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To cite this article: P McLaughlin, RC Banuelos, E.A. Camp, V. Kancharla & E.M. Sampayo (2021): The Clinical Respiratory Score: Investigating the Reliability of an Asthma Scoring Tool across a Multidisciplinary Team, Journal of Asthma, DOI: [10.1080/02770903.2021.1978481](https://doi.org/10.1080/02770903.2021.1978481)

To link to this article: <https://doi.org/10.1080/02770903.2021.1978481>



Accepted author version posted online: 16 Sep 2021.



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The Clinical Respiratory Score: Investigating the Reliability of an Asthma Scoring Tool across a Multidisciplinary Team

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ABSTRACT

Background: Asthma scoring tools are used by emergency department (ED) teams to communicate severity of illness. Although most have been validated, none has been found to be sufficiently valid to allow for use across a multidisciplinary team managing pediatric asthma exacerbations.

Objective: We sought to evaluate the inter-rater reliability of the Clinical Respiratory Score (CRS) among all members of an ED care team.

Design/Methods: We conducted a retrospective study of children aged 2 to 18 years presenting with an acute asthma exacerbation to an urban pediatric ED over a 2-year period. We determined reliability using two CRS measurements independently documented by two separate providers, 15 min apart. An inter-class correlation coefficient (ICC) was calculated to determine overall reliability among users. Subgroup analysis was conducted to determine reliability between types of providers and the six components of the CRS.

Results: A total of 9,749 patient encounters were identified and 1,562 (16%) met our inclusion criteria. The majority of score pairings ($n = 1096$, 70.2%) were documented by a registered nurse followed by a respiratory therapist. The overall reliability of the CRS, when documented by two providers, was acceptable with an ICC of 0.76 (95% CI: 0.74-0.78, $p < 0.001$). Removing CRS components with the lowest agreement did not affect the overall ICC when re-calculated.

Conclusion(s): The CRS is a reliable asthma severity scoring tool for pediatric patients presenting with an acute asthma exacerbation when utilized across care team members. Simplifying the CRS by removing the color and mental status components did not affect its reliability.

Keywords Asthma, Pediatric Emergency Department, Severity Score, Clinical Respiratory Score

INTRODUCTION

Respiratory distress is often a sign of an acute asthma exacerbation that prompts caregivers of children to seek emergency care. Though pulmonary function testing (PFT) is the accepted reference standard used to assess severity of acute asthma exacerbations in adults [1], the necessity of patient cooperation makes PFT measurement challenging in most children [2]. Therefore, clinicians often utilize various respiratory distress scales to assess the severity of asthma exacerbations in children

[3–10]. Increasingly the management of children presenting with an acute asthma exacerbation is often initiated by nurses and respiratory therapists prior to physician evaluation, utilizing clinical guidelines and standing delegated orders [16]. Triage nurses and respiratory therapists often utilize asthma severity scoring systems to communicate illness severity [17] or justify the use of standing orders to initiate treatment.

The majority of published asthma severity scores have been developed for use in clinical trials [11, 12], and do not necessarily apply to other populations in a clinical setting [11, 19]. Analysis from a systematic review determined that published clinical asthma scores are not validated to allow for clinically meaningful use in children with acute asthma exacerbations [11–14]. Clinical respiratory scores need to be reliable, easy to use and responsive in order to be considered valid [11, 12]. The components of some asthma scores in use may have components that were not validated to determine their value to the clinician to guide medical decision-making. Other scores studied are limited by scope of practice, as they were only validated for use when investigating reliability between physicians alone [4, 5, 11, 19]. Furthermore, nurses and respiratory therapists often initiate asthma exacerbation management according to clinical guidelines and standing orders as noted above [15, 16]. Therefore, it is necessary to have a validated asthma severity score that can be used by non-physicians [18, 20] who initiate management for ED patients with acute exacerbations.

The Clinical Respiratory Score (CRS) is a tool that was developed based on the National Asthma Education Program's guidelines for the diagnosis and management of asthma [15–17]. The CRS has six easily scored components (Table 1) consisting of respiratory rate, breath sounds, accessory muscle use, oxygen saturation, color, and mental status; it was developed for use specifically in children presenting with acute respiratory distress as a result of an asthma exacerbation.

