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Pediatric Observational Priority Score and Early Warning Scoring System to Predict Admission Status in Pediatric Patients in Haji Adam Malik General Hospital

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Abstract

BACKGROUND: Doctors must be able to quickly and accurately assess clinical condition of patients, especially in the emergency rooms. An easy scoring system but producing meaningful clinical conclusions is the reason for creating various scoring systems. It includes a scoring system for predicting the admission status of patients.

AIM: The aim of the study was to determine the diagnostic value of pediatric observational priority score (POPS) and early warning scoring system (EWSS) to predicting admission status of pediatric patients in the emergency department.

METHODS: Diagnostic tests for POPS and EWSS were done to predict the admission status of pediatric patients in the emergency department of Haji Adam Malik general hospital from May to October 2020. Subjects aged 1 month–18 years were excluded if they left the emergency department before assessment, had trauma cases, died, inpatients due to social indications, and patients who came only to continue therapy were also excluded from the study. POPS and EWSS assessments were carried out by the researcher and the admission status of the patients was determined by the doctor in charge in the emergency department.

RESULTS: There were 119 children meeting the inclusion and exclusion criteria. POPS score ≥3 had sensitivity 82.65%, specificity 85.71%, and area under curve (AUC) 0.88 ($p < 0.001$). EWSS score ≥2 had sensitivity 83.67%, specificity 71.43%, and AUC 0.83 ($p < 0.001$).

CONCLUSION: POPS and EWSS had good diagnostic values in predicting the admission status of pediatric patients in the emergency department. POPS has a slightly higher diagnostic value than EWSS.

Introduction

When a pediatric patient comes to the emergency room, the doctor must be able to quickly and accurately assess the patient's clinical condition [1]. Early treatment of emergency conditions is usually carried out after clinical sign assessment without the expensive tests or sophisticated technology [2]. Failure to recognize and treat patients is a major problem to patient safety in health services [3]. Since 2006, early scoring system has been recommended to evaluate patients' clinical condition [4]. Track and trigger tools used are varied by institutions, but all of them have the same goals, such as to predict and reduce adverse outcomes in patients [3]. Since July 2018, Haji Adam Malik general hospital, Medan, has been using EWSS assessment system adopted from the Irish Pediatric Early Warning System.

The pediatric observational priority score (POPS) is a method to identify the severity range of childhood illness, support medical staffs in taking decisions whether to redirect patients to primary care or discharge to self-care and help them in expediting senior or specialist assistance for deteriorating children [5]. The assessment is carried out in acute conditions and adjusted with age and physiological assessments, such as heart rate, respiratory rate, temperature, oxygen saturation, breathing pattern, consciousness, and general state [1]. A study done by Bonfield and Roland (2019) obtained POPS with moderate to excellent inter-rater reliability (IRR), even though the outcome was assessed by different clinical manifestations and assessors [6]. An analysis done to 24,000 patients with POPS assessment by Roland *et al*. (2014) reported area under the receiver operating characteristics (AUROC) of 0.8 to predict hospitalization [7]. Another study done by Roland *et al*. (2017) reported various cut-off score for POPS in inpatient or outpatient cares at different centers, which were adjusted by clinician decisions and other local factors [8].

Early warning scoring system (EWSS) is the first track and trigger tool for pediatric patients and it was modified from adult early warning scores [3], [9]. EWSS is generally used in inpatients and for repeated assessments, whereas in emergency rooms, EWSS is

more commonly used to predict clinical deterioration than to assess admission needs [1]. The scoring system assesses patient's vital signs, such as awareness, blood pressure, heart rate, capillary refill time, respiratory rate, and respiratory distress [3], [9]. Bradman and Maconochie (2008) reported sensitivity 37% and specificity 88% for EWSS score ≥2 in predicting patient admission [9].

In Haji Adam Malik Hospital, EWSS, as well as POPS, had never been used as an assessment to predict the admission status of pediatric patients in the emergency department. Meanwhile, the ability of the assessment system often becomes less effective when applied outside of the organization where the system was created. Therefore, this study analyzed the diagnostic value of POPS and EWSS scoring systems in predicting the admission status of pediatric patients who come to the emergency department of Haji Adam Malik general hospital, Medan.

