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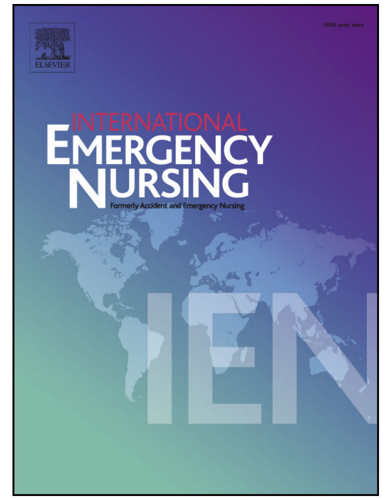

The impact of COVID-19 pandemic on the urgency of patients admitted to the emergency department

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"The Impact of COVID-19 Pandemic on the Urgency of Patients Admitted to the Emergency Department."

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All authors have no conflicts of interest.

Contributors:

AZ, FB & GT conceived and designed the project.

AZ, FB, SS, MFC, ER, GM, NP & GT acquired, analyzed, and interpreted the data.

AZ, FB and GT wrote the manuscript.

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INTRODUCTION

The first available analysis, which seems to show a change in the first months after the outbreak of the COVID-19 pandemic in both the number and quality of accesses to Emergency Departments (EDs), might suggest a transformation of the flows observed in EDs [1, 2]. During the first months of the pandemic, the reduction in patients was between 40 and 70% [1, 2, 3]. In terms of type of admissions, the effect of the COVID-19 outbreaks and, above all, the containment measures introduced by the countries, seem to have changed the type of admissions to the ED, with reductions in the exacerbations of chronic conditions or the decline in new cardiovascular and oncological diagnoses [4, 5]. Alongside the decrease in visits, there has been a reduction in the number of ED admissions but an increase in out-of-hospital mortality, supporting the idea that there is less tendency to require an ED evaluation even for non-trivial conditions [5, 6].

However, data on ED patient flow after the first COVID-19 wave seem limited and contradictory, not allowed at present to make conclusions on possible definitive structural changes imposed by COVID-19 on ED admissions [2, 7]. As any changes in ED flows immediately affect triage, an analysis of any changes in priority codes resulting from the prioritization process could provide an immediate impression of the effect of COVID-19 on EDs. Currently, no triage-focused analysis is available on the possible effect of the COVID-19 pandemic on ED flows and no comparison is available on triage prioritization between before and after the pandemic outbreak. Analysis of the change in access priority between before and after the pandemic may provide initial indications about the transformation of EDs due to the pandemic and may enable initial predictions to be made about the post-pandemic EDs.

Using the innovative techniques of interrupted time series analysis (ITSA), this study reports the analysis from the COVID-19 pandemic outbreak to assess whether priority codes in the ED have changed compared to the pre-pandemic period.

METHODS

Study Design and Setting

A quasi-experimental ITSA based on a retrospective review of data from all the ED admissions that occurred at the Hospital of Merano (Italy) from 1 January 2015 to 30 June 2021 was conducted. The Merano Hospital is located in an alpine area of Northern Italy, covering a district of 100,000 resident inhabitants.

The ED at Merano Hospital is active 24 hours and 365 days a year. During the COVID-19 pandemic, it remained active without any change in the admission criteria. During the first wave (March 2020-April 2020), Merano Hospital was designated as the provincial hospital for the management of COVID-19-positive patients, while after the second wave (November 2021-June 2021), COVID-19 patients were distributed among various hospitals in the province. The area of Northern Italy was one of the most affected by COVID-19; the region of Lombardy, which suffered the most victims in Italy during the first and second waves, is only 200 km away from the Hospital of Meran.

Every patient arriving at the ED of the Merano Hospital undergoes a triage procedure as the first step. Since 2014, the stratification of patients admitted to the ED is performed according to the Manchester Triage System (MTS) which, through 53 symptom-specific flowcharts, provides a standardized stratification of patient urgency by categorizing patients into one of five available priority codes: blue (non-urgent), green (deferable), yellow (urgent), orange (very urgent), red (immediate) [8]. Triage is performed by a specially trained nurse and periodic audits are performed to assess and maintain appropriate standards.

