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Emergency pediatric patients and use of the pediatric assessment triangle tool (PAT): a scoping review

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Abstract

Background We conducted a scoping review of the evidence for the use of the Pediatric Assessment Triangle (PAT) tool in emergency pediatric patients, in hospital and prehospital settings. We focused on the psychometric properties of the PAT, the reported impact, the setting and circumstances for tool implementation in clinical practice, and the evidence on teaching the PAT.

Methods We followed the Joanna Briggs Institute methodology for scoping reviews and registered the review protocol. We searched MEDLINE, PubMed Central, the Cochrane Library, Epistemonikos, Scopus, CINAHL, Grey literature report, Lens.org, and the web pages of selected emergency pediatrics organizations in August 2022. Two reviewers independently screened and extracted data from eligible articles.

Results Fifty-five publications were included. The evidence suggests that the PAT is a valid tool for prioritizing emergency pediatric patients, guiding the selection of interventions to be undertaken, and determining the level of care needed for the patient in both hospital and prehospital settings. The PAT is reported to be fast, practical, and useful potentially impacting overcrowded and understaff emergency services. Results highlighted the importance of instruction prior using the tool. The PAT is included in several curricula and textbooks about emergency pediatric care.

Conclusions This scoping review suggests there is a growing volume of evidence on the use of the PAT to assess pediatric emergency patients, some of which might be amenable to a systematic review. Our review identified research gaps that may guide the planning of future research projects. Further research is warranted on the psychometric properties of the PAT to provide evidence on the tool's quality and usefulness. The simplicity and accuracy of the tool should be considered in addressing the current healthcare shortages and overcrowding in emergency services.

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Keywords Pediatrics or paediatric, Pediatric assessment triangle, Children; emergency medicine; review

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Background

Emergency medical services (EMS) are crucial to emergency care systems providing effective emergency medical care to people in need [1]. The World Health Organization (WHO) Emergency Care System Framework [2] (see Additional file 1) notes that effective emergency care involves a coordinated and integrated system of care, including the provision of prehospital care, transportation, and emergency department (ED) services. The WHO framework emphasizes the importance of early recognition of health issues and the timely provision of appropriate interventions to reduce morbidity and decrease the incidence of death and illness. Pediatric emergencies, particularly acute injuries and illnesses, generate considerable numbers of ambulance calls and ED visits in developed countries [3, 4].

There is a general understanding that lack of pediatric emergency flow (or crowding) may lead to adverse outcomes for the child. However, the prevalence of pediatric emergencies poses significant challenges to emergency healthcare providers [5, 6]. In the UK, pediatric emergencies represent 5–10% of all emergencies [7] and in the USA, children represent 20% of ED patients [8]. Injuries are the leading cause of morbidity and mortality among children and adolescents [9, 10].

Caring for critically ill or injured pediatric patients can be challenging for emergency healthcare workers (EHWs) [11]. Patients' histories may be difficult to obtain if the patient cannot provide verbal information or has been found alone without a caregiver [12]. Taking vital signs can be difficult and may not provide accurate information due to normal age-based variations [12]. Furthermore, some EHWs may have not received training in pediatric emergencies, which can be stressful [13].

Despite these challenges, EHWs need to conduct a rapid and accurate assessment of the pediatric patient to deliver timely effective emergency treatment. EHWs also need to reassure patients and caregivers and bring order to potentially chaotic situations. EHWs who lack specialized training in pediatric emergencies may unintentionally exacerbate stressful situations [13]. Emergency pediatric training for healthcare professionals inside and outside of the hospital is essential to ensure the best outcomes for critically ill or injured pediatric patients [14, 15].

Emergency triage involves quickly identifying patients who require medical attention to prioritize treatment efficiently for those in greatest need [14]. Triage tools such as the Manchester Triage System and the Emergency Severity Index are helpful [16]. The Paediatric Canadian Triage and Acuity Scale (PaedCTAS) was developed specifically for pediatric patients [17], using the Pediatric Assessment Triage (PAT) tool as the first step in assessing emergency patients. It includes the "general impression" stage using the PAT, primary assessment with the airway, breathing, circulation, disability, and exposure (ABCDE) approach [18], secondary assessment, diagnostic assessment, and reassessment.

The Pediatric Assessment Triangle (PAT)

The PAT is used to quickly identify critically ill or injured children needing immediate medical attention. It focuses on three presenting components ("arms"): appearance, work of breathing, and circulation (Fig. 1). It can be used in prehospital or hospital settings for efficient rapid assessment of the patient's level of consciousness, breathing, and circulation, without requiring hands-on assessment or equipment [5, 19]. It can help identify key pathophysiological problems and whether urgent transport or resources are needed. The PAT assessment takes 30–60 s [5, 19] and it can be performed remotely (a "through the room" assessment).

