Emergency Care Journal

Official Journal of the Academy of Emergency Medicine and Care (AcEMC)

eISSN 2282-2054
https://www.pagepressjournals.org/index.php/ecj/index

Emerg care J 2023 [Online ahead of print]

To cite this Article:
Zaboli A, Sibilio S, Cipriano A, et al. **Italian validation of the Manchester Triage System towards short-term mortality: a prospective observational study.** *Emerg Care J* doi: 10.4081/ecj.2023.114433

Italian validation of the Manchester Triage System towards short-term mortality: a prospective observational study

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Key words: triage; Manchester triage system; emergency medicine; nursing; nurse triage.

Contributions: AZ, GT, conceptualization, methodology, investigation, formal analysis, data curation, writing-original draft preparation; SS, methodology, investigation, writing-original draft preparation; AC, NP: original draft preparation; AB: supervision; NP: data curation; AG: investigation; FB: supervision, original draft preparation, review, and editing.

Conflict of interest: the authors declare no potential conflict of interest, and all authors confirm accuracy.

Ethics approval: the study was approved by the local ethics committee (Comitato etico per la sperimentazione clinica, Azienda Sanitaria dell'Alto Adige, Bolzano, Italia, approval number 95-2019) and was conducted in accordance with the Declaration of Helsinki regarding the Ethical Principles for Medical Research Involving Human Subjects.

Informed consent: all patients participating in this study signed a written informed consent form for participating in this study.

Patient consent for publication: written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Availability of data and materials: all data generated or analyzed during this study are included in this published article.

Abstract

The study aimed to validate the Manchester Triage System in a hospital setting using data for short- and medium-term death rates. A prospective observational study was conducted at the Emergency Department of Merano Hospital for two years. The discriminatory ability of MTS was tested using AUROCs and contingency tables, reporting sensitivity and specificity levels for each study outcome. A total of 98,443 patients were enrolled, 237 of whom died within 72h; 422 patients died within seven days, and 1025 died within 30 days. The MTS demonstrated excellent discriminatory ability, reporting AUROC values of 0.890 for death within 72h, 0.853 for death within seven days, and 0.781 for death within 30 days. A sensitivity of 87.7% and a specificity of 79.4% were reported for death at 72h, while a sensitivity of 69.6% and a specificity of 79.8% were reported for death at

30 days. The MTS has proven to be a good triage system capable of accurately identifying patients who are at risk of death in the short or medium term.

Introduction

The progressive increase in the number of requests for evaluation in hospitals' Emergency Departments (EDs) after the COVID-19 pandemic, given an ever-decreasing number of available healthcare resources, makes triage one of the most important components of the emergency medical system.[1,2] At present, internationally validated triage systems (e.g., the Manchester Triage System, the Emergency Severity Index, and the South African Triage Scale) that can be compared between different regions and nations remain rare. Although there are recommendations supporting the use of globally standardized triage systems, many European countries today have adopted autonomous systems created according to local needs. These systems often lack scientific validation, making it impossible to perform comparisons.[3-6] In addition to being an expensive choice, given the significant amounts of resources required for the creation and design of new triage tools, these systems often merely simulate or integrate triage methodologies already widely developed in validated systems, hence becoming a pure relocation exercise that limits the development of a crucial aspect of the ED. A recent review of the literature on the performance of validated triage systems showed that there were no substantial differences in the ability to prioritize patients between the various systems and emphasized that regardless of the instrument used, performance remains comparable.[3] The decision not to import one of these already structured systems to invest in local systems has led to the failure to evolve international triage systems, thus leaving them virtually unchanged since their creation in the 1990s.[3-5] One of the most widespread and globally used systems is the Manchester Triage System (MTS), a system that classifies patients into five priority levels in association with 53 symptom-specific flow charts.[7-9] General information on the ability of MTS to correctly stratify patients is limited, and few studies are validating the performance of the system against short- or medium-term mortality.[4,8,10] Moreover, validation studies often used outcomes other than mortality and are often subject to the subjectivity of the evaluators (e.g., a pool of experts).[4,8,10,11]

Currently, there is no single triage system in Italy that is the standard for EDs in different regions; as a result, each department employs a contextual method with limited supporting scientific evidence. Moreover, the use of the MTS in Italian emergency and urgent care settings has not yet been examined. The present study aimed to validate the MTS against short-term (72 hours) and medium-term (7-30 days) mortality in an Italian context.

