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Analysis of the asthma scores recommended in guidelines for children presenting to the emergency department: a Pediatric Emergency Research Networks study

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ABSTRACT

Rationale While there are numerous published paediatric asthma scores, it is unknown how commonly scores are recommended in asthma guidelines across different geographical regions globally, and what their validation status is.

Objectives (1) To describe which clinical guidelines recommend asthma scores across different geographical regions. (2) To describe the initial and subsequent validation of the commonly recommended asthma scores.

Methods Observational study of asthma scores recommended in guidelines for the management of acute paediatric asthma from institutions across the Pediatric Emergency Medicine Network; global paediatric emergency medicine research network comprising all eight local and regional paediatric emergency medicine research networks.

Main results 158 guidelines were identified. Overall, 83/158 (53%) guidelines recommend a bedside clinical score for assessment of asthma severity. While a single country-specific clinical score was recommended in all guidelines from Spain and Canada, 27/28 (96%) of the USA guidelines recommend a wide variety of scores, and scores are rarely recommended in guidelines from other research networks (PERUKI, Paediatric Emergency Research in the UK and Ireland and PREDICT, Paediatric Research in Emergency Departments International Collaborative in Australia and New Zealand) and other countries (Costa Rica, South Africa, Nigeria, Singapore, India).
The Pediatric Respiratory Assessment Measure (PRAM) and the pulmonary score (PS) were the most frequently used scoring instruments. While the PRAM has undergone the most extensive validation, including construct validity, validation studies for the PS are limited. Inter-rater reliability, as well as the criterion, responsiveness and discriminative validity aspects represent the most common limitations in many of the scores.

Conclusions There are marked geographical differences in both the recommendation for and the type of clinical asthma score in clinical practice guidelines. While many asthma scores are recommended, most have insufficient validation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There is a plethora of paediatric asthma scores used both in research and clinical practice. However, we do not know which scores are recommended in clinical asthma guidelines in different geographical locations and what their validation status is.

WHAT THIS STUDY ADDS

⇒ This observational study of 158 clinical guidelines from a global paediatric emergency research network found a marked geographical variation in the frequency and the type of score used, with scores frequently recommended in the USA, Canada and Spain, and infrequently elsewhere. The most common scores were the Paediatric Respiratory Assessment Measure (PRAM) and the pulmonary score.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study highlights the need for future prospective validation studies of the commonly recommended asthma scores to establish their role. Overall, the PRAM score is the most extensively validated but would benefit from multisite validation studies. Further prospective studies are required to validate the remaining scores with a focus on their ability to discriminate differences in asthma severity and their responsiveness to changes in signs and symptoms for use in clinical practice guidelines.

INTRODUCTION

Asthma is a frequent reason for presentation to an emergency department (ED), and one of the most common reasons for paediatric hospitalisation after an ED visit.[1 2] Paediatric asthma carries a high

burden of disease, with global estimates of an escalating rate of admission and increasing associated costs.[3 4]

Clinical practice guidelines are commonly recommended for use in the ED management of acute asthma;[5–7] providing a background to the clinical condition, guiding the assessment of the asthma severity of an individual patient and recommending treatment based on this assessment. A recent qualitative study demonstrated that clinicians view clinical guidelines as a useful aid to decision-making in children with acute asthma.[8] Some of these guidelines may also make a reference to an asthma score.

