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Research Article

Evaluation of a Paediatric Early Warning System (PEWS) score on admission to a paediatric intensive care unit to predict mortality risk in a low resource setting, Guinea-Bissau

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Abstract

Context

The Paediatric Early Warning System (PEWS) is a clinical monitoring tool used routinely in emergency and observation rooms to detect rapid deterioration in paediatric patients, allowing timely action. MSF has been using an adapted version of PEWS in all paediatric projects since 2013 and started using it in the Simao Mendes National Hospital (HNSM) in 2017. The PEWS has not been previously considered as a predictive tool for mortality risk. In this study, we evaluate whether the PEWS could be validated as a paediatric mortality risk score in our Paediatric Intensive Care Unit (PICU) setting.

Methods

This is an observational study with prospective data collection among children admitted to the HNSM PICU, assessing an adapted version of PEWS on admission, 24 hours after admission, and notification of the outcome of the hospitalization. Data analysis, using State 15.0, was conducted in three stages: description of participants, univariate analysis, and multivariate analysis.

Results

The main analysis showed that the greater the PEWS score, the higher the risk of death. However, only a PEWS score >7 was significantly associated with an increased risk of death, OR =5.9; 95% CI: 2.3 - 12.9, p <0.001. In addition, having an underlying pathology increased the risk of death, OR=4.2; 95% CI: 1.3 - 13.2, p=0.015. Age was not significantly associated with increased risk of death, which may be due to the small sample size of patients less than one year old. A PEWS score greater than five, 24 hours after admission, indicated a significantly higher risk of death, OR=6.2; 95% CI: 2.8 - 13.6, p<0.001.

Conclusion

Our evaluation of PEWS among children on admission to the PICU found that it could be a simple and useful predictive tool of mortality risk in low resource settings. It may allow better organization of the human resources, and improve the analysis of the mortality ratio, in a PICU. However, adequate follow-up and management of those classified as orange, yellow, or even green by the PEWS should be maintained as the PEWS would fail to identify a significant proportion of patients at risk of death.

Keywords: Low resources setting; PEWS; PICU

Introduction

The Paediatric Early Warning System (PEWS) is a scoring system based on vital signs and clinical status. It aims to identify hospitalised paediatric patients that are at increased risk of deterioration to potentially allow early treatment and the prevention of further clinical deterioration [1-5]. The PEWS has been used as a tool to identify patients at risk of admission to the PICU [6-9]. However, it has not been validated nor designed to be used in the PICU, or as a tool to assess mortality risk in the PICU.

The PEWS score is the sum of different severity sub-scores assigned to each vital and clinical sign. Médecins Sans Frontières (MSF) has been using an adapted version of the PEWS based on the Brighton version (supplementary material) in most of its paediatric projects since 2013. In 2017, this adapted version of the Brighton PEWS (hereafter referred to simply as PEWS) was introduced as a routine clinical monitoring tool used in the emergency and observation rooms as well as in the PICU to detect early deterioration in patients in the Simao Mendes National Hospital (HNSM), where the MSF team works in collaboration with the Ministry of Health. In addition to PEWS score, the project systematically tested haemoglobin and capillary glucose on PICU admission.

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In the first four months of 2017, according to MSF data, among 199 admissions to the NHSM PICU, 41 deaths (20.6%) were notified. However, 45 deaths were reported among 362 admissions in the first six months of 2017, giving a case fatality ratio of 12.4. The case fatality ratio for the patients with a PEWS score ≥ 7 was 42.9 % against 11.9% for those with a score <7. It was 40.3% for children <2 years old versus 8.2% for those ≥ 2 years old. Although our sample was small and the results were not statistically significant, there was a high proportion of death among younger patients and those with a high PEWS score.

