[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

Original Article

Admission predictability of children with acute asthma

Maan Alherbish, Khalid F. Mobaireek, Abdullah A. Alangari

Department of Pediatrics, College of Medicine, King Saud University, Riyadh, Saudi Arabia

Address for correspondence:
Prof. Abdullah A. Alangari, Department of Pediatrics, College of Medicine, King Saud University, P.O. Box: 2925, Riyadh 11461, Saudi Arabia.
E-mail: aangari@ksu.edu.sa

Submission: 12-06-2017
Accepted: 10-07-2017

Abstract:

OBJECTIVES: We aimed to evaluate the seasonal variations of acute asthma presentation in children and the utility of the pediatric asthma score (PAS) and its components in early admission prediction.

METHODS: As part of a randomized controlled trial addressing the clinical efficacy of budesonide nebulization in the treatment of acute asthma in children, the PAS was measured at baseline, 1st, 2nd, 3rd, and 4th h from the start of medications. Decision of admission was taken at or beyond the 2nd h.

RESULTS: Out of a total 906 emergency department (ED) visits with moderate-to-severe acute asthma, 157 children were admitted. June to September had the lowest number of visits. The admission-to-discharge ratio varied throughout the year. During the ED stay, between baseline and 3rd h, admission predictability of the total score improved progressively with a small difference between the 2nd and 3rd h. The total score remained the strongest predictor of admission at every time point compared to its individual components. The drop of PAS from baseline to the 2nd h was not a good predictor of admission. Oxygen saturation (OS) and respiratory rate (RR) had relatively higher predictability than other components.

CONCLUSIONS: Decision of admission could be made to many children with moderate-to-severe acute asthma at the 2nd h of ED stay based on their total PAS. OS and RR should be part of any scoring system to evaluate acute asthma in children.

Keywords:

Acute asthma, admission, children, emergency, exacerbation

Asthma is the most prevalent chronic illness of childhood, and acute asthma is one of the most common complications of the disease that contributes significantly to health-care burden. Acute asthma has been defined as "episodes of progressive increase in shortness of breath, cough, wheezing, or chest tightness or some combination of these symptoms."[1,2] More recently, a group of experts proposed a definition of "a worsening of asthma requiring the use of systemic corticosteroids to prevent a serious outcome."[3] In the US, 2.3% of all emergency department (ED) visits and about 5.6% of all hospitalizations among children were attributed to acute asthma.[4] In Saudi Arabia, one center reported that over 1 year, an average of 5.7% of all ED visits were secondary to acute asthma.[5] This ratio can rise to 13.7% during the winter season as reported by another study from a different hospital.[6]

A proportion of children presenting to the ED with acute asthma are eventually admitted to the hospital with an estimated rate ranging from 7% to 23%.[7,8] This is determined by several variables including age, sex, the baseline severity of exacerbation,[9] early response to treatment in the ED (within the 1st h),[10] and the level of control of asthma symptoms in the past.[11] The severity of acute asthma is determined based on symptoms and signs such as respiratory rate (RR), wheezing, retractions, and oxygen saturation (OS). In addition, direct indicators of bronchoconstriction such as peak expiratory flow rate or forced expiratory volume in the first second (FEV_1) are very useful tools for assessing asthma severity when applicable.[12]

Access this article online
Quick Response Code:

Website: www.thoracicmedicine.org

DOI: 10.4103/atm.ATM_197_17

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Alherbish M, Mobaireek KF, Alangari AA. Admission predictability of children with acute asthma. Ann Thorac Med 2018;13:36-41.

© 2018 Annals of Thoracic Medicine | Published by Wolters Kluwer - Medknow

[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

There are several scores used in research and sometimes in clinical practice to evaluate the severity of acute asthma in a more standardized and accurate way. These scores vary considerably in the parameters they use and in the grading of each parameter. In this study, we aimed to evaluate the utility of the pediatric asthma score (PAS) in predicting admission to the hospital at different time points and the contribution of each of its components in this regard by utilizing data from a cohort of patients composed of all children presenting with moderate-to-severe acute asthma to the ED of a major children's hospital in Riyadh, Saudi Arabia, over 17 months' duration as part of a clinical trial.[13]