Data Collection

The outcome of the time analysis was the number of monthly accesses for each of the five priority codes standardized per 1000 accesses as given by the following formula:

$$Patients\ standardised\ by\ priority\ code = \left(\frac{Number\ of\ patients\ classified\ with\ a\ priority\ code\ in\ one\ month}{Number\ of\ visits\ per\ month}\right) \times 1000$$

The standardization on the number of monthly accesses was done in order to eliminate pandemic-induced variations in the general number of admissions in ED and thus to allow a more uniform comparison between before and after COVID-19 of individual priority codes.

The number of global monthly admissions in the ED and the number of admissions per single priority code were extracted through the management software QlickView directly from the ED computer database.

The Effect of the Pandemic on Non-Urgent Admissions: The Pandemic Variables

Subsequently, a specific analysis of the pandemic period was performed to analyze the possible effect of the pandemic on triage access prioritization.

The analysis of the pandemic period was performed using a weekly time interval from March 2020 (when the pandemic status was declared by World Health Organization and restrictions by the Italian government began to be applied) [9]. Non-urgent accesses were obtained by summing code blue and code green patients during the week.

The pandemic-related variables were: (a) incidence of COVID-19 patients in the province in the considered week (lag0); (b) incidence of COVID-19 patients in the province in one week before the considered week (lag1); (c) incidence of COVID-19 patients in the province two weeks earlier than the considered week (lag2); (d) incidence of COVID-19 patients in the province three weeks earlier than the considered week (lag3); (e) application of lockdown in the week under analysis (lag 0); (f) application of lockdown one week before the week under analysis (lag 1); (g) application of lockdown two weeks before the week under analysis (lag 2); (h) application of lockdown three weeks earlier than the week under analysis (lag3); (i) number of weeks during which governmental restrictions were active; (l) number of weeks without governmental restrictions; (m) reopening and removal of governmental restrictions in the week under analysis; (n) reopening and removal of governmental restrictions one week before the week under analysis; (o) reopening and removal of governmental restrictions two weeks before the week under analysis; (p) reopening and removal of governmental restrictions three weeks before the week under analysis.

All variables indicated were calculated for every single week since the outbreak of the pandemic. Pandemic variables were obtained from the data provided by the Italian Institute of Health (Istituto Superiore di Sanità).

Statistical Analysis

ITSAs are one of the most robust evaluation designs when randomization is not possible; moreover, they often allow a more detailed evaluation of the longitudinal impact of an intervention than is possible with a randomized controlled trial. This design should be applied to natural experiments where an intervention occurs or is implemented at a precise moment in time.

By collecting data at regular intervals over time, a pre-post comparison can be made taking into account underlying trends in the outcome [10, 11]

Several quasi-experimental ITSA were conducted by analyzing the time course of different levels of priority chosen over the period. ITSA is a methodological approach recently used to analyze the effects of discrete interventions on longitudinal data and to compare the development of a variable before and after a specific intervention or condition. The dependent variable is serially ordered over the number of observations in the time unit to form a time series and multiple observations are compared before and after the intervention. The strength of the impact of an intervention is determined by assessing any change in the trend of post-event observations compared to the projected pre-event trend. In this case, the intervention was the outbreak of the COVID-19 pandemic (March 2020) which created two time periods, pre- and post-pandemic. The ITSA, automatically follows a first-order autoregressive process, provided for each time trend of each variable understudy the following coefficients including their 95% confidence intervals and their p-values: a) the starting level of the variable; b) the trend before the intervention; c) the modification of the level by the intervention; d) the trend after the intervention.

A multivariate Poisson regression analysis was performed to analyze the effect of pandemic variables on non-urgent admissions. The possible association on the number of accesses was reported in terms of incidence rate ratio (IRR) by reporting their 95% confidence intervals. For all analyses conducted, a p-value of below 0.05 was considered significant. All analyses were performed with the statistical software STATA 16.1.

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 57-2020) and was conducted according to the Declaration of Helsinki regarding the Ethical Principles for Medical Research Involving Human Subjects.