An asthma score, in general, includes a combination of observations that a clinician can assign a numerical value to. These include oxygen saturation, heart rate, respiratory rate, accessory muscle use, wheezing and duration of the expiratory phase of the respiratory cycle. For each of these parameters, a child is assigned a score, usually between 0 and 3 points, with the sum of the points representing a total score. Clinical asthma scores are useful to guide severity-based treatment recommendations and to measure changes in a child's condition to determine response to treatment.[1 9]

The literature about the use of asthma scores in clinical practice, however, has been largely limited to surveys inquiring about clinicians' use of scores.[1 3 8] In research, asthma scores are frequently employed as a clinical trial entry criterion to measure severity[10–12] and as a measure of response to treatment.[13 14] A lack of consistency in asthma score utilisation contributes to the challenge of a meaningful comparison of the outcomes between clinical trials.[15] To our knowledge, the spectrum of the clinical asthma scores endorsed in guidelines for local hospitals and networks worldwide has not been documented. In this context and given our recent identification of the reliance the clinicians place on clinical guidelines,[8] this paper addresses the above knowledge gap by investigating which paediatric asthma scores are recommended across a broad sample of healthcare institutions internationally.

Objective

The Pediatric Emergency Research Networks (PERN) asthma working group was formed in 2017, with the aims of developing consensus-based and evidence-based asthma outcome measures (with input from patients, families and clinicians), and international consensus guidelines for the conduct and reporting of clinical trials of therapies for acute asthma exacerbations. Currently, this group comprises members from seventeen countries; with most belonging to formal regional research networks.[16]

This study aims to assess current clinical asthma scores recommended in paediatric practice guidelines in the EDs associated with PERN.

Specifically, we aim to describe:

1. The proportion of guidelines which include a clinical asthma score from each country.
2. The distribution of various asthma scores across different PERN networks.
3. The validation spectrum of the commonly recommended asthma scores.

The recommendations for the management of acute exacerbations of asthma and the quality of these guidelines are reported elsewhere.[17]

Design

This is an observational study of the guidelines for the management of acute paediatric asthma from the institutions belonging to the global PERN network. The project is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology statement.[18]

Setting and guideline collection

The hospitals and clinicians associated with the PERN asthma working group were invited to participate by email in October 2018 via the eight PERN partner networks. The PERN comprises the following networks: Research in European Paediatric Emergency Medicine (REPEM) in Europe; Pediatric Emergency Care Applied Research Network (PECARN) and Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics (PEM CRC) from the USA; Pediatric Emergency Research Canada (PERC); Paediatric Research in Emergency Departments International Collaborative (PREDICT) from Australia and New Zealand; Paediatric Emergency Research in the United Kingdom and Ireland (PERUKI); Red de Investigación de la Sociedad Española de Urgencias de Pediatría/Spanish Pediatric Emergency Research Group (RISEUP/SPERG); and Red de Investigación y Desarrollo de la Emergencia Pediatrica Latinoamérica.[19]

The email recipients were then invited to forward the email to other ED physicians and hospitals where there existed formal and informal professional and academic relationships, aiming to allow sampling in countries without formal organised research networks. The request for participation was also shared on social media

Each participating hospital was asked to provide a copy of its current guideline for the management of acute paediatric asthma. This could include local, regional or national guidelines, as well as any documents (such as order sets) providing recommendations on severity assessment and severity-based treatment of children presenting to the ED or hospital with acute onset of wheezing or asthma.

Data abstraction: guideline/order set content

To reduce the risk of bias, each clinical guideline was independently assessed by two trained reviewers, who were provided with clear definitions, rules for the interpretation of clinical guidelines and instructions for data extraction. Abstracted data were recorded on a paper-based form and then entered into a specifically designed Research Electronic Data Capture[20] database hosted at Monash University.

We originally planned for the guidelines written in languages other than English to be abstracted by two investigators fluent in both English and the language in which the guideline was written. While this was possible for guidelines written in Spanish and Catalan, we were unable to achieve this goal for those written in Dutch and French. An online translator (Google Translate) was therefore used to extract guideline content from Dutch and French guidelines.

Guideline content was extracted and analysed descriptively. Guidelines were collated into the following six groups, based on established PERN networks: UK and Ireland (PERUKI network); Spain (RISEUP-SPERG network); USA (PEM-CRC and PECARN networks); Australia and New Zealand (PREDICT network); Canada (PERC network) and 'Other' (single guidelines from Netherlands, Switzerland, France (REPEM network), Romania, Zimbabwe, Singapore, India, Costa Rica and two guidelines from South Africa).