The paediatric mortality rate in the PICU of HNSM, based on MSF data, varied from 9% to 48%, mostly reflecting the fluctuation of severely ill children admitted throughout the year. In high income countries, there are validated mortality risk scoring systems such as PRISM or PIM scores that can be used to predict short-term outcomes/death in PICUs [10-12]. However, these scores include laboratory tests and other data that are not always available in resource-limited settings. Capillary glycaemia and haemoglobin level are the only easy and routinely available tests in many low resource settings. Hypoglycaemia or hyperglycaemia has both been described as independent risk factors for mortality in PICUs in high resource settings [13] as well as in low resource settings [14]. Similarly, severe anaemia requiring blood transfusion in PICUs is associated with a worse outcome [15].

Using a simple mortality risk score in PICUs in low resource settings may facilitate the prediction of mortality risk and trigger adequate action by health care staff to reduce mortality. In addition, estimating the risk of death of patients may improve the interpretation of mortality data in a PICU and thus adapt resources. Therefore, the primary purpose of this study was to assess whether the PEWS can be used as a prognostic tool for mortality in PICUs in low resource settings. In addition, the study assessed whether a combination of parameters such as age, PEWS score, as well as basic and routinely used point-of-care biological parameters such as haemoglobin and glucose collected from capillary blood on PICU admission, could be used as a mortality risk score adapted to low resource settings.

Methods

This was an observational study with prospective collection of routine, individual data among children admitted to the HNSM PICU from April to September 2019, with an emphasis on the measurement of PEWS on admission, 24 hours after admission, and notification of the outcome of the hospitalization.

The HNSM PICU provides the highest level of care in the country. The PICU has 24 beds and admits an average of 75 children per month from one month to 15 years of age.

Based on empirical MSF data on the number of admissions and deaths in the HNSM PICU, which showed a death rate of 12.4% over a six-month period, considering that 10% of patients may be excluded for some reason (parent-caregiver self-withdrawal from the study, for example), the minimum sample size was estimated at 184 patients. Any patient beyond the neonatal period (>28 days of life) and ≤ 15 years of age, fulfilling the PICU admission criteria (supplementary material), and from whom informed consent from the caretaker for his/her child to participate in the study was obtained were included in the study.

This study utilised data routinely collected in the PICU. No additional data were collected specifically for the study. Nevertheless, a special refresher training on PEWS was conducted by paediatricians for medical staff (nurses and doctors) prior to the start of the study to ensure quality PEWS scoring.

Prospective systematic data collection included: date of admission/date of exit - length of stay, age, sex, presence or absence of known underlying conditions (sickle cell disease, cardiopathy, pulmonary disease, severe psycho-motor impairment, human immunodeficiency virus, or severe acute malnutrition), PEWS score on admission and 24 hours after admission, point-of-care capillary glucose and haemoglobin on admission as a component of routine management of PICU patients (unless not required for patient management), and final outcome.

Data were then entered and coded (each patient file number was attributed a code number) for analysis purposes. Across our entire sample, patient outcomes were categorised as: improved and transferred, died, or directly discharged.

After data cleaning, the study population was described and presented with percentages. The PEWS scores were tallied; the scores were classified as: green (0-2), yellow (3-4), orange (5-6) and red (≥ 7). Haemoglobin was classified as normal or low (supplementary material) according to the cut-off defined in the paediatric guidelines [16].

In univariate analysis, the association between death and independent factors was assessed by using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were transformed into categorical variables for analysis. Factors significantly associated with death with a p-value ≤ 0.2 were retained in multivariate analysis. In multivariate analysis, the variables selected in the previous stage were integrated into a logistic regression model to define the factors associated with death.

Prior to implementation, the study protocol was approved by the MSF Ethical Review Board and the National Ethical Committee of Guinea Bissau.

No extra participation or intervention was required from patients or caregivers. Data were anonymized. This study collected routine patient data. Consent from a parent/guardian of the patient was obtained prior to study participation.