Methods

Study design and population

Children 2–12 years of age who are presenting to the ED with acute asthma exacerbation were screened using the PAS[14] [Table 1]. The diagnosis of asthma was determined based on history of physician-diagnosed asthma or previous episode of shortness of breath that responded well to β2-agonist. The data were collected as part of a clinical trial on the efficacy of budesonide 500 mcg given 3 times in the 1st h of treatment mixed with β2-agonist and ipratropium bromide by nebulization to children presenting with moderate or severe asthma exacerbation (score >7). Another control group received normal saline placebo instead of budesonide. Prednisone or prednisolone 2 mg/kg (maximum 60 mg) was given at the beginning of treatment to all patients. Additional doses of β2-agonist were given at the discretion of the treating physician but maximally one dose every 30 min. More information was taken including family history, triggers of exacerbation, past history, and past use of rescue and prophylactic medications. Patients who were critically ill, had heart or chronic lung disease, or received systemic steroids within the past 7 days were excluded from the study.

PAS was measured at baseline (screening), 1st, 2nd, 3rd, and 4th h from the start of medications. Decision for admission was taken at 2, 3, or 4 h if the patient did not show satisfactory improvement. Patients who showed improvement but were not fit for discharge were kept in the ED to receive additional doses of albuterol. Discharge criteria were no accessory muscle use, minimal or completely resolved wheezing, and OS >92%. At the 4th h time point, a decision to either admit or discharge had to be finally made.

Statistical analysis

Receiver operator characteristic (ROC) curves were drawn by comparing and contrasting the scores of the eventually discharged and admitted patients at baseline, 1st, 2nd, and 3rd h. The sensitivity and specificity of the total PAS and each of its components was calculated at different points to calculate the area under the curve (AUC), which was utilized as a measure of predicting admission to the hospital. All data were analyzed using GraphPad Prism version 6 (GraphPad Software, San Diego, CA, USA).

Results

Frequency of admission and discharge

Within a 17 months' study period, from November 2010 to March 2012, 906 visits by children with moderate-to-severe acute asthma were made to the ED. Out of which, 157 resulted in admission. March had the highest number of ED visits within the year. A number of visits during January, February, April, May, October, November, and December were high and comparable while June, July, August, and to some extent, September had relatively low number of visits [Figure 1]. The ratio of admission to discharge varied throughout the year. The main characteristics of patients who were admitted or discharged are shown in Table 2. The two groups did not differ in their demographic and prehospital treatment features. Children were not admitted or discharged at

Table 1: Pediatric asthma score

Variable	Asthma score		
	1 point	2 points	3 points
Respiratory rate (breaths/min)			
2-3 years	≤34	35-39	≥40
4-5 years	≤30	31-35	≥36
6-12 years	≤26	27-30	≥31
>12 years	≤23	24-27	≥28
Oxygen saturation (%)	>95 with room air	90-95 with room air	<90 with room air or supplemental oxygen
Auscultation	Normal breathing or end-expiratory wheezing	Expiratory wheezing	Inspiratory and expiratory wheezing, diminished breath sounds, or both
Retractions	None or intercostal	Intercostal and substernal	Intercostal, substernal, and supraclavicular
Dyspnea	Speaks in sentences or coos and babbles	Speaks in partial sentences or utters short cries	Speaks in single words or short phrases or grunts

[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

baseline or 1st h, but at the 2nd h, 446 were discharged and only 6 children were admitted. The rest of the patients had their data available for analysis at the 3rd h.

Predictability of admission

The ability of the total score and each of its components to predict admission was assessed at baseline, 1st h, 2nd h, and 3rd h using the AUC of ROC curves [Figure 2a-d]. The magnitude of drop of the score from baseline to 2nd h, representing clinical improvement during that time, was also evaluated [Figure 2d]. The ability of the total score to predict admission at the 3rd h was highest followed by the 2nd h with only small difference (0.03) in the AUC and intersecting confidence intervals [Table 3]. However, there was a greater difference between the 2nd and 1st h (0.06) and even more difference between the 1st h and baseline (0.11) with no shared values in the confidence intervals [Table 3]. Predictability of the total score was also higher than each individual component at each time point. Among the PAS components, RR and OS had more weight than other parameters at the 2nd and 3rd h but not as baseline or 1st h. On the other hand, the AUC of the drop of the total score from baseline to 2nd h was less than the AUC of the total score at baseline and interestingly less than AUC of the drop in RR at the 2nd h [Figure 2e].

