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# Nurse-driven Clinical Pathway Based on an Innovative Asthma Score Reduces Admission Time for Children

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## Abstract

**Objective:** We recently demonstrated that an innovative asthma score independent of auscultation could accurately predict the requirement for bronchodilator nebulization compared to the physician's routine clinical judgment to administer bronchodilators. We aimed to standardize inpatient care for children with acute asthma by implementing a clinical pathway based on this innovative asthma score. **Methods:** We designed a nurse-driven clinical pathway. This pathway included standardized respiratory assessments and a protocol for the nursing staff to administer bronchodilators without a specific order from the physician. We compared the length of stay and the number of readmissions to a historical cohort. **Results:** Seventy-nine patients with moderate acute asthma completed the pathway. We obtained a total of 858 Childhood asthma scores in these patients, with a median of 11 scores per patient (interquartile range 8–17). Patients treated according to the nurse-driven protocol were 3.3 times more likely to be discharged earlier (hazard ratio, 3.29; 95% confidence interval, 2.33–4.66;  $P < 0.05$ ), and length of stay was significantly reduced (median 28 versus 53 h) compared to the historical standard practice. On request, the attending physician assessed the patient's respiratory status 42 times (4.9% of all childhood asthma score assessments). Patient safety was not compromised, and none of the patients were removed from the pathway. In each group, we readmitted two (2.5%) patients within 1 week after discharge. **Conclusion:** This nurse-driven clinical pathway for children with acute asthma based on an asthma score independent of auscultation findings significantly decreased length of stay without compromising patient safety. (*Pediatr Qual Saf* 2020;5:e344; doi: 10.1097/pq9.0000000000000344; Published online September 7, 2020.)

## INTRODUCTION

Asthma is one of the most prevalent childhood chronic diseases and one of the most frequent causes of hospitalization. Previously, in our department, physicians, either pediatricians or less experienced

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resident physicians, decrease or escalate the bronchodilator administration frequency based on serial assessments of the patient's respiratory status. In daily practice, this may result in variability and/or delay in the decision-making process to wean or intensify bronchodilator administration. We intended to improve the quality of care by standardizing inpatient asthma care and reducing the length of stay. Clinical pathways for acute asthma outline a sequence for assessment and interventions.<sup>1</sup> They have reduced admission time and healthcare costs.<sup>2–5</sup> Several asthma scores have proven to be useful in clinical pathways. However, all asthma scores require auscultation of the lungs to score the degree of wheezing or air entry. Therefore, all healthcare providers should be sufficiently trained in auscultation of the lungs before the possible implementation of such a score.<sup>6–11</sup> This issue prompted us to develop an asthma score that does not require auscultation of the lungs. This innovative asthma score was adapted from the physical findings in pediatric asthma scores validated previously.<sup>6,8</sup> We recently demonstrated that this childhood asthma score (CAS) could accurately predict the bronchodilator nebulization requirement compared to the routine clinical judgment of the attending physician

to administer bronchodilators.<sup>12</sup> As healthcare providers' training in lung auscultation is not necessary for this innovative asthma score, it might be an attractive tool to use in a nurse-driven clinical pathway.

This descriptive study aims to evaluate the implementation of a nurse-driven clinical pathway based on our innovative asthma score to standardize inpatient asthma care and reduce the length of stay.

## METHODS

We implemented the nurse-driven clinical pathway in the pediatric department of the Martini Hospital Groningen, The Netherlands. The Martini Hospital is a large general teaching hospital with an average of 3,000 pediatric emergency department visits per year. Of those, approximately 250 present with an acute asthma exacerbation, and 40% are admitted to the pediatric department. The local institutional review board approved the project. All children between 2 and 18 years admitted to the pediatric department for acute asthma were part of the study population. The emergency department's treatment followed national guidelines.<sup>13</sup> We determined the severity of asthma at presentation according to the Qureshi asthma score.<sup>14</sup> The guideline advocates starting intravenous magnesium sulfate if 3 consecutive administrations of bronchodilators do not significantly reduce the asthma score in the first hour of treatment. The attending physician admitted patients to the pediatric department at his or her discretion. All children with acute asthma are admitted to our general pediatric department unless they require immediate intensive care.

