Original Article

Validation of Brighton pediatric early warning score for predicting clinical deterioration in the emergency department

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ABSTRACT

Objectives: The objectives of the study were to validate the pediatric early warning score (PEWS) for predicting clinical deterioration in children attending the emergency department (ED) and its inter-rater agreement between nurses and pediatric trainees. **Methods:** This prospective observational study was done on patients aged 1 month–12 years attending the ED in tertiary care institute of South India, from June 2017 to June 2018. They were evaluated using PEWS at time of admission (S0) and after 1 h (S1) by both nurses and pediatric trainees. The scores were correlated with outcome. A receiver operating curve (ROC) was plotted to determine the cutoff value for PEWS in predicting deterioration. Inter-rater reliability between nurses and pediatric trainee was evaluated. **Results:** A total of 738 patients were included in the study. Patients admitted in pediatric intensive care unit (S0 2.623±2.075 and S1 2.024±1.592) had higher mean PEWS both at the time of admission and at 1 h, compared to patients admitted to the ward (S0 – 0.7551±1.129 and S1 – 0.5165±) ($p<0.001$). The optimal cutoff scores on the ROC for predicting clinical deterioration are S0 = 2 and S1 = 2 with areas under the curve of 0.76 and 0.78, respectively. The sensitivity, specificity, and likelihood ratios of these scores are as follows: S0 – sensitivity – 67.46%, specificity – 76.34%, positive likelihood ratio – 2.85, and negative likelihood ratio – 0.43; and S1 – sensitivity – 61.9%, specificity – 88.89%, positive likelihood ratio – 5.57, and negative likelihood ratio – 0.43. Inter-rater reliability between nurses and pediatric trainees was excellent (intraclass coefficient 0.99). **Conclusions**: Pediatric early warning score can be a useful clinical tool for identifying children at risk of deterioration. PEWS can be effectively used by nursing personnel in the triage room to identify a sick child.

Key words: Pediatric early warning score, Children, Triage

Pediatric early warning score is a standardized score assigned to a patient through assessment of various physiological, behavioral, and clinical parameters. These warning systems facilitate early detection of clinical deterioration. These scores have proven to improve multidisciplinary team work, communication, and confidence in recognizing, reporting, and making decisions about a child at risk of clinical deterioration [1,2].

Different pediatric early warning scores (PEWSs) were developed, modified, and validated in various places across the globe, with majority of contributions from developed countries [3-11]. There is a wide heterogeneity in PEWS used with regard to the number of parameters settings where they are applied and the outcomes measured. However, not all of them could be applied in resource restricted settings because of the need for special equipment and technical expertise. Brighton PEWS tool is a simple clinical score involving three parameters, which can be easily performed even by nurses without the need for special equipment [6].

Most of the studies have implemented Brighton PEWS in pediatric inpatient units [6,7]. There is a paucity of literature regarding the implementation of PEWS in pediatric ED; especially, in the Indian population. In resource-limited settings where specialists may not be available, registered medical practitioners or nursing personnel may be the first personnel to encounter pediatric patients. Availability of simple and validated clinical tool becomes crucial to identify the children at risk of deterioration in such settings. Hence, this study was designed to assess the validity of Brighton's PEWS tool in predicting clinical deterioration in children admitted from emergency departments (EDs) and to assess the interobserver agreement between nurses administered PEWS and pediatric trainee administered PEWS.

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MATERIALS AND METHODS

This prospective observational study was conducted in the ED of a tertiary care hospital in Puducherry for a period of 1 year from June 2017 to June 2018. Institutional Human Ethics Committee approved the study. All children aged 1 month–12 years admitted from the ED and irrespective of clinical diagnosis were included in the study. The decision for pediatric intensive care unit (PICU) admission was made based on presenting illness, severity, and the need for oxygen and monitoring. Our hospital has no separate high dependency units. Hence, even for oxygen requirement or post-ictal phase monitoring, children were shifted to PICU. Before study initiation, all emergency room (ER) registered nurses were trained by the investigator, using learning modules in multiple sessions. All nurses were taught about PEWS and its parameters, and assessment of all children visiting ER was done using PEWS, under the supervision of investigator for a period of 1 month before starting the study. Brighton PEWS was used in our study [7] (Table 1).

