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Role of the Pediatric Early Warning Score in Identification of Patients in Need to Pediatric Intensive Care Units Admission

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ABSTRACT

Background: Pediatric Early Warning Scores (PEWS) are physiologically-based scoring systems developed to identify patients admitted to inpatients pediatric wards and emergency departments.
Objective: Our study objective was to explore if the PEWS assigned in the ED or ward predicts the need for ICU admission from the ED or clinical deterioration in admitted patients.
Patients and Methods: This retrospective study was carried out at the Pediatric Intensive Care Units of Zagazig University Hospitals on 53 children admitted to Pediatric Intensive Care Units (PICUs) in the period from June 2017 to June 2018. PEWS scores were measured at initial assessment (H0) and time of admission (H1).
Results: We evaluated 12 different PEWS and the ability to predict early deterioration and the need to ICU admission. We also reported that ward has the highest percentage in admission by 60.4% to ICU, then emergency room by 39.6%. The patients included 32 (60%) males and 21 (40%) females with mean age 17.42 ± 28.002 months. Pneumonia had the highest percentage by 32.1%, and then fulminant hepatic failure comes in second place by 22.6%, followed by sepsis 13.2%. Mean duration length of staying in hospital before admission to PICU was 2.05 ± 2.89 days, and the mean after admission to PICU was 5.16 ± 6.69 days. Patients admitted from ward were statistically higher in hospital stay before admission to PICU. **Conclusion:** pediatric early warning score can be helpful in predicting patient disposition in pediatric emergency department (ED) with acceptable validity and can serve as a potentially excellent screening tool for prediction of ICU admission.
Keywords: Pediatric Early Warning Scores- Pediatric Intensive Care Units – Prediction.

INTRODUCTION

The early identification of patients at risk of clinical deterioration and matching the severity of illness to the appropriate level of care are integral components of high-quality medical care, as is appropriate resource allocation in the hospital setting. The establishment and implementation of inpatient medical emergency teams address the deterioration of hospitalized patients. Prior studies in adults and children have demonstrated that physiologic changes in patient status can be identified in the hours preceding cardiac arrest [(1)].

The medical emergency teams (MET) concept was designed as a direct response to the impending deterioration of a patient admitted to the hospital, but ideally such patients should be identified as early and accurately as possible. Recent studies have been geared toward early warning scores and their ability to identify at risk patients. For children, the original concept of a Pediatric Early Warning Score (PEWS) system was developed to provide a reproducible assessment of the pediatric patient's status based on physiologic parameters [(2)].

Multiple pediatric scoring systems have been developed worldwide, and Monaghan's PEWS is one of the most simple and flexible systems. It is quickly performed, not age specific and has five domains: behavior, cardiovascular status, respiratory status, nebulizer use and persistent postsurgical vomiting. Monaghan's PEWS has been validated in retrospective studies of the inpatient floor setting of pediatric hospitals [(3)].

Despite the extensive literature discussing PEWS in the inpatient setting, there are limited published studies evaluating the utility of PEWS systems in the pediatric emergency department (ED). To date, there are two studies evaluating the ability of PEWS systems to predict which patients in the pediatric ED need admission to the intensive care unit (ICU). A recent study from a pediatric hospital in Netherlands evaluated the validity of multiple PEWS scores. The authors tested the performance of ten different established PEWS in the ED, with the discriminative ability of each PEWS determined to be poor to moderate for predicting hospitalization and moderate to good for predicting ICU admission [(4)].

A second study by **Breslin *et al.*** [(5)] sought to determine the association between PEWS at time of ED disposition and level of care and included both admitted and discharged patients in the cohort. They concluded that PEWS is associated with the level of care at ED disposition, but cannot accurately be used in isolation. Most earlier studies investigating the various uses of PEWS in hospitalized patients had positive findings, implying that a PEWS will help identify those patients who will go on to need intensive care therapies.

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The study aimed to perform Pediatric Early Warning Scores (PEWS) on patients admitted to inpatient wards, which will enable health care providers in improving the outcome of children in the hospital.

