

# Emergency Department Resource Utilization in the Management of Croup

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## Abstract

**Objectives:** Croup is a common respiratory illness presenting to the ED and one of the most common causes of upper airway obstruction in children under 6 years. It is clinically diagnosed and enteral dexamethasone is treatment mainstay. Several small studies have described practices in other settings but no large cohort study has described ED resource utilization in croup. We aim to analyze trends in utilization of not routinely indicated resources (NRIR) in the management of croup.

**Methods:** Data from PHIS database was obtained and analyzed. We included encounters for children age 6 months to 12 years discharged from the ED from 2004 to 2017 with croup. Chronic conditions, asthma, other head, neck or lung infections, or where croup was a secondary diagnosis were excluded.

**Results:** We identified 630,432 ED visits over 14 years across 49 children's hospitals with the diagnosis of croup. 48% patients received any NRIR. Initially, NRIR utilization rates ranged around 55% of all encounters with a significant downtrend after 2013 to above 35% of all patient encounters, primarily driven by decreasing parenteral dexamethasone use with an inverse relationship to oral dexamethasone.

**Conclusion:** This is the first large cohort study to examine resource utilization in ED management of croup. We noted a significant decline in NRIR utilization in ED management of croup over time mainly driven by the decreasing use of parenteral dexamethasone. While NRIR rates are declining, continued high rates may be due to lack of formalized guidelines.

**Keywords:** Croup; Emergency medicine; Not routinely indicated resource; Dexamethasone; Resource utilization

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## Introduction

Croup, or laryngotracheobronchitis, is one of the most common respiratory illnesses presenting to the Emergency Department (ED) and is the most common cause of upper airway obstruction in children aged 6 months to 6 years [1,2]. Acute subglottic narrowing due to inflammation leads to symptoms including a hoarse voice, 'seal-like' barking cough, and inspiratory stridor. Often, these symptoms are most pronounced at nighttime, presenting a stridorous child who awakes in respiratory distress [3].

Since croup is a clinical diagnosis, there is consensus professional agreement that ancillary testing such as respiratory cultures, serum lab testing, and radiographic imaging are not useful for

illness recognition. Several previous studies have shown that glucocorticoids reduce time to croup symptom resolution, rate of subsequent visits for medical care, hospital admissions, and readmissions [4,5], and thus glucocorticoids, as well as nebulized racemic epinephrine, have become mainstay of treatment for this acute self-limiting illness. Furthermore, glucocorticoids given orally have been shown to be equally efficacious as the parenteral route [6]. Therefore, parenteral corticosteroids are not routinely indicated for treatment of mild to moderate croup. Since the illness is viral in etiology, antibiotic treatment is not routinely recommended [7].

In 2017, Tyler et al. used the Pediatric Health Information System (PHIS) database to describe hospital-level practice variability of

the inpatient management of croup and in particular, variation in the use of not routinely indicated resources (NRIR) [8]. The investigators classified the use of chest and neck radiographs, viral testing, antibiotics, and parenteral rather than enteral corticosteroids as not routinely indicated in the acute inpatient management of croup and saw significant variability in the use of these not routinely indicated resources. However, to our knowledge, no large cohort study has described emergency department trends in the treatment of croup. Our primary aim was to describe variation in patient-level emergency department testing and treatment, with specific focus on these not routinely indicated resources, in patients with croup deemed appropriate for discharge from the ED. Our secondary aim was to describe patient-level factors associated with presentation to the emergency department with mild to moderate croup.

## Materials and Methods

### Data sources

In this retrospective database review, we used the Pediatric Health Information System (PHIS), a database that contains ED administrative data from 51 of the largest children's hospitals in the United States (Children's Hospital Association, Lenexa, KS). Data is de-identified before inclusion in the database and data quality and reliability are assured through a joint effort between the Children's Hospital Association and participating hospitals. Forty-nine PHIS hospitals that submitted complete subject demographics and resource utilization data were included in this study.

