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Use of the Children's Observation and Severity Tool (COAST), an Adaptation of the Paediatric Early Warning Score, in the Emergency Department as a Predictor for Hospital Admission: A Retrospective Cohort Study

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Use of the Children's Observation and Severity Tool (COAST), an Adaptation of the Paediatric Early Warning Score, in the Emergency Department as a Predictor for Hospital Admission: A Retrospective Cohort Study

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Abstract: Background: Paediatric Early warning scores (PEWS) are designed to detect the clinically unwell or deteriorating child within a hospital setting. There is a drive within the NHS to standardise this scoring system across various settings. According to the Royal College of Paediatrics and Child Health, there is currently a national review on triage tools used within emergency departments, however evidence to date is scarce. Within Chelsea and Westminster NHS Foundation Trust, we utilise both the Manchester Triage System (MTS) and the Children's Observation and Severity tool (COAST), an adaption of PEWS, in our Paediatric Emergency Department (PED). Methods: This retrospective cohort study is the largest of its kind, and was performed to both validate COAST and determine if it is a good predictor of hospital admission. Demographic data, initial MTS scores, initial COAST scores and admission outcomes of 41030 paediatric emergency department attendances were analysed, encompassing 27196 unique patients. Results: Results demonstrated that high COAST scores on arrival are strongly correlated with hospital admission, with positive predictive values of 59.52% with COAST of ≥3 and 100% for with score threshold of ≥5. In comparison with the MTS, COAST is better at predicting admission. **Conclusions**: We conclude that COAST performs well in correlating to and thus predicting paediatric hospital admission outcome from the PED.

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1. Introduction

In 2018, NHS England, in conjunction with the Royal College of Paediatric and Child Health and the Royal College of Nursing, began a project to develop a national early warning scoring system for paediatric observations. [1] The aim was to develop a standardised system-wide program that allows for prompt recognition of the deteriorating child within healthcare settings. Appropriate escalation strategies are then triggered, which improves communication between teams and ultimately has a positive impact on improving patient outcomes and reducing adverse events. The hypothesis is that a standardised system would help to alleviate inconsistencies between English hospital sites and reduce challenges for staff moving between hospitals [2]. In November 2023, NHS England published the outcome of this collaboration as the National Paediatric Early Warning System (nPEWS) observation and escalation charts [3].

The nPEWS charts are intended for use on inpatient wards. In January 2024, the Royal College of Emergency Medicine (RCEM) released a statement warning that the nPEWS chart is not validated for use in the emergency department. It states that there may be other scoring systems which are better at quickly and reliably identifying those children who are likely to require admission [4-6]. This provided the stimulus for this project.

Previous studies and literature reviews have evaluated a range of escalation and observation tools within various hospital settings [7-10]. These show the wide heterogenicity in the use of

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paediatric triage and escalation tools used both in England and internationally, but that as a concept they can be useful in escalating care for unwell children. As such, RCEM recommend that each PED use an early warning score which they feel is most appropriate to their service [6].

Chelsea and Westminster Hospital NHS Foundation Trust is a busy hospital based in North-West London, serving a population of more than 1.5 million people [11]. It has a separate specialist PED and is a training site for sub-specialty Paediatric Emergency Medicine trainees.

Since 2014, Chelsea & Westminster Hospital PED has been utilising two tools to highlight patients requiring urgent treatment and identify children presenting with severe illness. The Manchester Triage Score (MTS) is used for nurse-led triage. Originally developed by the NHS Institute for Innovation and Improvement, a set of adapted PEWS charts called the Children's Observation and Severity Tool (COAST) is also used [5]. The COAST scoring system strives to rapidly determine which children may require enhanced medical attention based on an initial set of clinical observations.

