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Research Paper

Performance of the Interagency Integrated Triage Tool in a resource-constrained emergency department during the COVID-19 pandemic

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ABSTRACT

Background: The Interagency Integrated Triage Tool (IITT) is a three-tier triage instrument recommended by the World Health Organization, but only the pilot version of the tool has been comprehensively assessed for its validity and reliability. This study sought to evaluate the performance of the IITT in a resource-constrained emergency department (ED) during the COVID-19 pandemic.

Methods: This prospective observational study was conducted at ANGAU Memorial Provincial Hospital in Lae, Papua New Guinea. The study period commenced approximately six weeks after introduction of the IITT, coinciding with a major COVID-19 wave. The primary outcome was sensitivity for the detection of time-critical illness, defined by eight pre-specified conditions. Secondary outcomes included the relationship between triage category and disposition. Inter-rater reliability was assessed using Cohen's Kappa.

Results: There were 759 eligible presentations during the study period. Thirty patients (4.0%) were diagnosed with one of the eight pre-specified time-critical conditions and 21 were categorised as red or yellow, equating to a sensitivity of 70.0% (95%CI 50.6–85.3). There was a clear association between triage category and disposition, with 22 of 53 red patients (41.5%), 72 of 260 yellow patients (27.7%) and 22 of 452 green patients (4.9%) admitted ($p = < 0.01$). Negative predictive values for admission and death were 95.1% (95%CI 92.7–96.9) and 99.3% (95%CI 98.1–99.9) respectively. Among a sample of 106 patients, inter-rater reliability was excellent ($\kappa = 0.83$) and the median triage assessment time was 94 seconds [IQR 57–160].

Conclusion: In this single-centre study, the IITT's sensitivity for the detection of time-critical illness was comparable to previous evaluations of the tool and within the performance range reported for other triage instruments. There was a clear relationship between triage category and disposition, suggesting the tool can predict ED outcomes. Health service pressures related to COVID-19 may have influenced the findings.

Background

Emergency department triage

Emergency care is critical to the attainment of universal health coverage [1]. It provides an integrated platform for the assessment of patients with acute illness and injury, and has the potential to address a substantial proportion of the disease burden in low- and middle-income countries (LMICs) [1–4].

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An important function of all emergency care facilities, including emergency departments (EDs), is to identify and prioritise patients with time-critical care needs [5,6]. This process, known as triage, is especially important in settings where demand for care exceeds the available resources.

A small number of triage tools have been specifically developed for LMIC EDs [7]. The most widely studied is the four-tier South African Triage Scale (SATS), which has demonstrated acceptable performance in a range of contexts [7]. Despite extensive uptake of SATS, clinicians have called for simpler and more efficient tools to facilitate triage in LMIC EDs [8,9].

The Interagency Integrated Triage Tool

In the early stages of the pandemic, the World Health Organization (WHO) released the Interagency Integrated Triage Tool (IITT) as part of its COVID-19 clinical guidance [10,11]. Developed collaboratively with Médecins Sans Frontières and the International Committee of the Red Cross, the IITT is a three-tier, colour-coded triage instrument specifically designed for resource-constrained environments (Fig. 1 and Appendix 1) [10–12]. The pilot version of the tool has demonstrated reasonable performance characteristics in two single-centre studies [12,13].

Since the onset of the pandemic, the only evaluation of the IITT's predictive validity has focussed on patients with severe and critical COVID-19. [14] Beyond this, there has been no formal assessment of the final version of the tool, as released by WHO in early 2020. [10].

In the context of increasing global uptake of the IITT, [15] this research aimed to assess the predictive validity and inter-rater reliability of the tool in a resource-constrained, regional ED in Papua New Guinea (PNG). It was undertaken during PNG's third COVID-19 wave, which seriously impacted healthcare capacity across the country. [14,16,17].

Methods

Design and participants

This prospective observational study was conducted at ANGAU Memorial Provincial Hospital (AMPH) in Morobe Province, PNG. All ED presentations during the study period were eligible for inclusion. Patients who did not have a documented triage category were excluded from the analysis.