Objective

The objective of this study was to assess the reliability of the CRS for a population of children with acute asthma exacerbations when scored by registered nurses, respiratory therapists and physicians in the ED.

METHODS

Population and Procedures

This was a retrospective study designed to investigate the inter-rater reliability of the CRS. Charts were extracted from electronic medical records for children presenting to the ED between January 2014 and December 2015 with an ultimate diagnosis of an acute asthma exacerbation. Patients were excluded if they had any other comorbid condition that could also contribute to their respiratory distress such as pneumonia, bronchiolitis, foreign body aspiration, cystic fibrosis, tuberculosis, pulmonary/interstitial fibrosis, pneumothorax, sickle cell disease with acute chest syndrome, a prior history of a surgical intervention within the pleural space, history of congenital diaphragmatic hernia, restrictive lung disease, heart failure, or intubation prior to ED arrival.

Children between 2 and 18 years of age were assessed with the CRS and were included if two scores were documented in their medical record less than 15 min apart to limit the potential for change in that patient's presentation. The two scores must have been documented electronically by two different members from the emergency care team. This could include two scores from two different types of medical staff or two scores from the same type of medical staff, including registered nurses (RN), respiratory therapists (RT), physicians, and/or Advanced Practice Providers (APPs = nurse practitioners and physician assistants). Patients routinely receive their first CRS score

at triage and were subsequently roomed and evaluated by an RT utilizing a Respiratory Assessment and Management Protocol (RAMP). The time difference between those documented scores was then calculated to ensure that less than 15 min had elapsed between them. We excluded any patient who received any medication that could have altered the result of the second score, such as albuterol or levalbuterol.

In an effort to account for seasonal variation, a two-year timeframe was chosen to capture asthma patients. We chose to begin study of the CRS only after a 12 month period of use to ensure adequate education and familiarity among emergency room staff.

This study was completed at a large, quaternary care pediatric hospital and community site with approximately 120 000 annual visits combined. This study was approved by the local institutional review board.

Definition

The CRS contains six equally weighted variables (Table 1). It uses both objective and subjective criteria when evaluating a child with asthma to calculate a score. A CRS assessment requires a member of the care team to calculate a respiratory rate and record the room air oxygen saturation using a pulse oximeter. Auscultation of the lung fields, assessing use of accessory muscles, mental status and the child's color also contribute to the CRS. Respiratory rate scores are differentiated by normal values for age. Each of the 6 categories are then categorized as mild (score = 0), moderate (score = 1), or severe distress (score = 2), and the total score is calculated from 0 to 12.

The CRS has been in use at this institution for over 20 years and has been integrated as an electronic tool in the medical record since 2011 [15]. All raters who assessed patients and calculated a score had been previously trained on using the CRS to assess all children with respiratory distress, and not just those who present with symptoms of asthma.

Statistical Analysis

Patient demographic data were summarized for both continuous and categorical variables as seen in Table 1 and 3. To determine the inter-rater reliability of the CRS, an intra-class correlation coefficient (ICC) was calculated. A one-way random model with absolute agreement was chosen to report the single measure ICC. We chose a one-way random model because we did not have consistent raters. The CRS was categorized as continuous (ratio) data. We also ran a two-way random effects model to be used when you have the same raters with similar results. An $ICC \geq 0.7$ would be considered an acceptable agreement with a p values < 0.05 defined as statistically significant. Additional subgroup analyses were conducted to determine reliability between types of providers and the six components of the CRS. A sensitivity analysis was performed to determine if the removal of two subjective factors (color and mental status) changed the reliability of the score. The statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS), version 24 (IBM Corp., Armonk, NY).

RESULTS

A total of 9,749 asthma patients presented to our ED between January 1, 2014 and December 31, 2015 and were diagnosed with an acute asthma exacerbation without any identifiable comorbid condition. 1863 patients had two CRS scores documented from two unique raters within fifteen minutes. 301 were excluded if they received medication before or between CRS documentation (Figure 1). Descriptive analysis of the characteristics of the 1562 patients is shown in Table 2.