### Study population

Patients aged 6 months to 12 years old were eligible for inclusion if they presented to an emergency department between January 1, 2004 and December 31, 2017 and were then discharged with an ICD-9 or ICD-10 code representing viral croup. Subjects were identified with croup using the following ICD-9 or ICD-10 codes: 464.20, 464.21, 464.4, 464.50, 464.51, 786.1, 519.09, J04.2, J05.0, J04.30, J04.31, J06.0, J98.01. Assuming patients with severe croup or impending respiratory failure were admitted to the hospital for further care, the study population was limited to those subjects with mild to moderate croup discharged from the ED. Subjects with complex chronic conditions [9] were excluded because these patients may warrant nonstandard evaluation and management. We also excluded patients with diagnoses for which parenteral steroids, viral testing, radiographs, or antibiotics may be indicated, such as asthma, influenza, and bacterial head, neck, or chest infections. Finally, we excluded patients with diagnoses for which a croup diagnosis has a high likelihood of being secondary, such as congenital abnormalities of the airway, trauma, burns, and foreign body ingestion or aspiration.

### Study definitions

Extracted demographic characteristics included subject age, sex, race, payer status, discharge season, discharge year, and disposition location. Seasons were defined as Fall (September 1 to November 30), Winter (December 1 to February 28),

Spring (March 1 to May 31), and Summer (June 1 to August 31). Consistent with previously published studies, not routinely indicated resources (NRIR) were defined as the use of viral testing, chest or neck radiography, antibiotics, or parenteral glucocorticoids [8]. Additionally, we included serum testing as an NRIR, as this resource is not routinely needed for the diagnosis of croup. Serum testing was defined as any testing for white blood cell counts or blood cultures. Resource utilization data was determined by using the associated procedural billing codes.

### Statistical analysis

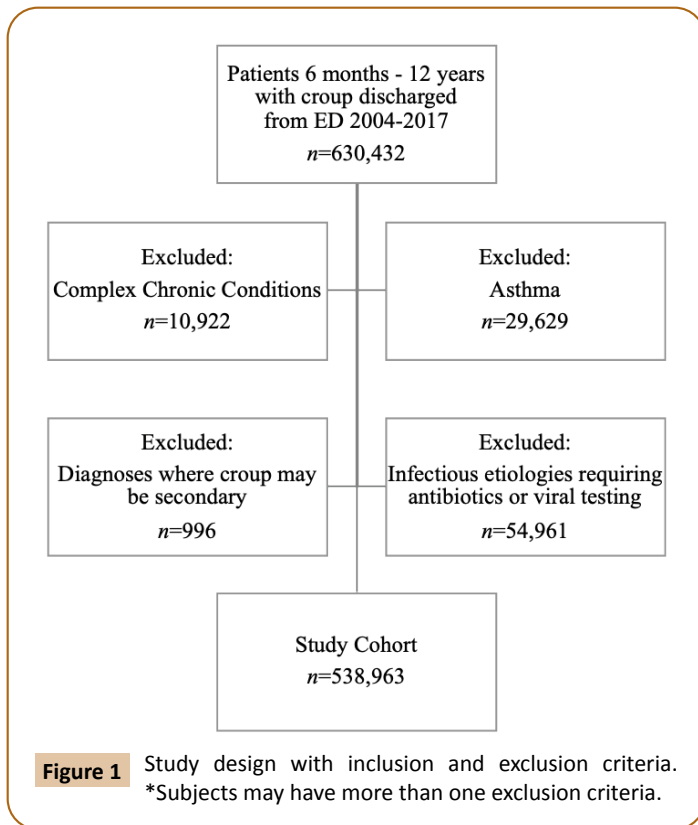
Data was formatted and recoded using IBM SPSS Statistics software. Study cohort was described using median with interquartile ranges for continuous variables, and frequencies for categorical variables. Unadjusted distributions for each resource utilization were determined by calculating the proportion of subjects who received each resource. Unadjusted rates of utilization were plotted over time and a polynomial best fit line was applied. Analysis was reported as the coefficient of determination ( $R^2$ ) with P values. Univariate associations between independent variables and NRIR utilization were determined using Wilcoxon Rank Sum test and Chi-square test. The Cochran-Armitage's trend test with bootstrap resampling was used to test for trend among NRIR utilization across the years. The bootstrap resampling method utilized 1000 resamples.

