EM - ORIGINAL

The COVID-19 epidemic and reorganisation of triage, an observational study

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Abstract

Recent studies have suggested different organisational strategies, modifying Emergency Departments (EDs) during the COVID-19 epidemic. However, real data on the practical application of these strategies are not yet available. The objective of this study is to evaluate the inclusion of pre-triage during the COVID-19 outbreak. In March 2020, the structure of the ED at Merano General Hospital (Italy) was modified, with the introduction of a pre-triage protocol to divide patients according to the risk of infection. The performance of pre-triage was evaluated for sensitivity, specificity and negative predictive value (NPV). From 4th to 31st March, 2,279 patients were successively evaluated at the pre-triage stage. Of these, 257 were discharged directly from pre-triage by triage out or home quarantine and none has subsequently been hospitalised. Of the 2022 patients admitted to ED, 182 were allocated to an infected area and 1840 to a clean area. The proportion of patients who tested COVID-19 positive was 5% and, of these, 91.1% were allocated to the infected area. The pre-triage protocol demonstrated sensitivity of 91.1%, specificity of 95.3% and NPV of 99.5%. In addition, none of the healthcare workers was infected during the study period. Pre-triage can be a useful tool that, if standardised and associated with a change in the structure of the ED, can limit the spread of infection within the ED, optimise ED resources and protect healthcare workers.

Keywords Emergency department · Triage · Pre-triage · COVID-19 · Coronavirus · Emergency · Medicine

Introduction

In February 2020, COVID-19 appeared in Italy, spreading initially in the Lombardy region [1]. As the disease spread, the neighbouring regions were quickly affected and, for this reason, the Italian government was forced, on March 10, 2020, to designate the whole country as a single red zone, declaring national lockdown. In the weeks that followed, other European nations and the USA also progressively adopted lockdown strategies in an attempt to contain the pandemic.

Within a few days, Emergency Departments (EDs) were involved in the crisis caused by the COVID-19 pandemic, having to manage not only cases of severe respiratory failure, but also a large number of patients with mild symptoms. In addition to the regular admission of patients, this caused overcrowding in many EDs across the country. Usually, all patients who require an ED assessment are admitted to triage [2], to distinguish between patients who need rapid treatment and those who can safely wait [2]. In the midst of an outbreak, in addition to its normal function of prioritising patients according to the severity of their condition, triage should attempt to distinguish patients who are potentially infected from those who are non-infected [3]. Studies from China, where the epidemic took hold some months before Italy, have hypothesised that strategies aimed both at regulating patient ED access and separating patients within the hospital could mitigate many problems related to the spread of the pandemic, such as hospital overcrowding, diffusion of the virus within the hospital and infection of healthcare personnel [3, 4]. However, to the best of our knowledge, the practical aspects of these strategies have not yet been reported.

The present study aims to evaluate whether the introduction of a pre-triage system, to identify possible infected patients and differentiate their in-hospital route, could help to improve ED function during the COVID-19 pandemic and prevent patients suspected to be carrying the infection from coming into contact with non-infected patients.

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Methods

Setting

On 4 March 2020, the ED at Merano General Hospital was reorganised to manage the local consequences of the COVID-19 pandemic. Merano General Hospital is located in the Alto Adige region, an Alpine area in the north of Italy with a high influx of tourists (2.4 million overnight stays per year). The district of Merano (120,000 inhabitants, 70,000 ED admissions per year) is less than 200 km from the Veneto and Lombardy regions, the second of which saw the outbreak of the Italian epidemic.

The first COVID-19 case in the area covered by Merano General Hospital was assessed on 24 February 2020. In the days following the spread of the pandemic, Merano General Hospital was designated among the seven hospitals in South Tyrol, as the hospital with several departments specifically equipped for the treatment of patients affected by COVID-19.

ED changes

To manage the COVID-19 emergency, Merano General Hospital ED was immediately divided into two parts: one 'clean' area dedicated to patients presumed not to be infected and one 'infected' area for patients suspected to be carrying the infection. This latter area was further divided into 'Area A' with a high intensity of care and 'Area B' with low intensity of care (Fig. 1). In addition to these structural changes, a pre-triage area was introduced at the entrance to the ED. A field facility, open 24 h a day, was placed on the ED access ramp and all patients admitted to the ED had to pass through pre-triage.