Results

Description of sample

The inclusion period lasted five months from April to September 2019. In total, 223 patients aged one month to 15 years, including 113 males and 110 females, met the inclusion criteria and were enrolled in the study. The male to female sex ratio was 1.02 and was similar across all age groups. A total of 94 (42%) patients were 5-15 years old, 66 (30%) 2-4 years old, and 63 (28%) under 2 years old.

The highest number of admissions occurred in August. There was a gradual increase in the number of admissions over the study period (supplementary material). The PICU receives patients from different locations, depending on the referring medical service. Most patients admitted to the PICU were referred from the emergency room (supplementary material).

Patients' clinical characteristics on admission

Among the patients included, 24% were classified as red based on the PEWS score on admission (≥7), while 21% were classified as green (0-2) (Table 1).

Factor	N = 223	%
PEWS score on admission		
Green (0-2)	46	20.6
Yellow (3-4)	73	32.7
Orange (5-6)	51	22.9
Red (≥ 7)	53	23.8
Total	***223***	***100.0***
Underlying conditions		
1	114	51.1
None	66	29.6
2	33	14.8
3	10	4.4
Total	***223***	***100.0***
PEWS score 24h from admission		
Green (0-2)	97	43.7
Yellow (3-4)	60	27.0
Orange (5-6)	41	18.5
Red (≥ 7)	24	10.8
Total	***222***	***100.0***
Clinical anaemia		
Yes	11	4.9
No	212	95.1
Total	***223***	***100***
Haemoglobin level on admission		
Normal	61	27.3
Low	162	72.7
Total	***223***	***100.0***
Glycaemia (mg/dl) on admission		
<60	11	4.9
≥ 60	211	95.1
Total	***222***	***100.0***

Table 1: Patients' characteristics on admission.

Diverse diagnoses on admission were observed, however respiratory pathologies (bronchiolitis, bronchopneumonia, others) were by far the most frequent (31% of admissions), followed by malaria and diarrheal diseases (supplementary material).

Hospitalization outcomes

Main outcomes

Of the 223 patients enrolled in the study, 38 died in the PICU. The hospital mortality for the PICU service during the study period was 17%. Overall, 155 (69.5%) improved and were transferred to other services, while 30 (13.4%) were directly discharged.

Univariate analysis, association between factors and death

In univariate analysis, the risk of dying during hospitalization was higher when the PEWS score was higher. Compared to patients classified as green, patients classified as yellow (3- 4), orange (5-6) and red (≥ 7) had a higher risk of death. This risk increased from yellow to orange, and then again from orange to red. However, this increase was greater and only statistically significant when the patient was classified as red, OR=7.4; 95% CI (2.3 - 23.8), p = 0.001 (Table 2).

Factor	No. of deaths / Total no. of patients (%)	Unadjusted risk ratio (95%CI)	p-value
Gender			
Male	15/113 (13.3)		
Female	23/110 (20.9)	1.8 (0.9-3.6)	0.120
Age			
One month to <2 years	10/63 (15.9)		
2-4 years	12/66 (18.2)	1.2 (0.5-2.9)	0.728
5-14 years	16/94 (17.0)	1.1 (0.5-2.8)	0.850
Referred service			
Emergency room	28/178 (15.7)		
Other	10/45 (22.2)	1.5 (0.7-3.4)	0.300
Clinical anaemia			
No	34/212 (16.0)		
Yes	4/11 (36.4)	2.9 (0.9 - 10.8)	0.094
Underlying condition			
No	4/66 (6.1)		
Yes	34/157 (21.6)	4.3 (1.5-2.6)	0.008
Glycaemia (mg/dl)			
≥ 60	33/211 (15.6)		
<60	5/11 (45.5)	4.5 (1.3-15.6)	0.018
Haemoglobin level			
Normal	10/61 (16.4)		
Low	28/162 (17.0)	1.1 (0.5-2.3)	0.875
Admission time			
Day (7 am to 6 pm)	19/134 (14.2)		
Night (7 pm to 6 am)	19/89 (21.4)	1.6 (0.8-3.3)	0.166
PEWS score on admission			
Green (0-2)	4/46 (8.7)		
Yellow (3-4)	7/73 (9.6)	1.1 (0.3-4.0)	0.870
Orange (5-6)	5/51 (9.8)	1.1 (0.3-4.5)	0.851
Red (≥ 7)	22/53 (41.5)	7.4 (3.2-14.4)	0.001
PEWS score 24 hours after admission			
Green (0-2)	7/97 (7.2)		
Yellow (3-4)	7/60 (11.7)	1.7 (0.5-5.1)	0.346
Orange (5-6)	12/41 (29.3)	5.3 (1.9-14.8)	0.001
Red (≥ 7)	12/24 (50.0)	12.6 (4.2-39.0)	<0.001