Data abstraction: analysis of scoring systems

For each guideline, we determined and recorded whether a scoring system/s was reported within the guideline, the name of

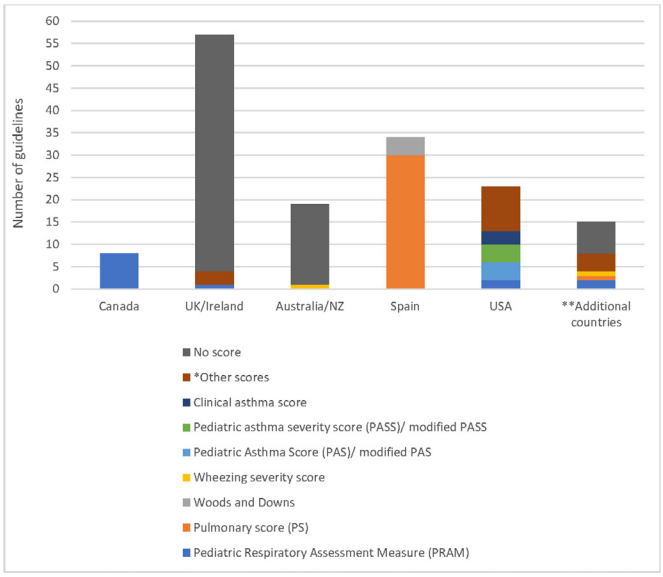

Figure 1 Geographical distribution of asthma score recommendation.

the scoring system/s and what the score was recommended for (ie, to assess severity, to measure change or to assist with disposition planning). The frequency of a particular scoring system recommended within each geographical region was presented as counts and percentages. If a scoring system was present in only one guideline, this score was included in the 'other scores' category. If a score was present in two or more guidelines, regardless of the geographical region, the name of that score was used.

Derivations of original scores and subsequent validation studies

The original studies outlining the development and purpose of scoring systems recommended in at least two clinical guidelines were sourced and categorised into the original validation measure by the lead author, CG. Bekhof *et al* in 2014[9] conducted a systematic review of asthma scoring systems. We included in this review (online supplemental appendix 1) validation studies since this time, between November 2011 (the last date of the literature search in the original publication) and 20 April 2024. It was outside the scope of this study to assess the quality of the studies as was done by Bekhof. Data was extracted by the lead author, CG, on the nature and timing of the validation measures studied.

Patient and public involvement

Patients were not involved in the design of this study

RESULTS

A total of 158 clinical guidelines were identified. The majority (95.6%) were obtained from hospitals participating in national or regional paediatric emergency research networks; the greatest number (72%) of guidelines originated from the UK and Ireland (PERUKI network), Spain (RISEUP-SPERG network) and the USA (PECARN and PEM-CRC networks). All the guidelines represent a single institution; however, just over half, 88/158 (55%) of guidelines referenced a national or regional guideline. The most referenced national guideline was the British Thoracic Society (BTS) accounting for 27/57 (47%) of the total guidelines from this region.

Most guidelines were written in English; the most common non-English language was Spanish. A bedside clinical score was recommended in all guidelines from Spain 34/34 (100%) and Canada 8/8 (100%), and in 27/28 (96%) of guidelines from the USA (figure 1). In contrast, bedside clinical scores were recommended less commonly in guidelines from other research networks, UK and Ireland 4/57 (7%), Australia and New Zealand 1/17 (5%) or from other countries 8/15 (53%) (Costa Rica, South Africa, France, Nigeria, Singapore, India). Overall, 83/158 (53%) guidelines recommended the use of a bedside clinical score for assessment of asthma severity. The scores recommended in two or more guidelines and the components that they assess are outlined in table 1. Of the guidelines which recommend the use of an asthma score, 98% recommended the score be used to assess severity on initial assessment. Further recommendations for the use of an asthma score were to assist with reassessment after initial treatment (51%) and to guide disposition (48%). Timing of reassessment recommended varied from 15 min post initial treatment to every hour during the patient's ED stay.