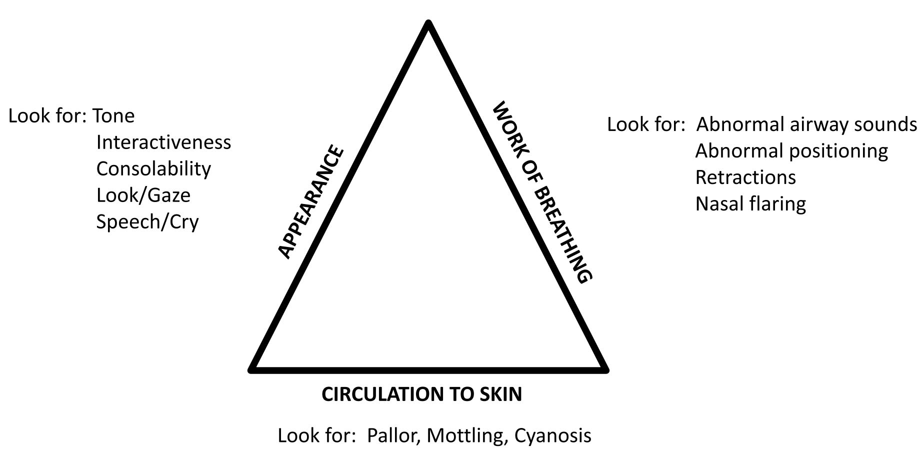

Fig. 1 The Pediatric Assessment Triangle components (arms). Figure adapted from Fuchs S and McEvoy M [20]]

Methods

Scoping review aim and design

Give the current shortage of healthcare personnel worldwide, and overcrowding of emergency departments, gathering of the PAT's evidence is essential. This review aimed to identify the available scientific evidence about the PAT and its use by EMS. Our objective was to complete a scoping review within the pre-and-hospital care to synthesize:

- What are the psychometric properties of the PAT (e.g., validity, reliability, applicability)?
- What are the reported impact(s) of the PAT? (e.g., improved triage, cost, better clinical outcomes)
- What are the requirements or circumstances for PAT implementation in clinical practice?
- What is the evidence on the value of teaching EMS workers about PAT?

We followed the Joanna Briggs Institute framework for scoping reviews [21]. The review protocol was registered [22]. The review is reported according to the PRISMA extension for scoping reviews [23] (Additional file 2).

Eligibility criteria

Eligible publications (Table 1) reported the use of the PAT with pediatric populations in prehospital, hospital or training settings. Eligible outcomes matched our specific aims as follows: 1) psychometric performance, 2) impact(s), 3) implementation of PAT utilization, and 4) evidence on teaching the PAT.

Searches

We searched MEDLINE (PubMed), PubMed Central (via LitSense), the Cochrane Library, Epistemonikos, Scopus and CINAHL, from 1995 to July 2022, to include publications before the introduction of the PAT in the curricula of Pediatric Education for Prehospital Professionals (PEPP) and Advanced Pediatric Life Support (APLS) in 2000 [24]. The database searches were conducted from 24 to 28 July 2022. Fourteen websites of organizations involved in policy making in emergency pediatrics were searched between 6 and 10 August 2022. We searched for unpublished (grey) literature using Grey Literature Report (http://www.greylit.org/) and Lens.org (https://www.lens.org/). Full searches are presented in additional file 3.

Study selection process

We deduplicated records in EndNote and conducted double independent screening (TT, AFL-B) in Covidence (Veritas) against the eligibility criteria (Table 1). Conflicts were resolved by consensus or arbitrated by a third reviewer (JB). Additional file 4 lists records excluded at full text with reasons. Records reporting the same study were grouped and we cite the earliest publication while presenting relevant data from any of the related publications.

Data collection process

Data were extracted from eligible studies into a Microsoft 365 Excel form which was piloted on a random sample of five included studies, and modified as required based on feedback from the team [22]. One reviewer (TT) completed data extraction and a second reviewer (AFL-B) verified the extracted data. Disagreements were resolved by consensus or arbitrated by a third reviewer (JB). Risk of bias was not assessed [21].

Table 1 Scoping review inclusion and exclusion criteria

Inclusion	Exclusion
• Participants/population: Emergency pediatric patients. 'Emergency' defined as any medical condition or trauma that requires contact with the health care system, prehospital and/or hospital. Pediatric means any patient from 0 to 18 years of age. Emergency health care workers. Pediatric Assessment Triangle (PAT) trainers • Concept: The PAT for clinical assessment • Context: Prehospital and hospital use. Prehospital includes, but is not limited to, Emergency Medical Services, out of hours clinics, search and rescue services, doctors' offices, "walk in" clinics, or ambulance services. Hospital use is not limited to emergency departments. In training settings • Outcomes: Psychometric properties of the PAT (e.g., validity, reliability, applicability), reported impact(s), requirements for PAT implementation, reported conditions of PAT utilization, and evidence on teaching/instructing people to use the PAT • Any publication status. Documents at all stages of publication were eligible (e.g., "in review", "accepted", "in press", "published")	Exclusions: • Non-English language literature unless there was an English abstract, in which case the abstract was data extracted • Podcasts, recorded lectures etc. • Incomplete records (i.e., those with no abstracts or where the full text was unavailable after exhausting all possible routes)

Knowledge user (KU)/patient engagement and methodological appraisal

We defined KU/ patient engagement as individuals who may be affected by the research findings. Since this review was time sensitive, we did not recruit knowledge users or patients.

We did not appraise methodological quality or risk of bias of the included articles, which is consistent with guidance on scoping review conduct.

Synthesis

The synthesis included quantitative (e.g. psychometric properties) and qualitative analyses (e.g. content analysis) of the components of the impact, implementation and teaching. A word cloud was drawn for the impact of the PAT using the online program WordClouds. The team members identified, coded, and charted relevant units of text from the articles using a framework established a priori as a guide. The framework was developed through team discussions upon reviewing the preliminary results. Data were grouped by question and overviews are provided using charts and tables generated using Microsoft 365 Excel.