Materials and Methods

Setting

The present single-center prospective observational study was conducted at the ED of the Merano General Hospital from 1 January 2021 to 31 December 2022.

The ED under study has been using the MTS as a triage system since 2014. Triage is performed by two dedicated nurses during the day shift (08.00-20.00) and by one nurse during the night shift (20.00-08.00). The nurses performing triage in the ED must have at least two years of experience in a critical area setting; they must have completed a two-day course on the MTS method and must have undergone a six-month coaching period with an experienced triage nurse.

Manchester Triage System

The MTS is based on stratifying patients into five priority levels, where code 1 (red, immediate) stipulates a waiting time until medical attention of 0 minutes; code 2 (orange, urgency) defines a target waiting time of 10 minutes; code 3 (yellow, urgency) specifies a target waiting time of 60 minutes; code 4 (green, deferrable urgency) specifies a waiting time of 120 minutes, and code 5 (blue, non-urgent) specifies a waiting time of 240 minutes.[11] In the case of a longer waiting time than that established by the priority code, the triage nurse must perform a new assessment of the patient to check their condition and consequently confirm or change the previously assigned priority code.

The classification system of the MTS is based on 53 specific symptom diagrams (e.g., chest pain, palpitations, or wounds), where a different flow chart is associated with each symptom. Each flow chart has rapid indicators (specific symptom questions) to be scrolled through that define the level of priority from most urgent to least urgent. If no indicators are positive, the patient is classified with a priority code of 5.

At the ED under study, the 3rd edition of MTS was used, using the German text.[10]

Patients and variables

All patients admitted to the ED during the study period were enrolled. Only patients that were non-residents (e.g., tourists) of the province under study were excluded due to the impossibility of reconstructing the subsequent outcome. For all patients who consented to participate, their data, completed triage forms, and ED medical records were collected. All information gathered was subsequently entered anonymously into an electronic database.

Outcome

The primary outcome of the study is composed of sensitivity, specificity, positive predictive value, negative predictive value, and the area under the ROC curve (AUROC) of the triage assessment compared to the 72-hour mortality. The secondary outcomes are composed of sensitivity, specificity, positive predictive value, negative predictive value, and the area under the AUROC of the triage assessment compared to seven and 30 days mortality. The outcome was reconstructed by manual re-evaluation of medical records in the case of hospitalized patients or via the register office.

Ethical considerations

The study was approved by the local ethics committee (Comitato etico per la sperimentazione clinica, Azienda Sanitaria dell'Alto Adige, Bolzano, Italia, approval number 95-2019) and was conducted in accordance with the Declaration of Helsinki regarding the Ethical Principles for Medical Research Involving Human Subjects.

Statistical analysis

Continuous variables were described as the mean or interquartile range. The comparisons between different patient classes were performed with the Mann-Whitney test or the Kruskal-Wallis test as appropriate. Categorical variables were expressed as a percentage of the number of events out of the total, and comparisons between the patient classes were performed with Fisher's exact test or the Chi-square test as appropriate.

The validity of the MTS was assessed by casting the data into 2×2 contingency tables to compare short-term (72 hours and seven days) and medium-term (30 days) mortality with MTS codes, where priority codes 1 (red) and 2 (orange) were combined as high priority codes, and priority codes 3 (yellow), 4 (green), and 5 (blue) was considered as low priority codes. This choice was made in agreement with previous studies. The 2×2 contingency tables were used to examine sensitivity (the ability of the MTS to correctly identify persons with high priority codes as being at risk of death in the short to medium term), specificity (the ability of the MTS to identify patients with low priority codes who did not die in the short to medium term), negative predictive value (NPV) (the probability of not dying in the short to medium term when the MTS assigned a low priority code), and positive predictive value (PPV) (the probability of dying in the short to medium term when the MTS assigned one of the high priority codes).