RESULTS

From January 2015 to June 2021, there were 416,560 patients admitted to the ED (357,980 before the pandemic outbreak, and 58,580 in the pandemic months). Monthly accesses by year are reported in Table 1.

From the beginning of the pandemic to June 2021, 75,331 COVID-19 positive cases were registered in the province under study with 1,180 deaths.

Patients triaged monthly as code blue, went from a mean of 3.3% (CI 95% 2.8 - 3.7) before the pandemic to 5.2% (CI 95% 3.8 - 6.5) after the pandemic outbreak ($p<0.001$), green patients went from a mean of 65.0% (CI 95% 64.6 - 65.3) before the pandemic to 67.9% (CI 95% 66.5 - 69.2) after the pandemic outbreak (p<0.001), yellow patients went from a mean of 25.9% before the pandemic outbreak (CI 95% 25.5 - 26.4) to 20.6% (CI 95% 18.8 - 22.3) after the pandemic outbreak (p<0. 001), orange patients went from a mean of 4.9% (95% CI 4.8 - 5.0) before the pandemic outbreak to 5.6% (95% CI 5.2 - 6.0) after the pandemic outbreak (p<0.001), and red patients went from 0.3% (0.2-0.3) before the pandemic to 0.2% (95% CI 0.1-0.3) after the pandemic outbreak (p=0.251).

Figure 1 shows the ITSA of the patients admitted in ED classified as blue by triage. According to the effect analysis of the intervention performed through ITSA on the hypothetical global time series trend, in the pre-pandemic period, there were 48.9 blue-patient/1000 accesses per month (CI 95% 35.2-62.6, p < 0.001) with a statistically significant decreasing trend of -0.5 blue-patient/1000 accesses per month (CI 95% -0.8- -0.2, p=0.002). In March 2020, the number of blue patients remained stable (p = 0.685) with a subsequent upward trend of 4.8/1000 accesses (CI 95% 3.1 - 6.5, p<0.001) (Figure 1).

[FIGURE 1]

During the pre-pandemic period, patients classified as green at the triage were 644.9/1000 accesses per month (CI 95% 638.4-651.4, p <0.001) with a slight increase, although not significant, until the outbreak of COVID-19 (p = 0.102) (Figure 3). In March 2020, the number of patients classified as green increased, although not significantly, by 15.3/1000 accesses per month (CI 95% -15.1- 45.8, p = 0.318) and remained stable in the following months (p=0.436) (Figure 2).

[FIGURE 2]

Figure 3 shows the ITSA of patients classified as yellow. Until the outbreak of the pandemic, patients classified as yellow were 250.9/1000 accesses (CI 95% 236.7 - 265.2, p<0.001) with an increasing trend, but not statistically significant (p=0.117). In the month of the outbreak of the COVID-19 pandemic the accesses of yellow patients remained stable, with a slight non-significant decrease of -20.6/1000 accesses (CI 95% -47.5 - +6.2, p=0.130), in the months following the pandemic, there was a statistically significant monthly decrease of -5.9/1000 accesses (CI 95% -8.2- -3.6, p<0.001).

[FIGURE 3]

Patients classified as orange before the pandemic were 49.8/1000 (CI 95% 47.6 - 52.0, $p<0.001$) with no fluctuation until the month of the pandemic outbreak ($p=0.949$). During the month of the pandemic outbreak, there was a non-statistically significant increase in patients classified as orange ($p=0.095$), which was also maintained in the subsequent months of the pandemic ($p=0.944$) (Figure 4).

[FIGURE 4]

In contrast, patients classified as red in the pre-pandemic period were 2.88/1000 (CI 95% 2.2 - 3.5, $p<0.001$) with a trend that remained stable throughout the pre-pandemic period ($p=0.569$). During the month of the pandemic outbreak ($p=0.063$) and subsequent months the trend remained stable ($p=0.155$) (Figure 5).

[FIGURE 5]

Considering only the COVID-19 pandemic period (March 20-June 21), the multivariate Poisson regression model of the possible impact of pandemic determinants on non-urgent patient access is reported in Table 2.