Table 2: Univar ate analysis, association between factors and death.

For the PEWS score 24 hours after admission, we observe the same trends as with the PEWS score on admission. However, the link between death and the PEWS score 24 hours after admission is stronger and more significant (Table 2).

An evaluation of the association between baseline factors and the occurrence of patient death was performed. We observed that age and haemoglobin level on admission was not significantly associated with patient death in this study. On the contrary, without considering other

factors, having an underlying condition as well as having hypoglycaemia on admission was significantly associated with the occurrence of death (Table 2).

Multivariate analysis, association between factors and death

In multivariate analysis, the PEWS score on admission, and having an underlying medical condition, were significantly associated with the occurrence of death of patients in the PICU.

Having a red PEWS score presented a risk of death almost six times higher than having another PEWS score (green, yellow, or orange), OR = 5.9; 95% CI (2.3 - 12.9), p<0.001. Having an underlying pathology increased the risk of death during hospitalization by more than four times compared to patients without an underlying pathology, OR = 4.2; 95% CI (1.3-13.2), p=0.015 (Table 3).

Factors associated with death	No. of deaths / Total no. of patients (%)	Adjusted risk ratio (95%CI)	p-value
Considering the PEWS score on admission			
PEWS score on admission			
Green/Yellow/Orange	16/178 (9.4)		
Red	22/53 (41.5)	5.9 (2.3-12.9)	<0.001
Underlying condition			
No	4/66 (6.1)		
Yes	34/157 (21.6)	4.2 (1.3-13.1)	0.015
Glycaemia (mg/dl)			
≥ 60	33/211 (15.6)		
<60	5/11 (45.5)	3.3 (0.82-13.1)	0.092
Considering the PEWS score 24 hours after admission			
PEWS score 24 hours after admission			
Green/Yellow (0-4)	14/157 (8.9)		
Red/Orange (≥ 5)	24/65 (36.9)	6.2 (2.8-13.6)	<0.001
Underlying condition			
No	4/66 (6.1)		
Yes	34/157 (21.6)	3.7 (1.2-1.2)	0.023
Glycaemia (mg/dl)			
≥ 60	33/211 (15.6)		
<60	5/11 (45.5)	6.4 (1.5-27.1)	0.012

Table 3: Multivariate analysis, association between factors and death.

We observed that a PEWS score 24 hours after admission to a PICU greater than or equal to five increased the risk of death by more than six times. In addition to the PEWS score, having an underlying pathology as well as low blood glucose levels on admission remained significantly associated with the risk of death in the PICU (Table 3).

Discussion

PEWS are monitoring tool that identifies children with rapid deterioration requiring an increased level of care. To our knowledge, it has not been used to assess patients' risk of death once admitted to an ICU. The present study sought to assess the link between the PEWS score of patients on admission to intensive care and their likely outcome. The main analysis carried out based on four levels of PEWS scores on admission, showed that the greater the score the higher the risk of death. However, only a PEWS score >7 was significantly associated with an increased risk of death, OR = 5.9; (95% CI: 2.3 - 12.9, p <0.001). In addition, having an underlying pathology increased the risk of death. Age was not significantly associated with increased risk of death, which may be due to the small sample size of patients under one year old.