Setting and context

AMPH is the major healthcare facility in the city of Lae, which has a population of approximately 150,000 [18,19]. The hospital's ED includes two resuscitation bays, eight acute beds and a consultation room. At the time of this study, staffing comprised one emergency physician, one registrar, three health extension officers and approximately 20 nurses and community health workers. Long-standing challenges for the department include poor infrastructure and a limited workforce.

In light of these issues, the Australian Government Department of Foreign Affairs and Trade, in partnership with the Government of Papua New Guinea, has been supporting the redevelopment of AMPH [18,19]. As part of this project, a Clinical Support Program was established to enhance clinical systems at the hospital, including emergency care. Through a needs assessment process, local clinicians identified that new approaches to triage and streaming were required. The urgency of this work was highlighted by serial waves of COVID-19, which caused immense disruption to healthcare facilities across PNG [14,16,17].

Although the Australasian Triage Scale (ATS) was nominally practised in the ED prior to this study, its use was not systematised. Given the challenges of applying a five-category system in a resource-constrained setting, clinicians expressed a preference for a simpler approach and identified the IITT as an appropriate tool. This decision was informed by experience with the pilot version of the IITT in other PNG EDs [12,13,20]. While it would have been desirable to directly compare the performance of the ATS and IITT in this context, the absence of a consistent approach to triage prior to this study prohibited head-to-head evaluation.

Triage intervention and process

The IITT allocates patients to one of three colour-coded categories of urgency based on their presenting complaint and/or vital signs (Fig. 1). The system is summarised in the IITT Quick Reference Guide (Appendix 1), which was developed specifically for the PNG context. Descriptors for red (emergency) and yellow (priority) categories were updated slightly from those used during piloting of the system (Appendix 2) [12,13,20].

The process to implement the IITT at AMPH has been described in detail elsewhere [21]. In brief, the tool was installed as part of a package of ED systems improvements, and involved a partnership between local and Australian emergency care clinicians. The change management process utilised a web-based digital learning application, supplemented by peer mentoring and review tutorials undertaken by visiting Australian emergency nurses [21]. This strategy has been evaluated separately, and found to be effective in improving knowledge and confidence [21]. All AMPH ED staff were eligible to receive training in triage assessment.

Other articles have described the operationalisation of the system [20,22]. In summary, all AMPH ED patients are allocated a registration form at the point of triage, which is placed in a colour-coded box based on their triage category. This allows clinicians to determine who is next to be seen. During the patient's period of emergency care, the registration form is used to record clinical and administrative information. Following their departure from the ED, this data is then manually entered into the department's electronic registry by a clerk. Photos illustrating the IITT in operation at AMPH are included in Appendix 3 [21].

Study period

This study commenced approximately six weeks after the implementation of the IITT (1 October 2021). Collection of validation data ceased three months later (31 December 2021), based on the sample size calculation detailed below. The gap between installation of the new system and commencement of the study was instigated to allow sufficient time for the new processes to become embedded; to offset any honeymoon effect; and to ensure that no Australian nurses involved in the introduction of the IITT were present during the evaluation.

Reliability data were collected over the subsequent nine months through to 30 September 2022. This extended time frame was necessary to ensure inter-rater reliability was assessed using an independent, experienced emergency nurse, who was undertaking intermittent visits to the ED in a capacity development role during this period.

Outcomes and analysis

Primary outcome

Study methods were informed by pilot evaluations of the IITT, [12,13] as well as experience evaluating triage systems in other LMIC contexts [5,7,23,24]. The primary outcome was sensitivity for the detection of time-critical illness, defined by eight, pre-selected diagnoses (severe trauma; major burns; severe head injury; ruptured ectopic pregnancy; septic shock; myocardial infarction; severe