Multivariable logistic regression models assessing the outcome of 0 versus  $\geq 1$  NRIR were also performed and adjusted for each patient-level variable (age, sex, race, insurance status, discharge season). The bootstrap resampling method was used to estimate the odds ratio from the multivariable logistic regression. This was accomplished by generating observations from the distribution of the sample itself. Each simulation results in a new sample, by randomly selecting (with replacement) individuals from the original sample, calculating the statistic, and taking the average of the calculated statistics. 20 bootstrap samples were performed for the whole sample and repeated on 50% of the sample. The bootstrap estimates were used to deal with the large sample size (which reduced the overall standard errors) and to examine the robustness of the result across sub-samples. Analysis was conducted using SAS 9.4 (SAS Institute Inc. Cary, NC) and a p value of less than 0.05 was considered significant.

## Results

### Description of cohort

During the fourteen-year study period, there were 630,432 unique ED visits across 49 children's hospitals with discharge diagnosis of croup and met other study inclusion criteria. Of these, 91,469 (14.5%) encounters were excluded, forming a study cohort of 538,963 subjects for analysis (**Figure 1**). The majority of subjects were aged 1-3 years old (62.3%; n=667,592), male (63.5%; n=538,953), non-Hispanic white (51.7%; n=278,360), public payers (49.3%; n=265,603), presented for care during the fall season (38.1%; n=386,539), and discharged to their personal home (98%; n=528,195) (**Table 1**).

**Table 1** Description of cohort.

Variables	Value
<b>Patients (N=538,963)</b>	
Median (IQR) age, months	25 (15-44)
<b>Age Group, % (n)</b>	
<1 year old	15.5 (83,329)
2-3 years old	30.7 (165,396)
4-6 years old	31.6 (170,142)
7-12 years old	5.6 (30,269)
<b>Sex, % (n)</b>	
Male	63.5 (342,275)
Female	36.5 (196,688)
<b>Race, % (n)</b>	
White	51.7 (278,360)
Black	13.9 (74,762)
Hispanic	23.8 (128,261)
Asian	2.0 (10,487)
Other	8.8 (47,093)
<b>Payer, % (n)</b>	
Public	49.3 (265,603)
Private	42.7 (230,280)
Other	8.0 (43,080)
<b>Discharge Season, % (n)</b>	
Fall	38.1 (205,437)
Winter	28.3 (152,424)
Spring	19.6 (105,394)
Summer	14.0 (75,708)

### Patient factors associated with resource utilization

Various resources were utilized for the management of croup in the emergency department before discharge. Lab testing was performed in 30,186 subjects (5.6%), which included serum testing (2.7%; n=14,673) and respiratory pathogen testing (2.9%; n=15,513). Of subjects who received serum testing, 87.0% (n=12,764) had blood cultures and 32.8% (n=4,808) had white blood cell counts. Chest or neck radiography was performed in 48,631 subjects (9.0%), composed of 37,354 (76.8%) chest x-rays and 19,529 (40.2%) neck x-rays. Medication administration included corticosteroids (85.6%; n=461,111), racemic epinephrine (17.8%; n=95,736), albuterol or ipratropium (4.9%; n=26,330), antibiotics (0.5%; n=2,715), and intravenous or intramuscular epinephrine (0.3%; n=1,592). In patients who received any corticosteroid, 97% (n=447,469) received dexamethasone, while 3% (n=13,642) received prednisone, prednisolone, or methylprednisolone. Of subjects who received dexamethasone, 53.2% (n=238,107) was administered through the enteral route while 47.8% (n=214,103) was administered parenterally.