Methods

This research was conducted using diagnostic test design in patients aged 1 month–18 years who came to the emergency department of Haji Adam Malik general hospital, Medan during May 2020–October 2020. The sample size required was at least 110 samples, calculated by large sample formula for diagnostic research with out-of-sensitivity. Patients who left the emergency department before being assessed by the medical team, were cared as outpatient by their own request, had trauma cases, were admitted by social indications, died, and came to the emergency department to continue therapy were excluded in the study. Parental or guardian approval from all samples was given prior to the research. This research had been approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara (No: 44/KEP/USU/2020) and the general hospital of Haji Adam Malik, Medan (LB.02.03/XV.2.3.2/2556/2020).

Characteristic data, such as gender, age, and the main categories of abnormalities suffered by patients, admission status, and type of inpatient room collected. Each sample was assessed with POPS and EWSS by researchers and the status of the admission was decided by the doctors on duty in the emergency department without knowing the results of the POPS and EWSS assessments.

Data were processed with Statistical Package for the Social Sciences for Windows (SPSS) computerized system version 2.1 with 95% confidence interval and significance level of $p < 0.05$. Univariate analysis was done to find out the distribution of samples. The diagnostic value of POPS and EWSS was derived from the receiver operating characteristic (ROC) curve analysis. The data were tabulated into Microsoft Excel program and plotted into chart forms to get cut-off points between sensitivity and specificity lines. The scores were analyzed into 2 × 2 table to obtain sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), and negative likelihood ratio (NLR).

Results

There were a total of 119 research subjects who met the inclusion and exclusion criteria, with 70 (58.8%) males and 49 (41.2%) females. The number of research subjects based on the age category was 9 children (7.6%) 1–3 months old, 6 children (5%) 4–11 months old, 31 children (26.1%) 1–4 years old, 37 children (31.1%) 5–11 years old, and 36 children (30.3%) 12–18 years old. The most common disorders that make patients came to emergency department were hemato-oncology (27.7%), COVID-19 (20.2%), and neurology (17.6%). After clinical assessments by the doctors, 98 children (82.4%) were admitted as inpatients and 21 children (17.6%) as outpatients. Among the subjects requiring inpatient care, 65 children (54.6%) required ward, 23 children (19.3%) required high care unit (HCU), and 10 children (8.4%) required pediatric intensive care unit (PICU). The characteristic data of research subjects are shown in Table 1.

The diagnostic value with cut-off score for POPS ≥3 is shown in Figure 1 and Table 2. The data show that the ability for POPS to predict the admission status of pediatric patients in emergency department

Table 1: Characteristics of subjects

Characteristics]	n = 119
Gender, n (%)	
Male	70 (58.8%)
Female	49 (41.2%)
Age, n (%)	
1–3 months	9 (7.6%)
4–11 months	6 (5%)
1–4 years old	31 (26.1%)
5–11 years old	37 (31.1%)
12–18 years old	36 (30.3%)
The main disorder, n (%)	
Allergy disorder	1 (0.8%)
Nutrition disorder	1 (0.8%)
Immunology disorder	2 (1.7%)
Gastroenterology disorder	4 (3.4%)
Infection disorder	5 (4.2%)
Nephrology disorder	6 (5%)
Respirology disorder	10 (8.4%)
Cardiovascular disorder	12 (10.1%)
Neurology disorder	21 (17.6%)
Hematooncology disorder	33 (27.7%)
Covid-19	24 (20.2%)
Admission status, n (%)	
Inpatient	98 (82.4%)
Ward	65 (54.6%)
HCU	23 (19.3%)
PICU	10 (8.4%)
Outpatient	21 (17.6%)

HCU: High care unit; PICU: Pediatric intensive care unit.