The point-of-care (POC) haemoglobin measure showed anaemia in 73% of our patients. However, patients admitted for clinical anaemia represented only 4.9% of all patients. Thus, more than 67% of cases of anaemia were not detected by clinical examination of the patients. This shows the difficulty of detecting clinical anaemia and highlights the added value of point-of-care haemoglobin tests. No statistically significant association was detected between anaemia and death. The study did not take place during the peak of the malaria period (from October to December in Guinea Bissau), therefore only a few patients had low haemoglobin levels (less than 4 g or even less than 6 g) or clinical anaemia; to explore the link between the risk of death and anaemia, research should be conducted at a time when the incidence of anaemia is expected to be higher.

We explored the interaction between a PEWS score 24 hours after admission >5, an underlying pathology, and a blood sugar level lower than 60 mg/dl. However, very few patients presented these factors at the same time, precluding our ability to draw conclusions on their potential interaction.

A PEWS score threshold of five or more 24 hours after admission discriminates as well as a threshold of seven on admission; it multiplies the risk of death by six. Similarly, this risk is multiplied by nearly four when there is an underlying pathology and by six when there is hypoglycaemia on admission.

We also observed that if the PEWS score remains greater than or equal to five 24 hours after admission in an intensive care unit, the risk of death remains high.

The PEWS score could then help revise our way of working; for instance, a single nurse could be assigned to a newly admitted patient (1:1 nurse/patient ratio) if the PEWS score is above seven at admission. Thereafter, if the PEWS score falls below five after 24 hours of hospitalisation, the nurse/patient ratio could be reduced. It should be noted, however, that the PEWS score on admission failed to detect in a timely manner the high risk of death of almost half of the patients who died. This suggests that although patients classified as red according to the PEWS score had a higher risk of death, intensifying the follow-up of these patients should not affect the follow-up and adequate management of those classified as green, yellow, or orange.

This association between the PEWS score and mortality risk may also improve the assessment of the performance of an ICU. Mortality in the ICU should be assessed in relation to the proportion of patients admitted with a high PEWS score (>7).

Limitations

The main limitation of this study was the short study period and the season which hindered the analysis of some variables. Although PEWS offers a more objective patient assessment, some minor subjectivity remains in scoring. Indeed, despite trainings in the unit we still found minor disparities in clinical assessments between nurses. The heterogeneity of the age of our participants must also be considered as a limitation.

Conclusion

We found that independent of other factors, having a PEWS score on admission greater than or equal to seven increases the risk of death by almost six. Having an underlying pathology was also significantly associated with a greater risk of death (OR=4) as was having a low blood glucose level on admission (OR=3.3), although the latter was not statistically significant. In addition, we found that regardless of the PEWS score at admission, a PEWS score greater than or equal to five 24 hours after admission indicated a 5-fold increased risk of death. The PEWS evaluated in children on admission to the ICU combined with the assessment of the presence of an underlying pathology on admission constitutes a simple and useful predictive tool of mortality risk in MSF-paediatric settings. Using this predictive tool may therefore allow better organization of the human resources in the PICU by allocating or redistributing staff to those patients identified as having a higher risk of death. However, adequate follow-up and management of those classified as orange, yellow, or even green by the PEWS measure should be maintained as the PEWS would fail to identify a significant proportion of patients at risk of death. It also could improve the analysis of the mortality ratio in a PICU.

Further research is needed to include patients during the peak season for malaria. This could allow the creation of a global score to predict the prognosis of patients admitted to the PICU based on the PEWS, blood glucose, haemoglobin, and underlying pathologies.

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Ethics

This study was approved by the MSF and the Guinea-Bissau Ministry of Health Ethics Review Boards.

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