**Table 2** shows patient factors that were associated with the use of  $\geq 1$  not routinely indicated resource (NRIR) in the unadjusted and adjusted multivariable logistic regression models. Resources include intravenous/intramuscular dexamethasone, antibiotics, serum or respiratory pathogen testing, and chest or neck radiography. Almost half (48%; n=256,666) of eligible subjects received  $\geq 1$  NRIR in the management of croup. Patient characteristics associated with higher odds of NRIR utilization include age greater than 6 years old, female sex, payer status other than private or public, and presentation in the spring or summer season. Patient characteristics associated with lower odds of NRIR utilization include age group of 4 to 6 years old, non-white race and private payer status.

### Resource utilization rates over time

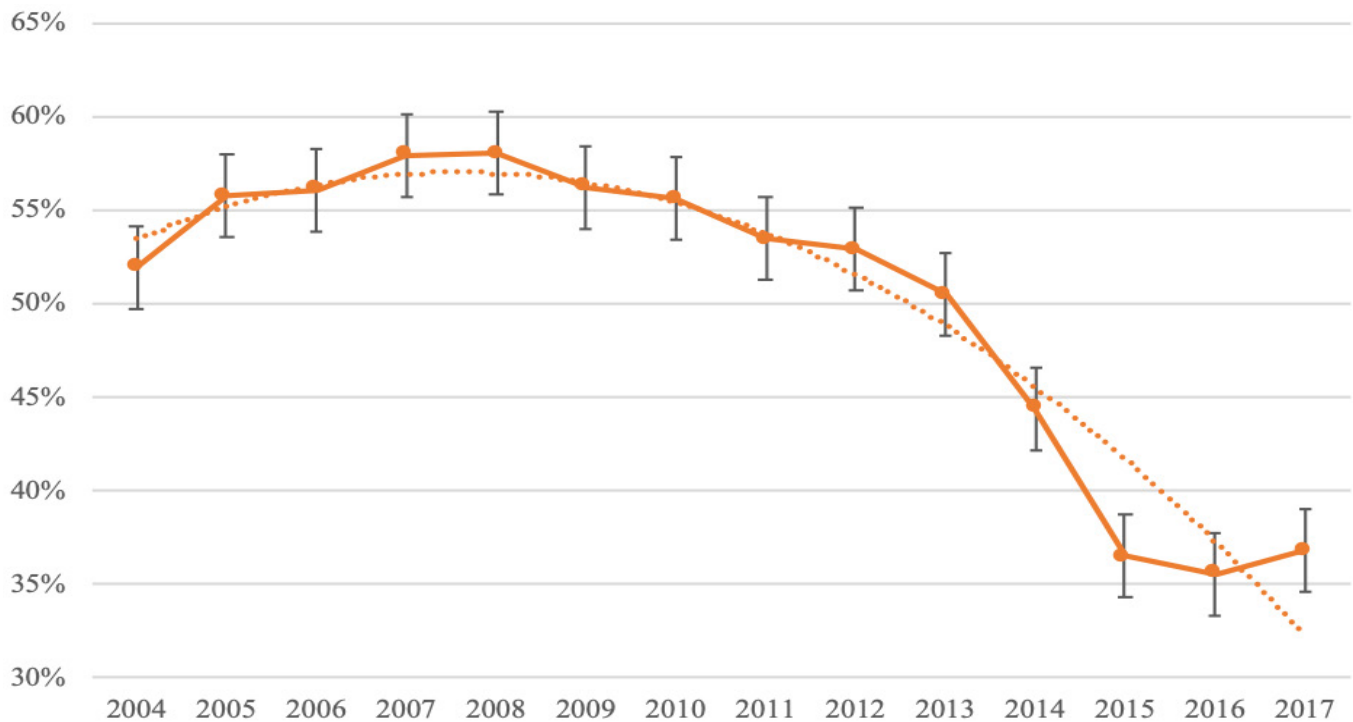
In 2004, total NRIR utilization rates ranged around 55% of all patient encounters. A downtrend in total utilization rates occurred after 2008 with the largest decreasing slope noted between 2013 and 2015 to plateau at a new baseline utilization rate above 35% of all patient encounters. An overall 36% decline in total NRIR utilization rates was demonstrated over the 14-year study period ( $p < 0.001$ ) (**Figure 2**).