We previously developed an innovative asthma score, which served as the basis for the nurse-driven clinical pathway for acute asthma. This childhood asthma score (CAS) was adapted from the physical findings in previously validated pediatric asthma scores.<sup>6,8</sup> The CAS is a composite score comprising oxygen saturation and three physical findings (Table 1). The total score ranges from 2 to 12, with a higher score indicating more respiratory distress. We have demonstrated that a cutoff value of 4 accurately predicts the bronchodilator administration requirement compared to the clinical judgment of the attending physician.<sup>12</sup>

Children 2 years and older admitted for acute asthma were eligible to be treated by the nurse-driven clinical pathway unless they required continuous administration of bronchodilators, intravenous magnesium sulfate, or intravenous albuterol. Patients were removed from the nurse-driven protocol if continuous administration of bronchodilators or intravenous magnesium was commenced after inclusion, and transferred to the pediatric intensive care if intravenous albuterol was started. We included patients with moderate acute asthma to obtain sufficient evidence that this nurse-driven pathway does not compromise patient safety. Patients with severe asthma received standard care. Patients admitted with

mild acute asthma solely because of the time of presentation (late in the evening or at night) were not eligible for the pathway. Patients were ineligible to enter the clinical pathway if they had other comorbid respiratory diseases (eg, bronchopulmonary dysplasia, cystic fibrosis, pneumonia requiring intravenous antibiotics, or cardiopulmonary or neuromuscular disease).

The nursing staff, pediatricians, and resident physicians attended educational sessions before the implementation of the pathway. During the first few months, one of the pediatricians and one of the residents frequently raised awareness of the pathway and answered questions from the nursing staff.

The pathway empowers the nursing staff to adjust treatment (whether or not to administer bronchodilators) without a specific order from the physician (Fig. 1). The pathway includes detailed information on when to assess the next CAS score. Also, in the case of severe dyspnea (CAS value > 8), at 2 consecutive time points in 15 minutes, the nurses were instructed to notify the attending physician. We recorded all CAS scores and administrations of bronchodilators on a clinical record form.

Physicians assessed patients daily during clinical rounds. The pathway indicated the requirement to notify the attending physician in case of worsening of asthma (CAS values exceeded 8), or if the child's condition deteriorated. Our department uses serial assessments of the pediatric early warning sign score to detect severely ill patients and those who are deteriorating. At their discretion, the nursing staff notified the attending physician to check the patient's respiratory status. If the patient improved after the intensification of bronchodilator treatment as indicated by the pathway, further treatment continued according to the pathway.

This study used the following standardized discharge criteria: weaning of bronchodilator administration to an interval of at least 4 hours, no need for supplemental oxygen during the last 12 hours, and patients or caregivers could demonstrate a correct inhaler technique. A leaflet provided to patients described a management plan for weaning albuterol administration.

We compared length of stay (LOS) for patients managed by the nurse-driven protocol between June 2015 and June 2018 with the historical standard practice for patients with moderate acute asthma between 2011 and 2014, matched for age and sex. Exclusion criteria described for patients in the nurse-driven protocol were also applied to patients in the historical standard practice group. We obtained dates and times of hospital admission and discharge from the electronic record form.