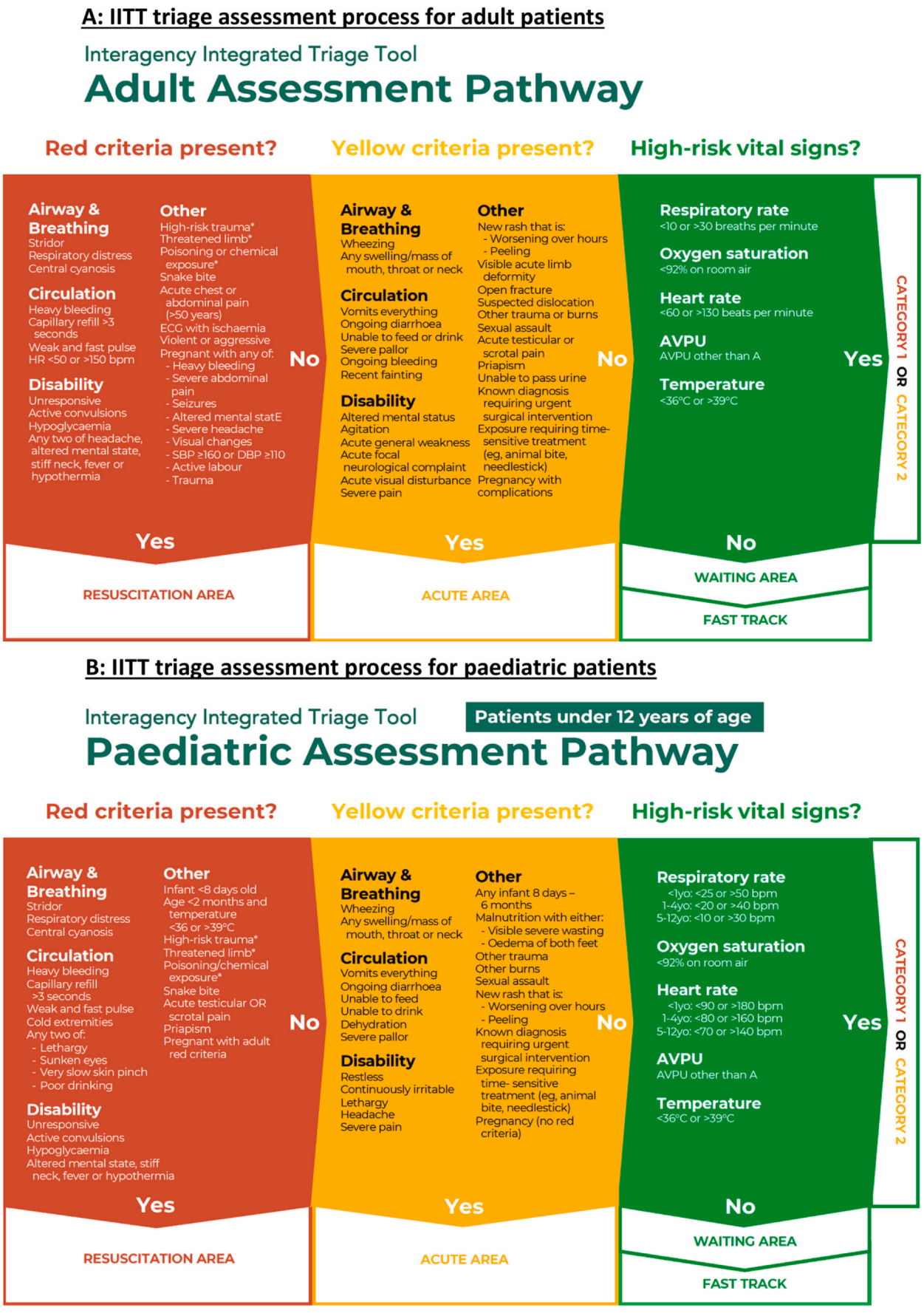

Fig. 1. A IITT triage assessment process for adult patients. B: IITT triage assessment process for paediatric patients.

asthma, chronic obstructive pulmonary disease or pneumonia; acute bacterial meningitis; and acute surgical abdomen). This list of conditions was derived from previous IITT validation studies, but updated to address limitations acknowledged by those authors [12,13]. Specific definitions for these diagnoses can be found in Appendix 4.

As explored in the discussion below, this primary outcome measure was utilised to address the issues associated with surrogate markers of urgency [7,23–26]. Although triage validation studies in LMICs have generally used disposition as a reference standard, not all patients who are admitted necessarily require time-critical assessment and treatment [7]. Conversely, some patients with truly urgent conditions (eg, anaphylaxis) can be safely discharged from the ED after effective emergency care.