The five priority levels of the MTS were also assessed via the AUROC. Subsequently, analyses were performed via the ROCs for subgroups of patients according to age (≥75 years, ≥65 years, >35 and <65 years, and ≤35 years), entry problem (medical-surgical entry symptoms, thus excluding fast-track), mode of arrival (out-of-hospital service or self-care), and conclusion after evaluation (admission or discharge). All results were described with their 95% confidence intervals (95% CI). Statistical analysis was performed using STATA 16.0 (StataCorp, College Station, TX, USA).

Results

The number of patients admitted between 2021 and 2022 was 120,258 (Figure 1). There were 98,443 patients enrolled in the study, of whom 0.4% (367/98,443) were code 1 (red), 4.7% (4636/98,388) were code 2 (orange), 5.6% (15,381/98,443) were code 3 (yellow), 69.5% (68,388/98,443) were code 4 (green) and 9.8% (6971/98,443) were code 5 (blue). The characteristics of the patients are shown in Table 1.

Patients with higher codes were older and came to the ED more often by ambulance, by an emergency physician, or by helicopter. Patients with higher codes were more likely to be placed on a stretcher or in a wheelchair in the ED and to have more interventions performed in triage (ECG, blood sampling, or venous access placement). Patients assigned higher codes experienced more hospitalizations and more short- and medium-term deaths. In contrast, patients with lower codes were younger and were more likely to have reached the ED independently. In addition, patients with lower codes had fewer altered vital signs in triage and required fewer admissions. Overall, the percentages of patients who died at 72h, seven days, and 30 days were 0.2% (237/98,443), 0.4% (422/98,443), and 1.0% (1025/98,443), respectively.

The median Length Of Stay (LOS) in the ED was 1.7 hours (95% CI: 0.9-2.9), while the median triage time was 3.3 minutes (95% CI: 1.8-6.6).

The discriminatory ability of the MTS against 72-h, 7-day, and 30-day mortality is shown in Figure 2. The AUROC values varied from 0.781 (95% CI 0.765-0.798) for 30-day mortality to 0.853 (95% CI 0.831-0.875) for 7-day mortality and finally to 0.890 (95% CI 0.865-0.916) for 72-hour mortality, performance for each cutpoint of the ROC and each outcome is reported in the Supplementary Table 1. Considering only patients assigned to the areas of medicine or surgery, the discriminatory ability scores of the MTS for 72-h, 7-day, and 30-day mortality were 0.877 (CI 0.851-0.952), 0.837 (CI 0.814-0.860), and 0.770 (CI 0.753-0.787), respectively.

The sensitivity of the MTS and thus the ability to accurately classify patients as high-priority codes regarding mid- and short-term mortality was very high, ranging from 87.7% for death at 72 hours to 69.6% for death within 30 days. The specificity of the MTS and thus the assignment of low-priority codes to patients who subsequently did not have the study outcome demonstrated excellent performance, with values ranging from 79.4% for death at 72 h to 79.8% for death at 30 days. Subsequently, subgroup AUROC values were calculated in comparisons of short- and medium-term mortality (Table 3). In the comparisons of the groups of older adult patients (≥ 65 years and ≥ 75 years) in all outcomes considered, the performance of the system was excellent, with AUROC values ranging from 0.673 to 0.865. The best performance was reported in patients aged < 35 years, with AUROC values ranging from 0.942 to 0.946, demonstrating nearly perfect discriminatory ability (Table 3).

The worst performance was reported in the subgroup of patients hospitalized after ED evaluation, with AUROC values ranging from 0.673 to 0.779; this was still considered a good performance for this subgroup (Table 3).

Discussion

The current study using a large cohort of patients from an Italian ED represents the first national-level validation of the MTS by examining the performance of the system regarding short-term mortality. Italy currently has no objectively validated national triage system. Instead, several different systems have been created over the years according to local needs, and these are often lacking external or even internal validation, and very few have been published.[12] In addition, there is considerable subjectivity in many of these systems, as the triage nurses do not always perform their assessment using objective criteria, but rather base their decisions on prior knowledge and experience, a concept that is largely outdated in the triage setting.[10,12-14]

This study demonstrated the remarkable ability of the MTS in stratifying patients accessing the ED, identifying those at risk of death in the short and medium term. Thus, the study suggests that given the difficulty of unifying triage systems in Italy, the MTS could be implemented in all national EDs given its worldwide dissemination and previously published validation studies.[10,13,14] In addition to being an objective system with good predictive ability and prioritization capability on objective data such as short-term mortality, the MTS could allow broad comparisons across the EDs among Western countries.