We did not compare LOS for patients with mild acute asthma. The hospitalization of these children was solely dependent on the time of presentation (late in the evening or at night and/or requested by the parents). The attending physician or resident ordered the treatment plan for these children rather than based on the pathway. We also decided not to compare LOS for patients whose

**Table 1. Childhood Asthma Score**

	0 Points	1 Point	2 Points	3 Points
Respiratory rate (breaths/min)				
2–3 y		<35	35–39	>39
4–5 y		<31	31–35	>35
6–12 y		<27	27–30	>30
>12 y		<24	24–27	>27
O <sub>2</sub> -saturation determined by pulse oximetry (%)		>95% in room air	90%–95% in room air	<90% in room air or supplemental oxygen
Accessory muscle use	Absent	Absent or intercostal	Inter- and subcostal	Inter-, subcostal, and supraclavicular
Dyspnea 2–5 y	Asleep or normal feeding, vocalizations and activity	One of the following: decreased appetite, increased coughing after play, hyperactivity	Two of the following: decreased appetite, increased coughing after play, hyperactivity	Stops eating or drinking, no vocalizations, drowsy or confused
>5 y	Asleep or Counts to >10 in one breath	Counts to 7–9 in one breath	Count to 4–6 in one breath	Counts to <4 in one breath

condition changed from moderate to severe asthma during admission due to a significant change in clinical practice. Kneyber et al demonstrated that substantially more children with severe acute asthma received intravenous magnesium and/or albuterol, in conjunction with the increased use of high flow nasal cannulas in the referring hospitals in the Netherlands.<sup>15</sup> Due to this change in clinical practice, we believe that we cannot compare LOS in this group of patients.

### Statistics

The primary outcome was the difference in LOS. Secondary outcomes were adherence to the pathway (process measure), the number of times a physician assessed the patient's respiratory status (balancing measure), and the percentage of patients readmitted within 1 week after discharge.

We present categorical data as counts and percentages, and continuous variables as mean (SD) or median [interquartile range (IQR)] values. We evaluated differences between the 2 groups for continuous data using the Mann–Whitney U test, and differences between the 2 groups for dichotomous data using Fisher's exact test.

We used the Kaplan–Meier analysis to calculate estimates of hospital stay probability from the time of admission until discharge, and the log-rank test to compare rates estimated among discharge curves. The effect of CAS on the length of stay was analyzed by using a Cox proportional hazards model. We performed statistical analyses using R Statistical Software (version 3.3.0; R Foundation for Statistical Computing, Vienna, Austria) and RStudio.

## RESULTS

During the study period, 517 children 2 years and older presented at the emergency department with acute asthma, of whom 302 (58.4%) were discharged, and 215 (41.6%) were admitted to the pediatric department for further treatment of acute asthma. The attending physician diagnosed severe acute asthma in 79 of admitted patients. Fifty-six patients received intravenous magnesium sulfate

and/or intravenous albuterol in the emergency department; 23 patients received these medications shortly after admission. In 8 (10%) of the patients with severe asthma, further treatment in the pediatric intensive care unit was necessary. In 24 patients, the diagnosis changed to pneumonia after admission, and bronchodilator treatment was discontinued. We classified symptoms of 33 of the patients as mild acute asthma. Therefore, 79 patients with moderate acute asthma completed the pathway (Fig. 2).

Table 2 presents the characteristics of patients and their matched controls. There were no significant differences between both groups. The patients with moderate-severe asthma were treated with low flow nasal cannula if supplemental oxygen was needed.

The median CAS at the time of admission of the patient to the pediatric department was 6.0 (IQR 5–7). The highest median CAS during hospitalization was 6.0 (5–11). We obtained a total of 858 CAS scores in these patients, with a median of 11 scores per patient (IQR 8–17). Bronchodilators were administered 654 times based on the clinical pathway. The attending physician assessed the patient's respiratory status 42 times (4.9% of all CAS assessments). For these patients, treatment was continued according to the pathway.

In 9% of all CAS assessments, the nurses deviated from the pathway; 35 times (4.1%) they administered bronchodilators when not indicated. It was not registered in the patients' electronic chart why they decided to deviate from the protocol. Also, 42 times (4.9%) they did not administer bronchodilators when indicated by the pathway. In these cases, the patients were asleep and had supplemental oxygen but were not tachypneic or dyspneic.