Results

Search results and publication characteristics

The searches identified 548 records (Fig. 2). Fifty-five publications were included (full citations listed in Additional file 5) of which three were books. Sixteen publications were in non-English languages, but with English abstracts, and of these we retrieved 14 full text publications (Spanish ($n=9$), German ($n=2$), French ($n=1$), Turkish ($n=1$), and assumed Taiwanese Mandarin ($n=1$)). Of these, there were seven papers that described the psychometric properties of the PAT, 18 were about the PAT's impact, 38 described implementation pros and cons, and 30 provided references to the PAT used in educational/training environments. The publication dates ranged from 1999 to 2022, representing 18 countries with the majority classified as "high income" (World Bank classification) [25] (see Additional file 6). Study designs were diverse: primary research ($n=27$, 49.1%), secondary research ($n=4$, 7.3%), and "other" ($n=24$, 43.6%). We identified no randomized controlled trials, systematic reviews, or scoping reviews.

Psychometric properties

The seven papers reporting psychometric properties were as follows. Four studies (Table 2) reported sensitivity and specificity, measuring test accuracy [26–29], of which one study reported an area under the receiver operating characteristic curve (AUROCC) [29] and four studies reported likelihood ratios (LR) [26–28, 30].

PAT sensitivity (Fig. 3) ranged from 77.4% to 97.3% (four studies) suggesting it can accurately identify a large proportion of patients with the targeted condition

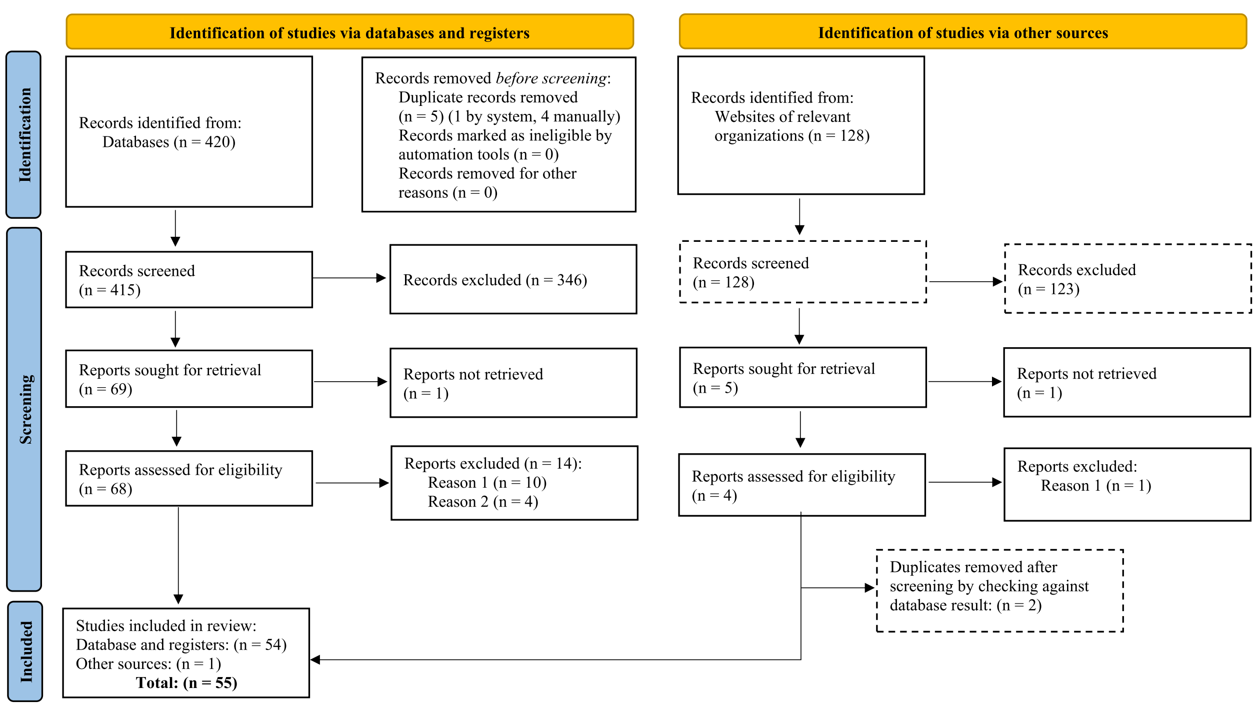

Fig. 2 PRISMA flow chart

Table 2 Psychometric properties of the Pediatric Assessment Triangle (7 studies)

Author (number of participants)	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)	Odds Ratio (95%CI)	Area under the receiver operating curve	Reliability (95% CI)
Aviles-Martinez 2016 [26] *N* = 1120 children	81 (78–84)	87 (84–90)	5.2 (5–7.8)	0.22 (0.18–0.26)	111 (73–168.6) $p < 0.001$	NR	NR
Fernandez 2010 *N* = 57,617 cases	NR (NR)	NR (NR)	NR (NR)	NR (NR)	NR (NR)	NR	93.6% (Kappa index 0.77 (0.75–0.79)
Fernandez 2017 [24] *N* = 302,103 episodes	NR (NR)	NR (NR)	NR (NR)	NR (NR)	Abnormal PAT findings at triage increased hospitalization probability 5.14 (4.97–5.32) $p < 0.01$ Age adjusted autonomous risk factors for hospitalization: abnormal PAT findings and urgent triage levels I-III: 2.21 (2.13–2.29); triage levels 6.01 (5.79–6.24) $p < 0.01$ Abnormal appearance or 1 + components of the PAT were associated with admissions: 3.99 (3.63–4.38) $p < 0.01$; 14.99 (11.99–18.74) $p < 0.001$ Adjusted age and triage were independent risk factor for intensive care unit admission 4.44 (3.77–5.24) $P < 0.001$ and longer stay 1.78 (1.72–1.84) $P < 0.001$ in the pediatric emergency department	NR	NR

