

EFFECTIVENESS OF THE PEDIATRIC ASSESSMENT TRIANGLE IN IDENTIFYING SICK CHILDREN IN EMERGENCY TRIAGE

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Abstract

Background

The number of children presenting to the ED is growing and delays in the evaluation of children who are extremely ill negatively affect patient outcomes. The Pediatric Assessment Triangle (PAT) is a simple, non-technological assessment tool to rapidly assess a sick child, but there is limited evidence from the LMICs.

Objective

To evaluate the diagnostic accuracy of the PAT in predicting hospital admission at a tertiary care hospital in Pakistan.

Methods

A prospective observational study was carried out at the Indus Hospital, Karachi during January – December, 2024. Children aged 0–14 years were consecutively enrolled. The association between Pediatric Assessment Triangle findings (sick vs. not sick) and the hospital admission were evaluated by chi-square test and logistic regression model after controlling for age and gender. The diagnostic accuracy (sensitivity and specificity, predictive values) was computed.

Results

Among 426 children (mean age 4.2 ± 3.9 years; 60.6% male), 143 (33.6%) were classified as sick. Hospital admission was significantly higher in the sick group compared to the not sick group (83.9% vs. 38.5%, $p < 0.001$). The odds of admission were more than eight times higher in children with abnormal Pediatric Assessment Triangle findings (OR = 8.33, 95% CI: 5.02–13.83). Admission rates increased progressively with higher scores: 38.2% for score 0, 74.5% for score 1, and 100% for scores 2 and 3. The tool demonstrated high specificity (88.3%) and positive predictive value (83.9%), with moderate sensitivity (52.4%). After adjusting for age and gender, abnormal findings remained an independent predictor of admission (adjusted OR = 8.29, 95% CI: 5.00–13.74, $p < 0.001$).

Conclusion

The PAT is a simple, effective, and independent predictor of hospital admission in pediatric emergency triage supporting its use as an initial screening tool in resource-limited environments.

INTRODUCTION

Emergency departments (EDs) are the first point of contact for healthcare services where direct care for patients with acute and life-threatening illnesses can be provided. Pediatric emergency department visits have increased at an exponential rate in the past decade worldwide, putting significant strain on emergency services and the need for an efficient triage process (Klassen et al., 2021). Globally, children under 15 years account for approximately 25% of all emergency department visits.

Early detection of the children who are seriously ill is important, as it may lead to rapid deterioration of the child's condition, a rise in morbidity and death that could have been prevented (Elbaih & Safi, 2021). Delayed assessment has a far greater impact in low and middle-income countries (LMICs) such as Pakistan where nearly 90% of the mortality among children is attributable to delayed assessment.

The care of children in emergencies poses unique challenges compared to adults. There are significant inter-age variations in HR, RR and BP, which makes assessment difficult. Furthermore, children may not be able to report their symptoms and very severe illness can have subtle or non-specific symptoms (Junior et al., 2022). They heighten the risk of under triage or delayed recognition of severely ill patients.

Popular triage systems have been demonstrated to be not consistent and reliable particularly in emergency contexts with high stress level (Ebrahimi et al., 2020). Further, most triage tools are based on detailed vital signs and clinical vital data that is not easily accessible in overcrowded or resource-poor environments.

Given the challenges, rapid observation-based assessment tools are becoming more prevalent. The Pediatric Assessment Triangle (PAT) is a multidimensional assessment tool that allows healthcare workers to evaluate a child's physiological state in the three areas detailed below: appearance, work of breathing and circulation to the skin (Elbaih & Safi, 2021). PAT is uniquely, there is no equipment needed and can be conducted in seconds, being ideal for

emergency triage and prehospital settings. It has been shown to be useful in answering "Is this child sick?" (Fernandez et al. 2017) and as the first step in triage (Ahmadi et al. 2023). More recently, its clinical value has been confirmed by many studies (Ma et al., 2021; Tørisen et al., 2024; Zhu et al., 2025; Nijman et al., 2021).

Recent studies have demonstrated its clinical value. Ma et al. (2021) reported that PAT was an effective tool to diagnose critically ill children at triage. A systematic scoping review supported the validity and reliability of PAT as a method for early child health assessment (Tørisen et al., 2024). In addition, PAT has been found to have potential for predicting clinical outcomes, and abnormal results have been found to be associated with disease severity, hospital admission, and the requirement for advanced care (Zhu et al. 2025; Nijman et al. 2021).

