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Comparison between pediatric respiratory assessment measure (PRAM) score and Wood's asthma score to assess acute asthma exacerbation

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Abstract

Background: Wood's score, the assessment of childhood respiratory failure, has been used to assess childhood acute asthma severity in Thailand since 19th century. However, PRAM score, which is increasingly used in Western countries has not been evaluated among Thai children with asthma.

Objectives: This study aims to determine whether Wood's or PRAM score is better prediction of severity of childhood asthma exacerbation.

Methods: The prospective comparative study of severity asthma score was performed in asthmatic children, 2–18 years old, with acute asthma exacerbation at Queen Sirikit National Institute of Child Health. PRAM and Wood's score were separately determined by 2 physicians. The patients were further assessed at 0, 4 or 24 hours after their admissions. The asthma treatment followed GINA guideline.

Results: There were 80 asthmatic patients, mean aged 5.71 ± 2.95 years. The admission rate was 28.8% with the mean length of stay = 4 ± 1 days. PRAM was correlated with Wood's score (Spearman's correlation $\rho = 0.900$, $p < 0.001$ at triage, and $\rho = 0.981$, $p < 0.001$). The highlight of this study is the finding that intraclass correlation of PRAM is better than Wood's asthma score (ICC = 0.944; 95%CI 0.913–0.964, 0.898; 95%CI 0.841–0.935, respectively). ROC indicated Wood's score ≥ 4 and PRAM ≥ 5, in the requirement for admission.

Conclusion: PRAM and Wood's score are both promising in prediction of severity and outcome of childhood asthma exacerbation.

Key words: asthma, asthma exacerbation, acute asthmatic attack, asthma score, children

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Introduction

Asthma is the most common chronic disease in children with the prevalence of 10%, worldwide.[1] In childhood asthma exacerbation, the triggers mainly by climates, inhalant allergens, smokes, pollutants, respiratory tract infections, and exercise. With the controller medication, such as inhaled corticosteroid and anti-leukotriene, asthma exacerbation seems to reduce in frequency and severity. However, many patients still require emergency room visits,[2] hospitalization.[3,4] In Global Initiative for Asthma (GINA) guidelines,[5] Expert panel report -3 (EPR-3),[6] the clinical assessment of asthma exacerbation was recommended to classify patients into mild/moderate or severe group to receive appropriate treatments. Since 19th century, many scores have been developed to assess asthma severity such as Wood's asthma score,[7] pediatric respiratory assessment measure (PRAM) score,[8,9] Pediatric asthma severity Score,[10] and Siriraj Clinical Asthma Score, the asthma score for Thai children.[11]

The Wood's and Downes score was initially distributed in 1972 as a scoring system to detect impending respiratory failure in children with status asthmaticus. This score composed

of 5 items including cyanosis, inspiratory breath sounds, use of accessory muscle, expiratory wheezing and cerebral function (details show in index part). The Wood's and Downes's score focused on oxygenation, gas exchange, work of breathing, airway obstruction, and cerebral function measurements to predict respiratory failure. However, when arterial blood gas measurement is not available, the presence of cyanosis in room air and with oxygen supplement and/or pulse extremity can be used to predict cyanosis. This study demonstrated high correlation between high score and arterial carbon dioxide tension (Pco2) (r = 0.69, $p < 0.01$), as well as the decreasing of arterial oxygen tension (Po2) (r = -0.44, $p < 0.05$).[7] Patients who have high score, potentially develop respiratory failure and needed to monitor closely. However, measurements in some items, such as, cyanosis and alteration of conscious, may be much varied among physicians.[7]