The present study has important consequences for clinical practice. First, the study yielded high AUROC values in the short- and medium-term mortality comparisons. A previous validation study of the MTS performed in German-speaking European areas by Graff *et al.* reported an AUROC of 0.613 for 30-day mortality, and the result was confirmed by subsequent research evaluating the performance of the MTS based on selected flow charts, with AUROC values ranging from 0.682 to 0.834 for in-hospital mortality.[14,15] The differences in results between the present and previous studies may lie in the improvements made in EDs under investigation (such as, for example, daily triage auditing practices), demonstrating that continuous and consistent attention can lead to higher performance and better outcomes for patients.[16]

The second novelty of the study in view of the current international literature is the choice of objective outcomes (72-h, 7-day, and 30-day mortality) for validation. In previous research, the outcomes chosen were generally subjective measures such as confirmation of code appropriateness as determined by a pool of experts or the use of reference standards.[13] Reference standards, however, are created by a panel of experts as study outcomes for validating triage systems, but at present, there are no data available regarding their actual effectiveness or usefulness.[13,17] The choice to use outcomes such as mortality, in contrast to previous studies that selected objective and subjective outcomes simultaneously, is supported by the absence of gold standards for the evaluation of triage systems.[17,18] Furthermore, a review by Kuriyama *et al.* concerning the validity of five-level triage systems suggested the use of outcomes different from reference standards or expert consensus, precisely because of the inherent subjectivity and the limited number of patients potentially re-evaluable by the expert pool.[17] However, it is important to point out the weaknesses of the objective outcomes considered; in fact, short- and medium-term mortality is undoubtedly influenced by the choices made and the events following the triage assessment.[17]

Furthermore, as reported by Challen, triage is not meant to diagnose a disease or predict death, but rather is meant to characterize urgency.[18] Objective outcomes such as death may not be appropriate for all patients (e.g., patients with severe pain as the result of a limb fracture will not be at risk of death but will need a higher code given the need for rapid pain management).[18] Third, considering subgroups of patients categorized by age, the MTS has been shown to perform well in both younger and older patient groups. Due to the increasing older adult population accessing the ED and their inherent frailty, research in recent years has focused on evaluating this class of patients.[19,20] Brouns *et al.* in a retrospective study of the MTS evaluated the performance of the triage system toward in-hospital mortality by dividing subjects into older patients (>64 years) and adult patients (18-64 years).[21] The results demonstrated a worse performance of the MTS for older patients (AUROC 0.71; 95%CI 0.68 - 0.74) compared to adults (AUROC 0.79; 95%CI 0.72 - 0.85), although indicating a good overall ability of the triage system.[21] The worse performance of the MTS in this group of patients may be related to the high number of comorbidities typical in older patients, a factor that the MTS does not consider and that may worsen or alter the manifestation in the short term, resulting in unexpected outcomes that are difficult to detect in triage. Given the overall aging demographic and the increase of multi-pathology patients accessing the ED, it is necessary to study and understand how to integrate specific assessments within a triage system.[22,23] The system should consider the patient's innate comorbidity quota, thus allowing the MTS to optimally classify older patients. Despite this limitation, the good performance against mortality supports the use of the MTS and argues for its future evolution rather than its abandonment.

The present study has several limitations. First, the single-center nature of the study limits the generalisation of the results. Second, the non-consideration of more subjective endpoints such as the assessment of code adequacy may have biased the results. Given the number of patients, it was impractical to manually re-evaluate all relevant records. Third, the correct application of the MTS was not assessed; rather, this was monitored daily through direct feedback within the ED under study, however, it is not possible to be certain about the correct application of MTS.[16] Fourth, the version used for the implementation of MTS is based on the German book and not on the original one. Fifth, the outcome used is limiting for the complete evaluation of a triage system and therefore the results cannot completely represent the real functioning of MTS.