The most frequently recommended scores included the pulmonary score (PS) 31/83 37% (all Spanish hospitals and one other hospital), the Pediatric Respiratory Assessment Measure (PRAM) score 13/83 16% (all Canadian hospitals and three other hospitals) and the Pediatric Asthma Score 4/83 5% (PAS) as well as the Pediatric Asthma Severity Score 4/83 5% (PASS), in the USA.

The development and purpose of each of the scores present in two or more guidelines, as well as further validation studies (regardless of the network or country they were reported in), are presented in table 2.

Table 1 Overview of the scores and the components they measure

Component	Pediatric Asthma Severity Score (PASS)	Clinical Asthma score (CAS)	Pediatric Respiratory Assessment Measure (PRAM)	Wood and Downes score	Pulmonary score (PS)	Wheezing severity score (WSS)	Pediatric Asthma score (PAS)
Oxygen Saturation		✓	✓	✓			
Accessory muscle use	✓	✓	✓	✓	✓	✓	✓
Duration of expiratory phase	✓						
Absence/presence of inspiratory breath sounds				✓			
Wheezing	✓		✓	✓	✓	✓	✓
Heart rate							✓
Respiratory rate		✓			✓	✓	
Dyspnoea		✓					
Air entry			✓				
Cerebral function				✓			

Table 2 Original derivations and recent validation of asthma scores reported in two or more clinical guidelines

	Study design and number of patients	Derivation or validation	Construct validity	Predictive validity	Discriminative validity	Responsiveness	Statistics reported
Pediatric Respiratory Assessment Measure Chalut *et al*[27]	Prospective cohort study. Total n=217	Derivation	To correlate with mild, moderate and severe airway obstruction as measured by PEFR as the gold standard		Mild<5 Moderate>5	Measured as a change in PRAM score correlated to % change from baseline Rf08	Modest discriminative properties Responsiveness r=0.58, p<0.004
Study by Alnaji *et al*[31]	Secondary analysis of prospective data set for children Total n=297	Validation		The ability of the score at 3 hours to predict the need for admission compared with the initial PRAM at triage			3-hour PRAM AUC 0.83
Arnold *et al*[32]	Single centre prospective study Total n=503	Validation				Comparison of change in PEFR compared with PRAM score at 2 and 4 hours.	The first 2 hours demonstrated change; 4 hours demonstrated ongoing change p<0.0001 compared with PEFR, which did not
Thaweerujirot and Daegsuwan[29]	Prospective study Total n=80	Validation		Admission versus discharge			ROC for PRAM 0.942
Eggink *et al*[29]	Prospective study Total n=50	Validation	Correlation with single clinical sign or oxygen saturation or airway obstruction	Admission versus discharge			No difference. Poor for most, slight correlation with 0_2 saturation.
Johnson *et al*[21]	Prospective observational study Total n=48	Validation		Admission versus discharge			After treatment, AUC 0.8923
Pediatric Asthma Score Quereshi *et al*[12]	Randomised, double-blind, placebo-controlled study Total n=434	Derivation			Mild 5–7 Moderate 8–11 Severe 12–15		No statistics provided
Study by Gardiner and Wilkinson[33]	Secondary analysis of prospective data Total n=101	Validation					IRR K=0.57 Triage PAS AUC of 0.62–0.65
Study by Jose and Namboodiripad[25]	Prospective study Total n=32	Validation	Ability of PAS to correlate with PEFR				p=0.004
Hulfish and Maloney[34]	Retrospective chart review Total n=44	Validation		Score PICU admission versus non-PICU admission			p<0.05
Pulmonary score Smith *et al*[22]	Convenience sample Total n=46	Derivation	The ability of the PS score to correlate with PEFR				R=0.57 p=0.0003
Paniagua *et al*[24]	Retrospective study n=14 953	Validation		Abnormal initial PS to predict children who would require hospitalisation			Initial PS>3 had a strong association with hospitalisation OR 8.1 and longer length of stay OR 6.2 and PICU admission OR 9.
Wood and Downes Wood *et al*[35]	Convenience sample Total n=18	Derivation	A score of 6 or more correlated with a PCO_2>65 mm Hg (this was the criteria for respiratory failure)				R=0.69, p<0.001
Thaweerujirot and Daegsuwan[36]	Prospective study Total n=80	Validation		Admission versus discharge			ROC=0.959
Pediatric Asthma Severity Score Gorelick *et al*[37]	Correlation between score and PEFR and oxygen saturations n=1224	Derivation		Admission versus discharge		Percentage change in score	AUC to predict hospitalisation 0.82 48% increase in score from start to finish of treatment, overall effect size 0.62
Ciftci *et al*[38]	Convenience sample Total n=70	Validation		Admission versus discharge Comparison for those who did and did not go on to get steroids			Sensitivity 95% for predicting need for admission
Eggnick *et al*[29]	Prospective study Total n=50	Validation	Correlation with single clinical sign or oxygen saturation or airway obstruction	Admission versus discharge			No difference. Poor correlation.
Clinical Asthma score Parkin *et al*[39]	Convenience sample Total n=58	Derivation	Correlation of score to three hypothetical constructs; hospital stay, amount of inhaled bronchodilator, pulse oximetry			Change in score from admission to discharge	Correlation with LOS=Spearman's correlation=0.47 Wilcoxon signed rank test p<0.01