Despite limited human resources, the two transformed areas of ED ('clean' and 'infected') were staffed by separate and non-interchangeable medical and nursing teams during a single work shift. Moreover, within the two areas, differing personal protective equipment (PPE) regimes for healthcare staff were applied: in the 'infected area', healthcare professionals were provided with a high level of protection, including an FFP3 respirator, long-sleeved disposable gown, eye protection and gloves while, in the 'clean area', PPE of a lower level but sufficient to ensure the safety of the worker was provided, including surgical masks, gloves, plastic aprons and eye protection if needed [5].

Triage modification and implementation of pre-triage

With the introduction of pre-triage, the usual triage operations took place in two separate but consecutive stages; pre-triage aimed to identify those patients who might be infected and triage aimed to rank the degree of urgency.

Pre-triage was performed inside the purpose-built structure by a team comprising a doctor and a nurse, in a facility organised to have parametric monitoring capability with a specific decision-making flow chart (Fig. 2). According to this flow chart, following pre-triage evaluation, the patient would be allocated to one of four different routes: 'infected area' admission, 'clean area' admission, triage out or home quarantine. Triage out leads to a prompt home discharge after pre-triage evaluation for those patients with non-urgent medical issues. Home quarantine was applied to those with a suspected infection but with clinical symptoms manageable outside the emergency setting. This also resulted in a prompt home discharge with a notification to the local services to continue following these patients, conducting additional nose-and-throat swabs.

In pre-triage, each patient had to wear a surgical mask and disinfect their hands, and blood saturation, body temperature and respiratory parameters were monitored (for dyspnoea, oxygen saturation and respiratory frequency). Patients with a possible infection were directly admitted to the 'infected area' where they were treated by a specialist team. Patients located in both 'infected' and 'clean' areas were subsequently subjected to the standard triage procedure according to the registered methodology of the Manchester Triage System used at Merano General Hospital since 2013.

Evaluation of protocol efficiency

Primarily, pre-triage protocol evaluation was performed to identify the proportion of COVID-19 positive patients admitted to the 'infected area', the proportion of COVID-19 negative patients located in the 'clean area' and the proportion of COVID-19 positive patients wrongly located in the 'clean area'. Sensitivity, specificity, positive and negative predictive values and accuracy were calculated to evaluate the performance of the protocol in correctly allocating patients. Secondarily, the evaluation considered the proportion of patients discharged to home quarantine who needed a second ED evaluation for worsened symptoms in the subsequent two weeks and the number of ED healthcare staff who presented COVID-19 infection symptoms or proved to be infected until 15 April 2020.