Patients were mostly male (64.7%) with diverse representation of Hispanic ethnicity (44.7%) and Black race (38.8%) and average patient age of 6.9 years ($SD \pm 3.7$) (Table 2). Most patients had public insurance (64.0%). The average time between the two CRS assessments was 8.9 ($SD \pm 3.8$) minutes with 15 min being the maximum amount of time between recorded scores (Table 2).

The majority of the first raters were RNs (94.1%), while RTs were a majority of the second raters (76.8%) (Table 3). Study scenarios typically included one CRS documented by a triage nurse in the waiting area, followed by a second CRS documented by a respiratory therapist after the child was placed in an exam room. There were no MDs or APPs who recorded both CRS assessments on the same patient (Table 4). RNs recorded the most score pairs that were assessed by the same provider type ($n = 274$) (Table 4).

Scores ranged from 0–12. Comparisons between scores were made overall and between provider groups. No ICC value was ≥ 0.80 , but several coefficients were at the acceptable level (≥ 0.70). Overall, reliability of the total CRS was acceptable (ICC = 0.76 (95% CI 0.74 – 0.78); p values < 0.001) (Table 5). When the six components were analyzed individually, pulse oximetry (SpO_2) on room air had the highest rater agreement (ICC = 0.71 (95% CI 0.68 – 0.73); p values < 0.001), while color had the lowest (ICC = 0.30 (95% CI 0.25 – 0.34); p values < 0.001). Similar results were found in the subgroup analysis based on rater type. Due to the low number of physician and APP assessments, ICC was not calculated for these providers.

When analyzing the RN-RN group, the total score had an acceptable agreement (ICC = 0.71 (95% CI 0.64 – 0.76); p values < 0.001) (Table 5). Mental status had the highest agreement (ICC = 0.64 (95% CI 0.56 – 0.70); p values < 0.001), while color had the lowest (ICC = 0.34 (95% CI 0.23 – 0.44); p values < 0.001) (Table 5).

In the third subgroup analysis, the first raters were RNs while the second were RTs, which was the most common sequence of paired assessments among providers. The total score was acceptable (ICC = 0.76 (95% CI 0.74 – 0.79); p values < 0.001). Room air oxygen saturation had the highest agreement (ICC = 0.74 (95% CI 0.71 – 0.76); p values < 0.001), while color had the lowest agreement (ICC = 0.26 (95% CI 0.21 – 0.32); p values < 0.001).

For the sensitivity analysis, the first and second total CRS assessments were recalculated excluding color, and both color and mental status, to determine if the ICC estimates changed (Table 6). There was a negligible difference between the six component ICC estimates and the 5 and 4 component estimates, which shows that the CRS reliability does not change (ICC ≥ 0.70) when color and mental status are removed as components of the score (Table 6).

DISCUSSION

Our study is unique because it investigates the inter-rater reliability of a pediatric asthma severity score during routine clinical use by a multidisciplinary team in a real clinical environment. A similar retrospective study done in adults created an asthma severity score based on data that were routinely recorded during patient visits, but the staff were not educated about the scoring tool [1]. Our data were collected from an electronic medical record designed to specifically document the CRS. The data were originally recorded in real-time, such that the documented respiratory rate and oxygen saturation matched the exam as documented by a score in the CRS flowsheet. Thus, we were able to definitively link two independent measurements from a patient's vital signs to an exam as they were concurrently documented in the CRS.

Our patient population was larger than similar prospective and retrospective studies on this topic. We chose to begin our study after the CRS had been in use and regularly utilized for

more than 12 months in our electronic medical record by all provider types, therefore improving its face validity. A two-year timeframe was chosen to account for seasonal variation in asthma and to capture patients prior to the initiation of a new steroid timeliness protocol in which oral dexamethasone was given to patients after the first CRS score was obtained in triage.