A brief literature review by the authors unveiled only one paper evaluating COAST's ability to predict hospital admission [5]. We feel that this small cohort study did not provide enough evidence for our department to continue using COAST without further validation. Note, the low evidence base for COAST is not unusual in the context of paediatric observation tools. [10]

Previous studies and literature reviews have evaluated a range of escalation and observation tools [7-10]. These show the wide heterogenicity in the use of paediatric triage and escalation tools used both in England and internationally, but that as a concept they can be useful in escalating care for unwell children. The Manchester Triage system is a validated tool which is also used at Chelsea & Westminster and provides a useful comparator to COAST in this study [8,12].

It is in this context that the aim of this study is to evaluate the efficacy of COAST in predicting hospital admission for children on presentation to the emergency department. With this study we hope to provide an improved evidence base for COAST that supports its continued use as a paediatric observation tool in the emergency department and to demonstrate that it is an effective tool to predict admission.

2. Materials and Methods

The site of this study was Chelsea and Westminster Hospital in London, England. Data collected was from 1st September 2023 to 1st September 2024. Data was pulled from Cerner, our electronic patient record system in use, in which nursing staff record a triage (MTS) score on arrival in PED and a COAST score based on a patient's initial set of observations. Data was analysed using Microsoft Excel and statistical software [13]. For this study only the first COAST score entered was chosen, as subsequent scores may have been altered by medical management or other changes in circumstances. Demographic data and unique patient number were discussed to allow greater context for the data.

The end metric chosen was admission to hospital. All other discharge outcomes were classed as "not admitted". Of important note, children attending Chelsea and Westminster PED with minor injuries or similar conditions do not have their observations taken. This accounts for the large number of "not recorded" results below.

Table 1 shows the COAST scoring criteria used by the nursing staff, giving a minimum score of 0 and a maximum score of 6. Table 2 shows the normal limits used for scoring heart rate and respiratory rate.

Table 1. COAST Scoring Criteria

COAST Scoring Section	Score 0	Score 1
Nurse/Parent Concern	None	Yes
Respiratory Rate	Within Normal Limits	Outside Normal Limits
Respiratory Distress	Nil/Mild	Moderate/Severe
Requiring O2	No	Yes
Heart Rate	Within Normal Limits	Outside Normal Limits

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Behavior (AVPU)	A	VPU

Table 2. COAST Normal Limits

Age	Heart Rate	Respiratory Rate
<1	90-160	30-60
1-4	90-140	20-40
5-12	70-120	20-30
13-19	60-100	10-20

Admission outcomes for initial COAST ≥1 to ≥5 were used to calculate sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), positive likelihood ratios and negative likelihood ratios with 95% confidence intervals using Excel and statistical software. This is in keeping with similar research on PEWS [7]. False positive rates were also calculated (patients not admitted who had scores over the score threshold / all patients not admitted). Performance of increasing COAST score thresholds are discussed below.

The Manchester Triage System (MTS) is used in triage. It uses standardised signs and symptoms to assess patients attending the emergency department, aiming to ensure patients are assessed in order of clinical priority [12]. We have analysed data from the same patient cohort to assess performance of MTS scores in predicting patient admissions, and to compare to values obtained for COAST analysis.

Table 3. Manchester Triage System (MTS)

MTS Score	Indicative clinical signs / symptoms
1 (Immediate)	Airway compromise, inadequate breathing, stridor, drooling, shock, unresponsive.
2 (Very urgent)	Very low PEFR, very low SaO2m increased work of breathing, unable to talk in sentences, significant respiratory history, acute onset after injury, responds to voice or pain only, exhaustion.
3 (Urgent)	Low PEFR, low SaO2, inappropriate history, pleuritic pain.
4 (Standard)	Wheeze, chest infection, chest injury, recent problem.
5 (Non-urgent)	No features mentioned above.

3. Results

In total, 41031 PED attendances were reviewed, attributed to 27197 unique patients. A single anomalous result, a COAST score of 8, was removed from analysis due to administration error (the highest possible COAST score is 6). Therefore 41030 attendances of 27196 unique patients were analysed.