Route of dexamethasone administration was noted to be the main driver of declining NRIR rates over time. While the rate of parenteral dexamethasone utilization declined by approximately 42% over the 14-year study period, the rate of enteral dexamethasone utilization inversely increased by 44% ( $p < 0.001$ ) (**Figure 3**). Neck or chest radiography, serum testing, and antibiotic utilization rates did show a small but statistically significant decline over the study period ( $\sim 2\%$ ,  $< 1\%$ ,  $< 1\%$  respectively;  $p < 0.001$ ), and viral testing demonstrated a small increase in utilization rates over time ( $\sim 2\%$ ,  $p < 0.001$ ) (**Figure 4**).

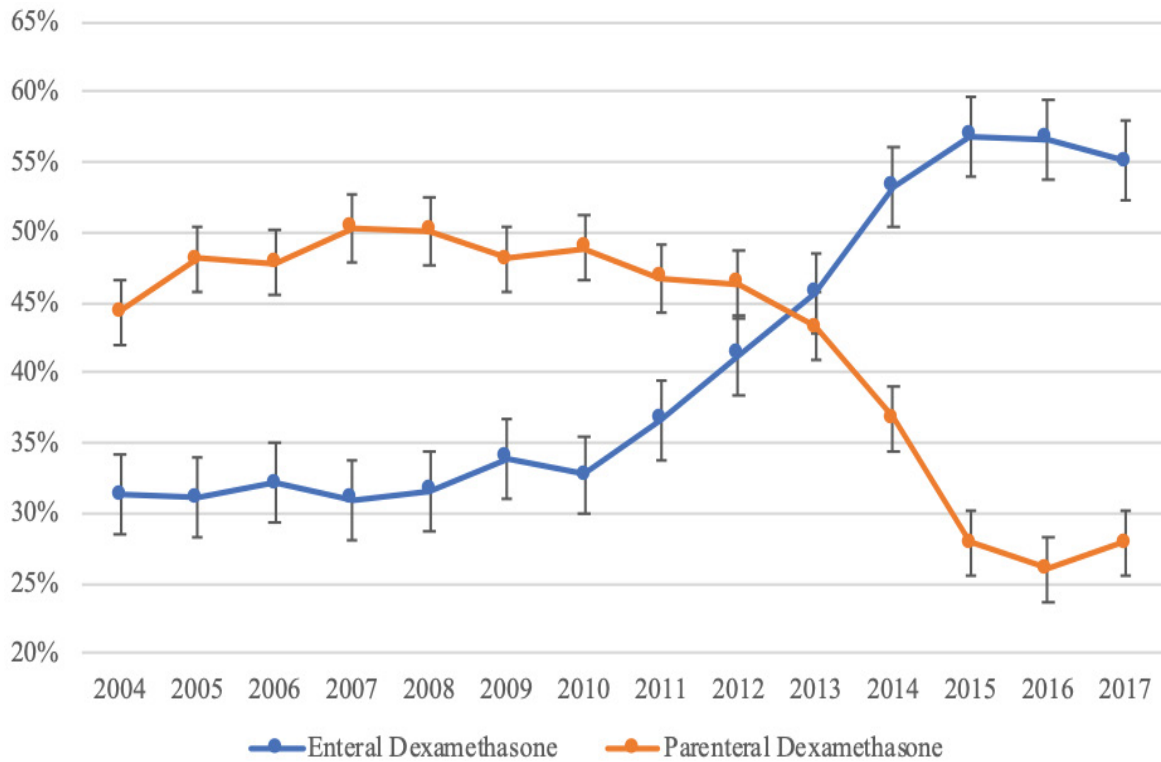
**Table 2** Associations with utilization of  $\geq 1$  NRIRs.

