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FEV₁ values corresponding to PRAM and AAIRS severity score values during pediatric acute asthma exacerbations

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Asthma severity score; acute asthma exacerbation; asthma assessment; spirometry; FEV₁; lung function

Acute asthma exacerbations are one of the most frequent reasons for emergency department (ED) visits and hospitalizations. Expert panel guidelines recommend measurement of %predicted forced expiratory volume in 1-second (%FEV₁) or peak expiratory flow (PEF) for exacerbation severity assessment and treatment decision-making.¹ These guidelines categorize exacerbation severity according to %FEV₁ values as mild-to-moderate (%FEV₁ 40%) and severe (%FEV₁ < 40%) but acute care facilities that treat pediatric exacerbations generally do not have the equipment or personnel for such measures of lung function. In addition we and others have reported that many children with exacerbations cannot perform spirometry meeting American Thoracic Society (ATS) acceptability criteria, and PEF may not be an accurate measure of lung function during exacerbations.^{2–6} Indeed, children less than 5 years cannot consistently perform spirometry, and only 17% of those greater than 5 years of age can do so during severe exacerbations.^{2, 5}

Bedside asthma exacerbation severity scores can be measured in all patients regardless of age or exacerbation severity. The 13-point (0 – 12, 12 most severe) pediatric respiratory

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assessment measure (PRAM) was validated against %-predicted airway resistance by impulse oscillometry (%IOS) and discriminated baseline severity and responsiveness to treatment in children with exacerbations.⁷ The 17- point (0 – 16, 16 most severe) Acute Asthma Intensity Research Score (AAIRS) was similarly validated against %FEV₁ and %IOS in pediatric patients aged 5 – 17 years during acute asthma exacerbations.⁸ The PRAM and AAIRS displayed similar performance in discriminating pre-treatment %FEV₁ and change of %FEV₁ during treatment.⁹ We have also reported associations of AAIRS values and change of AAIRS values during treatment with the outcomes hospital and PICU admission.⁸

We have reported associations of the AAIRS with %FEV₁ and with hospital and pediatric intensive care unit (PICU) admission using multivariable regression models in a cohort of children aged 5 – 17 years with 933 exacerbations amongst 813 unique participants in our urban children's hospital ED.⁸ For each participant we performed a comprehensive pulmonary examination that included measurement of all PRAM and AAIRS components. Score components were entered in a REDCap database that electronically calculated each score.¹⁰ Each participant attempted forced vital capacity maneuvers for spirometry in accordance with ATS standards.⁵ The study protocol was reviewed and approved by our IRB (protocol #080058).

Although we have reported correlations of the PRAM and AAIRS with %FEV₁,^{7, 8} knowledge of the %FEV₁ value corresponding to each ordinal score value have not been reported and might provide additional relevant information to clinicians. Our objective in this report was to report these %FEV₁ values in study participants who were able to perform spirometry for %FEV₁ that met all ATS acceptability and reproducibility criteria.⁵

Amongst the cohort, 500 (53.6%) participants were able to perform spirometry meeting all ATS standards. This sub-group had demographic characteristics similar to the complete cohort, with median age 9.2 (interquartile range [IQR], 7.6 – 11.3) years, 60% African American and 40% white race, and 60% male gender. Median [IQR] %FEV₁ was 50 [35, 71], PRAM 4 [1, 5] and AAIRS 5 [1, 7]. PRAM and AAIRS score values and %FEV₁ values corresponding to these ordinal values are displayed in the Table.

This investigation was performed in a single, urban tertiary children's hospital ED, and the cohort comprised African American and white participants. Although %-predicted values for FEV₁ are corrected for race, the results may nonetheless have limited external validity in other populations. An additional limitation is that no participants in the parent cohort of 933 with PRAM scores of 9 – 12 or with AAIRS scores of 13 – 16 were able to perform spirometry meeting ATS standards, consistent with prior reports and further supporting the utility of severity scores that might correlate with %FEV₁ values.^{2–4} In addition, knowledge of %FEV₁ values corresponding to PRAM scores up to 8 and AAIRS scores up to 12 may be useful to clinicians when spirometry or other objective measures of lung function are not available.

