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ABSTRACT

Introduction. Clinical deterioration in hospitalized pediatric patients is often preceded by early signs that healthcare personnel may not recognize. Implementing validated early warning systems, such as the EWAS (Early Warning Assessment Scale), aims to improve early detection of clinical deterioration. We describe the process of implementing EWAS in a general pediatric ward and analyze its impact on the incidence of clinical deterioration events and their morbidity and mortality.

Methods. Before-and-after study. Patients with clinical deterioration events before and after EWAS implementation were included. Event rates, mortality, and critical interventions in the general ward were compared.

Results. There were 7.64 events per 1000 patient days pre-implementation and 6.42 per 1000 patient days post-implementation ($p = 0.34$). Associated mortality decreased from 9.43% to 3.03% ($p = 0.14$). There were no significant differences in mechanical ventilation, inotropics, or length of stay. A significant reduction in critical interventions performed in the general ward was observed: 15.4% pre-implementation vs. 3.0% post-implementation ($p = 0.01$). The error rate in EWAS use remained <15% throughout the implementation.

Conclusion. The implementation of EWAS was feasible and had good adherence. Although no significant differences in mortality were observed, the reduction in critical interventions outside the PICU suggests improved identification and response to clinical deterioration, which is why we consider EWAS a useful tool in the context of care safety strategies.

Keywords: early warning; early warning score; mortality; clinical deterioration.

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INTRODUCTION

Clinical deterioration in hospitalized pediatric patients often follows a phase of physiological instability that may go unnoticed by healthcare personnel, leading to preventable adverse outcomes such as cardiopulmonary arrest (CPA).¹ Although the latter situation is rare, occurring in 2-6% of patients admitted to pediatric intensive care units (PICUs) and in 0.7-2% of those admitted to general pediatric wards, the associated mortality is high (50-57%), especially when arrests occur outside specialized units.²⁻⁶ Retrospective analyses have shown that most in-hospital pediatric deaths are potentially preventable; failure to recognize early signs of clinical deterioration and poor team communication were identified as major contributing factors.¹

To address this challenge, standardized pediatric early warning scale (PEWS) have been developed and validated internationally to help identify and promptly transfer patients whose condition is deteriorating.⁷⁻¹⁴ In our country, Elenchwajg et al. conducted an observational, cross-sectional study to evaluate the usefulness of the Brighton PEWS in predicting clinical deterioration in hospitalized children.¹⁵

Specific adaptations have also been made for children with complex comorbidities, such as congenital heart disease or cancer.¹⁶⁻¹⁸ In Latin America, the Early Warning Assessment Score (EAWAS) scale, derived from the Boston Children's Hospital PEWS, adapted to Spanish and promoted by St. Jude Children's Research Hospital, has shown promise in improving clinical outcomes in resource-limited settings, especially among pediatric cancer patients.¹⁸⁻²¹ The EWAS Project began in Guatemala's National Pediatric Oncology Unit in 2014, with results showing a significant reduction in unplanned PICU transfers.^{19,20} This led to multicenter expansion in 2017 to other Latin American hospitals that treat cancer patients.²⁰ Interested hospitals apply to join an annual cohort and are supported by regional training centers.^{20,21}

At our hospital, we conducted an observational study that identified a rate of unplanned PICU transfers of 21 per 1000 admissions, with a considerable associated mortality rate (8.96%).²² We then decided to join the EWAS collaboration to improve the early detection of clinical deterioration.

The present study seeks to describe the systematic implementation of EWAS in a general

pediatric inpatient unit and, secondarily, to compare the incidence and characteristics of clinical deterioration events before and after EWAS use, and to assess whether EWAS affects morbidity and mortality.

METHODS

Context and setting

This quality improvement initiative was carried out at a private, non-profit, high-complexity university hospital that cares for pediatric patients with a wide range of medical and surgical conditions, including oncology, bone marrow transplantation, cardiology, cardiac surgery, and solid organ transplantation.

