**Title**

Reliability and validity of three international triage systems within a private health-care group in the Middle East

**Abstract**

**Aim:** To measure and compare the reliability and validity of three international triage systems (CTAS, MTS and ESI) when applied to patient presentations in the emergency centres of a private health-care group in the United Arab Emirates.

**Background:** The ability of triage systems to sort patients into categories based on the urgency of their need and time to physician is a key indicator. Three international triage systems are being used for this purpose in private emergency centre settings.

**Method:** Bespoke reference scenarios, 50 vignettes (10 per severity level) were created and validated by a local expert panel. Nurses performing triage at four emergency centres in the Emirate of Dubai completed online surveys to categorise the vignettes based on the triage system they used in their emergency centre.

**Results:** Overall inter-rater reliability per triage category was substantial for allocations in category one, moderate for those in categories two and five, and fair for those in categories three and four. Agreement between raters and the reference standard was consistent throughout all four emergency centres. The accuracy of triaging allocations into categories one, two and five were good, whereas allocations in categories three and four were less accurate.

**Conclusion:** International triage systems focus on the identification of more urgent cases and perform poorly in discriminating between those that are less serious, which is less ideal in a setting where less-serious cases are more prevalent.

**Keywords**

Triage; reliability; validity; emergency centre; nurse

**Introduction**

Triage is the process of sorting patients based on the severity of their injury or illness to ensure that physicians attend to the most critical patients first [1]. The process usually starts soon after a patient arrives in an emergency centre (EC) through first contact with the triage nurse. Depending on the emergency workload demand of the EC, the triage process is done quickly to stream patients in the right order to be seen by a physician [2].

It has been established over time that mortality is directly linked to how quickly a physician sees a patient, and predictive models have been developed to organise and group different levels of urgency into triage categories [3]. Many triage systems have been developed throughout the world to address this need, based on the characteristics of their setting and the resources available [4,5]. How well a triage system can differentiate patients into such categories is crucial to ensure that the right patients are seen first. There are two main measures of triage system performance: reliability and validity. Reliability refers to a triage system’s ability to allocate similar patient presentations to the appropriate triage categories consistently [6]. Validity is a triage system’s accuracy in determining the correct triage category based on the severity of the patient’s condition [6].

A private health-care group in the United Arab Emirates (UAE) was using a variety of international triage systems in its four ECs in the Emirate of Dubai: the Canadian Triage and Acuity Scale (CTAS), the Manchester Triage System (MTS), and the Emergency Severity Index (ESI). The aim of the study was to measure and compare the reliability and validity of the three triage systems using presentations that are representative of the local patient population demographic. This study formed part of a larger research project that aimed to design and develop a standardised, locally appropriate triage system [7].

**Methods**

An observational, cross-sectional study was conducted to evaluate prospectively the reliability and validity of three triage systems (CTAS, MTS and ESI) used within four ECs (two hospitals and two clinics) of a private health-care group in the Emirate of Dubai. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist for reporting observational studies was used as a framework [8]. The study received ethical approval from the hospital group and the University of Cape Town Human Research Ethics Committee in South Africa (HREC REF: 744/2014), where the research was overseen. This study formed part of a larger research project (PhD thesis) that developed a tailored triage system based on the needs of this private hospital group [7].

A bespoke reference standard in the form of priority-validated case scenarios (i.e., vignettes) was created and delivered through an anonymised online survey. The three triage systems used in the four ECs all had five levels of acuity. Thus, 10 vignettes were constructed for each of the triage priorities (highest to lowest), resulting in a total of 50 vignettes. The vignettes were based on the training scenarios in the official training manuals of the triage systems [9–11]. They were amended to conform to local patient presentations in order to represent the private health-care group’s patient population. The vignettes’ descriptions ensured that all the required triage information was available, irrespective of which triage system was objectively applied. A panel of experts from the health-care group was asked to validate and approve the constructed vignettes’ and their priorities through a three-round internal consensus process. Experts included experienced clinicians with recognised local triage experience, knowledge of the patient population, understanding of the distributions of severity within the four ECs, and their involvement in triage training.