The Pediatric Respiratory Assessment Measure (PRAM) score was used to evaluate asthma severity in 5 items; suprasternal retractions, scalene muscle contraction, air entry, wheezing and oxygen saturation. A high score showed a good correlation with poor outcome and admission prediction. PRAM score was validated in children with asthma exacerbations, aged 2 to 17 years, by Ducharme, F.M. in 2008. He investigated PRAM score at triage and after initial bronchodilation and the results showed a strong association with admission (r = 0.4 and 0.5 respectively, $p < 0.0001$). The responsiveness coefficient of 0.7 indicated good ability to identify clinical change after bronchodilation. In addition, PRAM score showed a good internal consistency (Cronbach α = 0.71) and an inter-rater reliability r = 0.78) for all patients and all age groups.[9] Alnaji F. also reported a good association between severity of asthma, assessing by PRAM score and the rate of hospitalization in children, aged 2–17 years.[12] This score has been increasingly used among medical researchers to evaluate the severity of their asthmatic patients.[8,9] However, detections of scalene muscle contractions in children are not easy and required physicians' expertise.[8,9]

Although both of two scoring method can be used in different clinical setting, however in our hospital, we used Wood's asthma score to predict impending respiratory failure and severity both ICU and ER visit. Therefore, this study aims to determine whether Wood's asthma score or PRAM score are better predicting asthma severity in childhood exacerbation.

Methods

Patients

The prospective cohort study was performed at Queen Sirikit National Institute of Child Health, Bangkok, Thailand, from May 13th, 2016 to February 28th, 2017. Children, aged 2 to 18 years old, with asthma exacerbation were enrolled into this study.

Sample size calculation for correlation was

$$n = \left(\frac{z_{\alpha/2} + z_{\beta}}{C_1 + C_2} \right)^2 + 3$$

$$c_1 = 0.5 \ln \left(\frac{1 + r_1}{1 - r_1} \right) = \tanh^{-1}(r_1)$$

$$c_2 = 0.5 \ln \left(\frac{1 + r_2}{1 - r_2} \right) = \tanh^{-1}(r_2)$$

Designated: reliability and discrimination = 95% and 80%
Correlation = 0.5–0.7
n = 80

The inclusion criteria were

1. Patients who were diagnosed with asthma and presented with asthma exacerbation.
2. For patients are younger than 5 years. The asthma possibility was suggested by history of recurrent wheezing, defined by wheeze more than 3 times/year, and plus at least 2 following criteria.
    a. Cough, heavy breathing or wheeze more than 10 days during upper respiratory tract infections.
    b. Between viral episode, there was wheezing apart from cold symptoms.
    c. First degree relative with physician diagnosed with asthma
    d. Patients who have atopic dermatitis and/or allergic rhinitis.

The exclusion criteria were

1. Patients who had history of BPD, immunodeficiency, cystic fibrosis, primary ciliary dyskinesia, vascular ring, foreign body aspiration, chronic lung disease or heart disease.
2. Patients who had life threatening condition.
3. Patients who refused to give informed consent.

All participants agreed to be involved in our study and provided written informed consent which approved by the institutional ethics committee.

Study Protocol

Our volunteers were assessed asthma severity by using either Wood's asthma score, (cyanosis, inspiratory breath sound, accessory muscle used, expiratory wheezing and cerebral function; details as shown in index), or PRAM score (suprasternal retraction, scalene muscle contraction, air entry, wheezing and oxygen saturation; details as shown in index). Each patient was assessed for severity of asthma at least two times by 2 physicians separately. In non-hospitalization, patients were evaluated at 0 hour before initial treatment and before discharging from emergency room. In hospitalized patients, the further assessment was performed between 0 hour before initial treatment and at 24 hours of admission.

Patients' information including baseline demographic data, clinical characteristics, hospitalization, treatment and Wood's asthma score, as well as, PRAM score before and after treatment were recorded. (as shown in record form).

Primary outcome was correlation between PRAM and Wood's asthma score. Secondary outcomes were reliability of PRAM and Wood's asthma score between 2 physicians and cut-off for prediction hospitalization in both scores.