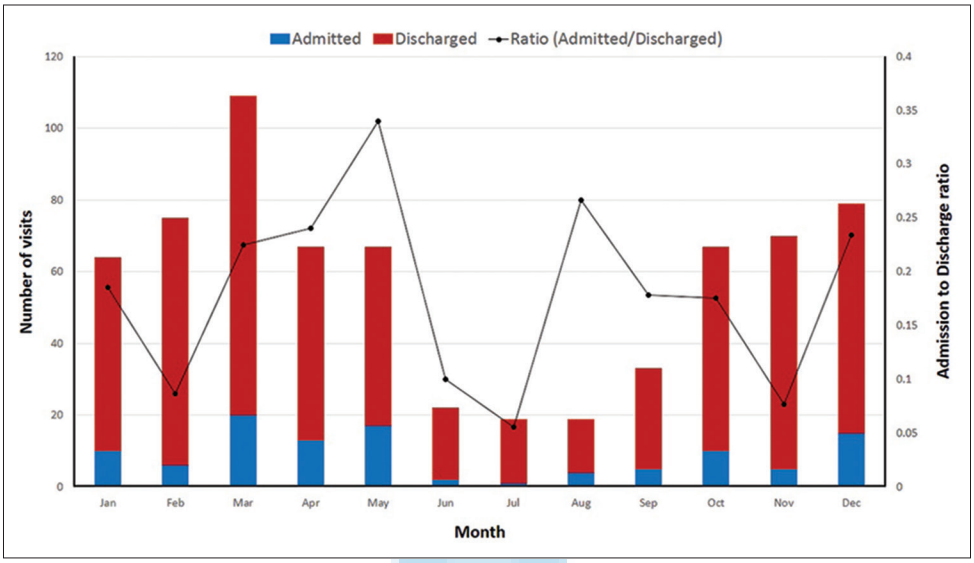

Figure 1: Frequency chart showing the distribution of admitted and discharged children with acute asthma and their ratio from the emergency department over 1 year

Table 2: Characteristics of admitted and discharged patients

	Admitted (*n*=157), *n* (%)	Discharged (*n*=749), *n* (%)	Total (*n*=906), *n* (%)
Gender (female)	62 (39.5)	255 (33)	317 (35)
2-6 years old	108 (68.8)	507 (67.7)	615 (67.9)
7-12 years old	49 (31.2)	242 (32.3)	291 (32.1)
Smokers at home	33 (21)	137 (18.3)	170 (18.8)
Pets at home	13 (8.2)	55 (7.3)	68 (8)
Previous ED visits	146 (92.9)	699 (93.3)	845 (93)
Use of β2-agonists	137 (87.3)	565 (75.4)	702 (77.5)
Use of inhaled corticosteroids	54 (36.3)	183 (24.4)	273 (30)

ED=Emergency department

Table 3: Area under the curve of receiver operator characteristic curves for each score parameter and total scores at every time point

PAS parameter	AUC (95% CI)			
	Baseline	1 h	2 h	3 h
Respiratory rate	0.56 (0.51-0.6)	0.7 (0.66-0.75)	0.78 (0.74-0.82)	0.83 (0.79-0.87)
Oxygen saturation	0.67 (0.62-0.72)	0.76 (0.7-0.8)	0.80 (0.76-0.84)	0.80 (0.76-0.85)
Auscultation	0.64 (0.58-0.68)	0.7 (0.65-0.75)	0.72 (0.67-0.77)	0.72 (0.67-0.78)
Retraction	0.64 (0.59-0.69)	0.7 (0.65-0.75)	0.72 (0.67-0.77)	0.71 (0.65-0.77)
Dyspnea	0.65 (0.6-0.7)	0.65 (0.59-0.7)	0.60 (0.53-0.65)	0.56 (0.50-0.62)
Total score	0.74 (0.7-0.79)	0.85 (0.82-0.88)	0.91 (0.89-0.93)	0.94 (0.91-0.96)