Continued

Table 2 Continued

	Study design and number of patients	Derivation or validation	Construct validity	Predictive validity	Discriminative validity	Responsiveness	Statistics reported
Ahmareen *et al*[40]	Prospective study Total n=223	Validation		Admission versus discharge and duration of stay in ED			Diff in admission rates p=<0.001. No correlation between CAS value and LOS in ED.
Ciftci *et al*[38]	Convenience sample Total n=70	Validation		Admission versus discharge			Sensitivity 95% for predicting need for admission.

AUC, area under the curve; CAS, Clinical Asthma score; ED, emergency department; LOS, Length of stay; PAS, Pediatric Asthma Score; PCO_2, partial pressure of carbon dioxide; PEFR, Peaked Expiratory Flow Rate; PICU, Pediatric Intensive Care Unit; PRAM, Pediatric Respiratory Assessment Measure; PS, pulmonary score; R, Pearson's correlation coefficient; ROC, receiver operator curve.

Since the Bekhof paper in 2014, our literature review (detailed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram in online supplemental appendix 1) identified 10 further studies, with one further study by coauthor, SS, on initial review of the paper[21] (total 11 studies). The most common validation measure of the scores was assessment of their predictive ability. The PRAM score has undergone the most extensive validation with five further trials, including one study which assessed responsiveness. Other validation works included the PAS in three studies, the PASS and the CAS in two studies, Wood and Downes score in one study. While the Wheezing Severity Score is cited in a paper by Foster *et al*, 2018 and described as a variation of the PS,[22] we were unable to identify any validation of this instrument.

DISCUSSION

This study demonstrates there is considerable variation in the recommendation of asthma scores in guidelines around the world. Asthma scores are commonly recommended in Canada and Spain, with a near-universal recommendation of a single (but different) score in each country. In contrast, there is little consistency with respect to asthma score recommended in the USA, with a large variety of recommended scores. Additionally, many countries do not use an asthma score at all. This may be in part, as is the case in the UK/Ireland, where many of the guidelines are based on an overarching guideline, the BTS, which does not recommend an asthma score. An ideal score for use in a clinical practice guideline has not been established. The principal aim for scores in clinical guidelines is to assist in categorising an individual into a disease severity category, guide therapy and measure clinical change after therapy. Therefore, an ideal score would have good discriminative ability and responsiveness and have good construct validity. However, few of the current scores address this need. Only the PRAM, PASS and CAS assessed their responsiveness in the original validation studies, and the PRAM is the only score that has undergone further validation of responsiveness in a single centre of 503 patients.[23] In addition, the only two scores that have been assessed for their discriminative ability are the PAS[12] and the PRAM.[23] It is also common that most of the validation studies are conducted solely on the scores that were developed in their geographical region.[23]