Variables	0 NRIR (52%), %	$\geq 1$ PIPN 1 (48%), %	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
<b>Age group</b>				
< 1 year old	8	7.4	1.01 (0.99 – 1.03)	1.00 (0.99 – 1.02)
1 year old	16.1	14.6	Ref	Ref
2-3 years old	16.6	15	0.99 (0.98 – 1.01)	0.99 (0.98 – 1.00)
4-6 years old	8.9	7.8	0.97 (0.96 – 0.99)	0.97 (0.95 – 0.98)
7-12 years old	2.8	2.8	1.09 (1.06 – 1.12)	1.09 (1.06 – 1.11)
<b>Sex</b>				
Male	33.4	30.1	Ref	Ref
Female	19	17.5	1.03 (1.02 – 1.04)	1.03 (1.02 – 1.04)
<b>Race</b>				
White	26.5	25.2	Ref	Ref
Black	7.2	6.7	0.97 (0.96 – 0.99)	0.93 (0.92 – 0.95)
Hispanic	12.6	11.2	0.94 (0.92 – 0.95)	0.90 (0.89 – 0.92)
Asian	1.1	0.8	0.79 (0.76 – 0.83)	0.79 (0.76 – 0.82)
Other	5	3.7	0.77 (0.75 – 0.78)	0.76 (0.74 – 0.77)
<b>Payer</b>				
Public	25.6	23.7	Ref	Ref
Private	23.1	19.6	0.92 (0.91 – 0.93)	0.89 (0.88 – 0.90)
Other	3.7	4.3	1.27 (1.24 – 1.30)	1.23 (1.21 – 1.26)
<b>Discharge Season</b>				
Fall	20	18.1	Ref	Ref
Winter	15.1	13.2	0.96 (0.95 – 0.98)	0.96 (0.95 – 0.98)
Spring	10.1	9.4	1.03 (1.02 – 1.05)	1.03 (1.02 – 1.05)
Summer	7.1	6.9	1.08 (1.06 – 1.09)	1.08 (1.06 – 1.10)

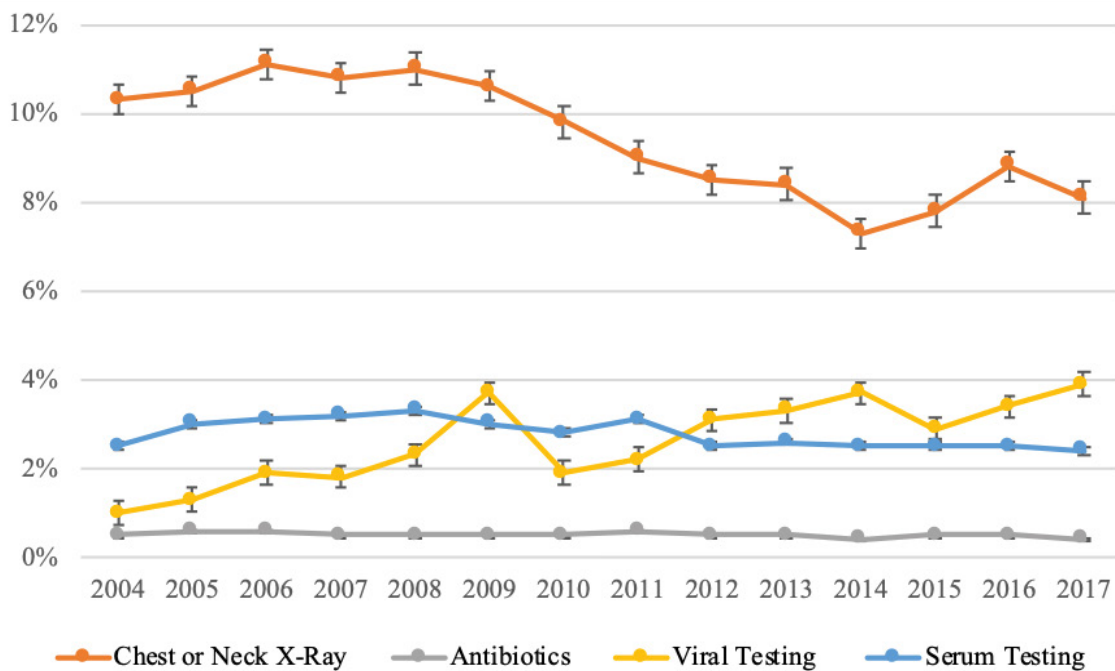
\*Adjusted odds ratios were controlled for all patient-level variables (Age, sex, race, insurance status, admission season).