AUC=Area under the curve, CI=Confidence interval, PAS=Pediatric asthma score

[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

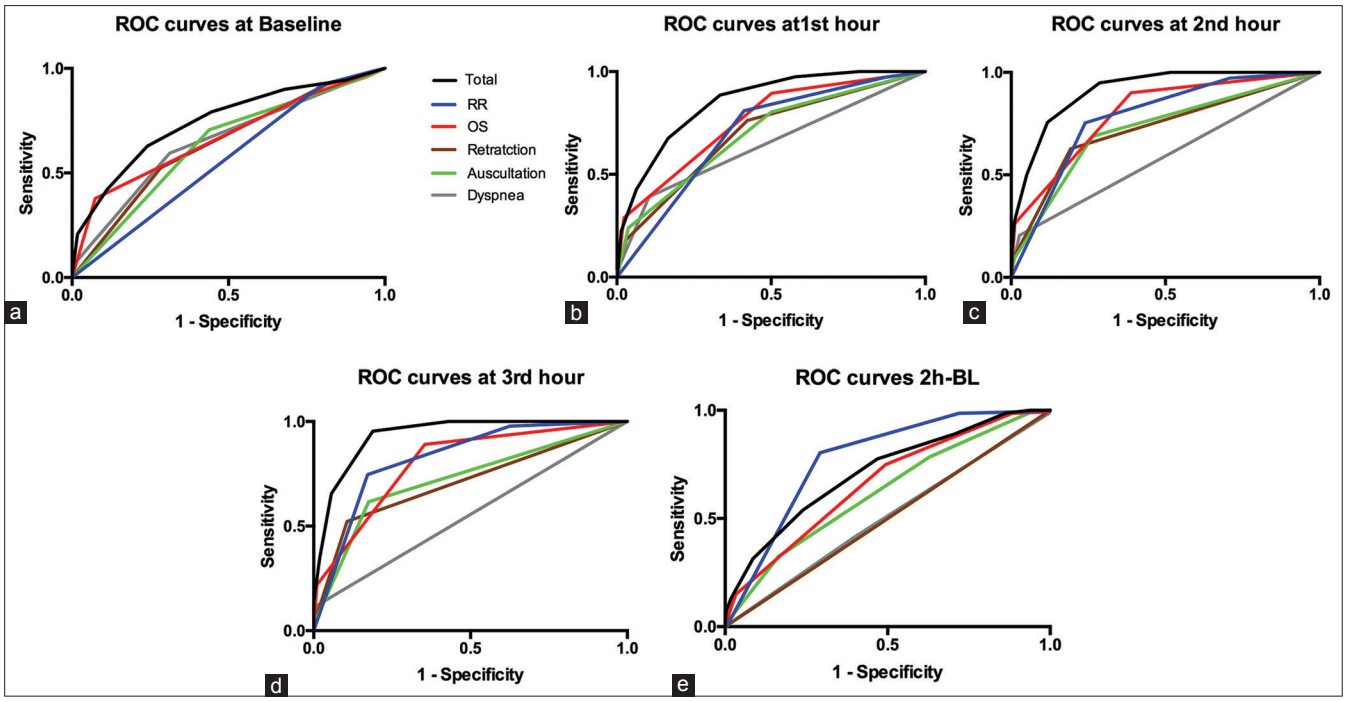

Figure 2: Receiver operator characteristic curves of the acute asthma scores at (a) baseline, (b) 1st h, (c) 2nd h, (d) 3rd h, and (e) the difference in score between the 2nd h and baseline. RR: Respiratory rate, OS: Oxygen saturation

Discussion

During June, July, August, and September the number of children presented to the ED dropped markedly. This is mainly attributed to the decrement in the incidence of upper respiratory tract infections.[15,16] Another possible factor is that many city residents travel abroad during the summer vacation, especially in July and August. The increased number of children with acute asthma presenting to the ED and subsequently the increased number of admission during March of that year is likely to be due by the unusual occurrence of several thunderstorms during that month in 2011. Thunderstorms are known to substantially increase the number and severity of asthma exacerbations.[17] Seasonal variation was also observed in other studies that were done in different geographical areas. For instance, two different studies, one in Toronto and another from 117 EDs in Korea, showed that the highest number of pediatric ED visits due to acute asthma was during winter.[18,19] In contrast, June was reported to have a higher number of admissions of asthmatic children in the Caribbean island of Trinidad, and this was attributed to the wave of the Saharan dust cloud during that month.[20]

The ROC curve analysis showed that the ability of PAS to predict admission improves with time during the first 3 h in the ED after starting treatment. The small difference in the AUC between the 2nd and 3rd h suggests that more patients could possibly be admitted earlier at the 2nd h. Studies should be conducted to assess the appropriate score above which children with acute asthma should be admitted at that time point. This may be very helpful in an overcrowded ED. On the other hand, the response to therapy at the 2nd h as judged by the improvement in asthma score from baseline was a much weaker predictor of admission compared to the total asthma score even at baseline and therefore should not be used to predict admission.