Table 2 (continued)

Author (number of participants)	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)	Odds Ratio (95%CI)	Area under the receiver operating curve	Reliability (95% CI)
Gausche-Hill 2014 [27] *N* = 1168 PAT study forms	77.4 (72.6–81.5) (instability)	90 (87.1–91.5) (instability)	7.7 (5.9–9.1) (instability)	NR	NR	NR	Paramedics used of the PAT in the three arms and formed a general impression with high consistency k = 0.93 (0.91–0.95) κ = 0.62 (0.57–0.66) (PAT paramedic's impression and investigators' retrospective chart review on final diagnosis and disposition) κ = 0.66 (0.62–0.71) (PAT paramedics' impression and investigator's impression: stability)
Horeczko 2013 [28] *N* = 528 children	Children deemed instable (n = 58): 97.3 (94.6–98.8) Respiratory distress (n = 290): 91.1 (86.6–94.2) Respiratory failure (n = 14): 25.0 (6.7–57.2) Shock (n = 109): 74.1 (53.4–88.1) CNS/ metabolic disorder (n = 49): 46.0 (30.0–62.9) Cardiopulmonary failure (n = 11): 75 (21.9–98.7)	Children deemed instable(n = 58): 22.9 (17–30) Respiratory distress (n = 290): 76.6 (71.1–81.3) Respiratory failure (n = 14): 97.9 (96.1–98.9) Shock (n = 109): 82.2 (78.5–85.4) CNS/ metabolic disorder (n = 49): 93.5 (90.8–95.4) Cardiopulmonary failure (n = 11): 98.5 (96.9–99.3)	Children deemed stable: 0.12 (0.06–0.25) Instability (n = 58): 1.2 (1.2–1.3) Respiratory distress (n = 290): 4 (3.1–4.8) Respiratory failure (n = 14): 12 (4–37) Shock (n = 109): 4.2 (3.1–5.6) CNS/ metabolic disorder (n = 49): 7 (4.3–11) Cardiopulmonary failure (n = 11): 49.1 (20–120)	Instability (n = 58): 0.12 (0.06–0.25) Respiratory distress (n = 290): 0.11 (0.078–0.17) Respiratory failure (n = 14): 0.8 (0.55–1.06) Shock (n = 109): 0.32 (0.17–0.60) CNS/ metabolic disorder (n = 49): 0.58 (0.43–0.78) Cardiopulmonary failure (n = 11): 0.25 (0.046–1.39)	NR	NR	Fleiss' κ (n = 38, 3 raters) Appearance = 0.7, (0.51–088) $p < 0.001$ Work of breathing = 0.24 (0–0.48) p 0.01 Circulation to skin = 0.32 (0–0.49) $p < 0.001$ Categories of pathophysiology Stable = 0.70 (0.51–0.88) $p < .001$ Respiratory distress = 0.16 (0 to 0.49) p 0.08 Respiratory failure = 0.74 (0–1) $p < .001$ Shock = 0.32 (0–0.49) $p < .001$ CNS/metabolic disturbances = 0.68, (0.51–0.88) $p < .001$

Table 2 (continued)

Author (number of participants)	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)	Odds Ratio (95%CI)	Area under the receiver operating curve	Reliability (95% CI)
Lugo 2012 *N* = 157 children	NR (NR)	NR (NR)	NR (NR)	NR (NR)	NR	NR	Trained observer and nurse agreement 150/157: k 0.90 (0.91) Concordance Index[a] Stable and non-urgent patients: k.0.83 (0.85) Stable and semi-urgent: κ: 0.95 (0.96) Respiratory distress and compensated shock with urgencies: κ: 0.79 (0.81) Emergency and respiratory failure or decompensated shock: κ: 0.5 (0.6)
Ma 2021 [29] *N* = 1608 children	93.24 (NR)	99.15 (NR)	NR (NR)	NR (NR)	NR	AUROCC 0.96 AUROCC PAT vs PWES: 0.96 vs 0.99 x^2 0.10 p 0.74 The PAT performed better in assessing non-respiratory critical diseases (vs. respiratory critical diseases), with values of AUROCC of 0.986 vs 0.930, YI of 0.969 vs 0.858, respectively	Rate of agreement between the PAT and the actual situation of the sick child was 93.24%

CI confidence interval, *CNS* central nervous system, *PAT* pediatric assessment triangle, *PEWS* pediatric early warning score, *YI* Yorden index

*Concordance Index – is not typically considered a measure of reliability. In this context it has been used to predict or classify outcomes, the concordance index has been used to evaluate the accuracy of the test's predictions

Kappa interpreted as < 0.20 weak k 0.21 – 0.40, moderate k 0.41 – 0.60, good k 0,61- 0,80 very good

Fleiss k coefficient <0.00 poor, 0.00-0.20 slight 0.21-0.40 fair 0.41-0.60 moderate, 0.61-0.80 substantial 0.81-1.00 almost perfect.