2960 patients were admitted, giving an overall admission rate of 7.2%. 38070 patients were not admitted, a figure which includes 1658 patients who left before treatment was complete and 504 who were streamed to other services. 4 patients were dead on arrival to PED and did not have PEWS recorded.

Table 4 shows the demographic breakdown of the patient population. A significant proportion of the patients were below the age of 5 (58.9%). 55.2% of patients were male. The varied ethnic diversity of the cohort reflects the central London population, allowing this study to be more widely generalised.

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Table 4. Demographics.

Demographics	Sub-section	Number	Percentage
Age	0	7599	18.5%
	1-5	16557	40.4%
	6-10	9089	22.2%
	11-15	7786	19.0%
Sex	Male	22664	55.2%
	Female	18361	44.7%
Ethnicity	Other White	11909	29.0%
	White British	8157	19.9%
	Asian	6767	16.5%
	Other	5595	13.6%
	Black	4272	10.4%
	Mixed	4048	9.9%
	Not stated	1618	3.9%

The relationship between initial COAST scores and admission rates is detailed in Table 5, where a clear trend emerges. There is a strong positive correlation between admission rate and increasing initial COAST: from 6.6% of patients who were admitted scoring 0, to 100% of patients who were admitted scoring 5.

Table 5. COAST scoring system and admission rates

Initial PEWS Score	Admitted	Not Admitted	Admission Rate (%)
0	1346	18932	6.6%
1	809	6693	10.8%
2	484	1497	24.4%
3	196	169	53.7%
4	64	18	78.0%
5	15	0	100%
Not Recorded	46	10761	0.4%
Total	2960	38070	7.2%

Table 6 groups together the data for COAST scores (≥1 to ≥5) to allow a more detailed examination of admission outcome against increasing 6EWS score thresholds.

Table 6. Analysis – grouped initial COAST Scores and admission numbers

	Admitted		Not Admitted	
Initial PEWS	PEWS score > threshold	PEWS score < threshold	PEWS score > threshold	PEWS score < threshold
≥1	1568	1346	8377	18932
≥2	759	2155	1684	25625
≥3	275	2639	187	27122
≥4	79	2835	18	27291
≥5	15	2899	0	27309

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To evaluate the predictive accuracy of COAST regarding admission, key analytic metrics of performance were calculated for each threshold, as presented in Tables 7a and 7b. At a threshold of ≥1, sensitivity was 51.81% and specificity 69.33%, with a positive predictive value of 15.77% and high negative predictive value of 93.36%. Sensitivity decreases with increasing thresholds of COAST, falling to less than 10% at scores ≥3, while specificity sharply rises with increased COAST scores. At COAST ≥2 the sensitivity for capturing admissions is 93.83%, rising to greater than 99% at COAST of ≥3 and to 100% for a threshold of ≥5.

Table 7a. Analysis – performance characteristics of initial COAST Scores in reflecting admissions

Initial PEWS	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
≥1	51.81% (51.98 to 55.63%)	69.33% (68.77 to 69.87%)	15.77% (15.27 to 16.28%)	93.36% (93.11 to 93.61%)
≥2	26.05% (24.46 to 27.68%)	93.83% (93.54 to 94.12%)	31.07% (29.45 to 32.73%)	92.24% (92.09 to 92.40%)
≥3	9.44% (8.40 to 10.56%)	99.32% (99.21 to 99.41%)	59.52% (55.08 to 63.82%)	91.13% (91.04 to 91.23%)
≥4	2.71% (2.15 to 3.37%)	99.93% (99.90 to 99.96%)	81.44% (72.48 to 87.97%)	90.59% (90.54 to 90.64%)
≥5	0.51% (0.29 to 0.85%)	100.00% (99.99 to 100%)	100.00% (78.20 to 100%)	90.40% (90.38 to 90.43%)

Table 7. b. Analysis – performance characteristics of initial COAST Scores in reflecting admissions.