All registered nurses who perform triage within any of the four ECs were invited to participate. Given the small size of the potential participant pool, a convenience sample was used. At the time, 69 registered nurses who regularly performed triage were employed among the four ECs. Data was collected using the SurveyMonkey® [12] online platform, where unique access links were automatically generated by the software and emailed to each participant. The demographics collected at the start of the survey included age, gender, nationality, level of qualification, years of experience as a registered nurse, years of experience in the private health-care group’s ECs, current EC of employment, years of triage experience and a triage skill self-assessment.

In evaluating the vignettes, the participants were instructed to assign the patient to the relevant triage category according to the five-level triage system used at their respective EC. Triage allocations, irrespective of system, could therefore be provided in a similar format. Participants were given a workstation away from the EC’s common area for the surveys to be completed in one sitting and at a suitable time during working hours. The participants were asked not to discuss the vignettes with their colleagues and were not allowed any external assistance such as mobile phones.

The performance of a triage system is determined by its reliability and validity. This study used agreement and association indicators to determine the reliability of the existing triage systems within the four ECs, using inter-rater (Cohen’s and Fleiss’s kappa) and inter-class correlation statistics. Agreements between the participants and the experts were made for each triage category, using a two-by-two framework. This was repeated for all triage categories, using the five levels to establish an overall five-by-five framework. Weighting the Cohen’s kappa allowed for ranking values to be allocated to the triage categories based on their levels of urgency. The agreement among the participants using Fleiss’s kappa was then calculated over all 50 vignettes and triage categories. The correlation between the participants and their triage category allocations was done using an inter-class correlation coefficient to determine whether the different participants could reliably triage the 50 vignettes. Interpretation of the agreement and association indicators were subject to the guidelines and strength of agreement descriptors set forth by Landis and Kock (1977) and used frequently as reference guidelines by other studies of this kind [13].

This study used performance indicators based on a confusion matrix to determine the validity of the existing triage systems within the four ECs [14–16]. Analysis included sensitivity, specificity, accuracy, over-triage, under-triage and diagnostic odds, the last of which were calculated with indicators derived from the confusion matrix. Analysis was performed using the latest version of Microsoft Excel (2016) with a statistical add-in analysis tool from Real Statistics (© Charles Zaiontz, Trento) [17].

A search of the literature revealed no universally accepted standards, norms or guideline values to reference the performance indicators against. This may be due to the difficulty of transposing such reference guidelines across a wide range of health-care applications, especially to triage where the system and setting dramatically affect the outcome measures. What could be done is a comparison of one value to another and then a description of which is better, or a comparison of the findings against similar studies [16,18–30]. It was accepted that a reference guideline should consider the severity level ranking and thus each triage category should ideally have its own reference standard. This is the first study of its kind in the Middle East private health-care sector and as a result of the unknowns related to the existing triage systems, it was decided *a priori* to use the hypothetical reference standard as presented by Landis and Kock (1977) (Table 1) [13].

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| Table 1. Hypothetical reference guideline of performance indicators |
| **Indicator proportion** | **Strength of performance** |
| 0%–20% | Very poor |
| 21%–40% | Poor |
| 41%–60% | Moderate |
| 61%–80% | Good |
| 81%–100% | Very good |

Over- and under-triage are performance indicators specific to the study of triage systems. They determine whether levels of urgency received a higher or lower triage category than expected. The American College of Surgeons Committee on Trauma (ACSCOT) considers a system to be acceptable when under-triage is not more than 5–10% and over-triage not more than 30–50% [15]. This, however, cannot directly apply to this study because private hospitals do not see major trauma in the UAE health-care framework. However, these values can be used as a rough guide for comparison because they are widely used in other triage studies [15,19,21,22,31].

**Results**

Of 69 potential participants, 59 (85.5%) enrolled and completed the survey. Of the non-participants, three nurses were outside the country at the time and seven others did not enrol for unspecified reasons. There were 2950 completed vignettes with 590 in each triage category. For perspective, this equates to 31% of the median monthly patient population (n = 9419) seen among the four ECs.