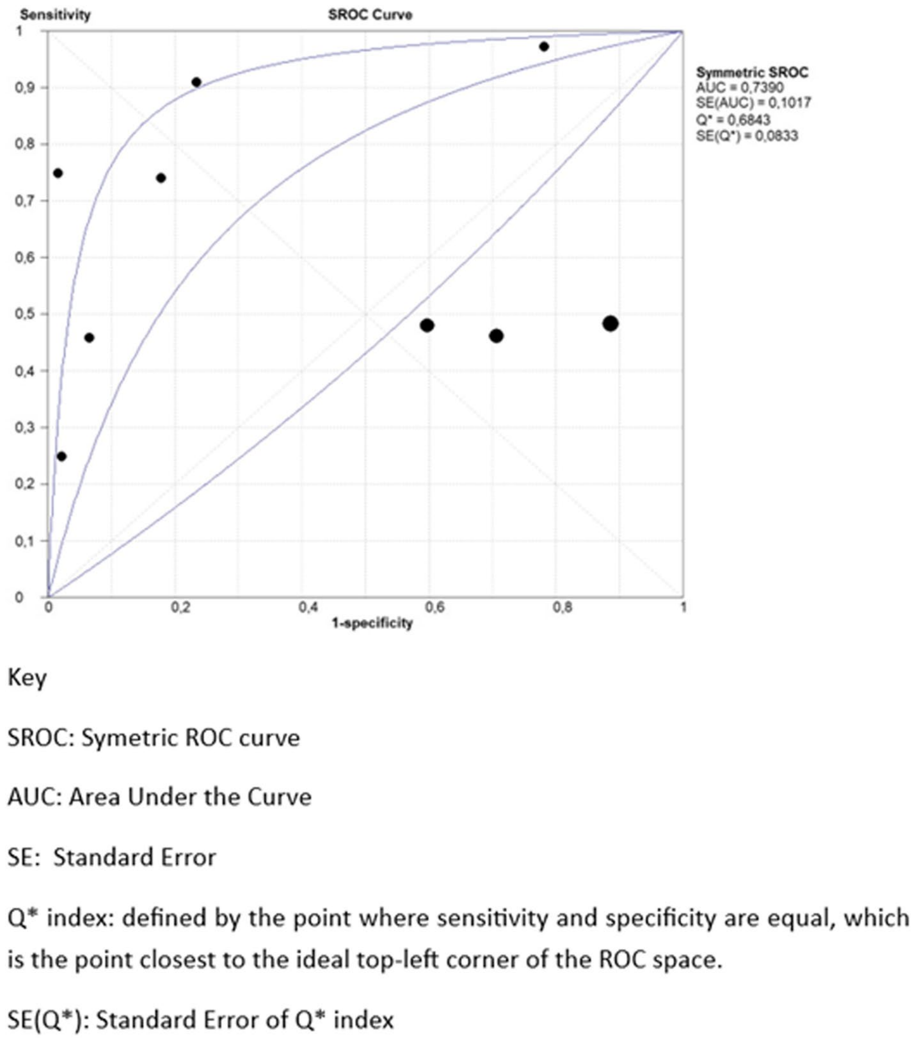

Fig. 3 PAT sensitivity and specificity

[26–29]. Specificity, measuring a test's ability to correctly identify patients without the condition, ranged from 22.9% to 99.15% (four studies) [26–29].

One study evaluated the PAT's validity and reliability [31] by collecting data for 157 patients triaged by a single trained observer and an "enfermera clasificadora" (classifying nurse). This single pair showed high inter-observer agreement in applying the PAT and no errors associated with polypnea, pre-existing pallor, or irritability.

Likelihood ratios (LR) measure a test's diagnostic accuracy which are less likely to change with the prevalence of a disorder. A positive LR (LR+) indicates a positive test result is more likely in people with the condition and a negative LR (LR-) indicates that a negative test result is more likely in people without the condition of interest. One study reported LR+of 5.2 (95% CI 5–7.8) [26] with a statistically significant high odds ratio (OR 111, 95% CI 73–168.6; $p<0.001$), indicating the PAT has a high ability to correctly identify and classify initial severity of disease during triage. A second study reported a LR+of 7.7 (95% CI 5.9–9.1) [27]. A third study triaged 1002 children using the PAT, reporting a LR+of 0.12 (95% CI 0.06–0.25) for children deemed stable by the PAT ($n=200$) [28]. This study's results for categories of pathophysiology (respiratory distress, respiratory failure, shock, central nervous system/metabolic disorder, and cardiopulmonary failure) highlighted the need to consider the clinical scenario when interpreting the PAT in EMS. However, the moderate LR- value (0.22, 95% CI 0.18–0.26) indicated that the test is less able to correctly identify children who do not need urgent care. The study reported a LR- of 0.12 (95% CI 0.06–0.25) for children found to be stable by the PAT ($n=802$) [28]. The LR- values for children with the five specified categories of pathophysiology suggest the PAT has relatively low LR for identifying respiratory distress and shock, indicating it is better at ruling out those conditions. However, the relatively high LR- for respiratory failure and cardiopulmonary failure suggests the PAT is less effective at ruling out those conditions.