After inclusion in the study, PEWS was done by both pediatric trainee and nursing personnel at the time of admission in ED and at 1 h in the respective wards. These scores along with demographic details were entered in the pro forma. Physicians were not informed of the assigned PEWS. The decision for admission to PICU or ward was taken by treating physician without knowledge of PEWS. Admission or transfer to PICU was considered as marker of clinical deterioration. All patients were managed as per protocol and followed up till discharge or death.

The sample size was calculated as per study done by Gold *et al*. [12], assuming sensitivity of PEWS as 0.78 using Buderer's formula. The sample size estimated was 488. As per universal sampling, all children admitted from the ER during the study period were included in the study. A total of 738 children were included in this study.

Statistical analysis was conducted with the statistical package for the SPSS version 21.0. Continuous variables were presented as mean ± SD, and categorical variables were presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using independent t-test. Nominal categorical data between the groups were compared using the Chi-squared test or Fisher's exact test as appropriate. $p<0.05$ was considered statistically significant. Intraclass correlation (R) statistics was used to compare pediatric trainee and nurses' score.

RESULTS

During the study period, 1525 patients were presented to the ED, out of which, 738 children admitted by treating physician were included in this study. Of these patients, 252 (34.1%) were admitted in PICU and 486 (65.9%) children were admitted to the ward (Table 2). The mean duration of hospital stay in children admitted in the PICU and ward was 5.78±3.6 and 3±1.7 days, respectively.

Children with initial admission score of ≥4 were mostly admitted in PICU (86.8%) than in the ward (13%), as shown in Table 3. There was a significant correlation between initial score and place of admission ($p<0.001$). Among the 20 children transferred to PICU within 6 h, 18 had initial PEWS of ≥ 2, while two had a score of < 2 and in seven children transferred within 6–24 h, initial PEWS did not have any significant correlation (Table 3).

Patients admitted in PICU had higher PEWS both at the time of admission and at 1 h, compared to patients admitted to the ward ($p<0.001$) (Table 4).

Initial admission score was significantly higher than the score at 1 h in both PICU and ward admitted groups (Fig, 1). Initial score by pediatric trainee (S0) showed receiver operating curve (ROC) with area under the curve (AUC) of **0.769 (**95% CI: 0.730–0.807) with standard error of 0.020. The AUC of S0 derived cutoff PEWS was 2 with sensitivity – 67.4% (95% CI: 61.30–73.21%), specificity – 76.3% (95% CI: 72.30–80.05%), positive likelihood ratio – 2.85 (95% CI: 2.38–3.42), and negative likelihood ratio – 0.43 (95% CI: 0.35–0.51). ROC for the score at 1 h (S1) had AUC of 0.788 (95% CI: 0.750–0.826) with standard error of 0.19 and cutoff score derived was 2 with sensitivity – 61.9% (95% CI: 55.60–67.93%), specificity – 88.8% (95% CI: 85.75–91.54%), positive likelihood ratio – 5.57 (95% CI: 4.26–7.29) (Fig. 2), and negative likelihood ratio – 0.43 (95% CI: 0.37–0.50). Initial PEWS done by nurse and pediatric trainee had good correlation (R=0.99).

Table 1: Brighton PEWS

Components	0	1	2	3
Behavior	Playing/appropriate	Sleeping	Irritable	Lethargic/confused or reduced response to pain
Cardiovascular	Pink and/or CFT 1–2 s	Pale and/or CFT 3 s	Gray and/or CFT 4 s or HR >20 above normal rate	Gray and mottled or CFT 5 s or HR >30 above normal rate or bradycardia
Respiratory	Within normal parameters, no retractions	RR >10 normal parameters, using accessory muscle or 30+% Fio2 or 3+ l/min	RR >20 normal parameters, retractions or 40+% Fio2 or 6+ l/min	RR >5 below normal parameters with retractions, grunting or 50+% Fio2 or 8+ l/min
Extra 2 points each	1/4 hourly nebulizer, bronchodilators every 15 min, and/or persistent vomiting after surgery			

***CFT: Capillary filling time, HR: Heart rate, RR: Respiratory rate**

DISCUSSION

Our study found that PEWSs at admission and at 1 h were significantly higher in patients admitted in PICU compared to patients admitted in wards. In addition, we found that it is possible to implement PEWS in ED using nurses with good interobserver reliability. Compared to patients in wards, higher number of children in age group of 2–3 months got admitted in PICU (9.9% vs. 3.9%, p<0.05). Age was found to be a contributing factor in deciding admission to PICU or ward since babies in the early infantile period require intensive monitoring as they tend to deteriorate quickly. These findings are similar to the study done by Chaisyakulsil and Pandee [13].