Conclusions

This is the first validation study of the MTS performed against short- and medium-term death. The system demonstrated excellent performance within an Italian hospital setting. The identification of patients at risk of death in the short and medium term was quite accurate, even for the most challenging groups such as older adult patients. If these results were subsequently confirmed by further studies, the use of a validated triage tool throughout the Italian country could be recommended.

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Submitted: 02-05-2023
Accepted: 30-06-2023
Early access publication: 11-06-2023

Table 1. Anamnestic and clinical characteristics of patients enrolled in the study divided according to the priority code assigned in triage. *Heart Rate* was collected in 38,683 Patients; Respiratory Rate was collected in 29,967 Patients; Oxygen Saturation* was collected in 39,783 Patients; Systolic blood pressure was collected in 33,361 Patients; Temperature* was collected in 65,859 Patients.*

Variables	Blue & Green priority code	Yellow priority code	Orange & Red priority code	p-value
Patients, n (%)	78,059 (79.3)	15,381 (15.6)	5003 (5.1)	
Age, years, mean (SD)	55.8 (25.1)	50.5 (28.2)	58.1 (25.7)	<0.001
Modality of arrival in ED, n (%)				
Autonomous	66,895 (85.7)	9,043 (58.8)	2,161 (43.2)	<0.001
Ambulance	10,517 (13.5)	5,420 (35.2)	1,869 (37.4)	<0.001
Emergency physician	580 (0.7)	808 (5.3)	856 (17.1)	<0.001
Helicopter	67 (0.1)	110 (0.7)	117 (2.3)	<0.001
After triage positioned, n (%)				
Walk	66,818 (85.6)	7,736 (50.3)	1,276 (25.5)	<0.001
Wheelchair	9,367 (12.0)	4,691 (30.5)	1,085 (21.7)	<0.001
Stretcher	1,873 (2.4)	2,953 (19.2)	2,641 (52.8)	<0.001
Vital parameters				
Heart Rate*, median (IQR)	85 (74-96)	85 (74-100)	90 (75-110)	<0.001
Respiratory Rate*, median (IQR)	16 (14-17)	16 (15-18)	18 (16-25)	<0.001
Oxygen Saturation*, median (IQR)	98 (97-99)	98 (96-99)	97 (93-98)	<0.001
Systolic blood pressure*, mean (SD)	137.6 (23.4)	137.7 (25.4)	136.7 (29.6)	0.128

Temperature*, median (IQR)	36.2 (36.0-36.5)	36.3 (36.0-36.8)	36.8 (36.4-36.8)	<0.001
Performances done in triage by the nurse, n (%)				
Venous access	6,731 (8.6)	3,984 (25.9)	1,978 (39.5)	<0.001
ECG	5,398 (6.9)	2,676 (17.4)	1,589 (31.8)	<0.001
Blood Sampling	6,700 (8.6)	3,793 (24.7)	1,887 (37.7)	<0.001
Area of the declared symptoms, n (%)				
Internal medicine	17,140 (22.0)	5,133 (33.4)	3,277 (65.5)	<0.001
Surgery	13,853 (17.7)	2,876 (18.7)	437 (8.7)	<0.001
Orthopaedics	22,736 (29.1)	2,794 (18.2)	130 (2.6)	<0.001
Urological	1,977 (2.5)	891 (5.8)	73 (1.5)	<0.001
Otolaryngology & dentistry	6,588 (8.4)	187 (1.2)	5 (0.1)	<0.001
Ophthalmology	3,851 (4.9)	424 (2.8)	32 (0.6)	<0.001
Paediatrics	6,519 (8.4)	1,520 (9.9)	216 (4.3)	<0.001
Gynaecological	3,000 (3.8)	986 (6.4)	787 (15.7)	<0.001
Psychiatric	442 (0.6)	525 (3.4)	45 (0.9)	<0.001
Dermatology	1,953 (2.5)	45 (0.3)	1 (0.0)	<0.001
Hospitalised, n (%)	4,094 (5.2)	3,454 (22.5)	2,562 (51.2)	<0.001
ED abandonment before medial evaluation, n (%)	2400 (3.1)	132 (0.9)	29 (0.6)	<0.001
Death within 72h, n (%)	29 (0.04)	51 (0.3)	157 (3.1)	<0.001
Death within 7 days, n (%)	76 (0.1)	105 (0.7)	241 (4.8)	<0.001
Death within 30 days, n (%)	311 (0.4)	289 (1.9)	425 (8.5)	<0.001