Because the management of acute asthma exacerbations is often started by nurses and respiratory therapists utilizing, it is necessary to have a validated asthma severity score that can be used by non-physicians who initiate management. Our study fills a gap in the literature since we compiled scores that were primarily assessed by nurses and respiratory therapists, both of whom are an integral part of most ED triage teams. Furthermore, our study may support the use of pediatric asthma care algorithms initiated in triage that are primarily driven by multidisciplinary teams. This has only been previously demonstrated in adult asthma patients [2].

Our scoring system is based on six components, two of which are objectively collected (RR and room air SpO₂) and the remainder of which are more subjective, based on a patient examination [15]. The CRS was developed to simplify scoring of patients' pulmonary exam findings, relative to other existing tools [3–4].

By calculating the ICC for not only the total CRS but also for each individual component of the score, we were able to determine if each component held comparative weight. The component with the greatest inter-rater reliability was the room air SpO₂. This result was expected since oxygen saturation is an objective value. This component did not have an ICC > 0.80, possibly due to the variability in oxygen saturations that occur over time, especially if the first rater initiated supplemental oxygen requiring the second rater to turn off the oxygen to assess a room air SpO₂. The components with the lowest inter-rater reliability were mental status and color. Color or cyanosis has previously been reported in other studies to have poor inter-observer reliability [6]. This may be attributed to color and mental status rarely being abnormal. Color assessment is subjective, and the categories are not mutually exclusive, with a "normal" characteristic having a possible score of 0 or 1. Based on the low ICC for color and mental status, we recalculated the ICC for the CRS. We found that the CRS could be simplified to four components without affecting the inter-rater reliability. Conducting a sensitivity analysis by removing the components of the score that had poor inter-rater reliability, we determined that the CRS is a robust score that is not dependent on subjective factors and could be simplified while maintaining its overall reliability [15].

Limitations of our study include the retrospective nature of the study. Though our data were collected retrospectively, they were recorded in real time during routine clinical practice primarily by RNs and RTs, which contributes to the face validity and utility of our findings. Also, we did not compare the CRS to a reference standard, such as pulmonary function tests. However, attempting to do so in our patient population of young children in the ED would be challenging due to lack of cooperation with forced expiratory volumes in this age group.

The literature is flooded with respiratory scores. Although there are challenges in choosing what score works best or changing the use of a score that is ingrained in the culture of an institution, the CRS may serve a role for those looking to standardize asthma protocols in a multidisciplinary team. The CRS is a reliable asthma severity scoring tool for pediatric patients presenting with an acute exacerbation to an ED when utilized across care team members, especially among nurses and respiratory therapists. More research is needed to validate the CRS, specifically in evaluating the responsiveness of the CRS to medication administration and the contribution of the CRS to communication between team members during patient handoffs.

Disclosures

PM and EMS conceived and designed the study. PM and EMS supervised the conduct of the trial and data collection. RB and VK managed the data, including quality control. EC provided statistical advice on study design and analyzed the data. PM drafted the manuscript, and all authors contributed substantially to its revision. PM takes responsibility for the paper as a whole.

We have no conflicts of interest or funding to report for this work.