Sensitivity was calculated using a dichotomised triage categorisation (red and yellow as urgent, and green as non-urgent), expressed with a 95% confidence interval (CI). The presence of one of the eight time-critical diagnoses relied on identification of the condition by the treating clinician at the time of ED discharge (ie, independent of the triage assessment). If present, the treating clinician would tick a box on the patient's registration form. The study definitions for these conditions were displayed on posters in the ED (Appendix 4).

Algorithms derived from Buderer's formula were used to determine the sample size. [27,28]. A sensitivity of approximately 70% (an estimate based on previous observations of IITT performance for detecting time-critical diagnoses) and a prevalence of 10% (ie, 1 in 10 patients presenting to AMPH ED would be diagnosed with one of the eight, pre-specified, time-critical diagnoses) were assumed. Based on these figures, a sample size of approximately 3227 was required to achieve a point estimate with a confidence interval of.05 (+/- 5%).

During successive COVID-19 waves, AMPH ED saw drastic reductions in ED attendance. This reflected the diversion of patients with suspected and confirmed COVID-19 to a temporary healthcare facility, and widespread community concern over the risk of nosocomial transmission. Similar patterns were seen across the country. [16] Based on experience earlier in the pandemic, local clinicians estimated approximately 40 patients would present each day to AMPH ED. On this basis, a study period of three months was determined to be required.

Secondary outcomes

Secondary measures of performance were the relationship between triage category and emergency care outcomes (hospital admission and death in the ED), expressed using sensitivity and specificity. Again, these were calculated using a dichotomised triage categorisation and reported with a 95% CI, based on an approach used elsewhere [12,13,24,26].

In the setting of three, ordinal triage categories, these relationships were also assessed using Cramer's V, derived from Pearson's Chi-Square. This methodology has been employed in similar studies [12,13,29]. For all analyses, a p-value of less than 0.05 was considered statistically significant.

To test the reproducibility of IITT triage assessments (ie, reliability), [23] inter-rater agreement between a local triage officer and an experienced Australian emergency nurse was assessed. Triage assessment was undertaken simultaneously. While both clinicians listened to the presenting complaint at the same time, triage categories were determined independently. To minimise the risk of bias, both clinicians were blinded to each other's assessment.

Reliability testing utilised continuous samples of patients across a series of shifts, and involved a range of local triage officers (nurses and health extension officers). The time taken for the local clinician to finalise and document the triage decision was also recorded. Inter-rater agreement for the assigned triage category was measured using a linearly-weighted Cohen's Kappa statistic (κ), with $\kappa > 0.8$ defined as excellent agreement. Time data were summarised by median and interquartile range (IQR), because application of the Shapiro Wilk test demonstrated non-parametric distribution. All statistical analyses were performed in Stata v18 (College Station, Texas, USA).

Data sources

With the exception of inter-rater reliability assessment, data used in this study were exported from AMPH's electronic ED registry. As described above, all data in this registry are entered by administrative staff, based on registration forms completed by clinicians during the relevant episode of care.

Ethics

Ethics approval, including a waiver for consent, was obtained from Monash University (MUHREC 27742) and endorsed by the PNG Medical Research Advisory Committee (MRAC 22.46). The study was also approved by the AMPH Executive. Data have been reported in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. [30].

Results

Sample and demographics

As detailed in Fig. 2, there were 765 eligible presentations during the study period. Demographic and clinical characteristics of these patients are summarised in Table 1. Seventy (9.2%) were aged less than 18 and 349 (45.6%) were female. Overall, 53 patients (6.9%) were classified as red, 260 (34.0%) as yellow and 452 (59.1%) as green.

Primary outcome

Thirty patients (4.0%) were diagnosed with one of the eight, pre-specified time-critical diagnoses. Of these, 21 were allocated a red or yellow triage category, equating to a sensitivity of 70.0% (95%CI 50.6–85.3) for the detection of the time-critical illness.

