, and 20% after the intervention (Fig 2A). This change met the statistical threshold for special cause variation on the basis of >8 consecutive months below the baseline mean and values outside the 3 SD control limits. In the inpatient setting, 18% of infants with bronchiolitis received albuterol in the preintervention period, compared with 13% in the intervention period and 11% in the postintervention period (Fig 2B). Although the reduction of albuterol use began during the intervention period in the inpatient setting, as well, because of high albuterol use in April 2016, the change did not meet the statistical threshold for special cause variation until the second month of the postintervention period, after which there were >8 consecutive months below the baseline mean in which the albuterol use rate approached our goal of 10%.

Balancing Measures

There was no special cause variation observed in any of the balancing measures over the study period: the proportion requiring admission to the hospital from the ED was 25% in the postintervention period and 28% in the historical control; the revisit rate within 72 hours to the ED was 6% in the postintervention period and unchanged from the historical control; the readmission rate within 72 hours of discharge from the hospital was 2% in the postintervention period and unchanged from the historical control; the median ED length of stay was 166 minutes in the postintervention period and 182 minutes in the historical control; the median inpatient length of stay was 37 hours in the postintervention period and 40 hours in the historical control.

Process Measures

There was strong order set use in both the inpatient and ED settings. Of the ED patients seen with bronchiolitis, 44% of patients had the bronchiolitis pathway orders initiated in the preintervention period and 37% had the bronchiolitis pathway orders initiated in the postintervention period, and 96% of pediatric patients admitted with bronchiolitis had the bronchiolitis pathway order set initiated during both the pre- and postintervention periods. In ED patients with the bronchiolitis pathway order initiated, albuterol was received by 70% of patients in the preintervention period and 31% in the postintervention period. In ED patients in which the bronchiolitis pathway order was not initiated, albuterol use was 21% in the preintervention period and 12% in the postintervention period.

TABLE 1 Demographics of Study Patients

Variable	Preintervention, *n*	Intervention, *n*	Postintervention, *n*
Characteristics of ED patients during the study period			
Total	1355	1044	1435
Age, mo			
0–3	179	145	163
3–6	473	343	527
6–12	703	556	745
Sex			
Male	800	621	827
Female	555	423	608
Race			
Asian American, Native Hawaiian, or Pacific Islander	32	22	39
African American	899	679	922
American Indian or Native American	7	3	13
White	288	253	284
Other or refused	129	87	177
Ethnicity			
Hispanic	133	103	160
Not Hispanic	1222	941	1271
Refused	0	0	4
Emergency severity index			
1	14	6	6
2	374	287	309
3	627	475	664
4	316	253	432
5	24	23	24
Characteristics of hospitalized patients during study period			
Total	413	321	385
Age, mo			
1–3	108	74	85
3–6	151	105	140
6–12	154	142	160
Sex			
Male	241	193	228
Female	172	128	157
Race			
Asian American, Native Hawaiian, or Pacific Islander	7	13	10
African American	235	184	213
American Indian or Native American	2	0	5
White	121	105	100
Other or refused	48	19	57
Ethnicity			
Hispanic	43	41	51
Not Hispanic	370	280	332
Refused	0	0	2

DISCUSSION

With changes to clinical pathways and order sets, as well as provider education, albuterol use substantially decreased in both ED (from 43% to 20%) and admitted (from 18% to 11%) patients during the 2015 to 2016 bronchiolitis season. This prevented an estimated 603 patients from receiving an unnecessary therapy in the intervention and postintervention periods. Admission rate, readmission rate, and length of stay remained unchanged. The decreased use of albuterol has been sustained through a second winter viral season.