Table 2: Characteristics of study population

Parameters (n=738)	PICU (n=252)	Ward (n=486)
Age		
2–3 months	25 (9.9%)	19 (3.9%)
4–12 months	69 (27.4%)	128 (26.3%)
1–2 years	79 (31.3%)	191 (39.3%)
2–12 years	79 (31.3%)	148 (30.5%)
Gender		
Male	156 (33.1%)	316 (66.9%)
Female	96 (36.1%)	170 (63.9%)
Duration of stay (in days)	5.78	3
Outcome		
Discharge	239 (94.8%)	477 (98.1%)
Referral/AMA	11 (4.4%)	7 (1.4%)
Death	2 (0.8%)	2 (0.4%)

Table 3: Initial PEWS (S0) and place of admission

Score	Direct admission		Transfer to PICU from ward	
	To PICU (n=252)	To ward (n=486)	Within 6 h (n=20)	6–24 h (n=7)
0	57 (22%)	295 (60%)	1	1
1	25 (10%)	76 (15.6%)	1	1
2	50 (20%)	74 (15.2%)	5	3
3	34 (13.4%)	27 (5.5%)	4	1
4	32 (12.6%)	9 (2%)	6	1
5	27 (10.7%)	4 (1%)	3	0
>5	27 (10.7%)	1 (0.2%)	0	0

Table 4: PEWS in PICU and ward admitted patients

Variables	S0 median (IQR)	S1 median (IQR)	p value
PICU	2 (1–4)	2 (1–3)	0.001
Ward	0 (0–1)	0 (0–1)	0.001

As in other studies, higher proportion of children (86.8%) with PEWS ≥4 got direct admission to PICU [4,12,14,15]. Mean PEWS in children admitted to PICU was significantly higher than ward admitted children, both at admission and at 1 h. This reflects that PEWS correlates well with the clinician's decision of predicting clinical deterioration. Children with PEWS of 0 even got admitted in PICU due to need for oxygen requirement and monitoring.

PEWS at admission was higher than PEWS at 1 h in both PICU and ward admitted children. This indicates that PEWS may be higher at admission due to several contributing factors such as fever, anxiety, transport related issues, and improvement in vitals after initial resuscitative measures. Using admission, PEWS for deciding transfer to PICU may result in unnecessary ICU admissions increasing parental anxiety and cost of care. Compared to admission PEWS, the score at 1 h had higher specificity and positive likelihood ratio. This reiterates the fact that serial monitoring of PEWS could be more useful in predicting ICU care rather than single admission score. Persistence of higher PEWS (≥2) even after admission portends risk of deterioration. Although high PEWSs correlate well with ICU admission, lower PEWSs have poor discriminative capacity for identifying children at risk.

We used the Brighton scoring system in the emergency room to categorize children [6]. This score was validated by Seiger *et al*. [11] with good prediction to PICU admission (ROC of 0.60–0.82). Initial score by a pediatric trainee had ROC with AUC of 0.76 and cutoff score derived was 2 with sensitivity – 67.46% and specificity – 76.34%. ROC for a score at 1 h had AUC of 0.788 and cutoff score derived was 2 with sensitivity – 61.9% and specificity – 88.89. A similar retrospective study done by Lillitos *et al*. [16] in two UK EDs also showed that PEWS over 2 had good specificity but poor sensitivity in predicting decline in clinical status. Most of the other studies which used