Fig. 1 Map of the ED before and after the implementation of the modifications to manage the COVID-19 emergency
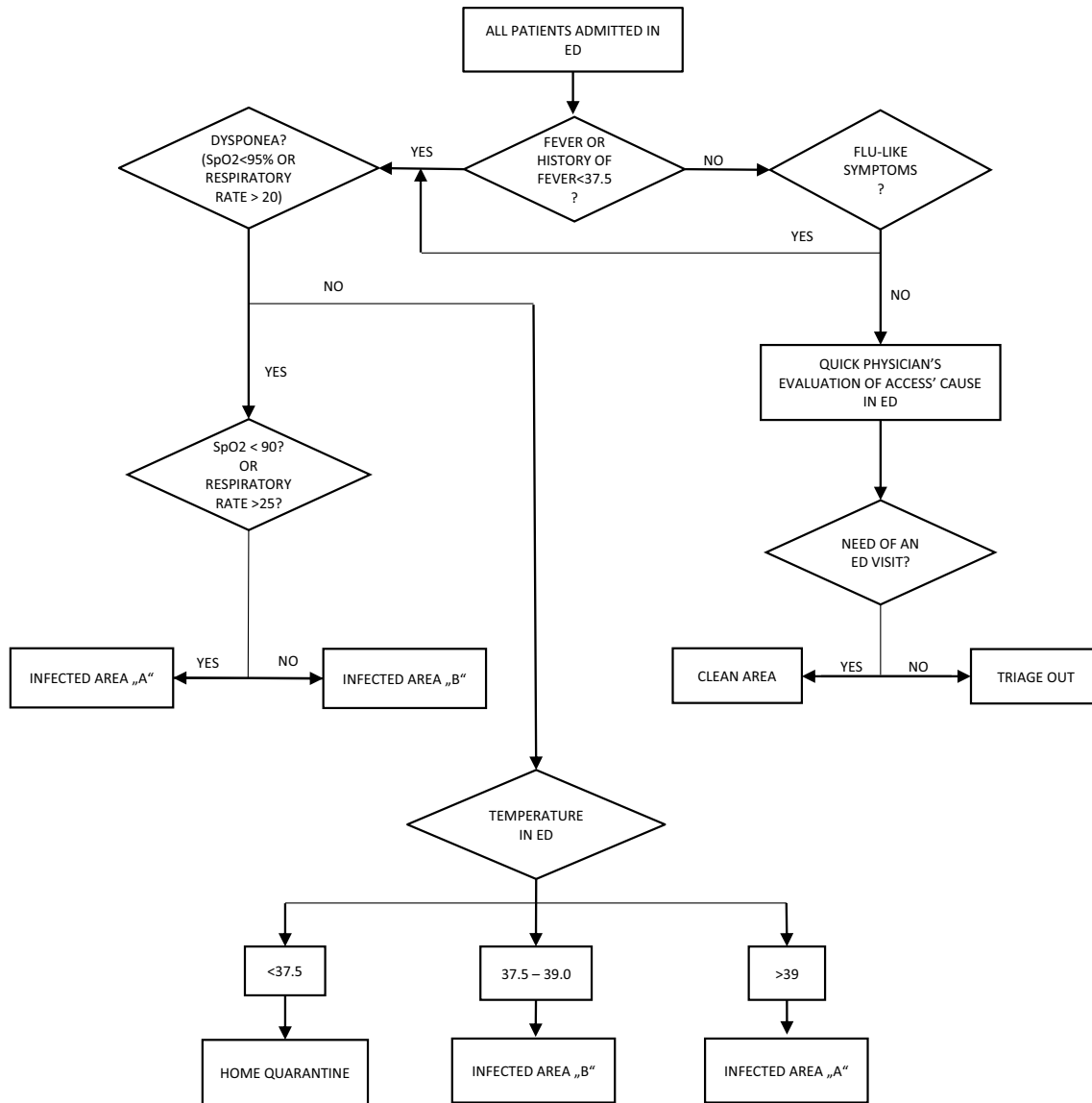
Fig. 2 Operative flow chart applied in pre-triage

COVID-19 positivity

The absence of a unanimous gold standard by which to evaluate COVID-19 infection and the necessity of identifying safe indications has led to those with a positive nose–throat swab within 15 days of an ED visit or with a chest CT scan suggestive of interstitial pneumonia being considered as COVID-19 infected patients [6]. Evaluation of COVID-19 positive patients was performed through manual evaluation of all medical fields available in the information database of Merano General Hospital and was performed by two emergency physicians with over 5 years' experience (GT and NP).

Statistical analysis

Statistical analysis was performed with STATA software. Categorical variables were described as a percentage and number of events on the total, and univariate comparisons were performed with the Fisher's exact test. Continuous variables were expressed as a median value and interquartile range (25th and 75th percentiles) and comparisons used the Mann–Whitney U test.

General protocol performance was evaluated through a 2×2 contingency table comparing COVID-19 positivity (infected vs. not infected) with the patient's allocation area (infected vs. clean area). Through this contingency table,

sensitivity, specificity, positive and negative predictive values were calculated. Each ratio has been described with a 95% confidence interval. All analyses were considered significant with a p value lower than 0.05.

Results

2279 patients arrived to ED in the study period. A 57.6% decline in ED arrivals was registered compared to the same period in previous years (5481 arrivals in 2017, 5355 in 2018 and 5286 in 2019). Figure 1 shows the ED modifications implemented in Merano General Hospital to tackle the COVID-19 pandemic, including the introduction of pre-triage and different care paths for patients (Fig. 1).