The median length of stay for patients treated according to the nurse-led clinical pathway and the control group was 28.0 (IQR 19.5–42.5) and 58.0 (44.5–74.0) hours, respectively.

The Kaplan–Meier analysis showed that the nurse-driven clinical pathway associates with a significantly shorter admission time (Fig. 3). When compared to patients treated according to standard care, patients treated according to the nurse-driven clinical pathway

Nurse-driven clinical pathway for acute asthma				
Do not use in case of iv magnesium sulfate or iv albuterol				
	0 points	1 point	2 points	3 points
Respiration 2-3 yr 4-5 yr 6-12 yr >12 yr		<35 <31 <27 <24	35-39 31-35 27-30 24-27	>39 >35 >30 >27
Oxygen saturation (%)		>95% without supplemental O2	90-95% without supplemental O2	<90% without or >90% with supplemental O2
Retractions	absent	intercostal	Intercostal and substernal	Intercostal, substernal, and supraclavicular
Dyspnea 2-5 yr  > 5 yr	Asleep or alert, no feeding difficulties  Asleep Or able to count to >10 in a single breath	1 of the following: decreased intake, cough during play, hyperactivity  Counts to 7-9 in a single breath	2 of the following: decreased intake, cough during play, hyperactivity  Counts to 4-6 in a single breath	No intake, agitated  Counts to <4 in a single breath

<b>CAS &lt; 4</b> Score after 2 hours*	<b>CAS 4-6</b> Administer bronchodilators And score after 1 or 2 hours **	<b>CAS 7-8</b> Administer bronchodilators And score after 30/60 minutes***	<b>CAS 9-12</b> Administer bronchodilators Score again after 15 minutes****
**** If CAS is > 8 twice, notify attending physician immediately			
***If CAS is 7-8 at two consecutive time points score again after 1 hour			
** If CAS is 4-6 at two consecutive time points score again after 2 hours			
*If CAS< 4 at two consecutive time points score again after 2 hour			

Bronchodilators can be administered by nebulizer or space chamber

If bronchodilator administration is weaned to an interval of  $\geq 4$  hours, and no supplemental oxygen has been needed for at least 12 hours the patient may be discharged with a management plan

Fig. 1. Pathway directing the nursing staff whether or not to administer bronchodilators, and when to obtain the next CAS.

(CAS) were 3.29 times more likely to be discharged earlier (hazard ratio, 3.29; 95% confidence interval, 2.33–4.66;  $P < 0.05$ ). In both groups, we readmitted 2 patients (2.5%) within a week after discharge.

## DISCUSSION

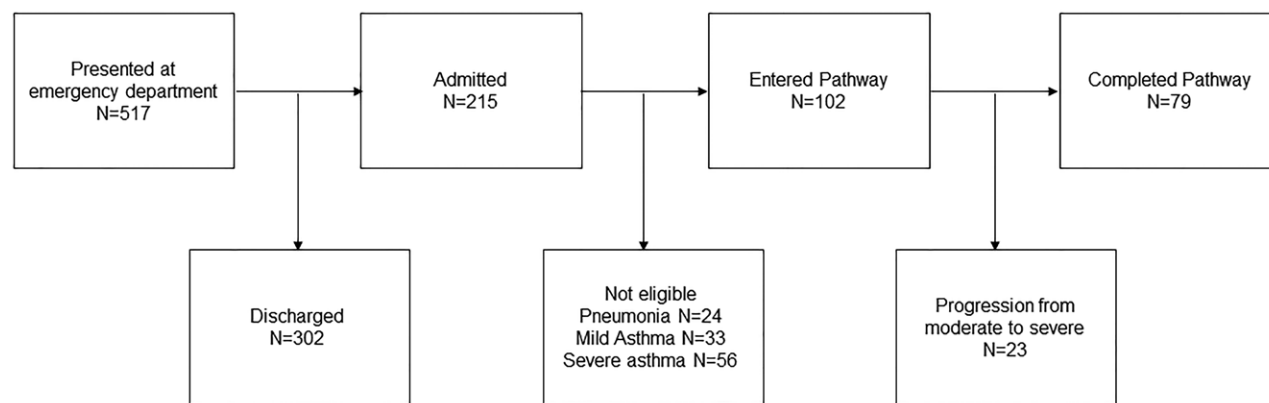
Our findings reveal that a nurse-driven clinical pathway based on an asthma score independent of the auscultatory conclusions was safe and significantly reduced LOS in children admitted with moderate acute asthma.