Prior Presentation

Poster format at Pediatric Academic Societies meeting on May 5, 2018

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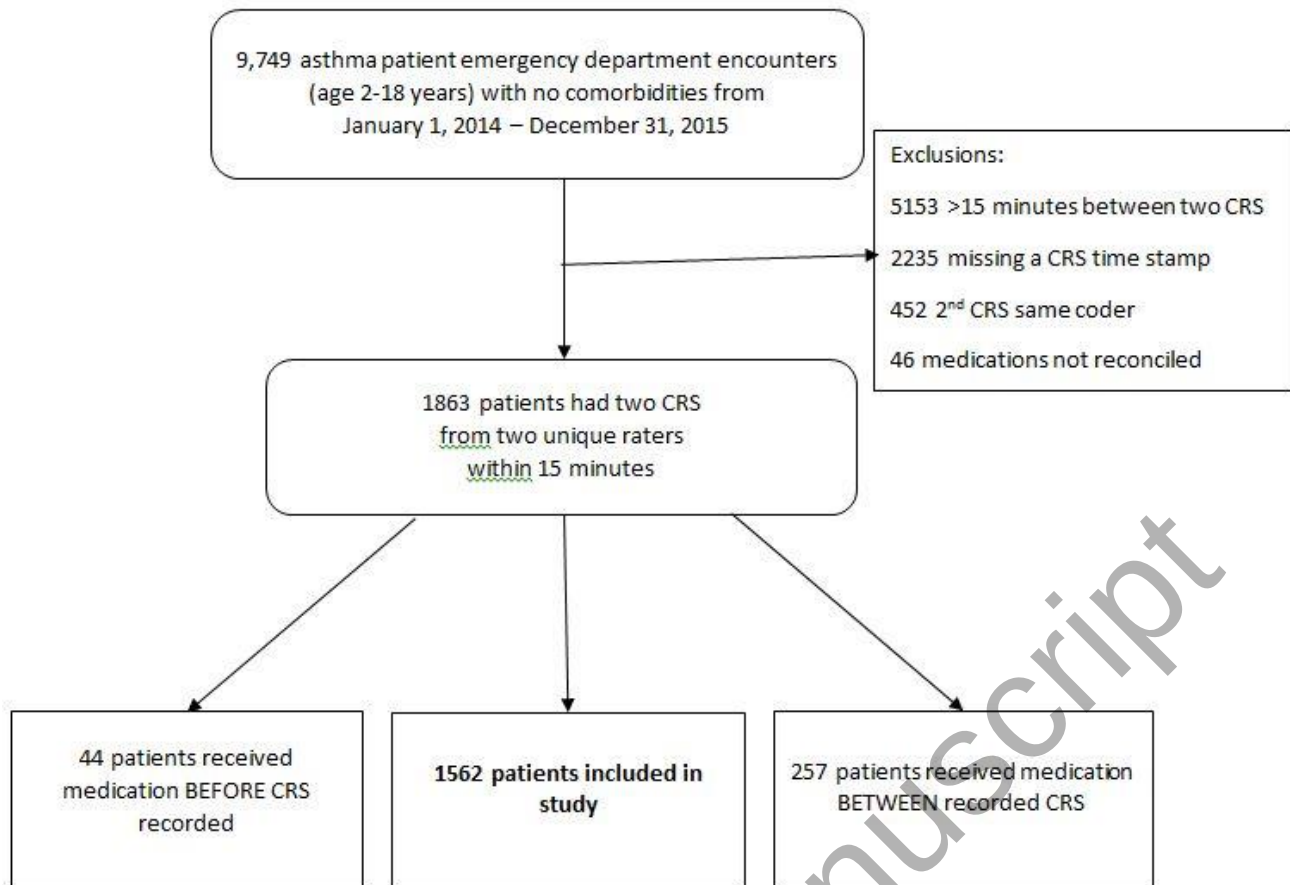


Figure 1. Flow Diagram of Patient Selection.

Asthma Clinical Respiratory Score

Table 1. Clinical Respiratory Score Based on the National Asthma Education Program's Guidelines for the Diagnosis and Management of Asthma.

Assessment	Score 0	Score 1	Score 2
Respiratory Rate	< 2 months: < 50 2 –12 months: < 40 1 –5 years: < 30 > 5 years: < 20	< 2 months: 50-60 2 –12 months: 40-50 1 –5 years: 30-40 > 5 years: 20-30	< 2 months: > 60 2 –12 months: > 50 1 –5 years: > 40 > 5 years: > 30
Auscultation	Good air movement, expiratory scattered wheezing or loose rales/crackles	Depressed air movement, inspiratory and expiratory wheezes or rales/crackles	Diminished or absent breath sounds, severe wheezing or rales/crackles, or marked prolonged expiration
Use of Accessory Muscles	Mild to no use of accessory muscles, mild to no retractions, OR nasal flaring on inspiration.	Moderate intercostal retractions, mild to moderate use of accessory muscles, nasal flaring	Severe intercostal and sub sternal retractions, nasal flaring
Mental Status	Normal to mildly irritable	Irritable, agitated, restless	Lethargic
Room Air SpO ₂	> 95%	90 –95%	< 90%
Color	Normal	Pale to normal	Cyanotic, dusky

Table 2. Descriptive Characteristics of Patient Population (N = 1562).