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Abbreviations

AAIRS	Acute Asthma Intensity Research Score
%FEV₁	percent predicted forced expiratory volume in one second
PRAM	pediatric respiratory assessment measure

References

1. NHLBI. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. Bethesda, MD: National Institutes of Health. National Heart, Lung, and Blood Institute; 2007. Available from: http://www.nhlbi.nih.gov/guidelines/asthma/01_front.pdf
2. Arnold DH, Gebretsadik T, Abramo TJ, Hartert TV. Noninvasive testing of lung function and inflammation in pediatric patients with acute asthma exacerbations. *The Journal of asthma : official journal of the Association for the Care of Asthma*. 2012; 49(1):29–35. Epub 2011/12/03. DOI: 10.3109/02770903.2011.637599 [PubMed: 22133263]
3. Langhan ML, Spiro DM. Portable spirometry during acute exacerbations of asthma in children. *The Journal of asthma : official journal of the Association for the Care of Asthma*. 2009; 46(2):122–5. Epub 2009/03/03. DOI: 10.1080/02770900802460522 [PubMed: 19253115]
4. Schneider WV, Bulloch B, Wilkinson M, Garcia-Filion P, Keahey L, Hostetler M. Utility of portable spirometry in a pediatric emergency department in children with acute exacerbation of asthma. *The Journal of asthma : official journal of the Association for the Care of Asthma*. 2011; 48(3):248–52. Epub 2011/02/22. DOI: 10.3109/02770903.2011.555036 [PubMed: 21332428]
5. Standardization of Spirometry, 1994 Update. American Thoracic Society. *American journal of respiratory and critical care medicine*. 1995; 152(3):1107–36. Epub 1995/09/01. DOI: 10.1164/ajrccm.152.3.7663792 [PubMed: 7663792]
6. Eid N, Yandell B, Howell L, Eddy M, Sheikh S. Can peak expiratory flow predict airflow obstruction in children with asthma? *Pediatrics*. 2000; 105(2):354–8. [PubMed: 10654955]
7. Chalut DS, Ducharme FM, Davis GM. The Preschool Respiratory Assessment Measure (PRAM): a responsive index of acute asthma severity. *JPediatr*. 2000; 137(6):762–8. [PubMed: 11113831]
8. Arnold DH, O'Connor MG, Hartert TV. Acute Asthma Intensity Research Score: updated performance characteristics for prediction of hospitalization and lung function. *Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology*. 2015; 115(1):69–70. DOI: 10.1016/j.anai.2015.03.020
9. Arnold DH, Saville BR, Wang W, Hartert TV. Performance of the Acute Asthma Intensity Research Score (AAIRS) for acute asthma research protocols. *Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology*. 2012; 109(1):78–9. Epub 2012/06/26. DOI: 10.1016/j.anai.2012.05.007
10. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*. 2009; 42(2):377–81. DOI: 10.1016/j.jbi.2008.08.010 [PubMed: 18929686]

%-predicted FEV₁ values according to PRAM and AAIRS bedside severity score values before treatment in 500 children aged 5 – 17 years with acute asthma exacerbations

Table 1

PRAM Score		AAIRS Score	
Score value	%FEV ₁	n	Score value
0	81 [68, 91]	85	0
1	68 [52, 86]	61	1
2	58 [45, 77]	44	2
3	59 [46, 70]	45	3
4	48 [41, 55]	49	4
5	39 [30, 49]	123	5
6	32 [27, 40]	66	6
7	32 [18, 48]	23	7
8	23 [18, 37]	4	8
9			9
10			10
11	NA		11
12			12
			13
			14
			15
			16

Values are median [IQR]

Abbreviations: PRAM, Preschool Respiratory Assessment Measure; AAIRS, Acute Asthma Intensity Research Score; %FEV₁, percent-predicted forced expiratory volume in 1-second.

NA: No participants with these severity values were able to perform spirometry.