The criteria for admission in our setting were

1. Clinical severe as describe by talk in words, sit hunched forwards, agitated, respiratory rate > 30 /min, accessory muscles being used, pulse rate > 120 bpm, O_2 saturation (room air) < 90%
2. Clinical mild to moderate as describe by talk in phrases, prefer sitting to lying, not agitated, respiratory rate < 30 /min, accessory muscles not used, pulse rate 100–120 bpm, O_2 saturation (room air) 90–95% and derived initial treatment with 3 doses of bronchodilator then were not improved

Statistical analysis

All data have been recorded and analyzed by SPSS software version 22. Spearman's correlation was used for assessing main objective. Intra-class correlation coefficient was analyzed for inter-rater reliability of 2 physicians. The ROC curve was applied for hospitalization prediction. Independent t-test and Mann Whitney-U test was used for continuous variables and Chi-square test was used for categorical variables.

Results

Eighty children with acute asthma exacerbation, age ranged from 2–18 years old participated in our study. All patients were assessed for asthma severity twice with Wood's asthma score and PRAM score by 2 physicians independently. The admission rate was 28.8% with the mean length of stay 4 ± 1 days. Male were predominant in both hospitalized and non-hospitalized group. Children in hospitalized group was older than in non-hospitalized group. Weight for height, onset of asthmatic attack, symptoms tachypnea and dyspnea were statistically significant difference between 2 groups. The details of patient characteristics are presented in **Table 1**.

Both mean PRAM and Wood's asthma score at triage were higher in hospitalization group (5.93 ± 1.29 and 4.50 ± 0.83, respectively) than non-hospitalization group (2.86 ± 1.33 and 2.35 ± 0.89, respectively) ($p < 0.001$). At follow up period, we similarly found that together with PRAM and Wood's asthma score were higher in hospitalization group (3.09 ± 1.10 and 2.57 ± 0.99, respectively) than non-hospitalization group (0.55 ± 0.87 and 0.48 ± 0.73, respectively) ($p < 0.001$).

Table 1. Characteristics of the patients

	Hospitalized 23 (28.8%)	Non-hospitalized 57 (71.2%)	*p*-value
Male (%)	14 (25.9%)	40 (74.1%)	0.421
Age, years¶	6.08 (3.50–9.83)	4.58 (3.00–7.50)	0.204
Birth data			
- Normal labor	14 (25.5%)	41 (74.5%)	0.334
- Term	22 (31.9%)	47 (68.1%)	0.121
BMI*	15.89 ± 3.93	17.52 ± 3.58	0.094
Onset, years¶	2.25 (1.00–5.00)	1.83 (1.33–3.00)	0.228
Time prior to hospital, days¶	1.00 (1.00–2.00)	2.00 (1.00–3.00)	0.009
Length of stay, days*	4 ± 1	-	-
Complaints			
- Tachypnea	18 (37.5%)	30 (62.5%)	0.034
- Dyspnea	22 (43.1%)	29 (56.9%)	< 0.001
- Cough	22 (28.6%)	55 (71.4%)	0.858
- Wheeze	7 (18.4%)	31 (81.6%)	0.052
- Chest tightness	5 (45.5%)	6 (54.5%)	0.187
Feeding history			
- Breast milk < 6 months	9 (23.1%)	30 (76.9%)	0.274
- Breast milk ≥ 6 months	6 (42.9%)	8 (57.1%)	0.199
- Cow milk	19 (28.8%)	47 (71.2%)	0.987
- Goat milk	0 (0.0%)	1 (100.0%)	0.523

* Mean ± SD
¶ Median (IQR)

Table 1. (Continued)

	Hospitalized 23 (28.8%)	Non-hospitalized 57 (71.2%)	*p*-value
Family history of allergic diseases			
- Paternal history of AR	5 (20.8%)	19 (79.2%)	0.306
- Paternal history of Asthma	9 (40.9%)	13 (59.1%)	0.139
- Paternal history of AD	1 (50.0%)	1 (50.0%)	0.501
- Maternal history of AR	9 (34.6%)	17 (65.4%)	0.421
- Maternal history of Asthma	5 (29.4%)	12 (70.6%)	0.946
- Maternal history of AD	1 (20.0%)	4 (80.0%)	0.655
- Sibling history of AR	2 (28.6%)	5 (71.4%)	0.991
- Sibling history of Asthma	4 (44.4%)	5 (55.6%)	0.269
Environmental factors			
- Day care	2 (33.3%)	4 (66.7%)	0.796
- Passive smoking	11 (23.9%)	35 (76.1%)	0.266
- Cat	5 (21.7%)	18 (78.3%)	0.379
- Dog	1 (8.3%)	11 (91.7%)	0.090
PRAM score at 1st presentation*	5.93 ± 1.29	2.86 ± 1.33	< 0.001
Wood's score at 1st presentation*	4.5 ± 0.83	2.35 ± 0.89	< 0.001
PRAM score at follow up*	3.09 ± 1.10	0.55 ± 0.87	< 0.001
Wood's score at follow up*	2.57 ± 0.99	0.48 ± 0.73	< 0.001