Table 2. 2x2 contingency tables divided according to the three study outcomes and the priority code assigned in triage, where low priority code considers patients with code 5 (blue) and code 4 (green) and high priority code considers patients with code 3 (yellow), code 2 (orange) and code 1 (red). Sensibility, specificity, PPV and NPV with respective 95% confidence intervals were calculated for each contingency table.

Death within 72h	**No**	**Yes**	**Sensibility**	**Specificity**	**PPV**	**NPV**
Low priority code	78.030	29	87.7% (82.9 – 91.6)	79.4% (79.2 – 79.7)	1.0% (0.9 – 1.1)	99.9% (99.9 – 100.0)
High priority code	20.176	208				
Death within 7 days	**No**	**Yes**	**Sensibility**	**Specificity**	**PPV**	**NPV**
Low priority code	77.983	76	81.9% (81.7 – 82.2)	79.5% (79.3 – 79.8)	1.7% (1.6 – 1.8)	99.9% (99.8 – 99.9)
High priority code	20.038	346				
Death within 30 days	**No**	**Yes**	**Sensibility**	**Specificity**	**PPV**	**NPV**
Low priority code	77.748	311	69.6% (69.4 – 69.9)	79.8% (79.5 – 80.1)	3.5% (3.4 – 3.6)	99.6% (99.6 – 99.6)
High priority code	19.670	714				

Table 3. AUROC of MTS performance calculated for subgroups of patients divided according to the three study outcomes.

Death within 72 h	**Subgroups**	**AUROC**	**95% Confidence Interval**
	≥ 75 years	0.863	0.835 – 0.892
	≥ 65 years	0.865	0.839 – 0.892
	Between 35 & 65 years	0.890	0.866 – 0.913
	<35 years	0.946	0.843 – 1.000
	Internal Medicine & Surgery	0.876	0.852 – 0.900
	Ambulance	0.802	0.762 – 0.841
	Autonomous	0.865	0.806 – 0.924
	Hospitalised	0.779	0.745 – 0.814
	Discharged	0.863	0.810 – 0.917
Death within 7 days	≥ 75 years	0.809	0.784 – 0.834
	≥ 65 years	0.822	0.799 – 0.844
	Between 35 & 65 years	0.853	0.832 – 0.873
	<35 years	0.946	0.843 – 1.000
	Internal Medicine & Surgery	0.836	0.815 – 0.858
	Ambulance	0.758	0.727 – 0.789
	Autonomous	0.796	0.744 – 0.849
	Hospitalised	0.741	0.713 – 0.769
	Discharged	0.792	0.745 – 0.840
Death within 30 days	≥ 75 years	0.742	0.724 – 0.761
	≥ 65 years	0.752	0.735 – 0.768

	Between 35 & 65 years	0.781	0.766 – 0.796
	<35 years	0.942	0.887 – 0.997
	Internal Medicine & Surgery	0.770	0.753 – 0.786
	Ambulance	0.685	0.664 – 0.706
	Autonomous	0.730	0.699 – 0.760
	Hospitalised	0.673	0.652 – 0.695
	Discharged	0.702	0.675 – 0.729