PATIENTS AND METHODS

This retrospective study was carried out at the Pediatric Intensive Care Units of Zagazig University Hospitals on 53 children in the period from June 2017 to June 2018.

Inclusion criteria:

Critically ill pediatric patients who admitted to PICU. Age from infants up to 12 years.

Exclusion criteria: Patients older than 12 years of age. Patients admitted to the neonatal ICU. Parents refuse consent.

Ethical Clearance

Written Informed consent was taken from the patients' parents to participate in the study. Approval for performing the study was obtained from Pediatrics Department, Zagazig University Hospitals after taking Institutional Review Board (IRB) approval.

All subjects in the study were subjected to:

1) ***History:*** Full detailed history taking included age, sex, source of admission and diagnosis.
2) ***Clinical and physical examination.***

PEWS:

PEWS scores were measured at initial assessment (H0) and time of admission (H1). Patients were stratified into outcome groups: those admitted from the ward and those admitted from the ED. Clinical deterioration was defined as transfer to the ICU within 6 hours or within 6 to 24 hours of admission. PEWS at 4 hours intervals or less for the 24 hours proceeding the event [6].

The scoring system:

The scoring system focused on three components of assessing a child: Behaviour, colour/cardiovascular status and respiratory status.

Behaviour was felt to be an important observation criterion as it is often an early sign of a shocked child and something the parents may also recognize. Behavioural signs are scored exactly as observed so the child who is uninterested in his or her surroundings would score three – lethargic.

Colour and capillary refill were chosen to assess cardiovascular signs rather than mean arterial blood pressure. Both signs are used, as not all staff are skilled in assessing capillary refill. Respiratory rate was included along with oxygen demand. **Goldhill *et al.*** [7] found that respiratory rate and adequacy of oxygenation were important physiological indicators of a critically ill ward patient and could be assessed without special equipment. This removes any reliance on equipment such as saturation monitors being available. Mean respiratory parameters are used in order to increase sensitivity. Having assessed the parameters in the figure the nurse calculates the child's total score.

Statistical Analysis

All data were collected, tabulated and statistically analyzed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) & MedCalc 13 for windows (MedCalc Software bvba, Ostend, Belgium). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) and Fisher exact were used to calculate difference between qualitative variables as indicated. Quantitative data were expressed as mean ± SD for parametric, median and range for non-parametric data. Independent T test and Mann Whitney test were used to calculate difference between quantitative variables in two groups for parametric and non-parametric variables respectively. Pearson's and Spearman's correlation coefficient were used. Receiver operating characteristic (ROC) curve was constructed.

RESULTS

Table (1): Demographic data of the studied patients (N = 53)

Demographic data		**The studied patients** (N=53)	
		No.	%
Age (months) Mean ± SD		17.42 ± 28.002	
Sex	Male	32	60.4%
	Female	21	39.6%
Source of admission			
Emergency Department (ED)		21	39.6%
Ward Department (WD)		32	60.4%

Table (1) showed that demographic data of the study with number of males was 32 and number of females was 21 with mean age 17.42 ± 28.002 months. Ward D. had the highest percentage in admission by 60.4% then Emergency D. (39.6%).

Table (2): Presentation of the studied patients (N=53).

Clinical	The studied patients (N=53)	
	No.	%
Duration		
Length of stay before PICU (days)	2.05 ± 2.89	
Length of stay in PICU (days)	5.16 ± 6.69	
Death		
Yes	6	11.3%
No	47	88.7%

Table (2) showed that mean duration length of staying in the hospital before admission to PICU was 2.05 ± 2.89 days and the mean after admission to PICU was 5.16 ± 6.69 days. There was 11.3% dead among the studied patients.