* Mean ± SD
¶ Median (IQR)

Table 2. Correlation between PRAM and Wood's asthma score

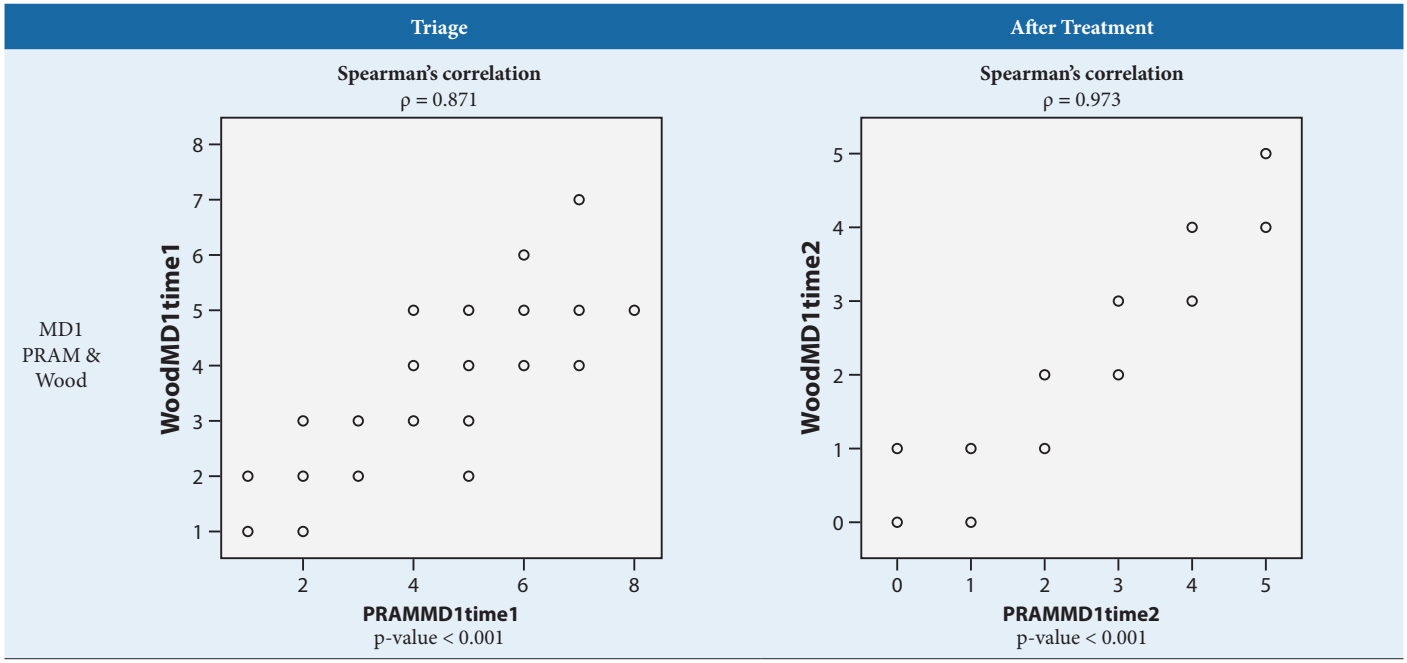
