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REVIEW ARTICLE

Review article: Pre-hospital provider clinical judgement upon arrival to the emergency department: A systematic review and meta-analysis

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Abstract

Pre-hospital providers (PHPs) undertake initial patient assessment, often spending considerable time with patients prior to arrival at ED. However, continuity of this assessment with ongoing care of patients in the ED is limited, with repeated assessment in the ED, starting with the process of triage in hospital. A systematic review of the literature was conducted to assess the ability of PHPs to predict patient outcomes in the ED. Manuscripts were screened and were eligible for inclusion if they included patients transported by non-physician PHPs to the ED and assessed ability of PHPs to predict triage scores, clinical course, treatment requirements or disposition from ED. The initial search returned 10 753 unique articles. After screening and full text review, 10 studies were included in data analysis. Of these, six assessed prediction of disposition (admission *versus* discharge) from ED, two compared triage score application, one assessed prediction of clinical requirements and one assessed prediction of mortality prior to discharge. Prediction of admission across five studies had a pooled sensitivity of 0.73 (95% confidence interval 0.67–0.79) and specificity of 0.78 (95% confidence interval 0.69–0.85). Triage score application had weighted kappa variables of 0.409 and 0.452 indicating moderate agreement on assessment priority between PHPs and triage nurses. The ability of PHPs to assign triage scores, predict clinical course and predict disposition from the ED have mild concordance with clinical assessment by ED staff. This is an area of potential expansion in PHPs' role; however, training would be required prior to implementation.

Key words: *emergency medicine, health resource, paramedic, triage.*

Key findings

- Prediction of disposition from ED by PHPs had pooled sensitivity of 0.73 (95% CI 0.67–0.79) and specificity of 0.78 (95% CI 0.69–0.85).
- Concordance of PHPs with triage categories, clinical course and patient outcomes was moderate.
- Further training and familiarity is indicated to incorporate opinions of PHPs into in-hospital clinical practice.

Introduction

Pre-hospital providers (PHPs) such as paramedics and emergency medical technicians (EMTs) often spend considerable amounts of time with patients prior to their arrival in the ED. Upon arrival, they generally present the patient's history, examination findings and clinical response to a triage nurse who assigns the patient a triage category and directs the patient to an appropriate area within the ED for further care.[1]

PHPs focus on information that enables them to determine underlying pathology/injury, required treatments and destination. They may have key insights about the unfolding of events, goals of care and the patient's environment.

In the last decade, ED design has focused towards streaming models of care with work collaboratively performed with the ED team to reduce repetition of assessment and diagnostics for patients. Attempts are being made to streamline communication to prevent repeated and unnecessary circulation of information. These include

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conjoint medical and nursing clinical notes and streamlined documentation. Such interventions are an integral part of the long-term strategy to improve access to timely and appropriate emergency care, and to reduce unnecessary time that patients spend in EDs.[2]

Previous systematic reviews have focused on PHP-initiated non-transport – where insufficient evidence to support PHP-initiated non-transport was found,[3] pre-hospital trauma triage – with similar findings[4] and ongoing research is focused towards information transfer from PHPs to hospital clinicians.[5] However, the accuracy of pre-hospital assessment to be used in prediction of clinical course in the ED have not been previously synthesised.

The aim of this systematic review and meta-analysis was to identify, evaluate and summarise current literature assessing the ability of PHPs to predict triage score, streaming destination, clinical course, treatment requirements or disposition upon arrival in ED.

Methods

Search strategy and information sources

A systematic search was conducted of the literature, through four databases (Medline, Embase, The Cochrane Library and CINAHL Plus) from the inception of these databases through to 15 March 2018. A search of the 'grey literature' was conducted through Google and Google Scholar. Reference lists from included articles and articles citing included studies were screened using Web of Science (Clarivate Analytics, Philadelphia, PA, USA).

The search strategy used a combination of controlled vocabulary and keyword searches. Box 1 shows the search for one database, OVID Medline. In order to maximise the sensitivity for the purposes of a thorough search, a paramedic literature search filter was used.[6] No restriction relating to publication language or year was implemented. Results were reported using items from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[7] The protocol for this systematic review was registered with PROSPERO (CRD42018093561).

Eligibility criteria

Studies were included if they assessed the ability of non-physician PHPs (e.g. paramedics and EMTs) to predict triage score, streaming destination, treatment requirements or disposition of patients upon arrival to an ED.