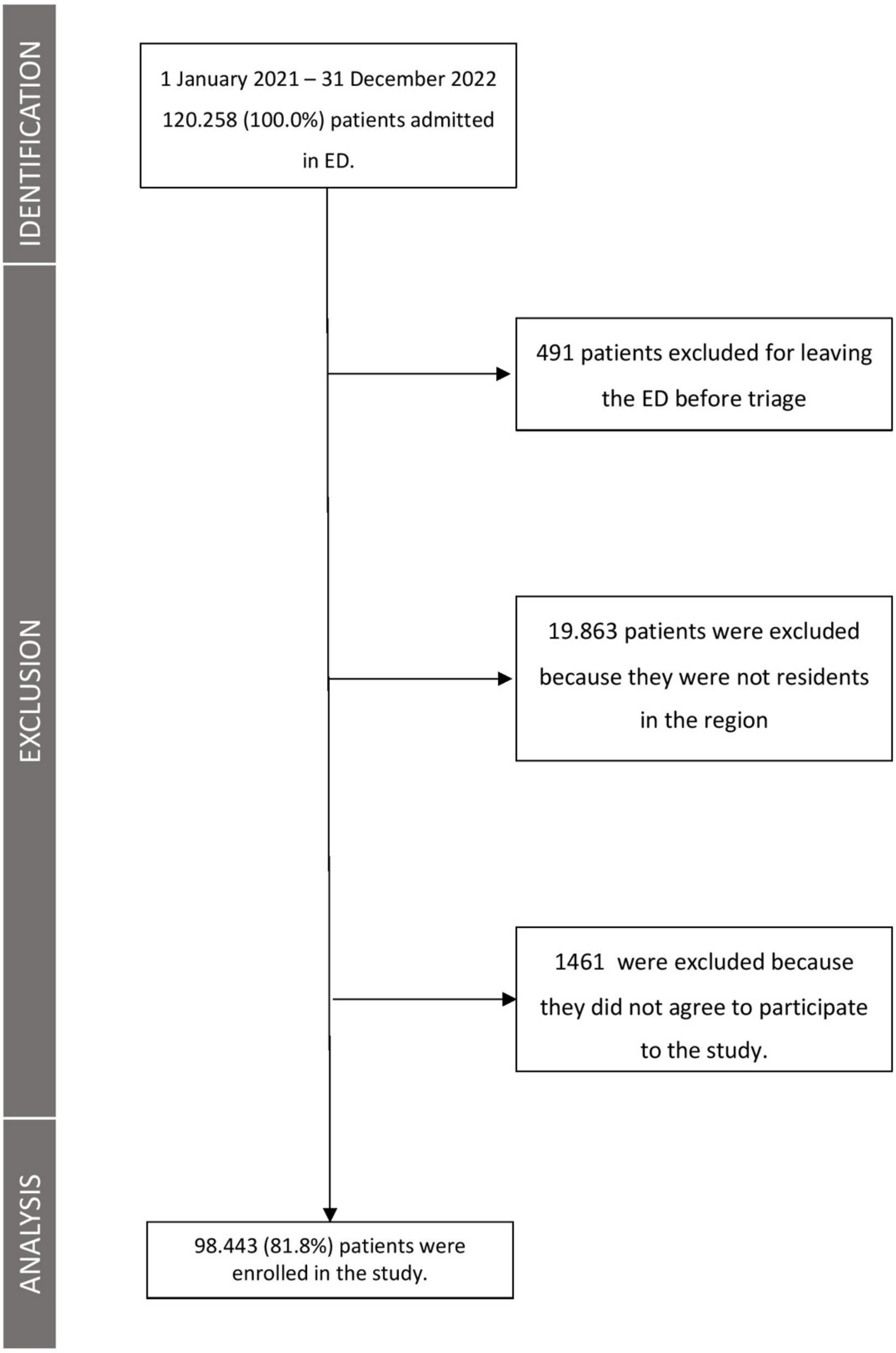

Figure 1. Flow-chart of patients enrolled in the study.