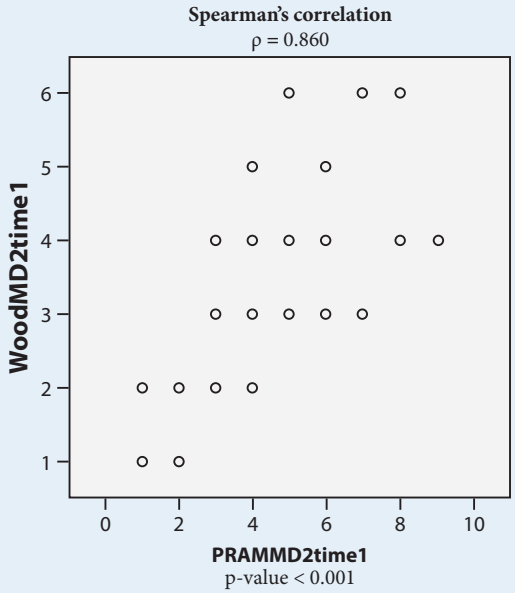
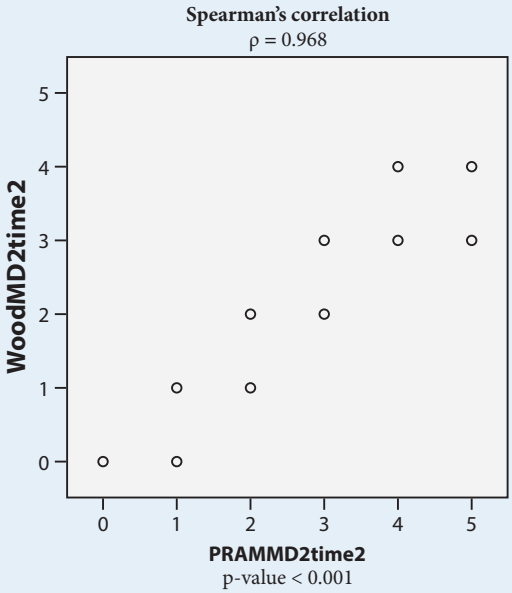
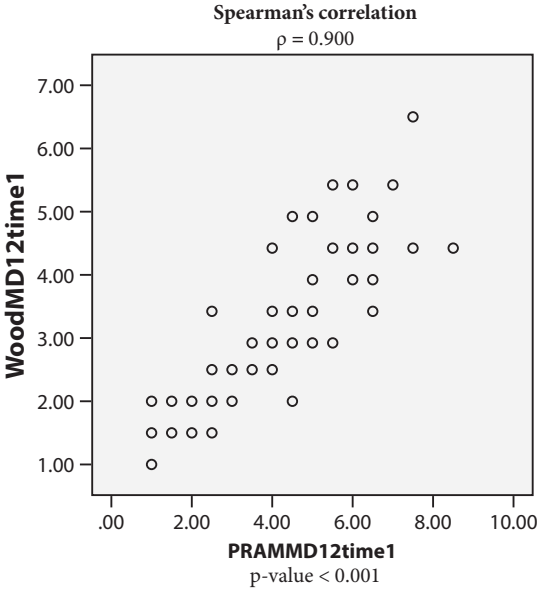
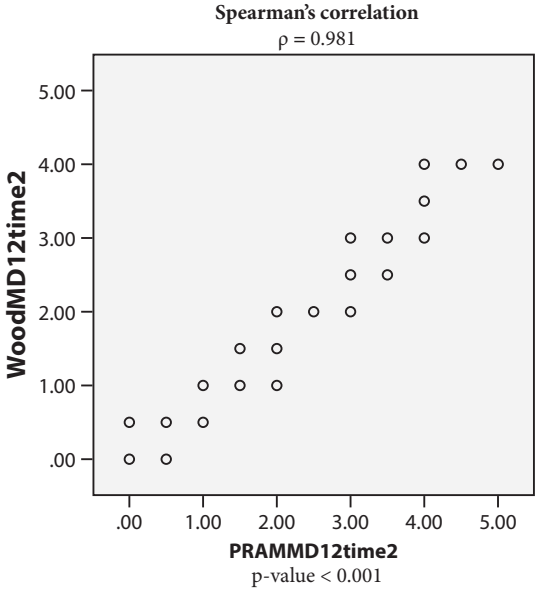