One study (2017) found that abnormal PAT results were associated with an increased risk of admission to the hospital (OR 5.14, 95% CI 4.98–5.32; $p<0.01$) [30]. Abnormal appearance (OR 3.99, 95% CI 3.63–4.38) or having one or more components of the PAT (OR 14.99, 95% CI 11.99–18.74) were significantly associated with hospital admission [30]. The study identified adjusted age (OR 4.44, 95% CI 3.77–5.24; $p<0.001$) and triage (OR 1.78, 95% CI 1.72–1.84; $p<0.001$) as independent risk factors for intensive care unit admission and longer stays in the pediatric ED [30]. One study reported the PAT performed similarly to the Pediatric Early Warning Score (PEWS) (AUROCC 0.963 (PAT) and 0.966 (PEWS); $x^2=0.10$; $p=0.74$) [29].

Four studies reported high levels of reliability in PAT results [27–29, 32]. One study reported 93.6% reliability (Kappa index 0.7, 95% CI 0.5–0.8) [29]. A second study found paramedics used the PAT highly consistently across its three arms (Kappa 0.93, 95% CI 0.91–0.95) [32] and the paramedics' impression, completed using PAT on first contact with the patient, showed substantial agreement with the investigators' retrospective chart review on diagnosis and disposition (Kappa 0.62, 95% CI 0.57–0.66) and categorization of stable versus unstable (Kappa 0.66, 95% CI 0.62–0.71). A third study reported substantial inter-rater reliability agreement on PAT scores ($n=1002$, two pediatric emergency physicians and a pediatric nurse practitioner) (Fleiss' κ 0.7, $p<0.001$) [28]. A fourth study reported an agreement rate of 93.24% between the PAT and the condition of sick children [29].

Reported impacts of the PAT

Eighteen publications reported on impacts after PAT implementation; the word cloud of impact names is display in Fig. 4. Terms most used were "triage –communication -vocabulary and care".

Impact reported were on mortality, safety, effectiveness of care, timeliness of care, triage, and communication [27–31, 33–44]. Three studies showed the ability of the PAT to correctly assess critical cases (e.g. higher risk of mortality in patients with sepsis with an altered or unstable PAT) [33, 34, 36]. Two studies found that PAT helped to avoid unnecessary interventions or potential harm to patients [27, 35]. One study reported that a normal PAT result did not exclude severe infections, and a proper examination was still necessary to diagnose emergency pediatric patients [33]. One study reported that the PAT was timely and rapid to apply (mean 32.4 s) [31] and two studies reported that the PAT was equally effective, but faster and easier to use, than the PEWS in predicting critical illness in pediatric patients [29, 38].

Communication and documentation were another way the PAT's impact were reported. The PAT's "general impression" aided in care communication and helped prioritize management options. The specific vocabulary to describe a patient's vital signs and physical findings allowed for easy documentation and transfer/flow of information between EHWs [27, 28, 37]. Two studies highlighted the power of a common vocabulary in EMS replacing subjective comments with specific assessments [27, 28].

Studies offered insights into achieving optimal triage outcomes using the PAT. One study demonstrated the PAT's usefulness when classifying non-urgent patients

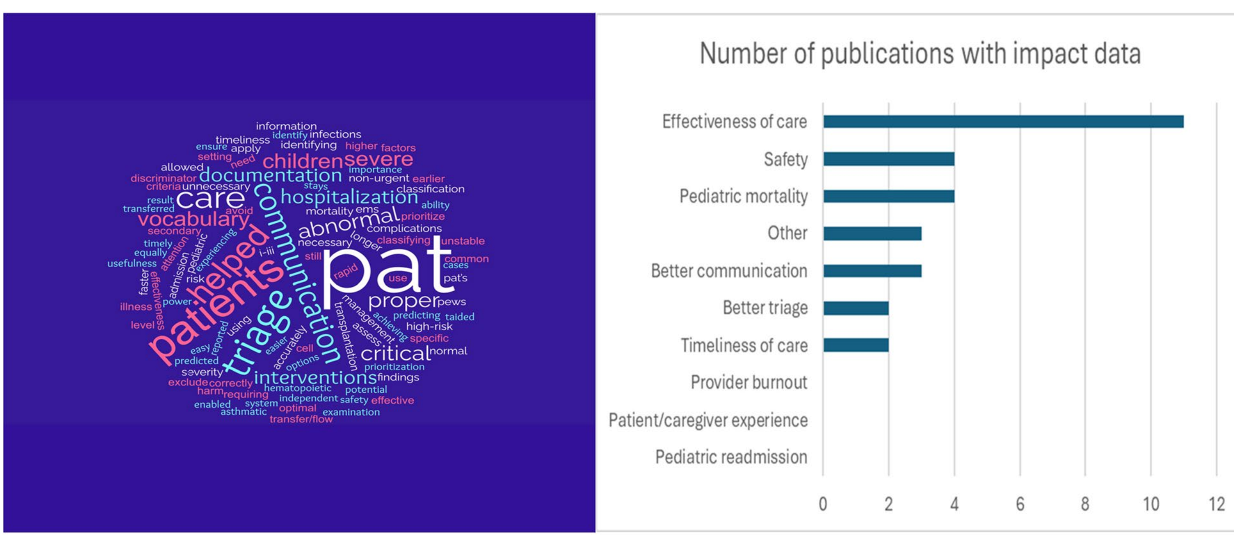

Fig. 4 The PAT reported impact

[40] and a second noted the importance of setting severity and prioritization criteria (1 to 5 depending on severity) and using the PAT to ensure proper attention [45].