Table (3): Frequency of diagnosis of the studied patients (N=53)

Diagnosis	The studied patients (N=53)	
	No.	%
Pneumonia	17	32.1%
Acute bronchiolitis	12	22.6%
Sepsis	7	13.2%
AEBA	3	5.7%
CHD	3	5.7%
Meningitis	3	5.7%
Status epilepticus	2	3.8%
Heart failure	2	3.8%
Post-cardiac arrest	1	1.9%
Apnea	1	1.9%
Fulminant hepatic failure	1	1.9%
Methaemoglobinemia	1	1.9%

This table showed that pneumonia had the highest percentage of diagnosis by 32.1% and then fulminant hepatic failure comes in second place by 22.6%, followed by sepsis 13.2% (Table 3).

Table (4): Clinical data of the studied patients (N=53)

Clinical	The studied patients (N=53)	
	No.	%
MV		
Non-invasive mechanical ventilation (MV)	30	56.6%
Invasive	6	11.3%
Non-invasive & invasive	11	20.8%
Inotropes		
One inotrope	9	17%
Two inotropes	2	3.8%

Table (4) showed that non-invasive MV had the highest percentage by 56.6% and non-invasive & invasive MV came in the second place by 20.8%, then invasive MV by 11.3%. One inotrope had the highest percentage by 17% and two inotrope come in the second place by 3.8%.

Table (5): Clinico-demographic data of the two studied groups

		Ward N = 32	ER N = 21	Test	p
Age (months) Mean ± SD		21.19 ± 34.31	11.67 ± 12.52	1.37	0.891
LOS before ICU Mean ± SD		2.944 ± 3.34	0.69 ± 1.123	**4.402**	**<0.001**
LOS in ICU Mean ± SD		5.77 ± 7.98	4.24 ± 3.99	0.779	0.436
Sex	Female Male	11 (34.4%) 21 (65.6%)	10 (47.6%) 11 (52.4%)	0.930	0.335
Death		4 (9.5%)	2 (12.5%)	0.112	0.738

This table showed that there was a highly significant difference between the two groups regarding length of stay before admission to ICU (Table 5).

Table (6): PEWS in different hours before admission between the two studied groups.

	Ward N = 32	ER N = 21	Test	p
SCORE_H4 Mean ± SD	5.56 ± 1.67	5.24 ± 1.61	.703	.485
SCORE_H8 Mean ± SD	4.56 ± 1.61	5.24 ± 1.87	1.404	.166
SCORE_H12 Mean ± SD	4.16 ± 1.17	5.10 ±1.76	**2.341**	**.023**
SCORE_H16 Mean ± SD	3.31 ± 1.11	4.75 ± 0.96	**2.472**	**.019**
SCORE_H20 Mean ± SD	3.54 ± 1.24	3.5 ± 0.71	.043	.966
SCORE_H24 Mean ± SD	3.7 ± 2.91	3 ± 0	.234	.817

This table showed that there was a significant difference between the two groups regarding PEWS at 12 and 16 hours before admission (Table 6).

Table (7): Variation of PEWS at different hours before admission between the two studied groups

		Ward N = 32	ER N = 21	χ^2	p
H4	≤5 >5	18 (56.2%) 14 (43.8%)	13 (61.9%) 8 (38.1%)	.167	.683
H8	≤5 >5	24 (75%) 8 (25%)	12 (57.1%) 9 (42.9%)	1.856	.173
H12	≤5 >5	28 (87.5%) 4 (12.5%)	11 (52.4%) 10 (47.6%)	**8.045**	**.005**
H16	≤5 >5	30 (93.7%) 2 (6.3%)	16 (76.2%) 5 (23.8%)	**7.477**	**.006**
H20	≤5 >5	29 (90.6%) 3 (9.4%)	19 (90.5%) 2 (9.5%)	.166	.684

This table showed that there was a significant difference between the two groups at 12 and 16 hours before admission (Table 7).

Table (8): Correlation between PEWS at different hours and length of stay in PICU in the whole studied patients.