With the expertise of physicians in different divisions, nurses, and respiratory therapists, we created clinical pathway changes, clinical decision support, and education plans that successfully improved the care of children with bronchiolitis. The inclusion of an undesired order in an order set with the explicit statement that albuterol is not recommended for routine use (the "do not order set" approach, as opposed to leaving the option out) was a novel and effective strategy. This approach provides reinforcement to clinicians about an improvement treatment goal along with needed orders, such as an order for nasal suctioning that was encouraged as part of the pathway. Excluding orders may leave clinicians frustrated and reduce use of the order set. A timely reminder facilitates providers ordering the preferred treatments. Education for nursing and respiratory therapy also encouraged "practicing with a questioning attitude" when providers ordered albuterol for their bronchiolitis patients. There are few reports in the English literature showing a successful effort to decrease albuterol use, and most of these studies only showed an absolute reduction of albuterol use by 7% to 16% or a reduction occurring in the outpatient setting.[3,8,11–14] Using a novel strategy of order set modifications, we were able to achieve absolute levels of bronchodilator use lower than the lowest rate of 33% reported in any previous inpatient work. Our order set intervention provides a more specific strategy for hospitals to adapt than a previous multicenter project.[11]

This project required a time commitment of 2 to 4 hours a month of the principal members of the quality improvement team for meetings and education of colleagues over the 6-month intervention period. The informatics expertise of physicians in the group greatly facilitated the order set changes.