Studies that assessed PHP ability to apply a previously developed triage tool prior to arrival at the ED were excluded, as were studies identifying PHP application of a triage tool for patients they had not personally transported (e.g. Kahveci *et al.*[8]). Studies in which the prediction did not have a matched comparator (e.g. triage score *vs* admission), or where the comparator was also an experimental group (e.g. nurses without triage experience) were also excluded.

BOX 1. *OVID Medline search strategy. Both subject headings '/' and keyword searches '.tw.' were conducted. '?' indicates an optional wildcard and '*' indicates an unlimited truncation*

1. Ambulances/ or Emergency Medical Technicians/ or Air Ambulances/ or Emergency Medical Services/ or paramedic*.tw. or ems.tw. or emt.tw. or prehospital.tw. or pre-hospital.tw. or first responder*.tw. or emergency medical technicians.tw. or emergency services.tw. or Ambulance*.tw. or HEMS.tw. or field triage.tw. or out-of-hospital.tw.
2. Triage/ or triage.tw. or judg?ment*.tw. or stream*.tw. or predict*.tw.
3. 1 AND 2

Study selection

Following searches of databases and grey literature, duplicate results were excluded using in-built protocols within EndNote X8.2 (Clarivate Analytics). Titles and abstracts were appraised against eligibility criteria by one author (JWA), and full text were sought for those meeting inclusion criteria, or not obviously excluded. Inclusion into analysis was through appraisal of full text, with any disagreement resolved by discussion between authors (JWA, AO).

Analysis

Extracted data included study population demographics, level of PHP training, concordance of prediction with actual course (e.g. kappa, sensitivity, specificity, positive predictive value, negative predictive value) or other data as presented by the included studies. Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) assessment was performed by one author (JWA) after piloting of a review-specific tool for included studies.[9]

Statistical analysis

A meta-analysis was performed on prediction of disposition studies using a Meta-analytical Integration of Diagnostic Test Accuracy Studies analysis. This analysis was performed using STATA v.11.0 (StataCorp, College Station, TX, USA).

Results

Studies

Searches of the four databases and grey literature identified 12 229 studies. After removal of duplicates, 10 753 were screened for eligibility, with full text sought for 92 articles. All non-English articles (n = 228) had English abstracts supplied by the journal, none of which required full text review. Articles were excluded for triage or