Study design

A before-and-after study was designed to compare clinical deterioration events in pediatric patients admitted to the general hospitalization unit before (April 1, 2019, to March 31, 2020) and after (April 1, 2020, to November 30, 2021) the implementation of EWAS.

Inclusion and exclusion criteria

All patients aged 30 days or older and 18 years or younger admitted to the general pediatrics ward during the study period were eligible. Patients receiving palliative care or those with planned transfers to the PICU were excluded.

Definitions

Unplanned transfer to the PICU: due to increased monitoring or care requirements, the patient must be transferred to the PICU on an unscheduled basis.

Deterioration event: any event requiring unplanned transfer to the PICU, and/or mechanical ventilation on the ward, and/or requirement for inotropic agents on the ward, and/or cardiopulmonary resuscitation on the ward, or when non-palliative death occurs on the ward.

PICU interventions on the ward: patients who, due to the severity of their clinical deterioration, require PICU-level therapeutic measures to be initiated in the general pediatric ward before being transferred to the PICU (invasive and non-invasive mechanical ventilation, inotropics, cardiopulmonary resuscitation).

Critical deterioration: patients who, due to the severity of their clinical deterioration, require the aforementioned PICU-level therapeutic measures to be initiated within the first 12 hours of admission to the PICU.

Intervention: implementation of EWAS

Description of EWAS

The EWAS scale is a tool administered by nurses that is based on five clinical domains: neurological, cardiovascular, respiratory status, nurse concern, and family concern, and gives a score from 0 to 11 (Figure 1). Based on the result, patients are stratified into risk categories (green: 0-2, yellow: 3-4, red: 5-11), which triggers pre-established escalation protocols that include increased monitoring and timely involvement of UCIP specialists (Figure 2). The decision to transfer a patient to a higher level of care is ultimately based on clinical judgment, not solely on the EWAS score.

Implementation process

Implementation was carried out in three phases:

Pre-implementation (April 2019-March 2020). The local team, composed of nurses and pediatricians from the inpatient ward and an intensivist, received guidance and training from the regional EWAS center. Subsequently, the local team trained all ward staff through structured theoretical and practical sessions, which included bedside demonstrations. A three-month pilot test (January-March 2020) allowed for adaptation

and refinement, which included, in addition to the project itself, the standardization of the vital signs measurement procedure. Baseline metrics were established through prospective, anonymous data collection on episodes of clinical deterioration and patient volume.

Implementation (since April 2020). Full implementation of EWAS involved continuous quality control. Success was defined as fewer than 15% errors in using the tool and algorithm for two consecutive months, a goal achieved in the first two months.

Sustainability (from achievement of implementation milestones through November 2021). Continuous monthly data collection and submission to St. Jude ensured ongoing oversight for 18 months, after which the hospital assumed independent administration of EWAS.

Quality measures

Quality indicators included the correct application of EWAS and compliance with the escalation algorithm. Errors were classified as omissions (failure to record EWAS with each vital sign assessment), calculation errors, and noncompliance with the algorithm during escalation. Biweekly reviews of all patient medical