The participants’ ages ranged from 31 to 39 years, with a median of 36 years. The majority (75%) of participants were under the age of 40. Eight (14%) were male and 51 (86%) were female, yielding a male-to-female ratio of 1:6.4. A total of 10 nationalities were recorded, with most participants indicating their nationality as either Filipino (n = 29; 49%) or Indian (n = 18; 31%) and all other nationalities (n = 12; 20%) individually counting between one and three (2–5%) each. The participants’ levels of education were: diploma (n = 12; 20%), advanced diploma (n = 1; 2%), bachelor’s degree (n = 45; 76%), and master’s degree (n = 1; 2%). Thirty-seven (63%) participants received triage training through the private health-care group and 22 (37%) did not. Most participants (n = 35, 59%) indicated that they have more than 10 years of overall health-care experience; however, they also indicated that their experience in triage (n = 53; 90%) was less than 10 years. Many participants gave themselves a triage self-assessment rating of either average (n = 21; 36%) or above average (n = 35; 59%) (Table 2).

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| Table 2. Participant triage self-assessment  |
| **Self-assessment** | **n (59)** | **%** |
| Little to none | 0 | 0 |
| Below average | 1 | 1.7 |
| Average | 21 | 35.6 |
| Above average | 35 | 59.3 |
| Specialist | 2 | 3.4 |

The CTAS (n = 41; 69.5%) was the most used triage system within the four ECs, followed by the MTS (n = 20; 33.9%) and the ESI (n = 6; 10.2%). In addition, it was reported that all (n = 19) EC1 participants used the CTAS exclusively; 19 EC2 participants used the MTS, and two additional participants used a combination of the two; all (n = 10) EC3 participants also used the CTAS exclusively, whereas all (n = 9) EC4 participants used the CTAS as their primary triage system, but six participants integrated it with the ESI as an adjunctive triage system in many cases. Triage category allocations by participants (i.e., raters) distributed closely around the reference standard (i.e., vignettes), presented in Table 3. Incorrectly triaged vignettes were mostly allocated to either one category above or one below the reference standard.

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| Table 3. Overall rater versus reference standard allocations of vignettes |
| **Triage Category** | Reference standard (n = 590 for each category) |
| **1** | **2** | **3** | **4** | **5** |
| Raters | **1** | **441 (74.7)** | 154 (26.1) | 29 (4.9) | 2 (0.3) |  |
| **2** | 130 (22.0) | **337 (57.1)** | 131 (22.2) | 44 (7.5) | 5 (0.8) |
| **3** | 17 (2.9) | 92 (15.6) | **281 (47.6)** | 233 (39.5) | 58 (9.8) |
| **4** | 2 (0.3) | 7 (1.2) | 131 (22.2) | **249 (42.2)** | 232 (39.3) |
| **5** |  |  | 18 (3.1) | 62 (10.5) | **295 (50.0)** |
| All values are n (%) of allocations; some columns may not add to 100% due to rounding. |

The agreement and association indicators describing the reliability of the existing triage systems between the raters and the reference standard (i.e., vignettes), among the raters (i.e., inter-rater), and by the correlation between the raters and their triage category allocations (i.e., inter-class) are presented in Table 4. Using the guidelines and strength of agreement descriptors set forth by Landis and Kock (1977), the overall agreement between raters and the reference standard per triage category was substantial for allocations in category one, moderate for those in categories two and five, and fair for those in categories three and four. This agreement between the raters and the reference standard was consistent throughout all four ECs, except for EC4, which showed less agreement of allocations in categories two, three and four compared to the other ECs. The overall agreement between the raters and the reference standard for all the triage categories showed an unweighted estimation of moderate agreement, a linear weighted estimation of substantial agreement and a weighted quadratic estimation of almost perfect agreement. The overall inter-rater agreement estimated through Fleiss’s kappa showed only fair agreement between the participants and this was consistent throughout all four ECs. The inter-class correlation was consistent throughout all four ECs, showing substantial association between the raters on their triage category allocations.