Abnormal PAT findings helped to identify patients with a higher risk of hospitalization [30] and enabled earlier interventions for high-risk patients [42]. One study used the PAT for children experiencing secondary complications to hematopoietic cell transplantation [44] and reported that an unstable PAT, along with other factors, accurately predicted the need for admission (relative risk 3.4, 95% CI 2.6–4.6; $p < 0.001$). A study investigated features of 17,243 cases referred from in-hospital areas to the pediatric ED (median age 42 months (range: 0–120)); 65% of transferred patients were PAT-assessed as stable [41]. One study assessed the PAT as a discriminator in the triage classification system and assessed the correlation between pathophysiological diagnosis and triage classification [31]. Four studies suggested the PAT was considered practical and helpful in identifying emergency pediatric patients in need of intervention and identifying the probable underlying cause of illness [26, 28, 38, 46]. Treatment priorities were met in children with fever, and to a lesser extent for pain, respiratory distress, and oxygen needs.

One study concluded that an abnormal PAT and a more severe triage level (I-III) were independent factors in identifying asthmatic children requiring hospitalization and longer stays [43]. One study suggested that the PAT did not perform well for patients with anaphylaxis and as a result patients did not receive timely interventions [39].

We found no data for impacts on pediatric readmission, patient/caregiver experience, or provider burnout.

Setting and circumstances for PAT implementation

Ten studies evaluated pre-hospital triage using the PAT [6, 20, 27, 30, 38, 47–50] and 28 evaluated hospital triage [24, 26, 28–36, 39–46, 50–58]. No studies reported PAT use in emergency call centers or telemedicine services. One study noted that the PAT may be implemented by midwives working in hospitals or prehospital settings [37]. A study of 391 admissions reported PAT was considered a useful triage tool in resource-poor hospitals [52].

Four studies recommended formal training on using the PAT as necessary for effective use [27, 28, 45, 47]. One study (n = not reported) found that a low utilization rate for the PAT (patient report forms collected over a three-month period) following its introduction increased significantly following training in PAT use (12% vs 63.3%) [47]. After implementation, one study reported that the 30 emergency nurses involved preferred using the PAT over the PEWS when assessing emergency pediatric patients [29]. In a study of the Advanced Pediatric Life Support (APLS) course, attendees considered the systematic assessment approach incorporating the PAT crucial to their clinical practice, highlighting the importance of training prior implementation [54]. Studies acknowledged that applying the PAT with young infants (7–89 days old) was challenging [33], implementing the PAT requires skills, on-site senior emergency pediatric care providers, and a pediatric-friendly environment [59] and that the feasibility of the PAT is promising, but further research for "clinical validation" (not further defined) was needed [30].

We found no information about the implementation of PAT in clinical guidelines, requirements for recertification after PAT implementation, cost of implementation, or sustainability.

Teaching the PAT

Thirty studies presented data on teaching PAT to EHWs as follows: an early report suggested that the PAT was ideal for pediatric life support courses in all settings, based on its simplicity and reproducibility for both teachers and clinicians [60]. The PAT is included in one textbook of general emergency pediatrics [61] and two textbooks for emergency pediatric care in the prehospital environment [20, 62]. Courses for EHWs on pediatric life support have incorporated the PAT for the "first impression" assessment, as well as training on the use of the PAT tool itself [29, 30, 63].

Methods for teaching the PAT tool included classroom-based, use of simulation, use of virtual reality and video for case training [54, 64, 65]. The PAT has been recommended as a teaching tool for the goal-directed management of shock in children [66].

The number of people who have received PAT training is unknown, but more than 170,000 EHWs had received formal training up to 2010 (worldwide) [63]. The numbers of EHWs trained in the studies ranged from 30 to 1520 [29, 54].

Eighteen studies reported the care of emergency pediatric patients and provide insights into best practices for care which can, in turn, inform educational programs or be used to develop evidence-based protocols [30, 37, 48–50, 56, 57, 59, 67–76]. Four publications describe how emergency care providers use the PAT to assess emergency pediatric patients generally or with specific medical problems [30, 49, 59, 67].

Discussion

We identified 55 documents reporting the use of the PAT in hospital and pre-hospital emergency pediatric care. Research indicates that the PAT is a valid and reliable tool for evaluating emergency pediatric patients, prioritizing interventions, and determining the appropriate level of care. EHWs found the PAT is fast and practical, akin to the intuitive 'gut feeling' of experienced clinicians., but they should complete formal training before implementing the PAT. Several emergency pediatric care course curricula and key textbooks include the PAT.

We found only seven publications on the PAT's psychometric properties, which suggest that the PAT has good sensitivity and some variability in specificity. The low research volume may reflect ethical challenges around research involving children, the unique and unpredictable nature of emergency situations, the impossibility of controlling all variables and difficulties in obtaining funding [77]. Research on psychometric properties can be expensive and funding for pediatric-focused psychometric research may not be a priority for research funders. The PAT's ease of use may have contributed to its rapid adoption in practice before adequate psychometric testing was conducted and published. Implementing the PAT may still be challenging in terms of training or resistance to change [47]. Despite the challenges of research in the emergency setting, a third of the included studies reported positive impacts when using the PAT, suggesting its potential for triaging and improving patient outcomes in clinical settings which merits further investigation in an era of emergency department overcrowding and shortages of healthcare personnel.