[TABLE 2]

An increase in the weekly incidence of new COVID-19 patients is associated with an increase in non-urgent accesses in the same week (IRR 1.007, $p<0.001$). The number of weeks spent in lockdown or in the presence of governmental restrictions seems related to increase in non-urgent access (IRR 1.103, $p<0.001$). The increase in non-urgent patient admissions also appears to be related to the reopening and removal of governmental restrictions three weeks earlier (IRR 1.091, $p=0.026$). In contrast, the incidence of COVID-19 patients three weeks earlier than the week considered, shows a decrease in non-urgent ED admissions (IRR 0.996, $p=0.002$). A strong decrease in ED accesses of non-urgent patients also seems to be related to the presence of governmental restrictions in the week under analysis (IRR 0.346, $p<0.001$), one week before (IRR 0.798, $p<0.001$), two weeks before (IRR 0.776, $p<0.001$), and also three weeks before (IRR 0.924, $p=0.025$). The decrease in ED accesses of non-urgent patients also correlates with reopening and removal of governmental restrictions one week before the considered week (IRR 0.807, $p=0.001$).

DISCUSSION

Through an observation period extended to 16 months after the pandemic outbreak and using the innovative technique of ITSAs, the current study demonstrates in quantitative terms how the COVID-19 pandemic outbreak affected and changed the priority observed in the ED. In contrast to the analyses on the first months of the pandemic, the wide extension of the study period allowed us to observe a progressive increase in the trends of non-urgent codes (blue and green), while substantial stability for urgent codes (orange and red) between before and after the outbreak of COVID-19. The analysis of priority codes could be a good starting point to analyze the impact of the pandemic on acute diseases and begin to draw some conclusions about the flows that will follow after the pandemic.

The comparison in the flows of the individual priority codes was carried out considering the significant reduction in total monthly/weekly accesses observed in the first months of the pandemic outbreak and subsequently the fluctuating trends that accompanied the different COVID-19 waves. Several studies have highlighted the fact that the COVID-19 pandemic has led to a general reduction in ED admissions [1, 3, 12, 13]. Jeffery et al., in a large multicenter study looking at EDs in five US states, observed that the number of ED admissions after the outbreak of the pandemic declined by between 41.5% and 63.5% [3]. Many other studies from different countries confirm the general decrease in ED admissions [1, 3, 12, 13]. Santi et al., reporting access data from non-COVID-19 patients, reported a drop in ED accesses of close to 70% in the three months following the outbreak of the pandemic [5]. The variation of admissions in the ED caused by COVID-19, therefore, appears to be an essential element in the assessment of possible changes observed in priority codes. Similar to the study conducted by Holland et al., the current study considered the monthly access rates of individual severity codes standardized on the total accesses of the same month in order to make the months before COVID-19 comparable with the pandemic months [14].

The analysis of urgent codes (orange and red) demonstrated substantial stability before and after COVID-19, suggesting that the pandemic outbreak did not change the proportion of daily visits for truly urgent or life-threatening symptomatic conditions. Mahmassani et al., considering non-standardized rates on general access, reported an increase in urgent patients (category 1 and 2 Emergency Severity Index) and in patients managed in the ED's high-intensity area (40.7% vs 50.6%, p<0.001) [1]. Van Aert et al, reported that there was no statistically significant pandemic-related difference in the incidence of patients evaluated in the ED for severe trauma, suggesting that flows of severe trauma patients did not appear to fluctuate due to the pandemic [15]. Although some reports initially suggested that the restrictions may have affected the incidence of non-COVID-19 serious cardiovascular or respiratory conditions, the following months have revealed a substantial normalization of urgent codes [16, 17, 18, 19]. Therefore, it is not only confirmed that urgent codes, which represent the real pathological condition that should be observed in EDs, are the minority of patients observed in EDs today (less than 30% of daily visits in EDs) but even that catastrophic events assessed in the medium to long term do not modify it [15, 19, 20]. Public health planning could look at this data to reiterate the need to find solutions for the many non-urgent patients who require assessment in an environment not suited to their condition such as EDs.