Assessing each component of the PAS separately showed variable results. OS had relatively high predictability at all-time points while RR showed improved predictability as time progressed, and dyspnea was overall the weakest predicting parameter and showed weaker predictability with time but still had some added value. Moderate predictability was seen with auscultation and retraction. The total score, however, remained the strongest predictor of admission at every time point. Surprisingly, improvement in RR at the 2nd h from baseline was a better predictor than the drop of the total score. This is interesting, especially that the RR was not among the discharge criteria in the original study.[13] Furthermore, in the original study, it was noted that a drop of a single point at the lower scale of the score has a much less influence on the likelihood of admission than a drop of a single point at the higher end of the score scale. This has to be taken in consideration when making modifications to the PAS in the future with more weight needs to be given to the RR and OS than to other parameters to make it more accurate. Other recent studies concurred that OS is a major predictor of admission in children with acute asthma[21] and that RR is a reliable

[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

physical sign of respiratory distress and correlates well with measures of lung function such as FEV_1.[22]

Several different scoring systems are utilized to assess patients with acute asthma. For example, hourly measurements of the Pediatric Respiratory Assessment Measure (PRAM)[23] score showed that predicting the need of hospitalization of acute asthma patients improves with time in the ED, consistent with our findings. It is worth noting that some acute asthma severity scores, such as pulmonary index score,[24] respiratory clinical score,[25] and Pediatric Asthma Severity Score,[26] do not include OS. On the other hand, PRAM and the modified Woods–Downes asthma scores do not include the RR. This may reduce the accuracy of these scores. In addition, although not evaluated in this study, adding the effect of high-risk asthma indicators such as previous ED visits could strengthen the predictability of hospitalization.[27]

Limitations

The study was conducted in a single center; this may limit the generalizability of the results. In addition, other factors that may influence patients' admission and were included in other scores were not taken into account in the PAS such as inspiratory/expiratory ratio, air entry, and mental status and therefore were not possible to evaluate.

Conclusions

Admitting more children with acute asthma earlier based on their asthma score, especially when ED beds are on very high demand, could save a lot of valuable time and money. The decision to admit patients with acute asthma should not solely be made on any individual component of the asthma score. There is a great need to have a standardized acute asthma severity score that includes all the important clinical determinants of acute asthma and gives each one an appropriate weight. This will help advance the medical care of acute asthma patients as well as research.

Acknowledgment

We highly appreciate the efforts of all physicians and nurses who participated and helped in the original clinical trial.

- The manuscript has been read and approved by all the authors, the requirements for authorship have been met, and each author believes that the manuscript represents honest work
- An abstract was presented at the Saudi Pediatrics Association meeting in Riyadh on 7–9 February 2017.

Financial support and sponsorship

The original clinical trial was funded by the Strategic Technologies Program ofthe National Plan for Science, Technology, and Innovation in the Kingdom of Saudi Arabia (Grant 08-MED520-02).The authors extend their appreciation to the Deanship of Scientific Research, King Saud University for funding this work through the Undergraduate Student's Research Support Program, (project no. USRSP-15-22).

Conflicts of interest

There are no conflicts of interest.