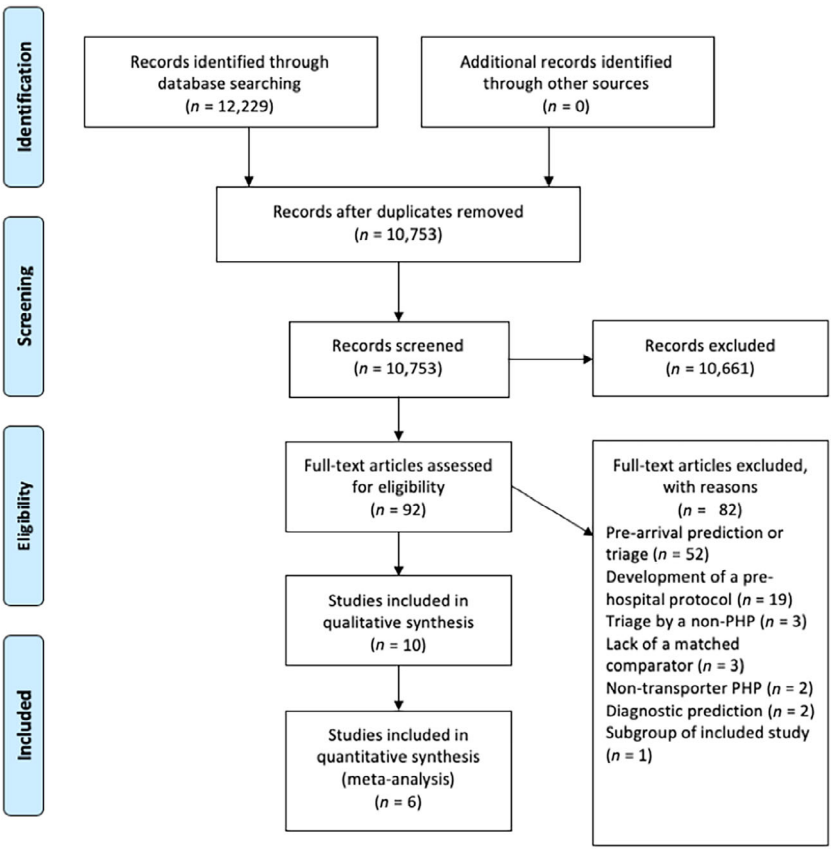

Figure 1. *Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram.*

prediction prior to hospital arrival (n = 52), development of a pre-hospital triage protocol (n = 19), triage by a non-PHP (n = 3), triage by a PHP who did not transport the patients (n = 2), lack of a matched comparator (n = 3), subgroup of included study (n = 1) and prediction of diagnosis (n = 2) (Fig. 1). Ten studies were included in the analysis, all of which were non-experimental cross-sectional studies. Study locations were USA (n = 6), UK, Ireland, Iran and Canada (n = 1 each).

Details of the included studies are presented in Table 1. Quality and bias assessments of the included studies are presented in Table 2 using a QUADAS-2 (Appendix S1). Across the seven risk of bias and applicability fields, one study was low risk, one study was of unclear risk and the remaining studies had at least one high risk criteria – mostly related to flow and timing of the PHP prediction. Included studies assessed paramedic prediction of ED disposition (n = 6), triage score upon arrival (n = 2), clinical requirements (n = 1) and prediction of mortality (n = 1).

Prediction of ED disposition

Six studies assessed PHPs' prediction of disposition from the ED of patients they transported.[10–15] The ability of PHPs to predict admission *versus* discharge from the ED is presented in Table 3 and meta-analysis presented in Figure 2). The pooled sensitivity (95% confidence interval [CI]) was 0.73 (0.67–0.79) and the pooled specificity was 0.78 (0.69–0.85).

Triage scale

Two studies compared PHP-assigned triage score to experienced triage nurses. Buschhorn *et al.*[16] trained PHPs to use the five-level emergency services index, which was reported upon arrival at ED for 75 patients. Forty-five (60%) cases reported perfect agreement, with a two-level disparity reported in five (6.7%) cases. A weighted kappa statistic of 0.409 (95% CI 0.256–0.562) was reported, representing moderate agreement.

Leeies *et al.*[17] trained PHPs to use the five-level Canadian Triage and Acuity Scale (CTAS). PHPs reported CTAS in their medical record upon arrival at hospital which was matched to the triage nurse's CTAS (which includes the ability for the triage nurse to override the protocol-based CTAS) for 14 378 transports. An exact or one-point difference between PHPs and triage nurse CTAS scores occurred 86.5% of the time. Weighted kappa was 0.452 (95% CI 0.437–0.466), indicating moderate agreement.

Clinical requirements

One study[18] compared PHP prediction of clinical requirements with actual clinical requirements within 24 h of admission. Predicted items, termed life-saving interventions (LSIs) included blood transfusion, fluid bolus, intubation or emergency surgery. Potential bias was introduced through the handover process, as the survey was administered only after handover had been completed. PHPs predicted the requirement for LSIs with varying accuracy. Negative predictive values for blood transfusion, intubation and emergency surgery were all greater than 0.90. Sensitivities ranged from 0.48 to 0.69 and specificities ranged from 0.81 to 0.92 for these LSIs. The ability to predict requirement for fluid bolus was poorer (sensitivity 0.37, specificity 0.76). This study also assessed the ability of nurses and doctors to predict LSI requirements, who were generally more accurate in their predictions compared to PHPs.

Mortality prediction

One study[19] compared PHPs' in-hospital mortality predictions on a 0–100% scale to actual mortality.

TABLE 1. *Details of included studies*

Author	Year	Country	PHP	*n*	PHP prediction
Afzalimoghadam *et al.*[11]	2013	Iran	EMT-I	267	Disposition from ED
Anazodo *et al.*[18]	2015	USA	EMT and paramedic	209	Clinical requirements
Buschhorn *et al.*[16]	2013	USA	EMT and paramedic	75	ESI triage scale
Clesham *et al.*[12]	2008	UK	EMT and paramedic	396	Disposition from ED
Cummins *et al.*[10]	2013	Ireland	Advanced paramedic	859	Disposition from ED
Emerman *et al.*[19]	1991	USA	EMT	1153	Mortality prediction
Leeies *et al.*[17]	2017	Canada	Paramedics	14 378	CTAS triage scale
Levine *et al.*[13]	2006	USA	Paramedics	932	Disposition from ED
Price *et al.*[14]	2005	USA	EMT and paramedic	411	Disposition from ED
Richards and Ferrall[15]	1999	USA	EMT and paramedic	887	Disposition from ED

CTAS, Canadian Triage and Acuity Scale; EMT, emergency medical technician; EMT-I, emergency medical technician intermediate; ESI, emergency services index; PHP, pre-hospital practitioner.