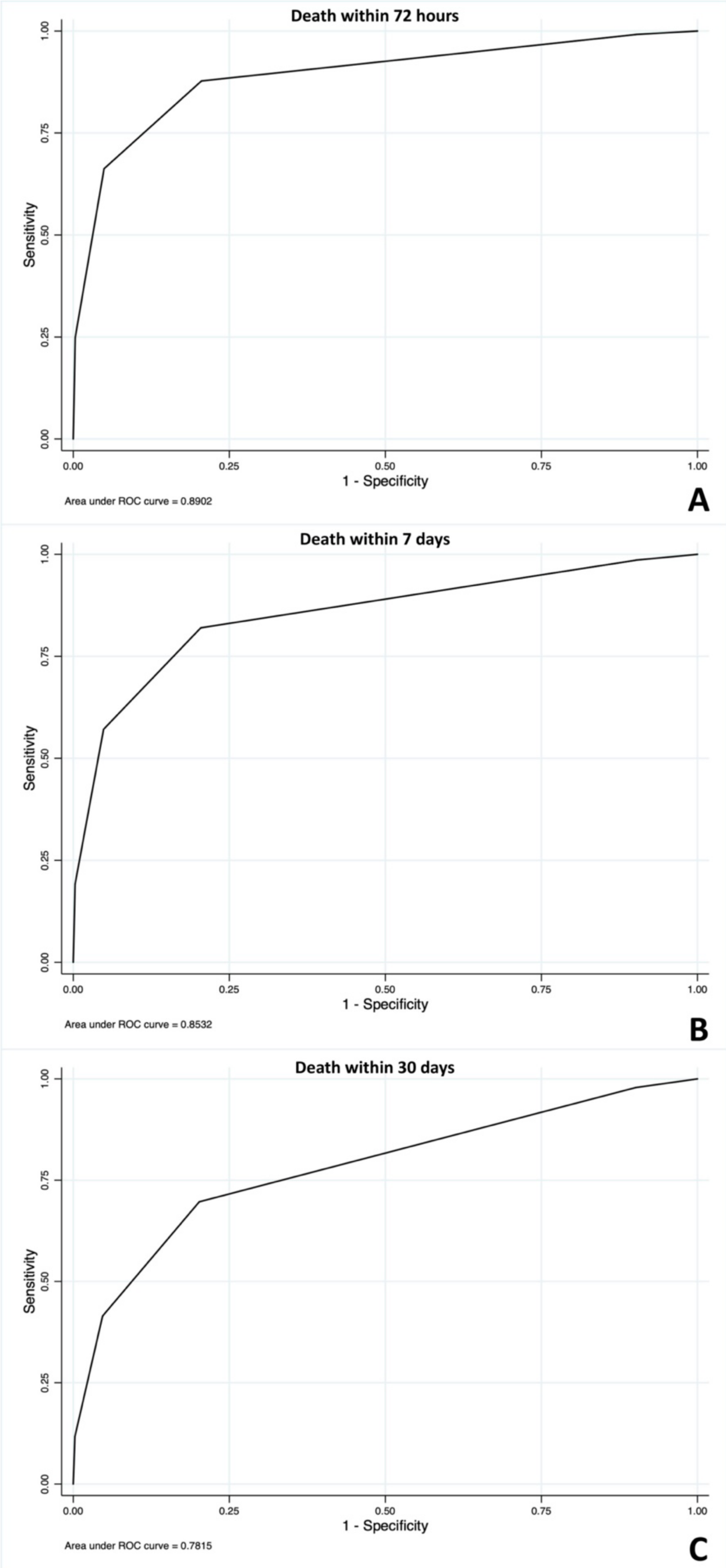

Figure 2: AUROC of MTS for the three selected outcomes.

Supplementary Materials

Table 1. Sensitivity, specificity and likelihood ratio values for each cut-point of the AUROC curves for the three study outcomes.

Cut-point	Sensibility	Specificity	LR+	LR-
Death within 72 h				
≥ Blue priority code	100.0%	0.0%	1.000	-
≥ Green priority code	99.1%	9.85%	1.099	0.085
≥ Yellow priority code	87.7%	79.4%	4.271	0.154
≥ Orange priority code	66.24%	95.1%	13.424	0.355
≥ Red priority code	24.89%	99.7%	76.880	0.753
Death within 7 days				
≥ Blue priority code	100.0%	0.0%	1.000	-
≥ Green priority code	98.6%	9.8%	1.093	0.144
≥ Yellow priority code	81.9%	79.5%	4.011	0.226
≥ Orange priority code	57.1%	95.1%	11.755	0.450
≥ Red priority code	19.2%	99.7%	63.563	0.810
Death within 30 days				
≥ Blue priority code	100.0%	0.0%	1.000	-
≥ Green priority code	97.8%	9.9%	1.086	0.216
≥ Yellow priority code	69.6%	79.8%	3.449	0.380
≥ Orange priority code	41.4	95.3%	8.823	0.614
≥ Red priority code	11.7%	99.7%	44.378	0.8885