Of the patients arrived in pre-triage during the study period, 11.3% (257/2279) were directly discharged home according to the protocol. Of those, 60.7% (156/257) fell into the group triaged out and 39.3% (101/257) were told to remain in quarantine at home (Table 1).

Compared to all patients seen in ED, those discharged home directly from pre-triage were younger (50 vs.

38 years, $p < 0.001$). The majority were male and arrived at ED by their own transport (94.2% vs. 68.4%, $p < 0.001$), complained of a cough (5% vs. 12.5%, $p < 0.001$), had vomiting or diarrhoea (3.7% vs. 8.6%, $p < 0.001$) or influenza-like symptoms (2.6% vs. 13.6%, $p < 0.001$). In comparison to all patients, those admitted to ED more often required a medical evaluation for dyspnoea (5.5% vs. 0.8%, $p < 0.001$), chest pain (4.4% vs. 0.0%, $p < 0.001$), trauma (22.0% vs. 13.6, $p = 0.002$) or for a gynaecological or pregnancy-related problem (5.0% vs. 12.5%, $p < 0.001$). Of the patients discharged home from pre-triage to quarantine, 2.9% (3/101) requested a second evaluation for worsening symptoms. None of them were hospitalised though one patient remained for observation in ED for 12.3 h. Of the patients assessed by pre-triage as requiring medical evaluation in ED, 9% (184/2022) were assessed in the 'infected' area (Table 2), while 91% (1840/2020) went to the 'clean' area.

Patients admitted to the 'infected' area were of a higher median age than those in the 'clean' area (63 vs. 48 years, $p < 0.001$) and had more serious clinical conditions according to MTS criteria (22.5% vs. 4.7% of orange/red codes,

Table 1 Characteristics of patients admitted to pre-triage, divided between those admitted to ED and those discharged directly home (triage out and quarantine at home)

Variables	Total	Admitted to ED	Not admitted to ED	p
Patients, n (%)	2279	2022 (88.7)	257 (11.3)	
Age, years, median (IQR)	48 (28–68)	50 (28–70)	38 (27–50)	< 0.001
Gender, n (%)				< 0.001
Male	1254 (55.0)	1121 (55.4)	133 (51.9)	
Female	1025 (45.0)	901 (44.3)	124 (48.1)	
Arrival mode, n (%)				< 0.001
Autonomous	1626 (71.4)	1384 (68.4)	242 (94.2)	
Ambulance	653 (28.6)	638 (31.6)	15 (5.8)	
Time range, n (%)				< 0.001
Day (07.01–21.00)	1987 (87.2)	1782 (88.1)	205 (79.8)	
Night (21.01–07.00)	292 (12.8)	240 (11.9)	52 (20.2)	
Symptoms (primary and secondary), n (%)				
Abdominal pain	135 (5.9)	118 (5.8)	17 (6.6)	0.577
Trauma	479 (21)	444 (22.0)	35 (13.6)	0.002
Flu-like symptoms	87 (3.8)	52 (2.6)	35 (13.6)	< 0.001
Dyspnoea	114 (5.0)	112 (5.5)	2 (0.8)	< 0.001
Vomiting or diarrhoea	96 (4.2)	74 (3.7)	22 (8.6)	0.001
Chest pain	88 (3.9)	88 (4.4)	0 (0.0)	< 0.001
Fever	177 (7.8)	152 (7.5)	25 (9.7)	0.212
Gynaecological symptoms	96 (4.2)	96 (4.8)	0 (0.0)	< 0.001
Maxillofacial symptoms	382 (16.8)	345 (17.1)	37 (14.4)	0.329
Cough	134 (5.9)	102 (5.0)	32 (12.5)	< 0.001
Others	666 (29.2)	614 (30.4)	52 (20.2)	0.001
Parameters (recorded at pre-triage), (IQR)				
Temperature (°C)	36.1 (35.8–36.5)	36.1 (35.8–36.5)	36.1 (35.6–36.8)	0.988
RR (breaths per minute)	17 (15–20)	17 (15–20)	16 (14–17)	0.003
Oxygen saturation (%)	97 (95–98)	97 (95–98)	98 (96–99)	< 0.001

Table 2 Characteristics of patients divided between the two areas located inside the ED: the clean area and the infected area