References

1. Global Initiative for Asthma Global strategy for asthma management and prevention. 2017. Available: http://ginasthma.org/download/317. [Last accessed on 2017 Jun 10].
2. National Asthma Education and Prevention Program Expert Panel Report 3 (EPR-3): Guidelines for the Diagnosis and Management of Asthma Summary Report 2007. J Allergy Clin Immunol 2007;120:S94-138.
3. Fuhlbrigge A, Peden D, Apter AJ, Boushey HA, Camargo CA Jr., Gern J, *et al.* Asthma outcomes: Exacerbations. J Allergy Clin Immunol 2012;129 3 Suppl:S34-48.
4. Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of childhood asthma in the United States, 1980-2007. Pediatrics 2009;123 Suppl 3:S131-45.
5. Ibrahim MA, El-Gamal FM, Kordy MN, Bahnassy AA. Epidemiological study of patients with acute asthma attending accident and emergency department. Ann Saudi Med 1993;13:52-5.
6. Siddiqui S, Ogbeide DO. Use of a hospital-based accident and emergency unit by children (0-12 years) in alkharj, saudi arabia. Ann Trop Paediatr 2002;22:101-5.
7. Rabe KF, Vermeire PA, Soriano JB, Maier WC. Clinical management of asthma in 1999: The Asthma Insights and Reality in Europe (AIRE) study. Eur Respir J 2000;16:802-7.
8. Pollack CV Jr., Pollack ES, Baren JM, Smith SR, Woodruff PG, Clark S, *et al.* A prospective multicenter study of patient factors associated with hospital admission from the emergency department among children with acute asthma. Arch Pediatr Adolesc Med 2002;156:934-40.
9. Moore WC, Bleecker ER, Curran-Everett D, Erzurum SC, Ameredes BT, Bacharier L, *et al.* Characterization of the severe asthma phenotype by the National Heart, Lung, and Blood Institute's Severe Asthma Research Program. J Allergy Clin Immunol 2007;119:405-13.
10. Rodrigo GJ. Predicting response to therapy in acute asthma. Curr Opin Pulm Med 2009;15:35-8.
11. Peters SP, Jones CA, Haselkorn T, Mink DR, Valacer DJ, Weiss ST, *et al.* Real-world evaluation of asthma control and treatment (REACT): Findings from a national web-based survey. J Allergy Clin Immunol 2007;119:1454-61.
12. Adams JY, Sutter ME, Albertson TE. The patient with asthma in the emergency department. Clin Rev Allergy Immunol 2012;43:14-29.
13. Alangari AA, Malhis N, Mubasher M, Al-Ghamedi N, Al-Tannir M, Riaz M, *et al.* Budesonide nebulization added to systemic prednisolone in the treatment of acute asthma in children: A double-blind, randomized, controlled trial. Chest 2014;145:772-8.
14. Qureshi F, Pestian J, Davis P, Zaritsky A. Effect of nebulized ipratropium on the hospitalization rates of children with asthma. N Engl J Med 1998;339:1030-5.
15. Yeh YH, Chou YJ, Huang N, Pu C, Chou P. Seasonal variations of prescriptions for the major syndrome types and manifestations of upper respiratory tract infection in tradition Chinese medicine. Complement Ther Med 2016;29:213-8.

[Downloaded free from http://www.thoracicmedicine.org on Thursday, February 22, 2018, IP: 94.34.49.23]

16. Goktas S, Sirin MC. Prevalence and seasonal distribution of respiratory viruses during the 2014-2015 season in istanbul. Jundishapur J Microbiol 2016;9:e39132.
17. D'Amato G, Vitale C, D'Amato M, Cecchi L, Liccardi G, Molino A, *et al.* Thunderstorm-related asthma: What happens and why. Clin Exp Allergy 2016;46:390-6.
18. Canny GJ, Reisman J, Healy R, Schwartz C, Petrou C, Rebuck AS, *et al.* Acute asthma: Observations regarding the management of a pediatric emergency room. Pediatrics 1989;83:507-12.
19. Won YK, Hwang TH, Roh EJ, Chung EH. Seasonal patterns of asthma in children and adolescents presenting at emergency departments in Korea. Allergy Asthma Immunol Res 2016;8:223-9.
20. Gyan K, Henry W, Lacaille S, Laloo A, Lamsee-Ebanks C, McKay S, *et al.* African dust clouds are associated with increased paediatric asthma accident and emergency admissions on the caribbean island of trinidad. Int J Biometeorol 2005;49:371-6.
21. Arnold DH, Gebretsadik T, Moons KG, Harrell FE, Hartert TV. Development and internal validation of a pediatric acute asthma prediction rule for hospitalization. J Allergy Clin Immunol Pract 2015;3:228-35.
22. Arnold DH, Penrod CH, Sprague DJ, Hartert TV. Count on it! accurately measured respiratory rate is associated with lung function and clinical severity in children with acute asthma exacerbations. J Pediatr 2016;175:236.e1.
23. Alnaji F, Zemek R, Barrowman N, Plint A. PRAM score as predictor of pediatric asthma hospitalization. Acad Emerg Med 2014;21:872-8.
24. Hsu P, Lam LT, Browne G. The pulmonary index score as a clinical assessment tool for acute childhood asthma. Ann Allergy Asthma Immunol 2010;105:425-9.
25. Liu LL, Gallaher MM, Davis RL, Rutter CM, Lewis TC, Marcuse EK, *et al.* Use of a respiratory clinical score among different providers. Pediatr Pulmonol 2004;37:243-8.
26. Gorelick MH, Stevens MW, Schultz TR, Scribano PV. Performance of a novel clinical score, the Pediatric Asthma Severity Score (PASS), in the evaluation of acute asthma. Acad Emerg Med 2004;11:10-8.
27. Tolomeo C, Savrin C, Heinzer M, Bazzy-Asaad A. Predictors of asthma-related pediatric emergency department visits and hospitalizations. J Asthma 2009;46:829-34.