		Length of stay in PICU
P_SCORE_H4	R Sig. (2-tailed)	**.379*** **.005**
P_SCORE_H8	R Sig. (2-tailed)	**.368*** **.050**
P_SCORE_H12	R Sig. (2-tailed)	**.316*** **.021**
P_SCORE_H16	R Sig. (2-tailed)	.105 .560
P_SCORE_H20	R Sig. (2-tailed)	.101 .609
P_SCORE_H24	R Sig. (2-tailed)	**-.413*** **.045**

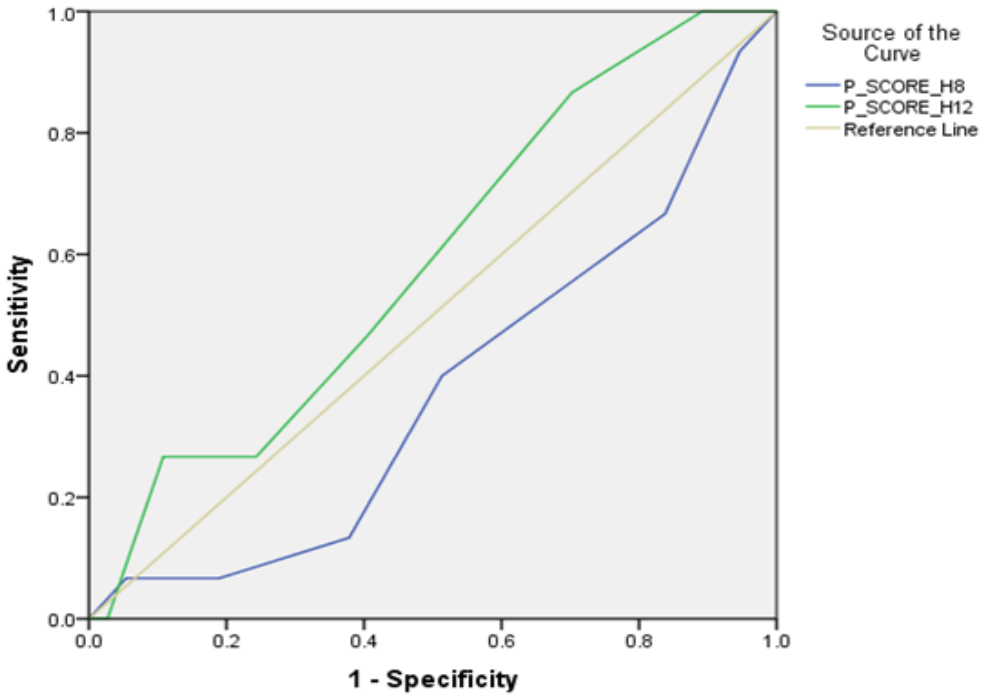
This table showed that there was a positive significant correlation between length of stay in PICU and PEWS at 4, 12 and 16 hours before admission. However, there was a negative significant correlation between length of stay in PICU and PEWS at 24 hours before admission (Table 8).

Table (9): Correlation between PEWS at different hours and length of stay in PICU in the two studied groups.

		Length of stay in PICU	
		ER	Ward
P_SCORE_H4	R Sig. (2-tailed)	.141 .542	**.557*** **.001**
P_SCORE_H8	R Sig. (2-tailed)	.018 .938	**.466*** **.007**
P_SCORE_H12	R Sig. (2-tailed)	.415 .062	.325 .069
P_SCORE_H16	R Sig. (2-tailed)	.056 .944	.048 .807
P_SCORE_H20	R Sig. (2-tailed)	---- ----	.064 .757
P_SCORE_H24	R Sig. (2-tailed)	---- ----	-.399 .059

This table showed that there was a positive significant correlation between length of stay in PICU and PEWS at 4 and 8 hours before admission in the ward patients (Table 9).

Figure (1): ROC curve for patient outcome using the PEWS.



DISCUSSION

Our results are similar to recent publications by **Seiger *et al.*** [8] and **Breslin *et al.*** [5]. **Seiger**'s study evaluated 10 different PEWS and their ability to predict admission to the hospital or ICU. Correspondingly, they found PEWS to be moderate to good at predicting admission to the ICU (AUC of 0.79 for the Monaghan's PEWS). The optimal cutoff level on the ROC was a PEWS score of 1. Our populations had similar admission rates to the hospital and ICU, as well as overall numbers of subjects. They addressed missing data with a multiple imputation model that imputes a value drawn from an estimate of the distribution of the variable to create a complete database.