The issues of paediatric emergencies in Pakistan are worsened by resource constraints, high patient load, and disparities in healthcare facilities. There are systemic problems in the emergency services, including the lack of adequate funding, trained personnel and standardized triage protocols (Shaikh et al., 2023). These factors contribute to delays in patient evaluation and treatment particularly in overcrowded tertiary care hospital.

Emergency medical services (EMS) are still developing in Pakistan and are not standardized among regions (Baig et al., 2024). This may lead to delayed presentation of the children to the healthcare centres making management more difficult. In recent times, the importance of effective triage mechanisms in resource-constrained environments has gained significant recognition through various initiatives, including the development of integrated emergency response systems (Rafaqat et al., 2025).

In urban settings such as Karachi, health facilities are often overcrowded, especially emergency departments of tertiary care centres. Large patient numbers may cause overburdening for healthcare providers and lead to late and poor outcomes for critically ill children (Saeed et al., 2024). Moreover, the communicable and the non-communicable diseases burden emergency services, which further emphasizes the need for

quick and efficient triage devices (Rashid et al., 2023).

Simple, quick and dependable tools such as PAT are particularly important in this context. PAT is suitable for resource challenged environments because it does not require any equipment to conduct a clinical assessment. However, despite its potential benefits, evidence evaluating its effectiveness in Pakistani emergency departments remains limited. Most existing literature comes from high-income nations, and their findings may not apply directly to the local situation.

Rationale of the Study

Although PAT is a quick and efficient approach to triage, there is little local evidence regarding the effectiveness of PAT in identification of sick children that are referred to tertiary care Emergency Department in Pakistan. In addition, there is not much existing literature that discuss its relationship to hospital admission with the use of simple and easily implementable statistical methods. Assessment of the effectiveness of PAT in this area can help to shed light on the practical value of PAT and help to facilitate its routine use.

Objectives

Primary Objective

To assess the effectiveness of the Pediatric Assessment Triangle (PAT) in identifying sick pediatric patients at emergency triage.

Secondary Objectives

1. To determine the association between abnormal PAT findings and hospital admission using simple statistical methods (e.g., chi-square test) and multivariable logistic regression.
2. To compare hospital admission rates between children with normal and abnormal PAT findings.
3. To evaluate the association between individual components of PAT (appearance, work of breathing, and circulation) and hospital admission.

MATERIAL AND METHODS

Study Design, Population, and Eligibility Criteria

This was a prospective observational study conducted at the pediatric emergency triage of The Indus Hospital, Karachi, Pakistan. The study was carried out over one year, from 1st January 2024 to 31st December 2024. The study was approved by the Institutional Review Board (IRB) of The Indus Hospital (approval number: IHHN_IRB_2023_12_017, dated 01.02.2024).

The study population included all pediatric patients aged 0 days to 14 years presenting to the emergency department triage during the study period. Children who were brought dead or those needed cardiopulmonary resuscitation (CPR) were not included.

Sample Size Calculation

The sample size was determined using the OpenEpi version 3.01 - single population proportion estimation. According to the previous study, sensitivity of Pediatric Assessment Triangle (PAT) for the identification of critically ill children was 93.24% (Ma et al., 2021). Based on this estimate, at a 95% confidence level, and a 5% margin of error, the minimum sample size was 97 patients.

To increase the precision and reliability of the study findings, all patients eligible during the study period were included resulting in a final sample size of 426 patients, which substantially exceeds the minimum required sample size.

Sampling Technique

A non-probability consecutive sampling technique was used. All eligible patients fulfilling the eligibility criteria during the study period were enrolled consecutively.

Data Collection and Analysis

Emergency physicians with training in PAT collected data at the triage area using a structured PAT assessment tool (Appendix A). The PAT is a simple, time-efficient, and equipment-free subjective assessment tool for emergency assessment of children presented first by Dieckmann et al. (2010) and confirmed by several studies (Tørisen et al., 2024; Ma et al., 2021). The presence or absence of abnormalities in each parameter were recorded as Yes or No and the

children were classified as "sick" if abnormality was found in any domain, and "not sick" if there was no abnormality in any domain. The outcome variable, hospitalization (Yes/No), was recorded for each patient.