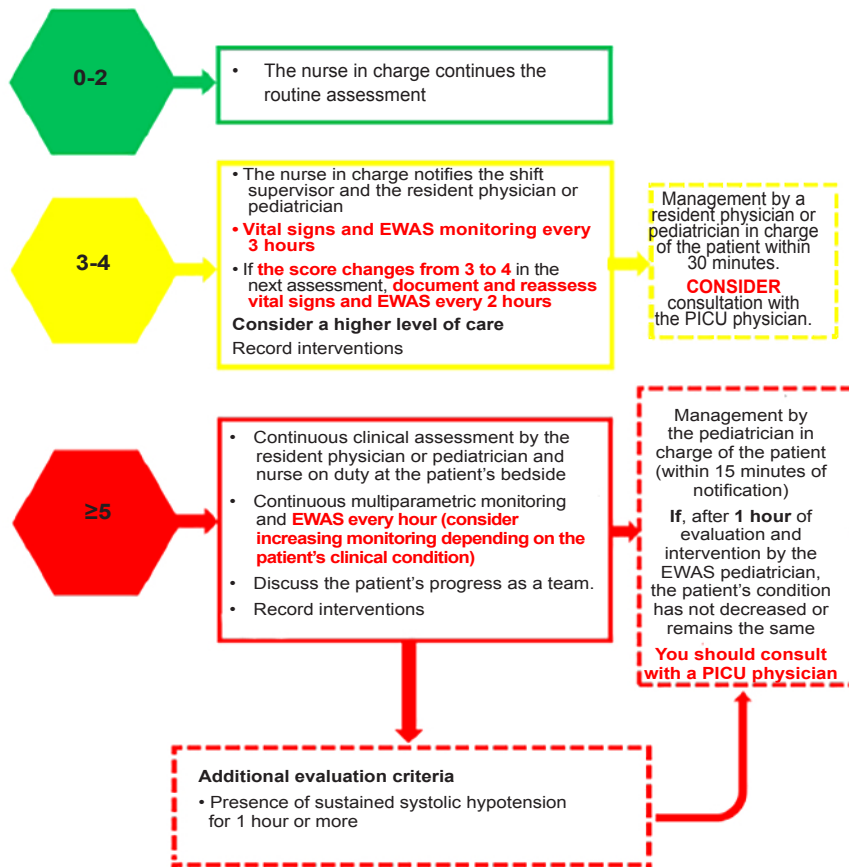
FIGURE 1. Early warning assessment scale (EWAS)

EARLY WARNING ASSESSMENT SCALE						
		3	2	1	0	Total
Assessment/behavior	Neurological	<ul style="list-style-type: none"> Lethargic Confused Lack of energy Does not respond to stimuli Has seizures Pupils do not respond to the light 	<ul style="list-style-type: none"> Irritable Difficult to control Responds only to painful stimuli 	<ul style="list-style-type: none"> Drowsy Responds to verbal stimuli 	<ul style="list-style-type: none"> Alert Sleeping comfortably Usual neurological status 	
	Cardiovascular	<ul style="list-style-type: none"> Reticulated Capillary refill time <5" Severe tachycardia for age* Symptomatic bradycardia (syncope, dizziness, sweating) Irregular heart rhythm (non-sinus, extrasystole) 	<ul style="list-style-type: none"> Cyanosis Capillary refill time 4-5" Moderate tachycardia for age* Peripheral pulses decreased 	<ul style="list-style-type: none"> Pale Rosy Capillary refill time 3" Mild tachycardia for age* 	<ul style="list-style-type: none"> Usual skin color for the patient Capillary refill time ≤2" Peripheral pulses present and regular 	
	Respiratory	<ul style="list-style-type: none"> Severe tachypnea for age* RR below normal for age Severe respiratory effort (generalized retractions, thoracoabdominal dissociation, gasping) Oxygen with a reservoir mask Saturation <90% with O₂ Apnea 	<ul style="list-style-type: none"> Moderate respiratory effort (nose flaring, intercostal retraction, moaning) 1-3 liters of O₂ with nasal cannula Venturi mask (all of them) Saturation 88-89% without O₂ 	<ul style="list-style-type: none"> Mild tachypnea for age Mild respiratory effort (subcostal) ≤1 liter of O₂ with nasal cannula Saturation 90-93% without O₂ 	<ul style="list-style-type: none"> Normal respiratory rate No retraction Saturation ≥94% 	
	Nursing concern				Concerned	Not concerned
Concern of the family				Concerned or absent	Not concerned and present	
Total result						

**See vital sign parameters according to age.

RR: respiratory rate.

Figure 2. Early Warning Assessment Scale intervention algorithm



records, including random weekend audits, assessed fidelity. For all EWAS scores ≥ 5 , compliance with escalation and patient outcomes was examined.