**Figure 2** Not routinely indicated resource (NRIR) utilization rates over time. \*The dotted line represents a curvilinear regression analysis ( $R^2=0.932$ ,  $p<0.0001$ ).



**Figure 3** Enteral versus parenteral dexamethasone rates over time.



**Figure 4** Individual resource utilization rates over time.

## Discussion

We examined resource utilization rates among >500,000 children with croup presenting to pediatric emergency departments in

the United States. A substantial decline in not routinely indicated resource (NRIR) utilization rates over time was observed, primarily driven by the decreasing use of parenteral dexamethasone and

inversely proportional to enteral dexamethasone utilization. There was also a small decrease in neck and chest radiography, no change in serum testing and antibiotic utilization, and a small increase in viral testing. While an overall downward trend in NRIR rates was noted, continued high rates of not routinely indicated resource utilization were seen. This may be due to a lack of formalized guidelines in ED croup management.

Despite its high incidence and typical care, there remains little guidance for best practice. The American Academy of Pediatrics has no published guidelines for the acute management of croup. Promising new quality metrics for emergency department and inpatient care have emerged, referred to as the Pediatric Respiratory Illness Measurement System [10], however, these require further validation and are based on typical practice without a unified policy statement. The Canadian Paediatric Society published a practice point in 2017 through its official journal, *Paediatrics & Child Health*, discussing evidence-based management of typical croup in the ED [11]. Yet overall, there remains a paucity of centralized guideline for croup management in the United States.

Future standard of care guidelines should focus on the importance of clinical acumen in regards to the diagnosis and treatment of mild to moderate croup. They should advise against the routine use of supplementary lab testing such as serum levels of inflammation, respiratory and blood cultures, use of antibiotics, and radiography. Preference should be given to the enteral route of glucocorticoid administration. It can be extrapolated that such standards would further decrease the variability of care in large children's hospitals demonstrated in this study as well as the previous inpatient study performed by Tyler et al. [8].

This study suggests there is a significant opportunity to decrease unnecessary utilization. Our finding in the children's hospital setting presumably already demonstrates best practice in the treatment of the pediatric patient. It can be inferred that

general emergency departments, where approximately 20% of visits consist of patients aged 0-17 years [12], may have even higher utilization in these not routinely indicated resources. We therefore believe our data underestimates the degree to which NRIR utilization occurs and affords prospect for future studies which could examine and compare children's hospital resource utilization with that of general emergency departments.

Limitations of this study have been noted. First, this retrospective database review might be subject to data miscoding inaccuracies or misclassifications however this is likely random and non-differential. Second, we used ICD-9 and ICD-10 codes to exclude patients with complex chronic conditions and other comorbidities, but these coding systems may not accurately capture all co-morbidities. Third, without complete clinical data, our ability to control for illness severity was limited to the assumption that patients with mild to moderate croup were appropriate for discharge from the ED. Fourth, as some patients may have been evaluated in another outpatient setting before presenting to a PHIS hospital, this data would not be captured in this study. Fifth, as previously mentioned, although this study includes subjects from numerous children's hospitals, our results may not be generalizable to all hospitals that care for children, urgent care centers, or to general emergency departments. Lastly, while a substantial decrease in NRIR utilization was noted, it is primarily due to corticosteroid use. However, it is noted that relatively high rates of NRIR utilization persist regardless of this change.

## Conclusion

Substantial improvement has been seen in the utilization of not routinely indicated resources for the ED management of croup; however, these rates still remain high. A large increase in the oral route of glucocorticoids and reflexive decrease in parenteral administration led to the large change in resource use. Additional investigation is necessary to evaluate the impact of resource utilization on outcomes in children with croup.

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