Our study included 53 patients, males were 32 (60%) and females were 21 (40%) with mean age of 17.42 ± 28.002 months. Our study agrees with **Gold *et al.*** [9] findings who reported that 12,306 patients included 45.6% females and 54.4% males with median age 47 months. They suggested that patients with missing data were more likely to go to the ICU, in contradistinction to their findings. In studies involving PEWS, the overarching conclusion was that an elevated score is associated with sicker patients at higher risk of needing ICU care [5]**.** This is logically to be expected, as PEWS is based in part on physiologic data and it is known that abnormalities in vital signs often accompany critical illness [10]**.** Notably, a study by **Panesar *et al.*** [11] on the effects of mandating medical emergency activation on the hospital floor based solely on PEWS score demonstrated an increase in medical emergency, with an overall decrease in interventions and ICU transfers and no significant change in "code blue" calls.

We also documented that pneumonia had the highest percentage diagnosis by 32.1% and then fulminant hepatic failure comes in second place by 22.6%, followed by sepsis by 13.2%. Our observation is similar to **Chaiyakulsil** and **Pandee** [12] findings where they reported that respiratory diagnosis had the highest percentage by 41.9% followed by gastrointestinal diagnosis by 24.3%. Similarly, in a survey by **Griffiths** and **Kidney** [13] in 254 general EDs in the United Kingdom, a majority of practitioners supported the use of early warning systems in the ED, despite the evidence that such scores lack sufficient sensitivity to be used as risk assessment tools.

In our study, we found that the mean duration of length of staying in hospital before admission to PICU was 2.05 ± 2.89 days, and the mean after admission to PICU was 5.16 ± 6.69 days. Patients admitted from ward were statistically higher in hospital stay before admission to PICU. Our finding are in agreement with **Breslin *et al.*** [5] and **Gold *et al.*** [9]**.** Gold found that the PEWS alone lacks sufficient statistical strength to optimally capture those patients at risk of deterioration from the ED and if used in isolation will result in the incorrect disposition of a significant cohort of patients.

We found that PEWS are likely to be critical at points in time during the 12-hours period before PICU admission in ER patients more than ward patients are and this is in line with **Gold *et al.*** [9]**.**

In P12, the patients with score less than 5 were statistically higher in ward patients while score more than 5 were lower. Notwithstanding the above findings, the continued investigation of alternative uses for the PEWS in the ED setting may be warranted. **Bonafide *et al.*** [14] published a qualitative evaluation of the PEWS

and its perceived effects on patient safety. They found that despite the marginal performance of PEWS when applied to data sets, clinicians who recently experienced failures of PEWS still considered the system valuable.

Ronald *et al.* [(15)] suggested combining the PEWS with clinician judgment to create a better system for recognition of clinical deterioration**.** They confirmed a significant increase in the use of PEWS since 2005, particularly in tertiary centers that have MET teams available. They recommended a coordinated national evaluation of implementation and standardization of the system to establish effectiveness**.** In light of such studies, the decision to implement such a tool in the ED may be undertaken as one of many clinical considerations the emergency physician balances or as a starting point for inpatient PEWS monitoring **[(16)].**

In addition, we reported that there was 11.3% dead among the studied patients. Our results concur with previous studies in demonstrating that a patient with higher PEWS is more likely to need an ICU bed. Yet, the more clinically relevant question asks whether there is an actual cutoff PEWS score determined in the ED that can reliably predict the need for ICU admission with acceptable test characteristics.

Finally, the study found that an elevated PEWS is associated with need for ICU admission directly from the ED or ward and as a transfer.

CONCLUSION

Pediatric early warning score can be helpful in predicting patient disposition in pediatric ED with acceptable validity and can serve as a potentially excellent screening tool for prediction of ICU admission.

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