Table 2. (Continued)

	Triage	After Treatment
MD2 PRAM & Wood		
Overall PRAM & Wood		

The score of PRAM correlated positively with Wood's asthma score at triage (Spearman's correlation ρ = 0.871, $p < 0.001$ for the first rater, and ρ = 0.860, $p < 0.001$ for the second rater). Likewise, PRAM score after treatment correlated positively with Wood's asthma score after treatment (Spearman's correlation ρ = 0.973, $p < 0.001$ for the first rater, and ρ = 0.968, $p < 0.001$ for the second rater). Similarly, Overall PRAM score significantly correlated with Overall Wood's score (Spearman's correlation ρ = 0.900, $p < 0.001$ at triage, and ρ = 0.981, $p < 0.001$ at follow up phase) as shown in **Table 2**.

There was a high inter-rater agreement between PRAM score and Wood's asthma score by 2 physicians' assessment as shown by intra-class correlation coefficient (ICC) 0.944 95%CI 0.913–0.964 and 0.898 95%CI 0.898 (0.841–0.935), respectively. This agreement trend was found at all age groups either measured by PRAM or Wood's asthma score as shown in **Table 3** and **Table 4**.

The admission prediction was well predicted by either PRAM or Wood's asthma score as shown in ROC curve. The area under the curve = 0.942 (95%CI = 0.894–0.990) and 0.959 (95%CI = 0.918–0.999) as shown in **Figure 1**. The ROC curve indicated PRAM ≥ 5 at triage has sensitivity 82.6%, specificity 89.5%, PPV 76%, NPV 92.7% and accuracy 87.5%. Similar trend to Wood's asthma score ≥ 4 at triage has sensitivity 82.6%, specificity 96.5%, PPV 90.5%, NPV 93.2% and accuracy 92.6%

Table 3. Inter-rater reliability for PRAM and its individual components at Triage and for each age group

Age groups	All ages (n = 80)	2–6 years (n = 49)	7–18 years (n = 31)
Individual components ICC (95%CI)			
Suprasternal retraction	0.974 (0.960–0.984)	0.957 (0.924–0.976)	1.000 (1.000–1.000)
Scalene muscle contraction	0.000 (-0.559–0.359)	0.000 (-0.773–0.436)	0.000 (-1.074–0.518)
Air entry	0.792 (0.675–0.866)	0.780 (0.609–0.876)	0.790 (0.565–0.899)
Wheezing	0.641 (0.439–0.769)	0.705 (0.477–0.834)	0.554 (0.075–0.785)
Oxygenation	1.000 (1.000–1.000)	1.000 (1.000–1.000)	1.000 (1.000–1.000)
PRAM	0.944 (0.913–0.964)	0.934 (0.884–0.963)	0.958 (0.912–0.980)

Table 4. Inter-rater reliability for Wood's asthma score and its individual components at Triage and for each age group

Age groups	All ages (n = 80)	2–6 years (n = 49)	7–18 years (n = 31)
Individual components: ICC (95%CI)			
Cyanosis	0.000 (-0.559–0.359)	0.000 (-0.773–0.436)	-
Inspiratory breath sound	0.760 (0.626–0.846)	0.717 (0.498–0.840)	0.810 (0.606–0.908)
Accessory muscle use	0.938 (0.903–0.960)	0.936 (0.887–0.964)	0.941 (0.877–0.971)
Expiratory wheezing	0.459 (0.157–0.653)	0.603 (0.296–0.776)	0.168 (-0.726–0.599)
Cerebral function	0.000 (-0.559–0.359)	0.000 (-0.773–0.436)	-
Wood's asthma score	0.898 (0.841–0.935)	0.901 (0.825–0.944)	0.895 (0.782–0.949)