The performance indicators described the validity of the existing triage systems as sensitivity, specificity, accuracy, over-triage, under-triage, and diagnostic odds (Table 5). Sensitivity was highest for category one allocations, with an overall rating of good, whereas all the other categories reached a moderate performance rating. Specificity was high across all the triage category allocations and reached an overall performance rating of very good. The accuracy of triaging allocations into categories one, two and five were high and received a very good performance rating, whereas allocations in categories three and four, although lower in performance, received good ratings. The diagnostic odds ratio was exceptionally high for allocations in triage categories one (i.e., the most urgent) and five (i.e., the least urgent). Triage categories two, three and four had lower diagnostic odds ratios, showing that the tests are discriminating correctly. Over-triage rates were the highest for allocations in triage categories four and five and were almost twice that of allocations in categories two and three. Under-triage rates were the highest for allocations in triage categories one and three; EC1 had an equally high under-triage rate for allocations in category two when compared to all the other ECs.

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| Table 4. Agreement and association between the raters and the reference standard, inter-rater and inter-class |
| **Measure** | **Overall** | **EC1** | **EC2** | **EC3** | **EC4** |
| Agreement between raters and reference standard per triage category a |
| **1****2****3****4****5** | **0.65** (0.62 – 0.69)**0.42** (0.38 – 0.46)**0.29** (0.25 – 0.33)**0.26** (0.22 – 0.30)**0.54** (0.50 – 0.58) | 0.68 (0.62 – 0.74)0.41 (0.34 – 0.48)0.28 (0.21 – 0.35)0.29 (0.22 – 0.36)0.60 (0.53 – 0.67) | 0.63 (0.57 – 0.68)0.44 (0.37 – 0.50)0.32 (0.25 – 0.38)0.28 (0.21 – 0.35)0.56 (0.49 – 0. 62) | 0.67 (0.59 – 0.75)0.54 (0.45 – 0.63)0.35 (0.25 – 0.45)0.28 (0.19 – 0.38)0.48 (0.37 – 0.58) | 0.64 (0.56 – 0.73)0.29 (0.18 – 0.39)0.18 (0.08 – 0.29)0.11 (0.00 – 0.21)0.44 (0.32 – 0.55) |
| Agreement between raters and reference standard for all triage categories a |
| **Unweighted****Linear****Quadratic** | **0.43** (0.41 – 0.45)**0.67** (0.65 – 0.68)**0.83** (0.81 – 0.84) | 0.44 (0.40 – 0.48)0.68 (0.65 – 0.71)0.84 (0.82 – 0.86) | 0.44 (0.40 – 0.48)0.68 (0.66 – 0.71)0.84 (0.83 – 0.86) | 0.46 (0.41 – 0.52)0.69 (0.65 – 0.72)0.84 (0.81 – 0.87) | 0.34 (0.28 – 0.40)0.58 (0.53 – 0.62)0.75 (0.71 – 0.79) |
| Agreement between raters b |
| **Inter-rater** | **0.35** (0.34 – 0.35) | 0.38 (0.37 – 0.39) | 0.38 (0.37 – 0.39) | 0.39 (0.37 – 0.41) | 0.29 (0.26 – 0.31) |
| Associative correlation between raters |
| **Inter-class** | **0.77** (0.70 – 0.84) | 0.80 (0.73 – 0.86) | 0.80 (0.73 – 0.86) | 0.79 (0.71 – 0.86) | 0.68 (0.55 – 0.79) |
| CI, confidence interval; a, Cohen’s Kappa; b, Fleiss’s Kappa  |