Initial PEWS	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)	False Positive Rate (FPR)
≥1	1.75 (1.69 to 1.82)	0.67 (0.64 to 0.69)	30.67%
≥2	4.22 (3.91 to 4.56)	0.79 (0.77 to 0.81)	6.17%
≥3	13.78 (11.49 to 16.53)	0.91 (0.90 to 0.92)	0.68%
≥4	41.13 (24.69 to 68.53)	0.97 (0.97 to 9.98)	0.07%
≥5	140.58 (18.58 to 1063.90)	0.99 (0.99 to 1.00)	0.00%

Likelihood ratios and predictive values further underscore this dynamic. Positive predictive values increased markedly with higher thresholds, increasing from 59.52% at COAST ≥3, to 81.44% at scores ≥4 and 100% at scores ≥5. In line with this, the likelihood of admission was shown to increase significantly with increasing initial COAST scores. An initial COAST ≥1 has a positive likelihood ratio of 1.75, increasing to 13.78 at initial scores ≥3, to 41.43 at initial scores ≥4 and peaking at a positive likelihood ratio over 140 with initial COAST ≥5. This strongly suggests that high initial COAST scores serve as a good indicator of hospital admission.

False positive rates decreased sharply with increasing PEWS scores, from 30.67% with initial PEWS ≥1, to 6.17% with initial PEWS ≥2, to less than 1% FPR with scores ≥3, and 0% with scores ≥5.

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An analysis of MTS triage scores and their predictive accuracy for admission was conducted for comparison with the findings for COAST. Table 8 shows admission rates for increasing severities of triage scores: 5 (Non-urgent), 4 (Standard), 3 (Urgent), 2 (Emergency), and 1 (Immediate).

Table 8. MTS Triage scoring system and admission rates.

Triage (MTS) Score	Admitted	Not Admitted	Admission Rate (%)
5	13	1006	1.3%
4	611	24003	2.5%
3	498	3930	11.2%
2	1688	8069	17.3%
1	102	470	17.8%
Not recorded	48	593	8.1%
Total	2960	38071	7.2%

This showed a weak positive correlation of increasing MTS score versus admission, where only 17.3% of patients scoring 2 and 17.8% of patients scoring 1 were ultimately admitted.

In performing analysis of MTS data, scores were grouped in the same way as COAST data. As explained in Table 3, an MTS score of 5 is least severe, whereas using COAST scoring, a score of 0 is least severe. Note that for ease of comparison, MTS data has been ordered in increasing severity (5 to 1). It was then grouped such that a score of ≥4 indicates a score of 4 or greater severity ('standard' priority and above, i.e. scores of 3, 2 and 1), and a score of ≥1 indicates the highest severity only (immediate: life-threatening).

Table 9a. Analysis – performance characteristics of triage MTS scores in reflecting admissions

MTS Score	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
≥4	99.55% (99.24 to 99.76%)	2.68% (2.52 to 2.85%)	7.36% (7.34 to 7.38%)	98.72% (97.82 to 99.26%)
≥3	78.57% (77.04 to 80.05%)	66.73% (66.25 to 67.21%)	15.51% (15.20 to 15.82%)	97.57% (97.39 to 97.73%)
≥2	61.47% (59.67 to 63.24%)	77.22% (76.79 to 77.64%)	17.33% (16.84 to 17.83%)	96.27% (96.10 to 96.43%)
≥1	3.50% (2.86 to 4.24%)	98.75% (98.63 to 98.86%)	17.83% (14.95 to 21.13%)	92.94% (92.90 to 92.99%)

An MTS score of ≥4 has a sensitivity of 99.55%, indicating that virtually all patients who were admitted scored more than 5 (non-urgent) in triage, with a low specificity of 2.68%. Sensitivity decreased while specificity increased with increasing MTS score severity. Positive predictive values for admission increase with increasing MTS values. For MTS ≥4 the PPV is 7.36% (half the value obtained from PEWS ≥1), tapering to at best a PPV of 17.83% for MTS scores ≥1. In comparison, the PPV of 100% for PEWS ≥5 using the COAST system.