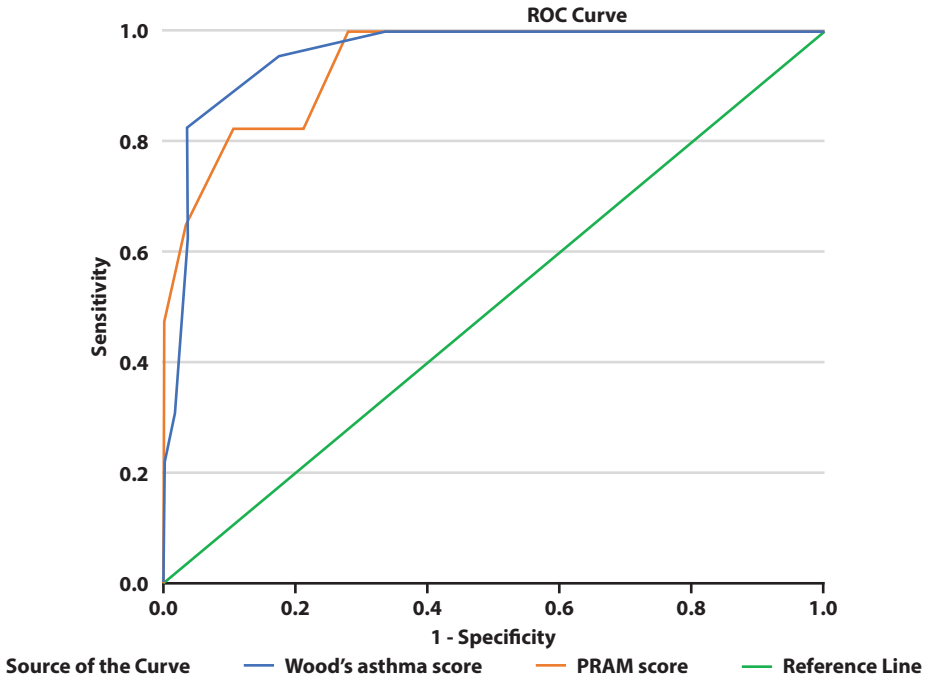


Figure 1. AUC for PRAM and Wood's asthma score as a predictor for admission

Discussion

The severity of asthma exacerbation should be evaluated by well validated asthma score in all patients for good outcomes. However, unfortunately, severe acute asthma assessment was not obtained in all patients. This might be from the lack of good and user-friendly asthma score. Wood's score developed in 1972 for asthmatic attack evaluation. In Thailand, many pediatricians use this score to assessed patient's asthma severity and to determine whether patients require admission, However, the limitation of this score is the arterial oxygenation evaluation. In addition, this score is not popular among worldwide clinicians. Currently, most studies use PRAM score to identify asthma severity and asthma recovery. Our study is the first study to validate PRAM and Wood's score in Thai children with asthma exacerbation. We agreed with the study of Chalut DS and Alnaji F that a 2-score different help to distinguish patients who require admission.[8]

This study demonstrated good correlation between PRAM score and Wood's asthma score among children at triage (Spearman's correlation $\rho = 0.900$, $p < 0.001$) and at the second assessment ($\rho = 0.981$, $p < 0.001$). We also showed a good inter-rater agreement of both scores, obtained by two independent physicians at triage (intra-class correlation coefficient (ICC) of PRAM, 95%CI = 0.944 (0.913–0.964) and Wood's asthma score, 95%CI = 0.898 (0.841–0.935). The prediction of hospitalization was shown in ROC curve, as good sensitivity, both Wood's asthma score and PRAM score (0.959 and 0.942, respectively). This suggested both PRAM and Wood's asthma score were the best predictors for hospitalization, with AUC 0.942 (95%CI = 0.894–0.990) and 0.959 (95%CI = 0.918–0.999) as shown in **Figure 1**.

Our results suggest that both PRAM and Wood's asthma score have good validity, high inter-rater agreement, and high sensitivity to predict severity and hospitalization requirement among children with acute asthmatic attacks. However, the highlight of this study is the finding that intraclass correlation of PRAM is better than Wood's asthma score suggesting that PRAM is the better tool for routine use. In practice, there are several assessors, therefore, the higher the interclass correlation is, the better it is.

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