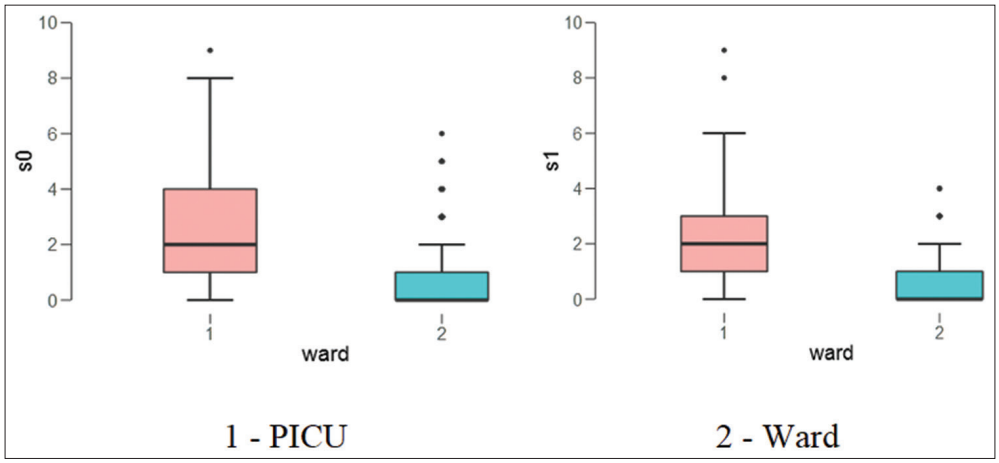

Figure 1: Pediatric early warning scores (S0 and S1) in pediatric intensive care unit and ward admitted children

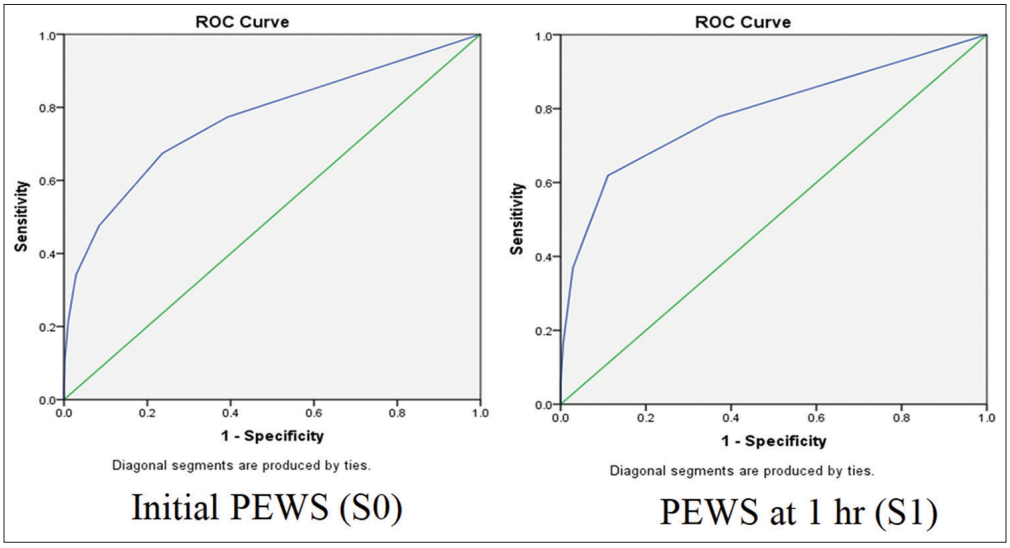

Figure 2: Receiver operating curve curves of both pediatric early warning scores

admission/transfer to PICU as marker of deterioration derived cutoff values of PEWS as 3 and above [17,18]. One study done by Chaisyakulsil and Pandee [13] showed cutoff score of 1 for predicting ICU admission. Using lower optimal cutoff scores for predicting ICU admission may result in multifold increase in ICU admissions. This may result in unwarranted ICU admissions, thereby compromising the quality of care.

PEWS at admission done by pediatric trainee and nurse had good interobserver reliability (intraclass correlation=0.99). This is similar to the study conducted by Tucker *et al*. [12] (ICC=0.92) and Gold *et al*. [17] (ICC=0.91). In primary health centers or resource restricted settings where specialists may not be available, nursing personnel can be trained to use this score in pediatric patients, facilitating timely interventions, or referral. Even in advanced centers, involvement of ED nurses in assigning these scores may reduce the burden of physicians; improve effective communication and team work

Our study is not without limitations. It is a single-center study and it cannot be generalized to the entire population. We assumed admission/transfer to PICU as the indicator of clinical deterioration. Since our hospital does not have high dependency units, even for oxygen requirement or monitoring, patients were admitted to PICU, which may actually not reflect clinical deterioration. Variation in indications and criteria for PICU admission may affect corroboration of our findings.

CONCLUSIONS

Pediatric early warning score can be implemented as an effective clinical tool in emergency settings for identifying sick children. It can also be used in resource-limited settings as it does not need special equipment or expertise. Although using admission score for deciding disposition to ICU may result in unnecessary admissions, serial monitoring of PEWS might be more useful in predicting clinical deterioration. Future large-scale multicentric studies are needed regarding the effective implementation of PEWS in emergency and inpatient settings and to determine whether they really affect quality of care and outcome in the pediatric population.

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