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| Table 5. Overall performance indicators per triage category  |
| **Indicator** | **Unit** | **1** | **2** | **3** | **4** | **5** |
| Sensitivity aSpecificitybAccuracy Over-triage c Under-triage d Diagnostic odds | %%%%%ratio | 74.7 (71.2 – 78.3)92.2 (91.1 – 93.2)88.7 (87.5 – 89.8)25.3 (21.8 – 28.8)34.8 (33.6 – 36.0) | 57.1 (53.1 – 61.1)86.9 (85.5 – 88.2)80.9 (79.5 – 82.3)26.1 (22.6 – 29.6)16.8 (13.8 – 19.8)8.8 (8.5 – 9.1) | 47.6 (43.6 – 51.7)83.1 (81.5 – 84.6)76.0 (74.4 – 77.5) 27.1 (23.5 – 30.7)25.3 (21.8 – 28.8)4.5 (4.3 – 4.6) | 42.2 (38.2 – 46.2)84.2 (82.8 – 85.7)75.8 (74.3 – 77.4)47.3 (43.3 – 13.0)10.5 (8.0 – 13.0)3.9 (3.8 – 4.0) | 50.0 (46.0 – 54.0)96.6 (95.9 – 97.3)87.3 (86.1 – 88.5)50.0 (46.0 – 54.0)28.5 (27.5 – 29.5) |
| CI, confidence interval; a Vignettes triaged correctly by the raters among all the true vignettes as determined by the experts; b vignettes triaged correctly by the raters among all the untrue vignettes as determined by the experts; c vignettes that received a higher triage category allocation from the raters compared to that determined by the experts; d vignettes that received a lower triage category allocation from the raters compared to that determined by the experts |

**Discussion**

This study was the first to investigate triage systems, how they are used, and their performance within the private health-care setting in the United Arab Emirates (UAE). It was established that there was no standardised triage system in use in this setting, or among the four ECs investigated. The most commonly used triage system in EC1, EC3 and EC4 was the Canadian Triage and Acuity Scale (CTAS), with EC2 reporting that the Manchester Triage System (MTS) was used the most. Understanding which triage systems were primarily used at the four ECs made it possible to compare the overall performances of the ECs and to compare the performances of the triage systems being used. The most reliable comparison could be drawn between the EC1 and EC2 hospitals, because they had the same patient demographic. Although these ECs used different triage systems, the performance indicators showed no significant variation when applied to the same vignettes.

Most staff participants were between the ages of 25 and 40, which is reflective of the workforce population. The overwhelming majority of EC staff are female. Within the UAE, it is a common local health regulation, and an anecdotal preference, to have female nursing staff, due to cultural and religious beliefs which make interaction with female patients easier. Most nursing staff come from the Philippines and India, like the majority of the expatriate UAE workforce. With many Filipino and Indian nurses conducting triage, their fluency in English as well as their training and triage experience may indirectly affect the efficacy of a triage system; triage is not commonly taught in those countries. Current licensure as a registered nurse in the UAE follows local regulation and requires a minimum of a Bachelor’s degree [32–34]. Prior to this regulation, a nursing diploma was accepted depending on the nationality, origin and evaluation of the qualification. Although the overall health-care experience level in terms of years was very high, the experience using triage systems was less than 10 years.

Overall, the sensitivity (i.e., triage rule out) was moderate, except for vignettes in triage category one which received a good performance rating across all four ECs. This suggests that the triage systems were applied appropriately to determine the highest severity category; however, there seems to be room for improvement in the sensitivity performance of the other categories. The overall specificity (i.e., triage rule in) was very good. Across the four ECs, there was confidence that inclusion and over-triage were more predominant than exclusion and potential under-triage. The diagnostic odds ratio showed that the triage systems do discriminate correctly between triage categories, especially with vignettes in triage categories one and five. This means that the current (international) triage systems used are most effective at the borders of the triage systems’ highest or lowest severity levels. It may be that the highest and lowest severities are the easiest to recognise and would seldom be incorrectly categorised. Reliability and validity studies of the CTAS, the MTS and the ESI have shown similar findings and variations between these systems, using both vignettes and actual patient triage evaluations [16,18–30].