Ethical considerations

From the outset, the project had institutional backing, complied with the Declaration of Helsinki, ICH E6 Good Clinical Practices, and national regulations (ANMAT Provision 6677/10 and Ministry of Health Resolution 1480/11), and was approved by the Institutional Ethics Committee (CIE 17-014). The data were anonymized and managed in accordance with Argentine law (Law 25326 on Personal Data Protection).

Data collection and statistical analysis

All admissions during the study period were included; each admission and each episode of clinical deterioration were analyzed as independent events. The exposed group consisted of patients treated with EWAS, and the unexposed group included those treated before the scale's introduction. Continuous variables

were described as mean \pm standard deviation (SD), or median with interquartile range (IQR), as appropriate, and categorical variables were reported as counts and percentages. Incidence rates (events per 1000 patient days) and relative risks were calculated. Differences between groups were assessed using t-tests or Wilcoxon rank sum tests for continuous variables and chi-square tests for categorical variables. Statistical significance was set at $p < 0.05$. Analyses were performed using Stata version 14.

RESULTS

During the pre-implementation phase, there were 2086 admissions and 53 cases of clinical deterioration (2.54%), in 6929 patient days (7.64 cases/1000 patient days). In the post-implementation period, there were 2566 admissions and 66 cases (2.57%) in 10275 patient days (6.42 events/1000 patient days; relative incidence rate [RIR]: 1.19, 95% CI: 0.83-1.71, $p = 0.34$). The mean age of patients, the proportion of males, and the prevalence of chronic comorbidities were

similar between groups, with a predominance of oncohematological diagnoses (*Table 1*).

Process measures

The application of the EWAS scale and the use of the algorithm always exceeded 90%, with error rates consistently below 15% (*Figure 3*). All patients with EWAS scores ≥ 5 were appropriately escalated according to the algorithm.

Incidence and severity of deterioration events

Although the proportion of admissions that experienced deterioration and the rate of events per 1000 patient days were numerically lower after EWAS implementation, these differences did not reach statistical significance (*Table 2*). The overall mortality associated with clinical deterioration was 5.88% (95% CI: 2.79-11.94). When comparing both periods, mortality decreased from 9.43% to 3.03%, but this difference did not reach statistical significance ($p = 0.14$; OR: 0.30, 95% CI: 0.05-1.65).

The need for PICU-level interventions in the general ward before transfer was significantly lower after implementation (from 15.38% to 3.03%; $p = 0.01$; OR: 0.17, 95% CI: 0.03-0.88), representing an 83% reduction. The incidence of critical deterioration events decreased from 40.38% to 28.79% ($p = 0.18$; OR: 0.59, 95% CI: 0.27-1.29).

The need for mechanical ventilation, vasoactive support, length of stay, and days in the PICU showed no significant differences between periods (*Table 2* and *Figure 4*).

DISCUSSION

This study presents the results of the structured implementation of the EWAS tool in a heterogeneous, highly complex general pediatric hospitalization setting. The greatest strength has been the description of the implementation of an early warning scale in Spanish, validated for a population other than oncology, providing evidence of its effectiveness in the general pediatric population. It also underscores the importance of warning about the need to perform critical interventions in time so that they can be implemented in a controlled, monitored environment. The data demonstrate a high fidelity to the intervention and suggest a clinically significant reduction in the need for urgent critical interventions in the general ward, as well as a trend toward lower event and mortality rates, in line with the main objectives of the EWAS collaboration.¹⁹⁻²² The results are consistent with previous EWAS reports, which document a decrease in unplanned transfers to the PICU, improved communication between teams, optimized resource utilization, reduced healthcare costs, and improved perceptions of the quality of care among pediatric cancer patients in the Americas.^{19,20,22-24}

TABLE 1. Characteristics of the population before and after implementation of the Early Warning Assessment Scale