To the best of our knowledge, the CAS is the first asthma score for children which does not require auscultation of

the lungs. We recently demonstrated that this innovative asthma score could accurately predict the bronchodilator nebulization requirement, compared to the routine clinical judgment of the attending physician to administer bronchodilators.<sup>12</sup> An advantage of the CAS is that it empowered the nursing staff to assess the patient's respiratory status without auscultation of lungs, and adjust therapy according to the clinical pathway.

This nurse-driven clinical pathway enabled the nursing staff to treat the children with moderate acute asthma autonomously without compromising patient safety. The attending physician assessed the patient's respiratory status in approximately 5% of all assessments performed by





**Fig. 2.** Flowchart of eligible patients. Patients 2 years and older admitted to the emergency department and diagnosed with acute asthma during the study period.

**Table 2. Patient Characteristics\***

	Clinical Pathway, N = 79	Standard Care, N = 79
Age (y)	3.0 (2–6)	4.0 (2–6)
Sex (boys)	52 (65.8)	52 (65.8)
Recurrent wheezing/asthma	55 (69.6)	59 (74.6)
Atopy†	32 (40.5)	37 (46.8)
Inhaled steroids at presentation	32 (40.5)	27 (34.2)
Systemic steroids	59 (74.7)	53 (67.1)
Supplemental oxygen	42 (53.1)	37 (46.8)
Season of admission		
Spring	21 (26.6)	17 (21.5)
Summer	29 (36.7)	29 (36.7)
Autumn	23 (29.1)	19 (24.1)
Winter	6 (7.6)	14 (17.7)

\*Continuous variables are presented as median (IQR), categorical variables as n (%).

†Doctor diagnosed eczema, inhalant allergy (IgE for house dust mite, grass-or tree pollen), proven food allergy.

the nurses, and none of these patients were removed from the pathway. Furthermore, the number of patients readmitted for acute asthma within one week after discharge was very low and comparable in both groups. Before implementing the nurse-driven protocol, some colleagues raised concerns that using CAS might not accurately detect the deterioration of the patient's condition. Thus, we decided to only use the pathway for moderate acute asthma during the study period. Also, our department uses the pediatric early warning sign to detect severely ill patients and the deterioration of a patient's condition.

To date, only a few studies report nurse-driven clinical pathways for acute asthma in children.<sup>5,16</sup> In the study by Johnson et al,<sup>16</sup> the nurses notified the attending physician when they met the weaning treatment criteria. The physician then assessed the patient's condition and determined whether to wean the patient's therapy.<sup>5</sup> In the study by Pound et al,<sup>5</sup> the nurses weaned albuterol administration according to an asthma score-based pathway. The nursing staff assessed the patients' respiratory status and adjusted therapy directed by the pathway without notifying the attending physician, comparable to our pathway. However, Pound et al<sup>5</sup> used a modified