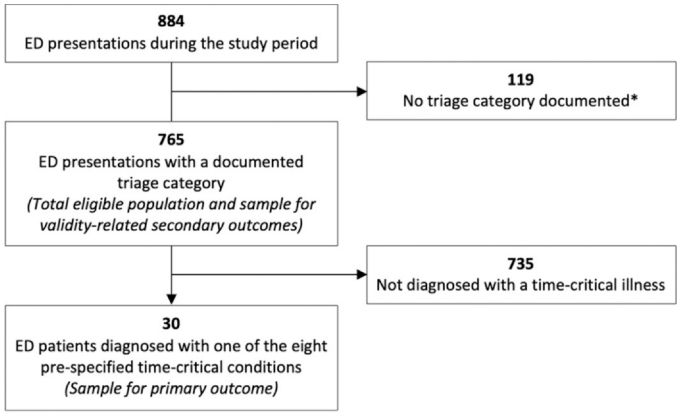

Fig. 2. Study sample.

Table 1
Study participants.

Variable		n (%)
Gender	Female	349 (45.6%)
	Male	415 (54.3%)
	Other	1 (0.1%)
Age	< 18	70 (9.2%)
	18–39	412 (53.9%)
	≥ 40	283 (37.0%)
Triage category	1	53 (6.9%)
	2	260 (34.0%)
	3	452 (59.1%)
Disposition	Admitted	116 (15.2%)
	Deceased	23 (3.0%)
	Discharged	626 (81.8%)

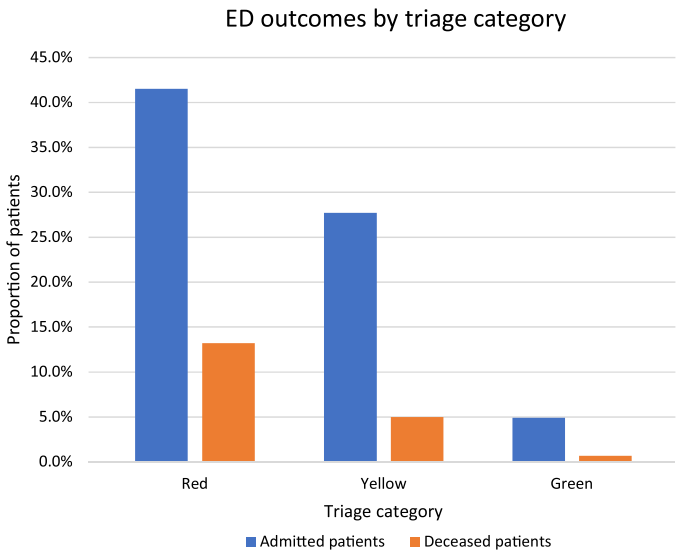

Fig. 3. ED outcomes by triage category.

Secondary outcomes

Admission

Overall, 22 of 53 red patients (41.5%), 72 of 260 yellow patients (27.7%) and 22 of 452 green patients (4.9%) were admitted (Cramer's V 0.36, p = < 0.01). These data are summarised in Fig. 3.

Sensitivity for the detection of admission was 81.0% (95%CI 72.7–87.7), with a negative predictive value of 95.1% (95%CI 92.7–96.9). Other performance characteristics are summarised in Table 2.

Deaths

With respect to mortality, 7 of 53 red patients (13.2%), 13 of 260 yellow patients (5.0%) and 3 of 452 green patients (0.7%) died in the ED (Cramer's V 0.20, p = < 0.01). These data are also summarised in Fig. 3. As reported in Table 2, sensitivity for the detection of death was 87.0% (95%CI 66.4–97.2). The negative predictive value was 99.3% (95%CI 98.1–99.9).

Table 2
IITT performance characteristics for predicting admission and death.

Performance measure	ED outcomes	
	Admission	Death
Sensitivity (95% CI)	81.0% (72.7–87.7)	87.0% (66.4–97.2)
Specificity (95% CI)	66.3% (62.5–69.9)	60.5% (56.8–64.0)
PPV (95% CI)	30.2% (25.2–35.7)	6.43% (4.0–9.8)
NPV (95% CI)	95.1% (92.7–96.9)	99.3% (98.1–99.9)
+ LR (95% CI)	2.4 (2.1–2.8)	2.2 (1.8–2.6)
- LR (95% CI)	0.3 (0.2–0.4)	0.2 (0.1–0.6)

PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio

Reliability

Reliability was assessed using a sample of 106 patients, and involved 10 AMPH nurses and health extension officers. Inter-rater agreement was excellent ($\kappa = 0.83$). The median time for a local triage officer to complete a triage assessment was 94 seconds [IQR 57–160 s].