Data was entered and analyzed in SPSS version 28. Continuous variables were presented as mean \pm SD. Categorical variables were described in terms of frequencies and percentages. A chi-square test was used to determine the association between the classification of PAT (sick vs. not sick) and hospital admission. The p value < 0.05 was regarded as statistically significant. The strength of association was expressed using odds ratios (OR) with 95% confidence intervals (CI).

The diagnostic performance of PAT in predicting hospital admission was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Binary logistic regression analysis was performed to examine the independent relationship between PAT status and hospital admission after adjusting for age and gender. Adjusted odds ratios with 95% confidence intervals were reported.

Results

A total of 426 pediatric patients were analysed. The mean age was 4.2 ± 3.9 years. Of the study population, 258 (60.6%) were male and 168 (39.4%) were female. In terms of age distribution, the largest proportion consisted of older children

aged 8–11 years (112, 26.3%), followed by children aged 3–7 years (105, 24.6%), toddlers aged 12–35 months (86, 20.2%), infants aged 1–11 months (67, 15.7%), adolescents aged 12–14 years (51, 12.0%), and neonates under one month (5, 1.2%). (Figures 1-2).

Evaluation of the PAT components showed that abnormalities in appearance were observed in 80 patients (18.8%), breathing abnormalities in 68 (16.0%), and circulatory changes to the skin in 57 (13.4%). Based on the overall PAT assessment, 143 children (33.6%) were categorized as "sick," indicating at least one abnormal domain, whereas 283 (66.4%) were classified as "not sick (Table 1)." When PAT findings were further categorized into a composite score ranging from 0 to 3, most patients had a score of 0 (256, 60.1%), reflecting no abnormalities. A score of 1 was recorded in 141 patients (33.1%), while 23 (5.4%) and 6 (1.4%) patients had scores of 2 and 3, respectively. A gradual increase in hospital admission rates was observed with higher PAT scores (Figure 3). Among patients with a score of 0, 92 (35.9%) required admission as compared to 110 (78.0%) with a score of 1. Among patients with a score of 2, 19 (82.6%) were admitted, while all patients with a score of 3 (n = 6) were admitted (100%). In comparison to patients with a score of 0, patients with a score of 1 had significantly increased odds of admission (OR = 6.02, 95% CI: 3.71–9.77, $p < 0.001$).