In fact, patients with non-urgent (blue and green) codes increased during the months following the outbreak of the pandemic, reaching much higher levels than before the pandemic. Garaffa et al, in their recent study evaluating ED accesses during the first COVID-19 wave (February 2020 - June 2020), reported a decrease in accesses triaged as non-urgent compared to the same period in 2019 (p<0.001) [7]. Bardin et al, considering only the elderly population (over 65 years) assessed during the first and second pandemic waves described substantial stability in non-urgent priority codes with comparable ED access rates between 2019 and 2020 (38.6% vs 37.0%) [21]. Analysis of individual months, however, shows that towards the end of the lockdown restrictions, non-urgent accesses begin to rise again, gradually tending towards pre-pandemic levels [7, 21].

Also in the present study, ED accesses with non-urgent codes appear to be strongly associated with different changes (openings/closings) of governmental regulations introduced to control subsequent pandemic waves. There seems to be a consensus in the literature that visits the ED dropped dramatically upon the introduction of government restriction measures and that the increase in visits is related to general re-openings [1, 7, 21, 22]. The many available analyses that have generally considered ED flows, therefore, agree in correlating the various observed fluctuations with both increases in the incidence of new COVID-19 cases and government-imposed measures restricting movement and sociality [1, 2, 7, 21, 22]. The current study, however, for the first time to the best of our knowledge, focuses only on non-urgent codes and shows that they are strongly influenced by all those determinants (incidence, restriction period, opening period) of the pandemic itself. The statistically significant increase in ED access trends of non-urgent patients may reflect many social and health changes caused by the pandemic. The levels of anxiety caused by the pandemic have certainly affected the psychological state of the population and the spread of fear of infection may have been reflected in a demand for evaluation in the ED even in cases of minor symptomatic conditions due to fear of infection [14, 23, 24, 25]. Secondly, many territorial services were reduced or closed at the outbreak of COVID-19. In general, it is possible that non-urgent codes have been strongly affected by the reduction of visits offered by general practitioners (GPs), who appear to have reduced face-to-face visits by GPs in the early pandemic period by 4 times compared to the previous 2019 and by more than 25% if the observation period is extended to mid-2021 [26]. Although GPs have introduced and strengthened new modalities (telemedicine and telephone consultations), some non-urgent patients may still have gone to EDs, which are always open, with no obligation to make an appointment and with the face-to-face modality progressively abandoned by territorial medicine [26, 27]. This is one of the central points of the effect of the pandemic on the ED and the territory. While this might be justified during the early stages of the pandemic, the continued substitution of the ED for the GPs should alarm EDs. This would mean a devastating impact of the pandemic on the organization of EDs in the immediate future.

The study suffers from a number of limitations. First, the retrospective and single-center nature of the study subjects it to all the biases due to this type of study bias since the study operations, data collected, data entry, and data quality assurance, were not planned prior to the start of the study [28]. Second, the correct application of the triage system was not assessed. However, the use of a validated and standardized triage system and the presence of a continuous clinical audit may have limited the impact of this limitation. Thirdly, an analysis was made only on triage accesses and final medical diagnoses were not taken into account to correlate accesses with real underlying severities. Fourth, the number of patients admitted to the ED during the COVID-19 period who were COVID-19 positive is not known. Fifth, the choice to perform a weekly analysis during the COVID-19 period was made a priori; however, this choice was made in accordance with the weekly reports performed by the World Health Organization. In addition, a detailed analysis on the correct code assignment by the triage nurse was not performed; however, the continuous monitoring performed at the ED in our study and the use of a validated Triage System should have limited the impact of this limitation.

CONCLUSIONS

This analysis of priority codes assigned in triage, demonstrated that the pandemic apparently did not change trends in admissions for urgent codes. In contrast, patients with non-urgent codes increased at the outbreak of the pandemic with strongly increasing trends compared to general access in the following months. These data might suggest that there is a need for health policies to protect EDs from the increase in minor codes that the pandemic seems to have relocated from the territory to the EDs.