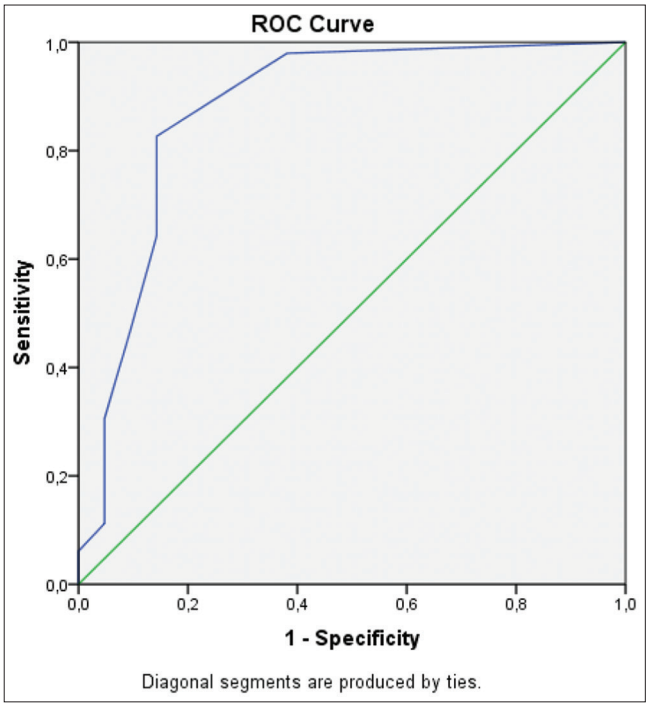

Figure 1. ROC curve of POPS score in predicting the admission status (p< 0.001; area under the curve 0.877

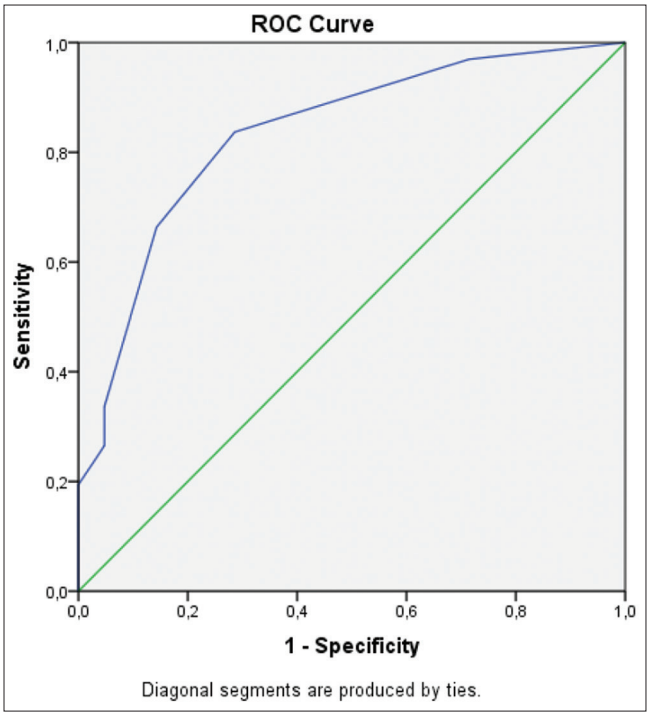

Figure 2. ROC curve of EWSS score in predicting the admission status (p< 0.001; area under the curve 0.834)

with sensitivity 82.65%, specificity 85.71%, PPV 96.43%, NPV 51.43%, PLR 5.79, NLR 0.20, and area under curve (AUC) 0.88 (p < 0.001).

Table 2: POPS diagnostic test with cut-off score ≥3

Cut-off score POPS	Inpatient (n)	Outpatient (n)	Diagnostic value
≥3	81	3	Sensitivity = 82.65%
<3	17	18	Specificity = 85.71%
Total	98	21	PPV = 96.43%
			NPV = 51.43%
			PLR = 5.79
			NLR = 0.20
			AUC = 0.88

PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio; AUC: Area under the curve.

The diagnostic value with cut-off score for EWSS ≥2 is shown in Figure 2 and Table 3. The data show that the ability for EWSS to predict the admission status of pediatric patients in emergency department with sensitivity 83.67%, specificity 71.43 %, PPV 93.18%, NPV 48.39%, PLR 2.93, NLR 0.23, and AUC 0.83 (p < 0.001).

Table 3: EWSS diagnostic test with cut-off score ≥2

Cut-off score EWSS	Inpatient (n)	Outpatient (n)	Diagnostic value
≥2	82	6	Sensitivity = 83.67%
<2	16	15	Specificity = 71.43%
Total	98	21	PPV = 93.18%
			NPV = 48.39%
			PLR = 2.93
			NLR = 0.23
			AUC = 0.83

PPV: Positive predictive value; NPV: negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio; AUC: Area under the curve.

The comparison of the diagnostic test results between POPS and EWSS showed that POPS was slightly more accurate than EWSS. The diagnostic validity of POPS and EWSS to predict the admission status of the pediatric patient can be seen in Table 4.