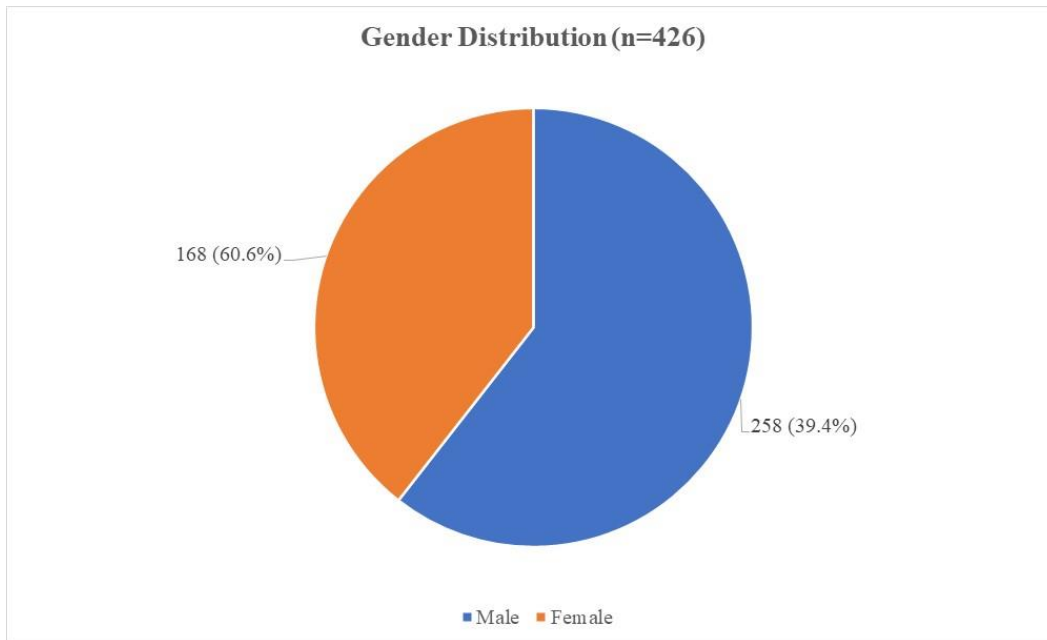


Figure.1 Gender Distribution of Study Population

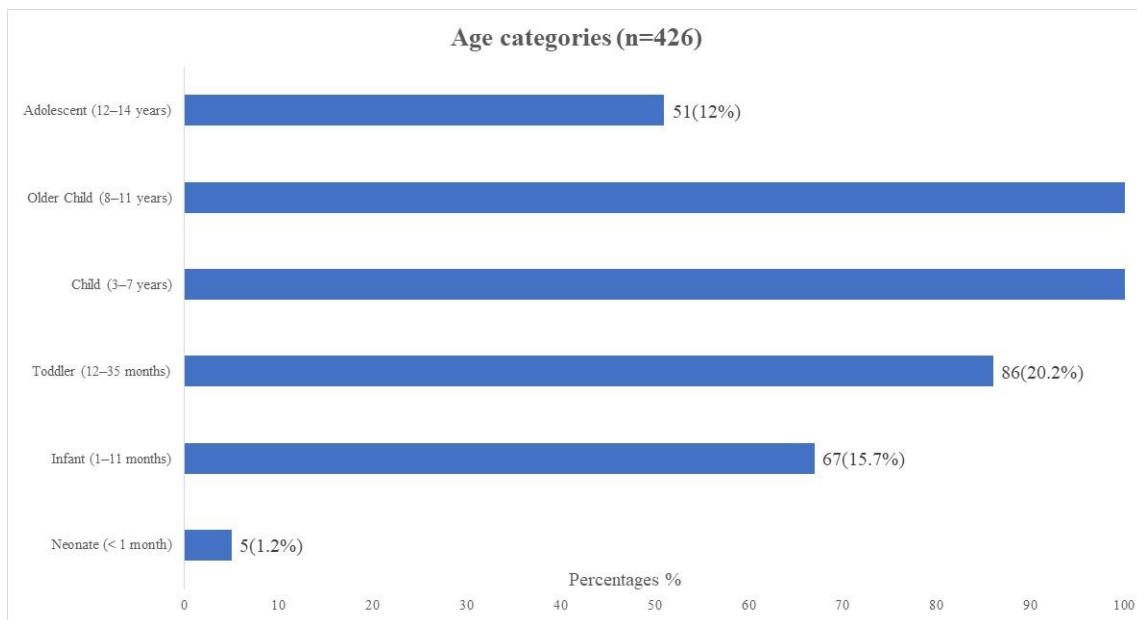


Figure.2 Age Distribution of Study Population

Table.1 Distribution of Pediatric Assessment Triangle (PAT) Findings (n = 426)

Variable	Yes n (%)	No n (%)
Appearance abnormal	80 (18.8%)	346 (81.2%)
Breathing abnormal	68 (16.0%)	358 (84.0%)
Circulation abnormal	57 (13.4%)	369 (86.6%)
Overall, PAT (Sick)	143 (33.6%)	283 (66.4%)

A strong association was identified between overall PAT status and hospital admission. Among children classified as sick, 135 (79.4%) were admitted, whereas only 92 (35.9%) of those categorized as not sick required hospitalization.

Children with an abnormal PAT had over seven times higher odds of admission compared to those with a normal assessment (OR = 7.15, 95% CI: 4.58-11.16, $p < 0.001$) (Table 2).