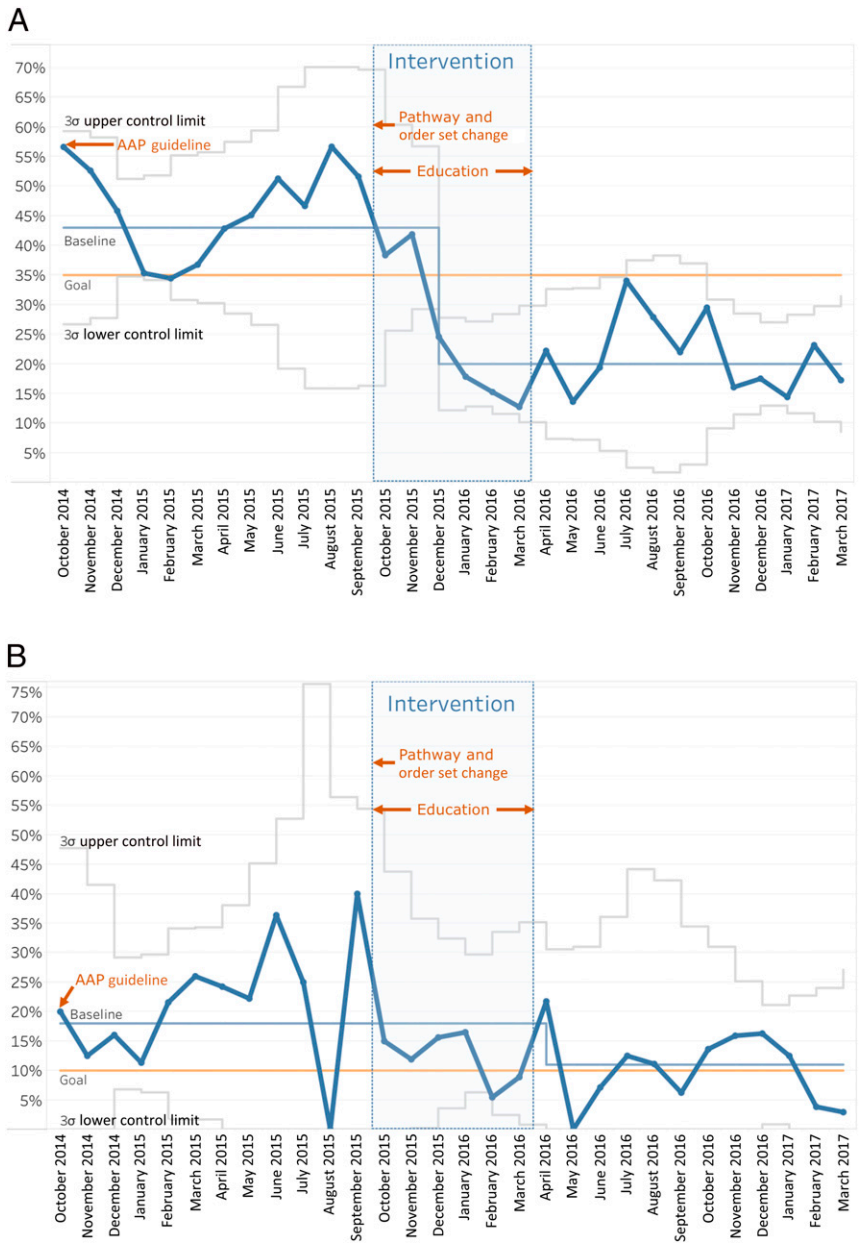

FIGURE 2

A, Proportion of ED patients receiving albuterol. B, Proportion of inpatients receiving albuterol. Albuterol use in the ED decreased from 43% of patients with bronchiolitis to 20% after intervention (A). Inpatient albuterol use decreased from 18% of patients with bronchiolitis receiving albuterol to 11% after 2015 changes (B). Both changes in the ED and inpatient settings met statistical thresholds for special cause variation on the basis of 8 consecutive months below the mean.

Having a data analyst who created a clinical application allowing ongoing tracking of project metrics was extremely valuable to the improvement effort. A knowledgeable project manager also contributed substantially to the success of this project.

This project was limited by identifying patients by diagnosis code, thereby possibly missing some patients with bronchiolitis who were coded with a different diagnosis. We also did not include the NICU or PICU in our efforts. Thus, the sickest patients were excluded from our intervention and analysis. We did not include PICU admissions as a balancing metric because we did not believe albuterol use would impact these rates given the evidence for lack of efficacy. PICU admission may be driven by many factors, including increasing use of other treatments, such as high-flow oxygen and noninvasive ventilation, and should be evaluated in further research. Our project was also limited by releasing a bundle of interventions at 1 time as opposed to individual plan-do-study-act cycles. Given the seasonality of bronchiolitis, we had limited time to enact change when it could benefit the most patients. This limits our ability to know exactly which intervention was most effective. Use of the bronchiolitis order set in the ED was lower than inpatient, possibly secondary to the limited number of interventions required for ED patients, most of whom receive only suctioning. Increased order set use potentially could have further decreased albuterol use and presents an opportunity for future work. The 2014 AAP guideline could have influenced physician use of albuterol independent of our interventions. The lack of a control group in our study does not allow us to see if part of the change we saw was due to a secular trend. In reviewing the data, there was a transient decrease in the use of albuterol around the time of the publication of the AAP guidelines in November 2014 (see Fig 2A). However, albuterol use rapidly returned to baseline and did not show a significant and sustained reduction until the quality improvement intervention the following season. Albuterol use decreased in patients in which the order set was used and those in which it was not. We do not exactly know why this happened but hypothesize this could have occurred from providers' recall of previous guidance not to use albuterol. During our intervention, albuterol use

decreased independent of order set use and in fact decreased more for ED patients for whom the order set was not used, compared with others. This may reflect familiarity with the recommendation among providers who had previously used the order set or a lower need for any intervention in these patients because a major driver for order set use was the suctioning order. Consistent with a study in which researchers demonstrated that despite having read the guidelines, 38% of providers at children's hospitals in New York reported continuing bronchodilator use,[15] our study emphasizes the importance of moving beyond clinical practice guidelines to implement them within the local systems of care.

This quality improvement project was conducted in an academic tertiary medical center with a well-developed program for supporting quality improvement efforts and a reliance on clinical pathways and order sets for many common diagnoses. The interventions could be easily spread to other institutions, especially where clinical pathways and order sets are already used. Clinician buy-in to evidence-based care is essential.

CONCLUSIONS

Using clinical pathways and clinical decision support, reduction in albuterol use in children with bronchiolitis can be achieved. Providers now use albuterol much less frequently, and these changes have been sustained through a second bronchiolitis season. The methods used in this study can be spread to other diagnoses in which there is overuse of testing and interventions. The next steps for improving bronchiolitis care at our institution include focusing on the use of high-flow nasal cannula, an emerging therapy for infants with severe bronchiolitis.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
ED: emergency department
EHR: electronic health record

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