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Total accesses per month												
Years	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2015	5960	5002	5468	5516	5664	5771	6052	6139	5396	5556	4804	5496
2016	5483	5349	5992	5818	6220	5765	6289	6431	5909	5726	5073	6030
2017	6234	5353	5872	5918	6277	6151	6048	6351	5445	5810	5047	5754
2018	6023	5104	5792	6070	6275	6201	6079	6415	5728	5797	5139	5626
2019	5799	5472	5901	5645	5778	5956	6187	6304	5835	5763	5111	5488
2020	5733	5590	2387	1927	3227	3776	4798	5225	4517	3886	2578	3059
2021	3447	2863	3438	3978	4390	5060	-	-	-	-	-	-

Table 1: Total monthly accesses during the entire study period.

Non Urgent Patients			
Variables	IRR	95% CI	p-value
COVID-19 incidence			
Incidence in the considered week	1.007	1.004-1.009	<0.001
Incidence in the previous week	0.999	0.995-1.003	0.785
Incidence two weeks before	1.004	0.999-1.008	0.066
Incidence three weeks before	0.996	0.994-0.998	0.002
Government restriction and lockdown			
In the considered week	0.346	0.319-0.375	<0.001
In the previous week	0.798	0.722 – 0.883	<0.001
Two weeks before	0.776	0.722-0.835	<0.001
Three weeks before	0.924	0.863-0.990	0.025
Number of weeks with governmental restrictions or lockdowns in the considered week	1.103	1.093-1.112	<0.001
Reopening and removal of governmental restrictions			
In the considered week	1.047	0.940-1.166	0.396
In the previous week	0.807	0.709-0.918	0.001
Two weeks before	0.997	0.920-1.080	0.951
Three weeks before	1.091	1.010-1.178	0.026
Number of weeks without governmental restrictions in the considered week	0.998	0.995-1.000	0.101

Table 2: Poisson regression during the COVID-19 period (March 2020-June 2021) considered on a per week and factors related to the pandemic and its influence on Emergency Department access for non-urgent patients (blue and green).

Figure 1: Interrupted time series analysis assessing the rate of patients with a blue code assigned in triage standardised per 1,000 emergency department visits per month.

Figure 2: A) Interrupted time series analysis assessing the rate of patients with a green code assigned in triage standardised per 1,000 emergency department visits per month. B) Interrupted time series analysis assessing the rate of patients with a yellow code assigned in triage standardised per 1,000 emergency department visits per month.

Figure 3: A) Interrupted time series analysis assessing the rate of patients with a orange code assigned in triage standardised per 1,000 emergency department visits per month. B) Interrupted time series analysis assessing the rate of patients with a red code assigned in triage standardised per 1,000 emergency department visits per month.

"The Impact of COVID-19 Pandemic on the Urgency of Patients Admitted to the Emergency Department."