Discussion

Key findings

This study assessed the performance of the IITT in a resource-constrained ED experiencing the impacts of the COVID-19 pandemic. In this context, sensitivity for the detection of time-critical illness was 70.0%, and there was a clear association between triage category and ED outcomes. Inter-rater reliability for the tool was excellent, with a median triage assessment time of less than 100 seconds. Clinicians interpreting these findings should be aware that the study was under-powered because of lower-than-expected presentation numbers, and this may have impacted the precision of the primary outcome measure.

Interpretation

The primary objective of any ED triage tool is to differentiate patients with time-critical illness and injury from those who can safely wait. Consistent with this, the present study was designed to assess the ability of the IITT to detect conditions that objectively require urgent intervention, such as antibiotics for septic shock and oxygen for severe pneumonia.

In this regard, the performance of the IITT in this study was sub-optimal. Ideally, the tool would have detected a higher proportion of patients presenting with urgent care needs, minimising the risk of preventable morbidity and mortality. Interestingly, the sensitivity reported in this study was almost identical to that found in the first pilot evaluation of the IITT [12].

Sub-optimal sensitivity for the detection of time-critical illness is a common, almost universal, weakness of ED triage tools [7,24,25]. A 2019 systematic review identified sensitivities of between 36% and 92% for a range of urgent conditions, including severe sepsis (36–74%), pulmonary embolism (54%) and ST-elevation myocardial infarction (56–92%) [24]. These findings were observed across a range of high-resource settings [24].

Data on the ability of triage tools to detect time-critical illness in LMICs appears to be limited to a single study from Turkey that used intensive care unit (ICU) admission as a surrogate marker of urgency [7,31]. Armagan et al. found that patients identified as high acuity by the Modified Early Warning System had an odds ratio of 1.95 for admission to the ICU compared with those deemed to be low acuity [31]. Methodological differences make it difficult to compare these results with the performance of the IITT at AMPH.

There are several possible explanations for the primary outcome findings of this study. First, some patients diagnosed with one of the pre-specified time-critical conditions, as documented by the treating clinician, may have deteriorated during their episode of care. For instance, it is conceivable that a patient with acute pneumonia may have presented with acceptable oxygen saturations (based on IITT criteria) but become progressively hypoxic during their ED stay. In other words, they may only have met criteria for severe pneumonia at the point of ED departure, when documentation was completed, but not at the time of triage. During the study period, the median

length of stay for urgent patients was over 16 hours, which may explain this effect. This issue is a recognised methodological challenge for triage validation studies, [23] and highlights that some patients will require re-triage (and/or repeat assessment) because of clinical deterioration.

Second, in order to avoid 'over-triage', the IITT's range of acceptable vital sign parameters (ie, 'normal values') are relatively liberal (Fig. 1). This may explain why some patients with a time-sensitive condition, but only minor abnormalities in their observations, were designated as green. For example, an adult with a heart rate of 125 would still be categorised as 'non-urgent' provided no other red or yellow criteria were present. This is a design feature of the IITT, and represents a trade-off between sensitivity and specificity in the detection of critical illness.

Finally, PNG's third COVID-19 wave had a major impact on PNG EDs, including AMPH. [14,16,17,32] At times, staffing levels were extremely low and this may have impacted the quality and thoroughness of triage assessments. As has been observed elsewhere, it is not possible, in general, to separate the performance of triage systems from the environments in which they are evaluated [23,26]. It is possible, therefore, that the IITT may perform differently in better-resourced facilities.

Despite sub-optimal sensitivity for detecting time-critical illness, the IITT was able to predict ED outcomes. Performance characteristics for identifying patients at risk of admission and death were encouraging, with high negative predictive values. This is an important finding, because it confirms that green patients are highly likely to be discharged from the ED. These data align closely with other assessments of the IITT, and support the streaming of green patients to low acuity or fast track areas [12,13]. Overall, these secondary outcome results suggest that the tool's performance is comparable, if not superior, to other triage instruments evaluated in LMIC contexts [7].