The PS was the instrument most often recommended overall, representing the sole score recommended in hospitals across Spain. The use of a single scoring system within a geographical region facilitates communication between healthcare providers about asthma severity and treatment decisions. The potential advantage of the PS is its requirement for the measurement of only three parameters: respiratory rate, wheeze and degree of accessory muscle use.[22] A large single-centre retrospective study of the PS suggested that initial assessment of PS>3 points is a good predictor of the need for hospitalisation.[24] However, this instrument had limited prospective validation because it was developed with the goal of comparing the score to an established 'gold standard' of asthma severity, that is, the pulmonary function tests (PFTs). PFT is rarely used in the ED setting because preschoolers who represent 60% of asthma visits to paediatric EDs cannot perform these tests, and 40% of the school-aged children are also unable to perform spirometry (PFTs).[25 26]

The PRAM score was the second most recommended score in this study. In previous asthma research, it has been used as a threshold for study eligibility and to measure trial outcomes.[13 14] Additionally, it has undergone the most extensive external validation,[27] including its ability to predict disposition and assessment of responsiveness.[21 23 28] A recent study by Thaeweerujirot *et al* (n=80) reported a PRAM score of greater than 5 at triage, prior to any treatment, strongly predicted the need for admission. However, a similarly sized study by Eggnick and colleagues (n=50) found there was no statistical difference in the change in the score, from presentation to 30 min after treatment, between children that were hospitalised versus discharged.[29] Further, PRAM requires palpation of suprasternal and scalene muscle contraction not commonly used in the assessment of asthma in EDs.[27] Future multisite studies may be useful to further clarify the results of previous PRAM studies.

Limitations

This study was limited to reviewing clinical guidelines from hospitals recruited predominantly through the PERN network, which may limit generalisability. All the participants were from active research sites, which may have introduced some bias in the recommendation of asthma scores. In addition, there is underrepresentation in both guidelines from non-English speaking countries and both lower and lower-middle income countries.

Although we conducted a thorough search for derivation and validation papers relevant to each asthma score, we did not conduct a full systematic review. It is possible that some published information was not identified using our search strategy.

Guidelines were collated in 2018, and it is possible that some guidelines have changed since the study was conducted. Other scores with validation data may be less widely recommended in clinical practice guidelines, for example, the Acute Asthma Intensity Research Score which has been compared with the PRAM score.[30]

CONCLUSION

This study demonstrates large international variation in the frequency of asthma scores as well as in the recommendation of specific scores in guidelines. While many asthma scores have been recommended in asthma clinical guidelines, the majority have insufficient validation. Further validation efforts at national

and international levels may clarify their clinical utility for inclusion in clinical practice guidelines.

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Contributors SC and CG identified the research question. SC and CG were responsible for the study design and research protocol, with input from all authors. JB, RV, MC, SC and CG obtained data supervised data extraction and analysis. CG was responsible for statistical analysis. CG drafted the initial manuscript. All authors contributed equally to writing, reviewing and editing the manuscript. All authors provided comments on the drafts and have read and approved the final version of the article. All authors had full access to all of the data (including statistical reports and tables) at the conclusion of the study and take responsibility for the integrity of the data and the accuracy of the data analysis. CG is the guarantor for the paper, accepts full responsibility for the work and/or the conduct of the study, had access to the data and controlled the decision to publish.

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