Variables	Infected area	Clean area	p
Patients, n (%)	182 (9.0)	1840 (91.0)	
Age, years, median (IQR)	63 (44–78)	48 (28–69)	<0.001
Gender, n (%)			<0.001
Male	112 (61.5)	931 (50.6)	
Female	70 (38.5)	909 (49.4)	
Triage priority code, n (%)			<0.001
Blue and Green	84 (46.2)	1201 (65.3)	
Yellow	57 (31.3)	552 (30.0)	
Orange and Red	41 (22.5)	87 (4.7)	
Parameters, (IQR)			
Temperature (°C)	37.1 (36.5–38.1)	36.2 (36.0–36.6)	<0.001
RR (breaths per minute)	20 (16–28)	16 (14–18)	<0.001
Oxygen saturation (%)	93 (89–97)	98 (96–99)	<0.001
Systolic BP (mmHg)	150 (105–170)	140 (125–160)	0.093
HR (bpm)	90 (78–107)	82 (75–92)	<0.001
Symptoms (%)			
Abdominal pain	4 (2.2)	114 (6.2)	0.029
Trauma	1 (0.5)	443 (24.1)	<0.001
Flu-like symptoms	17 (9.3)	35 (1.9)	<0.001
Dyspnoea	67 (36.8)	45 (2.4)	<0.001
Vomiting or diarrhoea	5 (2.7)	69 (3.8)	0.677
Chest pain	2 (1.1)	86 (4.7)	0.020
Fever	119 (65.4)	33 (1.8)	<0.001
Gynaecological symptoms	0 (0.0)	96 (5.2)	<0.001
Cough	62 (34.1)	40 (2.2)	<0.001
Maxillofacial symptoms	0 (0.0)	345 (18.8)	<0.001
Nose and throat swab executed, n (%)	175 (96.2)	421 (22.9)	<0.001
Thorax CT executed, n (%)	87 (48.1)	85 (4.6)	<0.001

Table 3 2×2 contingency table comparing the two areas (infected and clean) of ED with patients affected by COVID-19

	Infected by COVID-19	Non-infected by COVID-19
Infected area	92	90
Clean area	9	1831
Sensitivity	91.1% (88.3–93.3)	
Specificity	95.3% (94.8–95.7)	
NPV	99.5% (99.3–99.6)	
PPV	50.5% (43.2–57.7)	
Accuracy	90.5% (89.8–91.1)	

NPV Negative Predictive Value; *PPV* Positive Predictive Value

$p < 0.001$). Vital parameters also seemed to show a higher initial severity in patients located in the 'infected' area.

Among patients allocated to the 'infected' area, 50.5% (92/182) experienced a COVID-19 infection, compared to only 0.5% (9/1840) of those allocated to the 'clean' area. Decisional protocol showed a sensitivity of 91.1%, a specificity of 95.3%, a negative predictive value of 99.5%, a positive predictive value of 50.5% and an accuracy of 90.5% (Table 3).

Among all the medical and nursing staff who worked in ED during the study period to tackle the COVID-19 epidemic, none presented signs or symptoms of infection. In the 30 days after the study period, no one was found positive for COVID-19. Sixty-three swabs were tested for epidemiological purposes; all resulted negative.

Discussion

Triage in ED is a decision-making process that classifies patients according to their need for emergency treatment and optimises ED resources [7]. During an epidemic, it is the first contact between the patient and the hospital and can play a crucial role in identifying the risk of infection in patients and limiting the spread of the infection within the hospital and among healthcare workers [3].

This study, using proposals from previous studies, implemented modifications to an ED and introduced a pre-triage protocol to identify potentially infected patients immediately upon arrival in ED and initiate individualised pathways. Pre-triage displayed good sensitivity as well as very good specificity and accuracy in allocating patients to designated areas, good security in prescribing home quarantine and played a key role in protecting healthcare workers.