TABLE 2. *QUADAS-2 assessment of bias in included studies*

Study	Risk of bias				Applicability concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Afzalimoghadam *et al.*[11]	☺	☺	☺	☹	☺	☺	☺
Anazodo *et al.*[18]	☺	☹	☺	☹	☺	?	☺
Buschhorn *et al.*[16]	☹	☺	☺	☺	?	☺	☺
Clesham *et al.*[12]	☺	☺	☺	☺	☺	☺	☺
Cummins *et al.*[10]	?	☺	☺	☹	?	☺	☺
Emerman *et al.*[19]	?	☺	☺	?	☺	☺	☺
Leeies *et al.*[17]	☹	☺	☺	☹	☺	☺	☺
Levine *et al.*[13]	☺	☺	☺	☹	☺	☺	☺
Price *et al.*[14]	☹	?	☺	☹	?	☺	☺
Richards and Ferrall[15]	☹	☺	☺	☹	?	☺	☺

☺, Low risk; ☹, high risk; ?, unclear risk.

The patient population (n = 1153) was composed of trauma patients of all ages from Ohio, USA. Most patients presented with blunt trauma (87.3%), and there were 39 (3.4%) fatalities in the cohort. Seventeen (44%) of these deaths were because of penetrating trauma. The majority (37/39, 94.9%) of fatalities had PHP mortality predictions of ≥60%. One fatality occurred in a patient with a predicted mortality of less than 10%, and one occurred with a predicted mortality of 20–30%.

This manuscript found similar performance between PHP predictions and pre-existing trauma prediction scores (pre-hospital index, CRAMS [circulation, respiration, abdomen, motor, speech] and triage-revised trauma score).

Discussion

PHPs clinical judgement upon arrival to the ED is not routinely

TABLE 3. *Sensitivity and specificity of pre-hospital provider (PHP) prediction of admission to hospital* versus *discharge from the ED*

Author	PHP training	Sensitivity (95% CI)	Specificity (95% CI)
Afzalimoghadam *et al.*[11]	EMT	0.84 (0.79–0.89)	0.66 (0.48–0.81)
Clesham *et al.*[12]	EMT and paramedics	0.72 (0.65–0.78)	0.77 (0.71–0.82)
Cummins *et al.*[10]	EMT and paramedics	0.77 (0.72–0.81)	0.65 (0.61–0.69)
Levine *et al.*[13]	EMT	0.62 (0.54–0.68)	0.89 (0.86–0.91)
Price *et al.*[14]	EMT and paramedics	0.77 (0.69–0.83)	0.83 (0.77–0.87)
Richards and Ferrall[15]	EMT	0.68 (0.62–0.73)	0.85 (0.82–0.88)

CI, confidence interval; EMT, emergency medical technician.