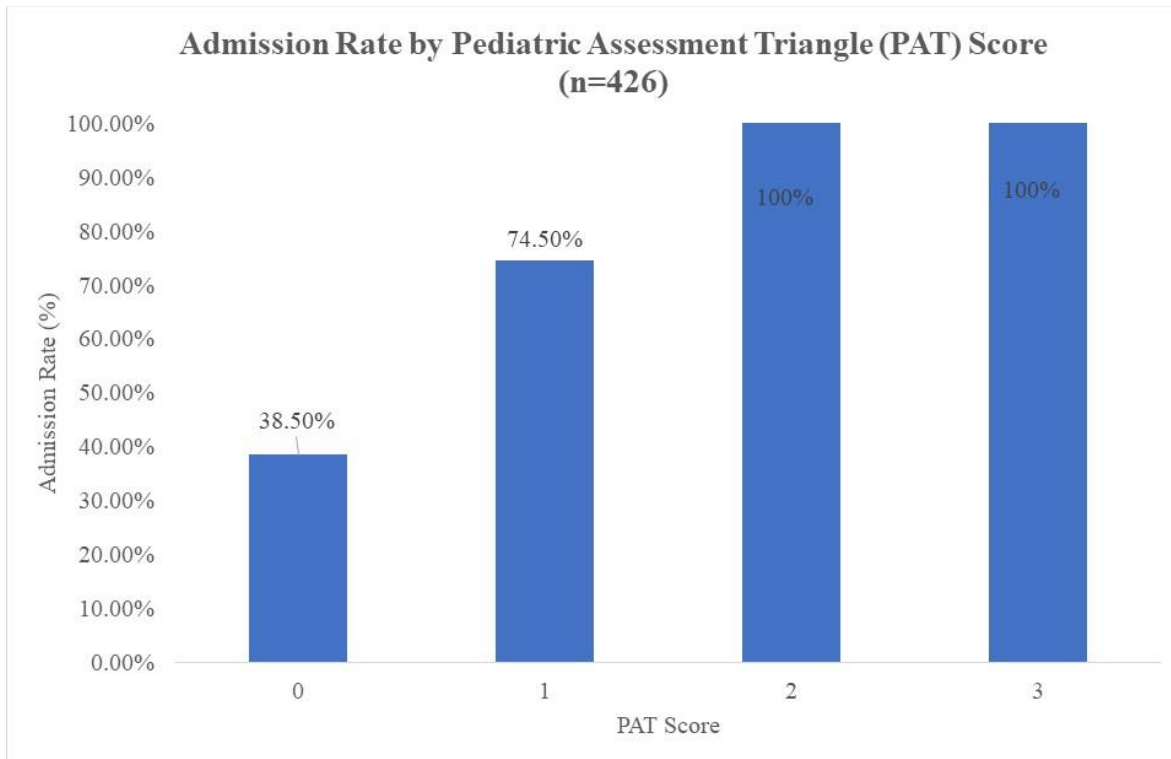


Figure.3 Admission Rate by Pediatric Assessment Triangle (PAT) Score

Table.2 Association Between PAT Status and Hospitalization

PAT Status	Hospitalized n (%)	Not Hospitalized n (%)	p-value	Odds Ratio (95% CI)
Sick (n=143)	120	23	<0.0001	8.33 (5.02-13.83)
Not Sick (n=283)	109	174		

Analysis of individual PAT components also showed significant associations with hospital admission.

Among patients with abnormal appearance, 61 (76.3%) were admitted compared to 166 (48.0%) with normal appearance (OR = 3.41, 95% CI: 1.95-5.94, $p < 0.001$). Similarly, 56 (82.4%) of patients with abnormal breathing required

admission versus 171 (47.8%) with normal breathing (OR = 4.99, 95% CI: 2.59-9.62, $p < 0.001$). The strongest association was found for abnormal circulation, where 51 (89.5%) patients were admitted compared to 176 (47.7%) with normal findings (OR = 9.12, 95% CI: 3.82-21.78, $p < 0.001$) (Table 3).

Table.3 Association of Individual PAT Components with Hospitalization

Variable	Hospitalized n (%)	Not Hospitalized n (%)	p-value	Odds Ratio (95% CI)
Appearance				
Abnormal (n=80)	61 (76.3%)	19 (23.7%)	<0.0001	3.41 (1.95-5.94)
Normal (n=346)	168 (48.6%)	178 (51.4%)		
Breathing				
Abnormal (n=68)	56 (82.4%)	12 (17.6%)	<0.0001	4.99 (2.59-9.62)
Normal (n=358)	173 (48.3%)	185 (51.7%)		
Circulation to Skin				
Abnormal (n=57)	51 (89.5%)	6 (10.5%)	<0.0001	9.12 (3.82-21.78)
Normal (n=369)	178 (48.2%)	191 (51.8%)		

Standard measures of diagnostic accuracy were used to evaluate the performance of PAT in predicting hospital admission. The area under the ROC curve (AUC) was 0.713 (95% CI: 0.664-0.763, $p < 0.001$), indicating fair discriminative

ability (Figure 4). Sensitivity was 59.5% (95% CI: 52.8-66.0), specificity was 82.4% (95% CI: 76.3-87.5), positive predictive value was 79.4% (95% CI: 73.1-84.8), and negative predictive value was 64.1% (95% CI: 57.9-69.9) (Table 4).