Characteristic	N (%)*
Age, Mean (SD)	6.91 (3.66)
Gender	
Female	551 (35.3)
Male	1011 (64.7)
Ethnicity	
Non-Hispanic	848 (55.3)
Hispanic	686 (44.7)
Missing	28
Race	
White	854 (55.9)
Black	593 (38.8)
Asian	72 (4.7)
Other/Missing	43 (2.8)
Insurance	
Private	528 (36.0)
Public	940 (64.0)
Missing	94
Time between first and second CRS (min), Mean (SD)	8.88 (3.82)

CRS = clinical respiratory score; IQR = interquartile range; min = minute; SD = standard deviation;.

* unless otherwise specified.

Table 3. Frequencies of Healthcare Providers as First and Second Raters ($N = 1562$).

Professional Type	N (%)
	First Rater
Physician	24 (1.6)
Registered nurse	1445 (94.1)
Respiratory therapist	39 (2.5)
Advanced practice provider	28 (1.8)
Missing	26
	Second Rater
Physician	17 (1.1)
Registered nurse	325 (21.5)
Respiratory therapist	1159 (76.8)
Advanced practice provider	9 (0.6)
Missing	52

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Table 4. Frequency of Paired Clinical Respiratory Scores by Healthcare Providers.

Inter-rater Relationships		Rater #2			
		Physician	Registered nurse	Respiratory therapist	Advanced practice provider
Rater #1	Physician	0	5	19	0
	Registered nurse	15	274	1096	9
	Respiratory therapist	2	34	3	0
	Advanced practice provider	0	2	25	0

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Table 5. Reliability of the CRS Tool between Two Healthcare Professionals.

CRS components	ICC	95% CI	P-value
Overall (N = 1562)			
Total Score	0.76	0.74 – 0.78	<0.001
Respiratory Rate	0.56	0.52 – 0.59	<0.001
Auscultation	0.53	0.49 – 0.56	<0.001
Accessory Muscle	0.53	0.50 – 0.57	<0.001
Mental Status	0.48	0.44 – 0.51	<0.001
Room Air	0.71	0.68 – 0.73	<0.001
Color	0.30	0.25 – 0.34	<0.001
RN & RN (n = 274)			
Total Score	0.71	0.64 – 0.76	<0.001
Respiratory Rate	0.44	0.34 – 0.53	<0.001
Auscultation	0.47	0.37 – 0.56	<0.001
Accessory Muscle	0.46	0.36 – 0.55	<0.001
Mental Status	0.64	0.56 – 0.70	<0.001
Room Air	0.61	0.53 – 0.68	<0.001
Color	0.34	0.23 – 0.44	<0.001
First Score RN & Second Score RT (n = 1096)			
Total Score	0.76	0.74 – 0.79	<0.001
Respiratory Rate	0.57	0.52 – 0.60	<0.001
Auscultation	0.53	0.48 – 0.57	<0.001
Accessory Muscle	0.55	0.51 – 0.59	<0.001
Mental Status	0.44	0.40 – 0.49	<0.001
Room Air	0.74	0.71 – 0.76	<0.001
Color	0.26	0.21 – 0.32	<0.001

CRS = clinical respiratory score; RN = registered nurse; RT= respiratory therapist.

Table 6. Sensitivity Analysis of the Recalculated CRS and Mental Status Removed.

Group	ICC	95% CI	P-value
Only Color Removed from Score			
Overall	0.76	0.74 – 0.78	<0.001
RN & RN	0.72	0.65 – 0.77	<0.001
First Score RN & Second Score RT	0.76	0.74 – 0.79	<0.001
Color & Mental Status Removed from Score			
Overall	0.75	0.73 – 0.77	<0.001
RN & RN	0.70	0.64 – 0.76	<0.001
First Score RN & Second Score RT	0.75	0.72 – 0.78	<0.001

CRS = clinical respiratory score; RN = registered nurse; RT = respiratory therapist.

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