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Table 9b. Analysis – performance characteristics of triage MTS scores in reflecting admissions

MTS Score	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)	False Positive Rate (FPR)
≥4	1.02 (1.02 to 1.03)	0.17 (0.10 to 0.29)	97.32%
≥3	2.36 (2.31 to 2.42)	0.32 (0.30 to 0.34)	33.27%
≥2	2.70 (2.61 to 2.79)	0.50 (0.48 to 0.52)	22.78%
≥1	2.79 (2.26 to 3.45)	0.98 (0.97 to 0.98)	1.25%

Similarly, positive likelihood ratios for admission increased but less convincingly, at 2.79 for MTS of highest severity (compared to over 140 for highest severity using the COAST system, PEWS ≥5). False positive rates were significantly higher using MTS scores, at 97.32% with MTS ≥4, to 33.27% with MTS ≥3, to 22.78% with scores ≥2, and 1.25% with scores ≥1.

4. Discussion

COAST may not be a widely validated PED observation tool, however this paper demonstrates that it performs remarkably well as a predictor of admission to hospital. Data analysed has shown a strong correlation between rising COAST scores and the probability of admission.

One or more abnormal observations as part of this scoring system (PEWS ≥1) is a balanced indicator for capturing potential admissions while maintaining acceptable specificity. The sensitivity of lower initial COAST for reflecting the probability of admission should be interpreted within the broader patient picture, considering that patients are admitted for many reasons other than abnormal physiological observations; a diverse range of children are admitted to hospital, including those who may be admitted for psychiatric, safeguarding or non-acute surgical needs. Decreasing sensitivity of higher initial COAST scores reflects the fact that the majority of paediatric admissions are not in an extreme critical condition.

The analysis shows that while COAST cannot be used in isolation in patients with lower scores, its high specificity, positive predictive values and positive likelihood ratios with higher score thresholds (particularly with COAST ≥3) make it a useful tool in the arsenal of a PED. COAST effectively highlights those patients who require more urgent medical attention, triggering clinical reviews, prompting timely escalation to increasing clinician seniority, supporting clinical decision making and aiding allocation of resources. Furthermore, patient flow and forward planning can be improved using COAST. Action can be taken earlier in children with high scores, such as booking ward beds or taking viral swabs required prior to admission.

Evaluating COAST against MTS shows that COAST is a far superior tool when predicting admissions from PED. MTS has higher false positive rates, lower positive predictive values and lower positive likelihood ratios. These findings show that high MTS scores in triage do not correlate strongly to admission outcome. This is likely due to the role that the MTS plays within PED, which is to have swift clinician reviews of unwell patients. It is better to have clinicians review and step-down patients who trigger via MTS than miss patients who require urgent reviews.

We note some limitations to this paper. It is a single-centre, retrospective study. Nurse/parent concern is a subjective measurement which, although used in other tools, is open to user error [4]. Of 41030 analysed attendances, 10807 did not have COAST scores recorded, a significant loss of data for the study.

This study is by far the largest of its kind, analysing 41030 attendances of 27196 patients, compared to the 1921 patients in the previous study of COAST and 18073 patients of the largest similar study [5,9,10]. With the planned nationwide implementation of nPEWS this paper provides a

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vital baseline to compare the performance of nPEWS in PED. RCEM guidance is that it should be left up to individual PEDs to decide which observation tool they wish to use based on local practices and resources available [6]. As authors we strongly suggest that other PEDs consider the use of COAST within their departments as an effective observation tool and predictor of hospital admission.

5. Conclusions

In conclusion, this paper provides vital evidence in a poorly researched field, supporting the use of COAST in PED and proving its utility in predicting admissions. Continued and wider research is also required around the use of PED observation tools. It would also be useful to capture end patient outcomes in future research, such as morbidity, mortality and critical care admission.

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Data Availability Statement: The data presented in this study may be available on request from the corresponding author subject to patient confidentiality and applicable data protection and privacy laws.

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Conflicts of Interest: The authors declare no conflicts of interest.

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