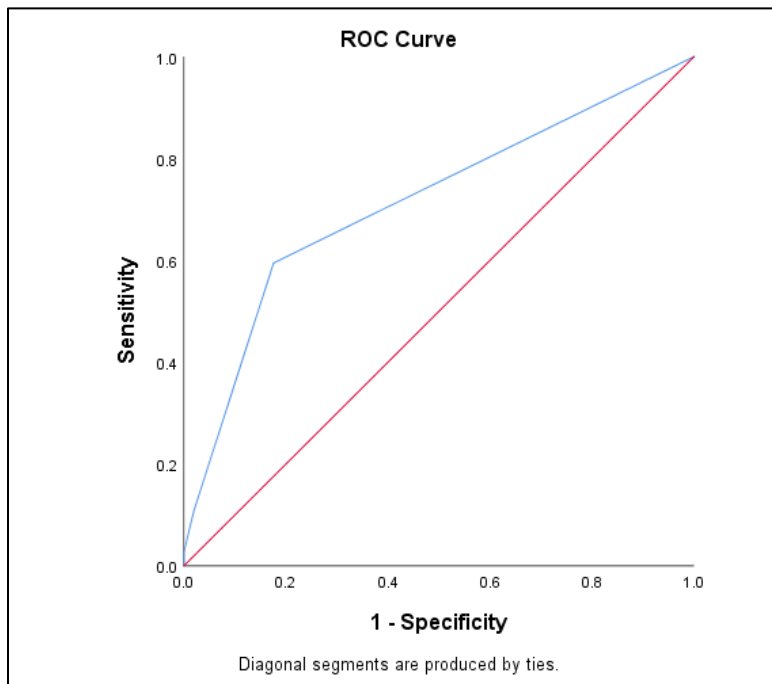


Figure 4: Receiver Operating Characteristic (ROC) Curve of PAT Score for Predicting Hospital Admission

The blue curve represents the diagnostic performance of the PAT score. The diagonal line represents chance (AUC = 0.5). The area under the curve (AUC) is 0.713 (95% CI: 0.664-0.763, $p < 0.001$), indicating that the PAT score has fair

discriminative ability in identifying children who require hospital admission. The point on the curve corresponds to a PAT score cut-off of ≥ 1 , with a sensitivity of 59.5% and specificity of 82.4%.

Table 4: Diagnostic Accuracy of Pediatric Assessment Triangle (PAT) in Predicting Hospitalization (n = 426)

Measure	Value (%)	95% CI
Sensitivity	52.4	47.2-57.6
Specificity	88.3	84.1-92.5
Positive Predictive Value (PPV)	83.9	79.3-88.5
Negative Predictive Value (NPV)	61.5	56.1-66.9

To further assess the predictive role of PAT, a multivariable logistic regression analysis was performed after adjusting for age and gender. The results confirmed that abnormal PAT remained a significant independent predictor of hospital admission (adjusted OR = 6.89, 95% CI: 4.38-

10.84, $p < 0.001$). In contrast, neither age (adjusted OR = 1.02, 95% CI: 0.96-1.08, $p = 0.512$) nor gender (adjusted OR = 1.35, 95% CI: 0.88-2.07, $p = 0.172$) revealed a statistically significant association with admission in the adjusted model (Table 5).

Table 5: Multivariable Logistic Regression Analysis for Factors Associated with Hospital Admission (n = 426)

Variable	Adjusted OR	95% CI	p-value
PAT Status (Sick vs. Not Sick)	8.29	5.00-13.74	<0.001
Gender (Male vs. Female)	1.4	0.91-2.17	0.126
Age (years)	1.02	0.96-1.07	0.563

Discussion

In this study we assessed the effectiveness of the PAT as a rapid triage tool for identifying sick pediatric patients and predicting hospital admission in an emergency department setting. The findings demonstrate that PAT is a practical and clinically useful tool with a strong association with patient outcomes.

In our study, 39.9% of children were classified as sick based on PAT assessment. Children classified as sick were admitted significantly more often (79.4%) than those classified as not sick (35.9%), with over seven times higher odds of admission (OR = 7.15, 95% CI: 4.58-11.16, $p < 0.001$). The diagnostic performance of PAT in our study showed a sensitivity of 59.5% and specificity of 82.4%, with an AUROC of 0.713 (95% CI: 0.664-0.763).