The concept of pre-triage is well known in disaster medicine [8]. Its application in various crisis scenarios has been extensively validated, demonstrating a positive impact on patient outcomes [9, 10]. The use of rapid clinical criteria in triage in patients with fever was an effective strategy in controlling the SARS epidemic in China [11]. For this reason, Zhang et al. proposed 'following clinical strategies in adult fever clinics' during the COVID-19 epidemic [11]. Early clinical assessment and consequent isolation of patients suspected to be carrying the infection could be a strategy to be implemented upon arrival in ED to contain the highly contagious COVID-19 and limit the risk of intra-hospital spread [3, 4, 12]. Recently, strategies have been proposed to limit the spread of infection within healthcare facilities [4]; the majority focus on attempting to limit hospital transport only to the most severely infected patients and on implementing structural changes within the EDs.

At the outbreak of the COVID-19 epidemic, the Emergency Medical System (EMS) of the metropolitan area of Milan (Italy), reached by dialling 112, the European emergency number, introduced a team of experts to assess who should be admitted to dedicated hospital facilities, selecting only those patients with respiratory symptoms who met precise pre-established epidemiological and clinical criteria [13]. They were, thus, able to differentiate between those patients needing hospitalisation and those for whom nose-and-throat swab for SARS-CoV-2 could be performed at home, managing the flow of patients into hospitals, the availability of beds and the crowding of EDs [13].

Isolation of suspected COVID-19 positive patients is one strategy to reduce person-to-person transmission [12, 14] and, at hospitals, this begins with triage workstations in appropriate settings [4]. Wu et al. suggest that triage should be located outside the ED, organised to guarantee the correct social distancing and equipped with a team comprising a physician and a nurse [4].

To the best of our current knowledge, this study is the first to have applied theoretically proposed measures and to report data from their application in a real setting. The clinical criteria included in the decision-making flow chart derived from recently published proposals and are essentially based on the assessment of fever status and respiratory dynamics [15, 16]. The identification criteria for cases of suspected infection cannot achieve 100% sensitivity and specificity at the same time. Giving preference to sensitivity will cause more patients to be admitted into the infected area, increasing the risk of transmitting infection to healthy patients incorrectly placed there. Conversely, preferring specificity will allow infected patients to enter a clean area where they may infect healthy patients.

The application of triage out or home quarantine has not only avoided the hospitalisation of paucisymptomatic patients who may not be infected, but has also prioritised medical and nursing resources for the most seriously ill patients. Since COVID-19 pneumonia has proved to be complicated, with the need for close monitoring even in cases apparently responding to oxygen therapy, the choices made in triage have made it possible to direct the limited resources to the most severely affected patients, as suggested in the disaster scenarios [17, 18].

Finally, pre-triage can play a role in the protection of healthcare workers. One of the most serious problems related to the COVID-19 epidemic is the spread of the infection to healthcare workers. The identification of patients with different levels of infectious risk has made it possible to optimise the use of the available PPE by dedicating more to be used in the 'infected' areas. This has enabled hospitals to address both the lack of PPE itself and the need to protect healthcare workers.

This study suffers from some limitations: first, it is a preliminary, monocentric study, performed within a limited time period and may, therefore, be affected by bias related to these conditions. The strictly registered methodology has, however, certainly allowed the standardisation of decisions. Second, we do not know how many patients were found to be infected among those triaged out and prescribed home quarantine. However, the re-evaluation of only one patient (subsequently discharged) seems to be a good measure of the outcome. We do not know if the incorrect allocation of few infected patients in the 'clean area' could have caused other patients to be infected within the hospital. However, of nine patients found positive in the 'clean area', seven were isolated before the hospitalization. The medical examination after pre-triage, in cases of pre-triage error limited the spread of the virus in the hospital, also this system with multiple examination appears safe. Fourth, we did not routinely perform a nose-and-throat swab on patients who went into the 'clean' area and, therefore, lacks a gold standard to prove the accuracy of the pre-triage decision. However, these patients had one or more medical evaluations or hospitalisations and all patients at risk, or who subsequently presented with suspected infection during the evaluations, were tested for SARS-CoV-2 with a nose-and-throat swab.

Conclusion

Triage is a key element in the ED structure. Even in such extreme circumstances as this pandemic, effective triage can affect and improve the management of the entire ED.

Although further evidence is needed, potentially from different structures, pre-triage can be a useful tool that, if standardised and associated with a change in the structure of the EDs, can limit the spread of infection within the ED, optimise ED resources and protect healthcare workers.

Compliance with ethical standards

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