Although these results are positive, using admission as an outcome measure is somewhat problematic. This reflects that many patients with genuinely urgent conditions (large joint dislocations, for instance) can safely be discharged after effective emergency care. Conversely, some patients with low urgency conditions will still require admission to meet their care needs. These issues are widely acknowledged, and have stimulated considerable discussion about the optimal primary outcome measure for triage validation studies [7,23–26].

Importantly, the inter-rater reliability identified in this study was comparable with other evaluations of the IITT, [12,13] and favourable when compared to assessments of SATS and the ATS [7]. This is a promising finding for a tool that has been specifically designed for application in resource-constrained settings. Similarly, the rapid triage assessment time appears to be a strength of the IITT, and represents a positive attribute for a triage instrument that is likely to be applied in EDs experiencing high demands for care.

Limitations

Several factors limit the generalisability of this study. First, it was conducted at a single site experiencing significant operational challenges related to COVID-19. As discussed above, it is generally not possible to consider the performance of a triage tool, as measured in a study such as this, independent of the context. This reflects that evaluations of triage systems are highly likely to be influenced by the unique characteristics and capabilities of the facilities in which they are conducted [26].

The study was also under-powered for the primary outcome, owing to lower-than-anticipated presentation numbers during the study period. It is unclear whether this represents under-reporting, or reflects the drastic reductions in healthcare attendance that were experienced across PNG during this period [16] The lower-than-expected number of participants is likely to have impacted the precision of the primary outcome measure.

Additionally, as a pragmatic study in a resource-constrained context, it is possible that some patients identified by clinicians as having one of the eight time-critical illnesses may not have met the specific criteria for each of these diagnoses. Given the limited number of variables captured in the AMPH registry, there was no way to confirm that these patients were appropriately identified. Equally, it is possible that other patients meeting criteria for a time-critical illness were not identified by the treating clinician. These issues reflect the practical challenges of conducting emergency care research in real-world LMIC settings [23,33].

Implications

This study has significant implications, primarily because it represents the first comprehensive evaluation of the IITT in a pandemic context. It provides evidence that the tool has sound predictive validity in relation to ED outcomes, with a high level of inter-rater reliability. The short triage assessment time is also important because it confirms that the tool is efficient as well as effective.

Overall, the findings are broadly consistent with the results of other IITT validation studies, increasing the likelihood that they reflect the true performance of the system in a PNG ED context. Although the IITT is not a perfect triage instrument, [34] the available data suggest that its predictive validity and reliability are comparable to other triage instruments designed for LMIC settings [7]. This is an important finding, given that the tool has been endorsed by leading global health organisations.

Conclusion

This study assessed the performance of the IITT in a resource-constrained ED impacted by the COVID-19 pandemic. Sensitivity for the detection of time-critical illness was less than ideal, but well within the performance range reported for other triage instruments. There was a clear association between triage category and ED outcomes, with negative predictive values for admission and death exceeding 95.0%. Inter-rater agreement was excellent. Although these data are consistent with the performance of the IITT in other PNG settings, evaluation of the IITT in other countries and contexts will provide a more comprehensive assessment of the tool's validity and reliability.

Contribution statement

RM was primarily responsible for study design, supported by GOR and PC. Introduction of the IITT at AMPH was undertaken by a team including WS, DP, RM, SB and CB, with WS and DP maintaining ongoing responsibility for triage performance. AB was responsible for collecting reliability data, while WA and AB contributed to registry data entry. RM developed the data registry, performed all statistical analyses and drafted this manuscript. All authors reviewed and approved the final version.

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Fund Practitioner Fellowship. Funders had no role in study design, results analysis or manuscript preparation.

Data Availability

Study protocols and de-identified data that underpin these findings may be available (up to 24 months after publication) to investigators whose proposed use of data has been approved by an independent review board, subject to any restrictions imposed by the relevant research and ethics committees (including the PNG Medical Research Advisory Committee), funder (the Australian Government) and health service (ANGAU Memorial Provincial Hospital). Requests should be made in writing to the corresponding author and ANGAU Memorial Provincial Hospital.

Declaration of Competing Interest

None to declare.

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Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.auec.2023.07.005.

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