Highlights

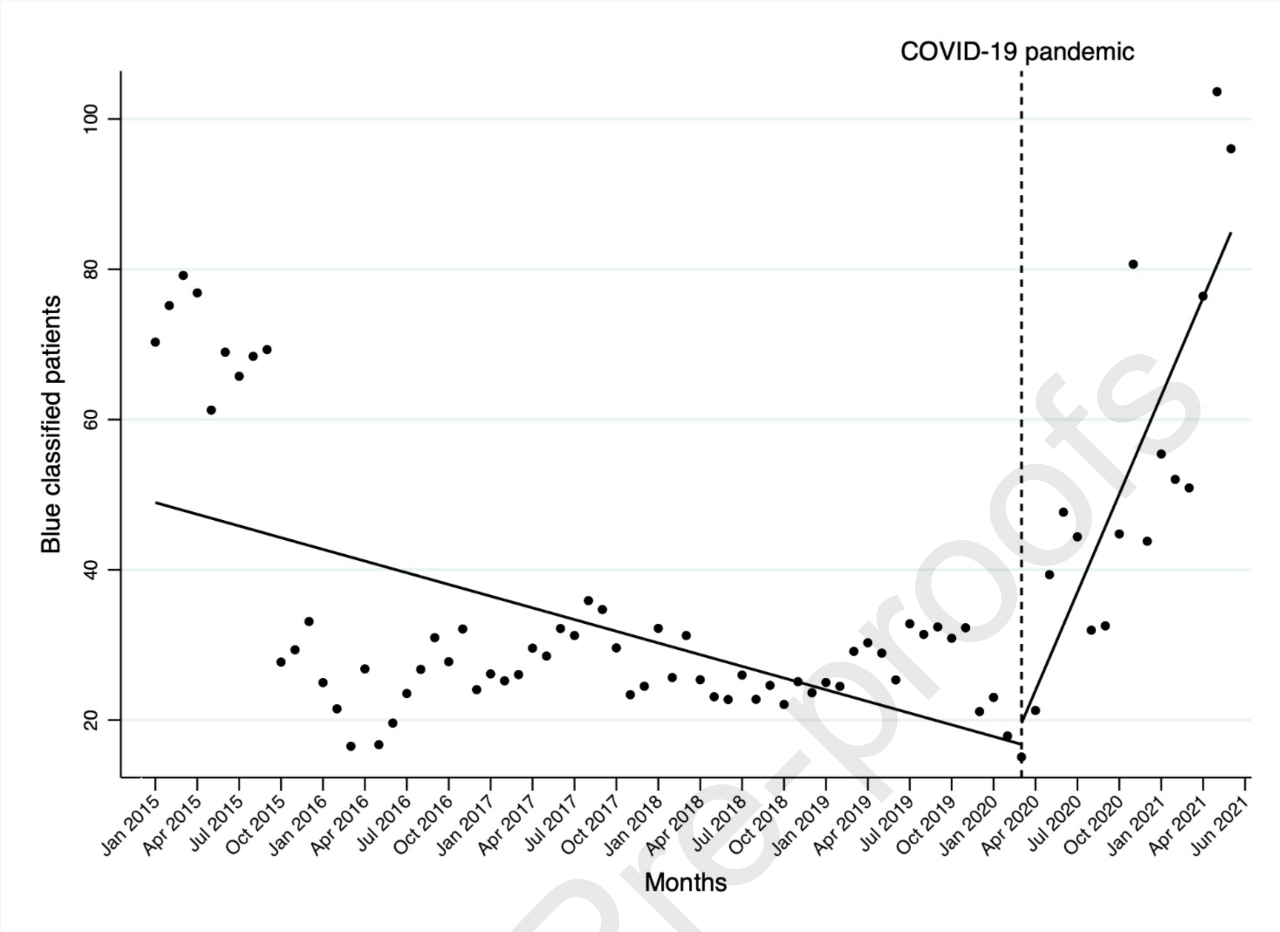
1) Through the innovative ITSA, variations in the prioritisation of patients in the ED were assessed.

2) COVID-19 pandemic has not altered the rate of urgent patients requiring ED assessment.

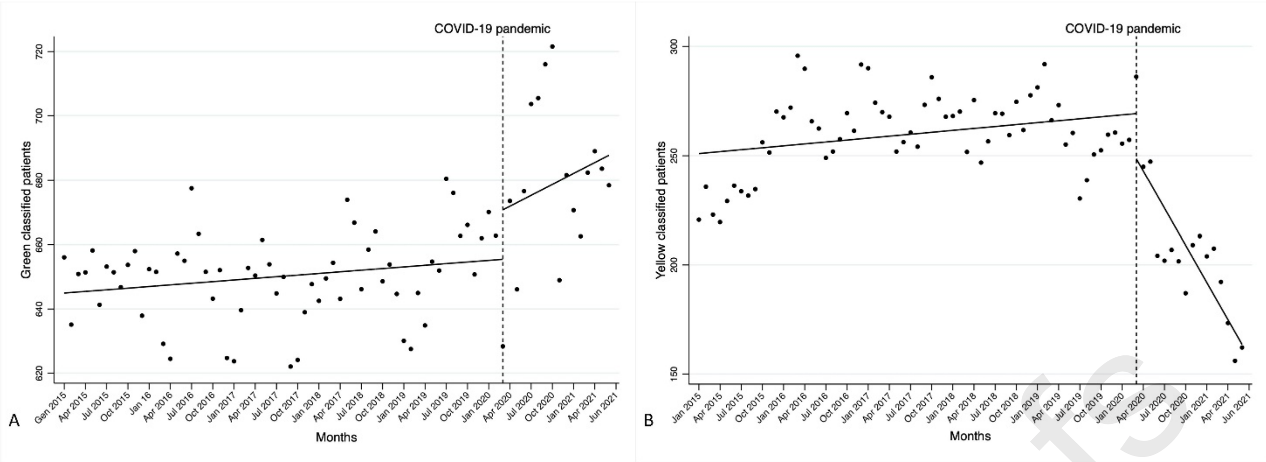
3) Since the outbreak of the pandemic non-urgent patients have increased in the ED.