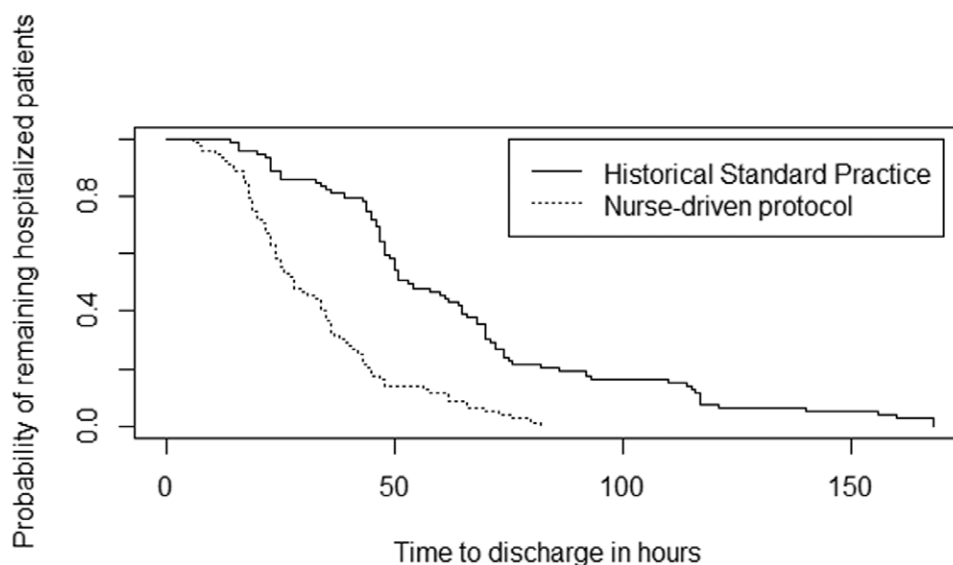
Pediatric Respiratory Assessment Measurement score, which includes lung auscultation.<sup>16</sup>

Our study confirms the results of prior reports that clinical pathways can improve the efficiency of inpatient care. The LOS was substantially reduced (approximately 50%). In previous studies, the reduction in admission time was 25%–50%.<sup>3,16</sup>

The limitations of our study are the following. We only applied the pathway to patients admitted with moderate acute asthma. This decision may have created a selection bias. The results may be different if the pathway is applied to patients with more severe acute asthma. Further study will have to show if it is feasible to use this pathway for children admitted with more severe asthma. The results of our study will also require replication in a larger population. We also need to address a potential bias of the results due to unmeasured confounding variables.

We contemplated whether or not to conduct this study as a randomized controlled trial. We chose to conduct a trial with historical controls because we felt that it would be challenging to implement a nurse-driven clinical pathway for some patients but not for others, especially if one of the treatment regimens would appear advantageous for the patient or nurses. Standardizing inpatient management of acute asthma by our nurse-driven protocol appeared to be feasible and safe and reduce admission time. We realize that regulatory authorities may restrict nurse-driven administration of medication in some institutions or countries.

Although the nursing staff felt comfortable using the clinical pathway, they frequently reported one major drawback. Patients who need supplemental oxygen had a CAS of at least 4 indicating the need for bronchodilator therapy even though it appeared that the patient was not tachypneic nor dyspneic (eg, when the patient was asleep). We based the current pathway on our previous study. We demonstrated that a cutoff value of 4 yielded a positive predictive value of 0.83 and a negative predictive value of 0.87 to administer bronchodilators.<sup>12</sup> However, low oxygen saturation may result from atelectasis and ventilation/



**Fig. 3.** Kaplan-Meier analysis showing that the nurse-driven clinical pathway was associated with a significant shorter admission time.

perfusion mismatch without small airway obstruction. Our results encourage us to further evaluate and adapt the pathway for patients who need supplemental oxygen.

## CONCLUSIONS

Implementation of a nurse-driven clinical pathway based on an asthma score independent of auscultatory findings appeared to be safe and significantly reduce LOS of children admitted with moderate acute asthma.

This nurse-driven clinical pathway might be an attractive alternative compared to other clinical pathways. All healthcare providers will be able to use this score without being trained to auscultate the lungs.

## DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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