A key finding of this study is that there was a strong association between abnormal PAT findings and hospital admission. In our data, children classified as sick were admitted much more frequently (83.9%) compared to those who were not (38.5%), with a significant difference ($p < 0.0001$). In other words, children who had an

abnormal PAT were over eight times as likely to have been hospitalized (OR = 8.33; 95% CI: 5.02-13.83).

Tørisen et al. (2024) recently conducted a scoping review of 55 studies that highlighted the validity and reliability of PAT in a variety of emergency contexts, including a range of sensitivities from 52% to 93% and specificities from 82% to 99%. Our findings fall within this reported range.

Ma et al. (2021) reported higher sensitivity (93.2%) and specificity (99.2%) for identifying critically ill children in a Chinese pediatric emergency department, with an AUROC of 0.963. Similarly, Zhu et al. (2025) found an AUROC of 0.966 for PAT in predicting hospitalization. The differences between our results and these studies likely reflect variations in patient populations, admission rates (53.3% in our study vs. 4.6% critical illness prevalence in Ma et al.), and outcome definitions (hospital admission vs. critical illness).

The analysis of individual PAT components indicated that all three domains were significantly related to hospital admission. The strongest association was with circulatory abnormalities (OR

= 9.12), followed by breathing (OR = 4.99) and appearance (OR = 3.41). These findings are in accord with previous literature that identifies perfusion and respiratory status as the most important early warning signs in acutely ill children (Smits et al., 2025; Romaine et al., 2021). Admission rates increased progressively with higher PAT scores: 35.9% (score 0), 78.0% (score 1), 82.6% (score 2), and 100% (score 3) ($p < 0.001$). This gradient indicates that PAT helps to not only identify sick children, but also provides a measure of illness severity. This has also been found in pediatrics early warning systems, where higher scores are associated with poorer clinical status and a need for intervention (Chong et al., 2022; Branes et al., 2021)

The moderate sensitivity of PAT (59.5%) in our study reflects that many rapid triage tools prioritize specificity to avoid overwhelming resources with false positives (Romaine et al., 2021; Branes et al., 2021). Thus, PAT should be used as a screening tool and then the patient needs to be monitored continuously rather than it being used as a diagnostic tool alone (Hafez et al., 2025).

Multivariable logistic regression confirmed that abnormal PAT remained an independent predictor of hospital admission after adjusting for age and gender (adjusted OR = 6.89, 95% CI: 4.38–10.84, $p < 0.001$). There was no significant association of age ($p = 0.512$) or gender ($p = 0.172$) with admission, suggesting that PAT is able to detect clinically relevant physiological changes that are independent of demographic variables. The same has been found by Nijman et al. (2021) who found that physical parameters always outperformed the demographic ones in the prediction of the serious illness.

These findings are significant especially in countries like Pakistan, where emergency departments are often overcrowded, have inconsistent triage systems, and do not have enough trained staff (Baig et al., 2024; Shaikh et al., 2023; Saeed et al., 2024). While there are advanced methods being developed to improve the accuracy of triage, like machine learning, these need technical and financial resources that may not be available (Halwani et al., 2025; Viana et al., 2024). PAT is an easy and equipment-free tool that

can be applied without technological infrastructure. It is scalable, meaning that it can be used in tertiary and peripheral facilities (Mitchell et al., 2025; Rath et al., 2025).

This study has several limitations. First, it was a single-centre study conducted at a single tertiary care hospital, potentially compromising generalizability to other health care settings. Second, we did not follow patients after hospital discharge, so outcomes such as readmission or mortality were not assessed. Third, there was no formal assessment of inter-rater reliability among different triage nurses. Fourth, the moderate sensitivity (59.5%) suggests that some sick children may be missed, requiring ongoing clinical vigilance

Conclusion

The Pediatric Assessment Triangle is a simple, equipment-free triage tool that demonstrates a strong and independent association with hospital admission in children. The progressive increase in admission rates with higher PAT scores supports its utility as both a screening instrument and a severity indicator. While its moderate sensitivity necessitates continued clinical evaluation, the high specificity and positive predictive value make it useful as a first-line test for prioritizing children who are sick, especially in low resource emergency environments.

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