Table 4: POPS and EWSS diagnostic validity to predict admission status of pediatric patient

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	PLR	NLR	AUC (%)
POPS ≥3	82.65	85.71	96..43	51.43	5.79	0.20	88.0
EWSS ≥2	83.67	71.43	93.18	48.39	2.93	0.23	83.0

Discussion

One of the most important functions of the emergency department is to assess patient status [10]. Appropriate assessment of admission likelihood in emergency department can reduce over admission and under admission in patients [11]. Inappropriate admission would increase costs and possibility of hospital acquiring complications in patients, whereas under admission could result in delayed medical care as well as morbidity and mortality [10], [12]. Over the past decade, several methods have been used to assess the likelihood of admission for pediatric patients in the emergency department with various results. In this study, researchers wanted to assess the validity of POPS and EWSS in predicting the admission of pediatric patients in the emergency department of Haji Adam Malik general hospital as the primary referral hospital in North Sumatra.

The POPS is an assessment tool in pediatric emergency departments to identify children with suspect of serious illness while at the same time provides support to the medical staffs in redirecting or discharging patients [13]. The study done by Roland *et al*. (2011) showed an increased risk of admission with POPS score of >2 [14]. The study was opposing this study, in which

cut-off score POPS ≥3 was able to predict the admission of pediatric patients in the emergency department with sensitivity 82.65%, specificity 85.71%, and AUC 0.88. However, the study in the United Kingdom by Kelly *et al*. (2013) found that cut-off score POPS ≥3 had sensitivity 36% and specificity 93%, but at one point, the increase in POPS was associated with 70% increase in the odds ratio of admission ($p < 0.001$) [15].

EWSS is a valid tool with good diagnostic accuracy in recognizing children who are at risk of serious and life-threatening deterioration in the emergency department [16]. This study found that cut-off score EWSS ≥2 had sensitivity 83.67%, specificity 71.43%, and AUC 0.83 in predicting admission. These results were better diagnostic scores than the study done in the Netherlands by Seiger *et al*. (2013), who assessed validation of 10 types of EWSS to predict the admission in 17943 children, in which the sensitivities were 36.4%-85.7%, specificity 27.1%-90.5%, and AUC 0.56-0.68 [17]. Similarly, research in Thailand by Chaiyakulsil and Pandee (2015) found that EWSS ≥1 had sensitivity 78%, specificity 59.6%, and AUC 0.73; but EWSS scores ≥3 had excellent AUC (0.98) in predicting the need of PICU [11].

This research has demonstrated that POPS had a slightly higher diagnostic value for predicting the likelihood of admission than EWSS. These results are similar to research in the United Kingdom by Cotterill *et al*. (2016), who compared POPS with EWSS, where the AUC for POPS and EWSS was at 0.72 and 0.67, respectively [1]. Several other studies have also shown the effectiveness of POPS in determining the admission status in patients [7], [8], [13], [14]. POPS assessment is easier and simpler than EWSS, especially when it does not require blood pressure measurement which is usually difficult to do in children. According to the emergency severity index triage system version 4, blood pressure measurement is not critical in the determination of patient status [18]. However, POPS cannot be used in patients with trauma cases. Cotterill *et al*. (2016) compared POPS assessments in trauma and non-trauma cases and obtained AUC of 0.73 and 0.69 for non-traumatic and trauma cases, respectively [1]. POPS scoring system is only carried out 1 time, while EWSS scoring system has hourly monitoring formats. Therefore, EWSS can early detect deterioration in patients on top of determining admission status. Some components in POPS have several subjective criteria which are necessary to consider modifying them without mitigating their sensitivity and specificity. Clinical assessment by expert staffs in this case was still needed to complement the interpretation of POPS or EWSS assessment.

This is a study done in Haji Adam Malik general hospital as a tertiary hospital. Therefore, the results could have been different in other primary or secondary hospitals due to different arrangements of services and admission thresholds. The decision to admit or not admitting patients was decided by the doctors using their subjective clinical experience, as well as departmental guidelines. Nonetheless, the lacking of gold standard for admission criteria. The study also did not monitor the admission status of the patient for a certain period of time, so the likelihood of patients coming back to emergency installations was invaluable in this study. However, this study is the first study assessing POPS and EWSS in the emergency department of Haji Adam Malik general hospital. The results of this study can be reference data to help medical team in determining the status of the admission, especially those working in tertiary hospitals, to improve the quality of patient care.

Conclusion

POPS and EWSS had good diagnostic values in predicting the admission status of pediatric patients in the emergency department. POPS had a slightly higher diagnostic value than EWSS.

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