The accuracy across all four ECs was consistently good to very good and was apparent in the distribution of triage category allocations. The triage allocations are tightly clustered around the reference standard and even though there were high proportions of over- and under-triage, the variation was only one urgency level up or down. The American College of Surgeons Committee on Trauma (ACSCOT) would consider this high over-triage rate unavoidable; however, the high under-triage rate does exceed their accepted safety limits. A high under-triage rate is a cause for concern, because this may result in sicker patients being assigned a lower triage category, leading to unacceptably increased time to physician and treatment [15,19,21,22,31]. This concern is evident by the number of cases that should have received a category one triage allocation and were therefore deemed critically ill versus those that received a lower allocation. The four ECs mostly see less-severe cases and it is presumed that the increased under-triage rate may be due to the triage nurses not seeing many acute cases, thus creating a bias towards allocating patients to lower categories over time. It is also acknowledged that real-life cases with visual cues may result in higher category allocations than simply allocating a category from a vignette might [20,35].

The over-triage rate increased from urgent to low-need categories, showing that over-triage was more predominant in the less-urgent vignettes. Over-triage is the safer option. This, however, increases the demand on resources. Ideally, all patients would be seen and treated immediately by a physician if resources were unlimited. Over-triage should be monitored and reduced when possible to keep a balance and avoid exceeding the available resources. It is troubling that a high rate of under-triage, coupled with a high rate of over-triage and these sensitivity and specificity findings may lead to patients with less-urgent need being attended to before those whose need is more urgent. This is far from an ideal situation in emergency care.

The agreement between raters and the reference standard per triage category at all four ECs followed the same pattern as the sensitivity findings; it suggests that the participants were equally confident in their triage decisions when excluding cases from certain triage categories. Category one vignettes received substantial agreement; however, the other categories only managed fair to moderate agreement with the reference standard. When all the triage categories were put together without any weights applied to the different urgency levels, the agreement between the raters and the reference standard remained moderate. When weights were applied to the urgency levels, either linear or quadratic (e.g., category one vignettes deemed more important than category five’s), the agreements rose significantly to substantial and almost perfect agreement, very similar to what is presented by other studies [16,18,21,26,29,30]. This shows that as the urgency levels increase, the agreement between both the participants and the reference standard also increase. This is substantiated by the previously described performance indicators, showing that the triage systems used are more focused on identifying patients with greater need than on those who could wait. Although it is important to identify urgent cases quickly, a triage system should also remain focused on most of the patient population. The participant inter-rater agreement was only able to provide a fair performance throughout all four ECs, and the associated correlation remained similar between the ECs. This shows that it did not matter which triage system was being applied; they all performed similarly in this private health-care group’s EC environment. With existing triage systems performing similarly and favouring more-urgent cases, it appears evident that none of these triage systems is likely to be a good fit for this less-urgent setting.

**Limitations**

Constructing appropriate and unbiased vignettes was the biggest limitation of this study. No previous studies have been done to compare triage systems with the aid of vignettes in this setting; thus specific vignettes had to be constructed. The training manuals of the existing triage systems provided some guidance as to the content of the vignettes. It is accepted that triaging written vignettes is very different from triaging a real patient. Vignettes do provide the benefit of experimental conditions when evaluating the application of a triage system against an objective set of variables, thus somewhat reducing subjectivity. Validation of the vignettes was submitted to a local expert panel that reviewed each of the vignettes. Some bias may be applied to the vignettes based on expert experience and opinion; however, no fixed standard was available for the construction of such vignettes; thus, to mitigate potential bias, the experts applied the existing triage systems to guide their review. This study depended on nursing staff volunteering their time, showing their commitment to system improvement through exceptional participation.

**Conclusion**

A locally appropriate reference standard was constructed against which triage system performance could be evaluated. This study shows that the application of international triage systems is most effective in identifying and assigning greater-severity triage cases, especially category one cases. The triage systems in this study have middling reliability and validity performance when compared to an expert reference standard. They perform similarly against each other; however, the variations found between the four ECs require further investigation and understanding. International triage systems focus on the identification of cases that are more serious and urgent and perform poorly in discriminating between those and cases that are less urgent, not ideal in a setting where less-urgent cases are more prevalent. Although not an impacting factor on patient care in this setting, it may result in time to treatment delays or sending patients down incorrect treatment pathways in lesser resourced environments.

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