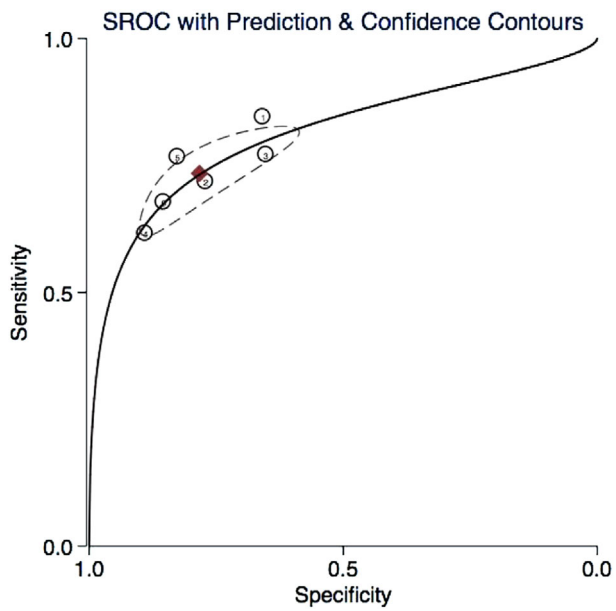

Figure 2. *Meta-analytical Integration of Diagnostic Test Accuracy Studies analysis of prediction of ED disposition. (○) Observed data; (◆) summary operating point (sensitivity = 0.73 [0.67–0.79]; specificity = 0.78 [0.69–0.85]); (——) summary receiver operating characteristic (SROC) curve (area under the curve = 0.81 [0.77–0.84]); (——) 95% confidence contour; (- - - -) 95% prediction contour.*

incorporated into handover of care to in-hospital providers. Concordance of PHP prediction and actual outcome of patient disposition from the ED, triage scale, clinical requirements and mortality were mild to moderate. The present study confirms the complexity of patient flow within EDs. Without inherent knowledge of processes within the ED, the unique nature of patient flow and changes to patient outcomes based on investigations and management within the ED, the utility of PHP assessments appear limited to decisions of pre-hospital transport and management.

PHPs in the included studies received basic training in the use of prediction instruments; however, longer-term familiarity may improve their predictive capabilities to have more widespread utility. The moderate agreement between PHPs and triage nurses is comparable to the findings of a study by Dallaire *et al.* – which showed moderate agreement (kappa 0.44, 95% CI 0.40–0.48) between experienced triage nurses using the CTAS.[20] This study used nurses who had not recently undergone training in CTAS application. Factual knowledge, rather than years of experience was reported to improve accuracy of triage decisions in a systematic review, indicating that the skill of triaging may be effectively taught.[21] If armed with a more in-depth and contemporary knowledge of ED capacity and processes, PHP assessment may be invaluable in further streamlining patient flow.

A push towards more efficient modes of service delivery in EDs has led to the development of 'streaming' models of care. In these streaming models, the streaming clinician generally assigns patients to resuscitation/trauma, rapid assessment area which feeds into monitored and unmonitored beds or a minor condition area (or fast track).[22–25] In these systems, the prediction of care requirements and streaming destination (resuscitation/trauma, rapid assessment zone or minor condition area) is more important than the numerical triage scale, which may favour the PHP's appreciation of clinical course.

This streaming approach may be an area in which EMTs and paramedics could expand their scope of practice. Paramedics taking over the role of triage or streaming for patients they transfer may reduce time to triage for non-ambulance attendances by freeing up triage nurses in settings where limited

triage nurses are present. A study by Betz *et al.* found that among non-ambulance attendances, 20.8% of the most acute patients (CTAS 1 and 2) waited more than the recommended time-to-physician interval while waiting to be triaged.[26]

Despite time spent awaiting triage assessment being one factor, paramedic ramping times (time spent with patient prior to transfer to a physical ED stretcher) has been correlated with access block and admitted patients.[27] Reductions in time to triage may, overall, play a small role in ramping times, but paramedic triage may allow triage or streaming nurses the ability to focus on non-ambulance attendances and ensure that higher-acuity patients are seen in a more timely manner.

The attitude of PHPs to an expansion of their role upon arrival to the ED should be investigated prior to commencement of any training programmes to build upon these skills. Similarly, risks of inaccurate predictions of disease severity, assessment and outcomes should be weighed against potential benefits of improved times to care.[28]

Limitations

Heterogeneity between studies, as well as the diverse levels of PHP training, pre-hospital systems, and health services represent a significant limitation to the generalisation of these results to other settings. The present study is also limited by likely publication bias with studies at the interface of pre-hospital and in-hospital care mostly limited to high-income countries, further limiting its applicability to low- and middle-income settings. Standardising the recognition of disease severity through use of smartphone applications and checklists has the potential to improve pre-hospital assessment and communication in these settings.[29]

Conclusion

Pre-hospital provider prediction of triage score, streaming destination, clinical course, treatment requirements or disposition from ED upon arrival to the ED were mildly concordant with actual processes. This represents an area of potential expansion to assist improved streaming of patients on arrival, with potential to improve patient outcomes and experience.

Competing interests

BM is a section editor for *Emergency Medicine Australasia*.

Data availability statement

Data sharing is not applicable to this article as no new data were created in this study.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. QUADAS-2 criteria for primary studies related to disposition prediction.