CRediT authorship contribution statement

All authors (AZ, FB, SS, MFC, ER, MG, NP & GT) have made substantial contributions to the drafting of this article or revising it critically for important intellectual content and final arrival of the version to be submitted. AZ, FB & GT contributed to the conception and design of the study; AZ, SS, GT and MG contributed to the acquisition of data; AZ, GT, & FB contributed to the analysis and interpretation of data. AZ, GT & FB wrote the manuscript. All members of the study research group reviewed and approved the final version.



COVID-19 pandemic
Blue classified patients
100
80
60
40
20
Jan 2015
Apr 2015
Jul 2015
Oct 2015
Jan 2016
Apr 2016
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Jul 2017
Oct 2017
Jan 2018
Apr 2018
Jul 2018
Oct 2018
Jan 2019
Apr 2019
Jul 2019
Oct 2019
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jun 2021
Months


COVID-19 pandemic
Green classified patients
620
640
660
680
700
720
Gen 2015
Apr 2015
Jul 2015
Oct 2015
Jan 16
Apr 2016
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Jul 2017
Oct 2017
Jan 2018
Apr 2017
Jul 2018
Oct 2018
Jan 2019
Apr 2019
Jul 2019
Oct 2019
Jan 2020
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jun 2021
Months
A
COVID-19 pandemic
Yellow classified patients
150
200
250
300
Jan 2015
Apr 2015
Jul 2015
Oct 2015
Jan 2016
Apr 2016
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Jul 2017
Oct 2017
Jan 2018
Apr 2018
Jul 2018
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Apr 2019
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Oct 2019
Jan 2020
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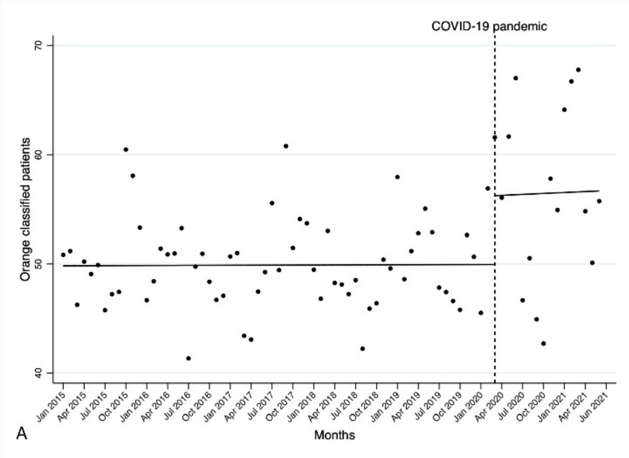
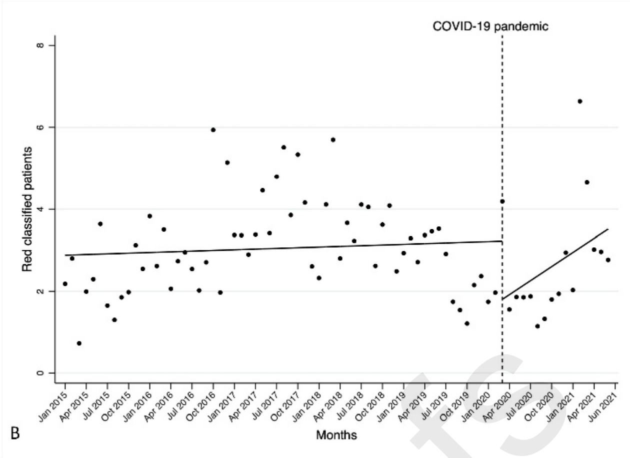
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jun 2021
Months
B


COVID-19 pandemic
Orange classified patients
Months
A


COVID-19 pandemic
Red classified patients
Months
B