Variable	Pre-EWAS (n = 53)	Post-EWAS (n = 66)	p
1-Age (years)	6.06 (95% CI 4.46-7.66)	5.83 (95% CI 4.52-7.13)	0.81
2-Male gender n (%)	32 (60.38%)	34 (51.52%)	0.33
3-Comorbidity present n (%)	45 (84.91%)	56 (84.85%)	0.99
4-PIM-2 (mean)	4.13 (95% CI 2.63-5.62)	3.07 (95% CI 2.09-4.05)	0.23
4-Type of underlying pathology n (%)			
a-Oncohematological	22 (48.89%)	23 (41.07%)	
b-Solid organ transplant	6 (13.33%)	2 (3.57%)	
c-Congenital heart disease	2 (4.44%)	6 (10.71%)	
d-Neurological disease	5 (11.11%)	7 (12.50%)	
e-Other pathologies	10 (22.22%)	18 (32.14%)	
5-Main reason for transfer n (%)			
a-Respiratory distress	30 (56.60%)	25 (37.88%)	0.32
b-Hemodynamic instability	10 (18.87%)	15 (22.73%)	
c-Neurological cause	3 (5.66%)	8 (12.12%)	
d-Other reasons and monitoring needs	10 (18.86%)	18 (27.28%)	

EWAS: Early Warning Assessment Scale, PIM-2: Pediatric Index of Mortality 2.

TABLE 2. Pre- and post-implementation clinical results of the Early Warning Assessment Scale

Result	Pre-EWAS (n = 53)	Post-EWAS (n = 66)	p / OR
Mortality n (%)	5 (9.43%)	2 (3.03%)	p = 0.14; OR 0.30 (95% CI 0.05-1.65)
MV n (%)	23 (43.40%)	18 (27.27%)	p = 0.066; OR 0.48 (95% CI 0.22-1.06)
Inotropics n (%)	14 (26.42%)	13 (19.70%)	p = 0.38; OR 0.68 (95% CI 0.28-1.62)
PICU floor interventions n (%)	8 (15.38%)	2 (3.03%)	p = 0.01; OR 0.17 (95% CI 0.03-0.88)
Critical deterioration n (%)	21 (40.38%)	19 (28.79%)	p = 0.18; OR 0.59 (95% CI 0.27-1.29)
Days hospitalized in PICU (mean)	11.47 (95% CI 7.80-15.13)	12.83 (95% CI 8.16-17.49)	p = 0.64 p = 0.77
Total hospital stay (mean)	35.33 (95% CI 20.05-50.62)	38.03 (95% CI 27.76-49.29)	

MV: mechanical ventilation; PICU: pediatric intensive care unit.

Mortality has been widely explored as an outcome in the evaluation of early warning systems. Although a recent multicenter observational study demonstrated a decrease in mortality associated with clinical deterioration following the implementation of EWAS,²¹ we did not observe statistically significant reductions in overall mortality or other outcomes such as mechanical ventilation, use of inotropes, total length of stay, and length of stay in the PICU in our study, as was also the case in larger multicenter studies.²⁵

Meta-analyses and systematic reviews have failed to demonstrate consistent mortality benefits associated with early warning systems in pediatric

populations treated in highly complex settings. This could be explained by the low incidence of critical events at this stage of life and by the fact that early detection of clinical deterioration is neither linear nor simple.^{7,9,10,26,27} Conversely, in resource-limited settings, early warning systems have been shown to reduce mortality, despite the logistical and structural challenges they pose.^{9,21,28} These observations underscore the importance of context in both the implementation and evaluation of safety interventions.