Other tools are also used for emergency pediatric assessment (e.g., the Pediatric Glasgow Coma Scale, the PEWS, and the Pediatric Vital Sign Score) and each has its strengths and limitations. Choosing a tool depends on the specific circumstances and the healthcare provider's expertise. Based on the included comparative studies, the PAT is often favored for its simplicity, rapidity, and ease of use in remote or face-to-face emergency settings, since it does not require hands-on assessment or the use of specialized equipment. The available research and comparative studies merit further investigation.

Evidence was identified on training EHWs to use the PAT to assess accurately a child's appearance, work of breathing, and circulation. Proficiency is needed in using the tool and there is a need to use it regularly, to maintain their knowledge. While the PAT can provide a quick snapshot of a child's overall condition, it is only one part of a comprehensive assessment, and EHWs should use additional tools and techniques to assess a child's condition. Online courses, in-person workshops, and continuing education courses offered by professional organizations as well as guides or manuals with step-by-step instructions on how to use the PAT are all available. Healthcare providers who are considering preparing or updating their PAT training, perhaps using simulation-based approaches, should review these sources of evidence-based training [78].

The main challenges to PAT instruction noted to date are the limited provision of hands-on experience (i.e. real-life emergency situations), limited feedback on site to the EHW on their performance (to enable them to identify and correct areas of weakness in their assessment skills) and lack of standardization in the training programs. Skill decay is problematic as EHWs may forget the PAT steps without regular use. Re-certification requirements depend on the EHW's professional organization and any employer's certification requirements.

Although research evidence seems to show that the PAT is considered a valuable tool for rapid assessment of the status of a distressed patient, and its simplicity makes it easy to implement across a range of settings, we identified limited evidence on using the PAT in low-income settings [52, 79]. Resource-limited settings may lack coordinated emergency systems including at the scene aid, a system of triage, emergency medical care and critical care [80]. In these situations, different approaches to pediatric assessments may be adopted, limited data may be recorded on the frequency and quality of PAT assessments [81] and access to PAT training may be limited. Workforce shortages can impact the availability of trained EHWs to provide PAT instruction. Despite the limited evidence, we anticipate that the PAT is still a feasible tool for EHWs with limited resources [52]. The PAT's simplicity can be helpful in rural areas, remote communities, and resource-limited clinics. Based on evidence from this review, the PAT provides a practical and effective way for EHWs to assess children in emergency situations and make informed decisions about their care.

Limitations

This scoping review has limitations. Firstly, we focused on English language articles and there may be additional full text publications in non-English languages that might have provided information on low- and middle-income countries' experiences of the PAT, its impact, or its psychometric properties. This scoping review was pragmatic, but a follow up review may identify additional studies in languages other than English. Secondly, the search for grey literature was conducted on 14 websites, was hampered by the varying quality (and sometimes absence) of website search engines and the list of websites was prepared by one author (TT). A full systematic review would ideally search a larger number of websites and other sources of grey literature to potentially identify further research, particularly for LMICs. and might have been enhanced by suggestions from experts in the field.

Options for a future systematic review and other areas of research

A full systematic review would likely focus on those research questions for which there are most data following the scoping review and would also include detailed data extraction as well as the grouping of studies by outcomes of interest to provide summaries of the evidence for each outcome. Scoping reviews typically do not conduct risk of bias assessments or evaluate publication bias. A future systematic review could include these steps to assess the strength and quality of the evidence for the use of the PAT.

Other areas for research identified are how the PAT affects pediatric readmissions, patient/caregiver experience, and provider burnout. This scoping review did not find evidence of implementation, that is requirements of recertification and costs or data on utilization for example use of the PAT by emergency call centers, assessments by videoconference or other telemedicine services. Evidence on the utilization of the PAT specific to different emergency transport services such as air medical services, disaster response, etc. was not found.

Conclusion

In summary, this scoping review shows that the PAT has been used in clinical settings for over 20 years. There is some evidence of its validity and reliability, impacts and that the tool is broadly accepted by EHWs. Although the PAT condenses years of experience into a practical and useful assessment suitable for use by less experienced personnel, the need for prior training and certification was highlighted. Although there are gaps in the literature, the evidence has increase in recent years. Scoping reviews are used to inform research agendas and identify implications for policy or practice. As such, psychometric tool data are imperative. Further research on impact and implementation is warranted, and in particular, there is a need to standardize the teaching of PAT teaching and its certification. The simplicity, friendliness and low resources requirement of the tool should be considered in addressing the current healthcare shortages and overcrowding in emergency services.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12873-024-01068-w.

Additional File 1: Appendix B. PRISMA-ScR

Additional File 2. Appendix C. Search Strategy

Additional File 3. Appendix D. Excluded studies with reasons for exclusion

Additional File 4. Appendix E. Included studies

Additional File 5. Tables

Additional File 6. Appendix A – WHO Emergency Care System Framework

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Authors' contributions
Project conceptualization was done by TT, JB, JG, and AFL. TT and JB were primarily responsible for the methodology and resources, while TT, JB, and AFL carried out the data extraction and validation process, and TT led the analysis and synthesis. TT and JB wrote the original draft, with input and feedback from JG and AFL during the review and editing process. The visualization was primarily handled by TT and AFL. TT and JB supervised the project, and TT managed project administration. JB was responsible for software acquisition.

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Availability of data and materials
All data generated or analysed during this study are included in this published article [and its additional information files].

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
Tore A. G. Tørisen is an instructor and medical supervisor for courses in "Pediatric Education for Prehospital Professionals" (PEPP) and he is registered with the American Academy of Pediatrics (AAP). The remaining authors declare no conflict of interest.

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