Early warning systems, including EWAS, serve not only as diagnostic aids but also as catalysts for cultural change, promoting situational awareness among staff and proactive escalation

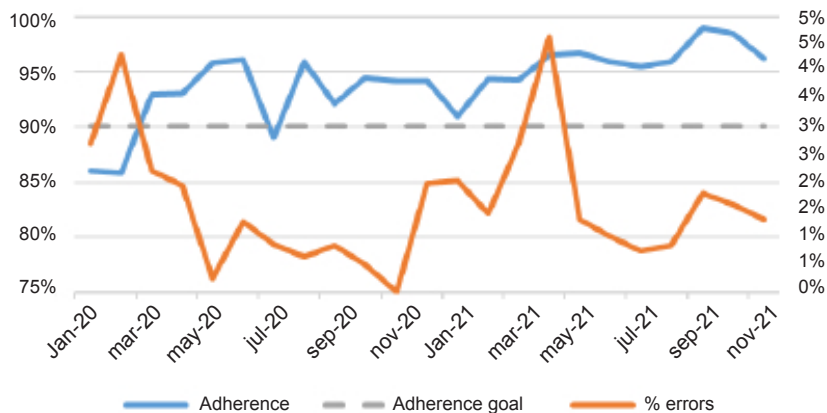
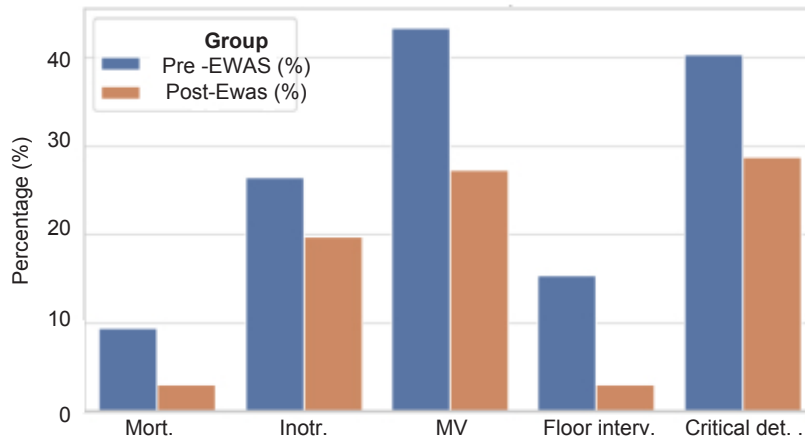
FIGURE 3. Adherence and errors in the Early Warning Assessment Scale

FIGURE 4. Comparison of clinical outcomes before and after implementation of the Early Warning Assessment Scale

Mort.: mortality

Inotr.: use of inotropic agents

MV: mechanical ventilation

Floor interv.: critical floor interventions performed before transfer to the PICU

Critical det.: critical deterioration

of care.^{22,23,29} Our results, particularly the significant reduction in the need for urgent critical interventions in the general ward, highlight the system's success in facilitating timely transfer to higher-acuity settings where specialized staff and resources are available. This is consistent with the primary goal of the EWAS project: to improve the quality and safety of pediatric hospital care by ensuring that critical interventions are performed in the most appropriate setting.²⁰

Given the low frequency of mortality and cases of serious deterioration in tertiary pediatric care, the reliability of these outcomes as sole measures of effectiveness is increasingly being questioned.^{26,29,30} Process measures, such as the rate of critical interventions performed outside the PICU, may provide more sensitive indicators of the impact on safety and quality improvement.

Limitations

There are several limitations worth mentioning. Given that this study was conducted in a single highly specialized center, it may limit generalizability. However, it provides evidence that can be replicated and tested in simpler centers, as EWAS implementation is cost-effective and does not require complex technology. The observational design and small sample size reduce statistical power, especially for rare events such as mortality. Although rigorous process monitoring was employed, unmeasured

confounding factors and secular trends cannot be ruled out. Finally, as with all diagnostic scores, the effectiveness of EWAS depends on its consistent use, its integration into clinical workflows, and the presence of responsive escalation systems, all of which may vary between institutions and health systems.

CONCLUSION

The implementation of EWAS in a general pediatric inpatient unit was feasible, achieved high adherence, and was associated with a significant reduction in the need for urgent critical interventions outside the PICU. Although reductions in event and mortality rates were observed, these did not reach statistical significance, consistent with the previous literature. These findings support the usefulness of early warning systems as part of a broader patient safety culture, emphasizing the timely recognition of deteriorating pediatric patients and the escalation of care. ■

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