

COVID-19

The impact of SARS-CoV-2 on emergency health care demand: inverse relationship between COVID-like illnesses and ED accesses in Genoa, Italy

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Keywords

SARS-CoV-2 • COVID-19 • ARI • Syndromic surveillance • Epidemiological surveillance • Emergency department • ED

Summary

Introduction. SARS-CoV-2 has changed the demand for in-person health care. The aim of this study was to retrospectively analyzed data on access to San Martino Hospital Emergency Department (ED), Genoa, Italy, during the COVID-19 pandemic.

Methods. Descriptive statistics for 180,117 records of patients accessing the ED between 2019 and 2021 were reported. A linear regression model was built to evaluate the relationship between the weekly number of COVID-like illness cases and ED attendances.

Results. In comparison to pre-pandemic levels, the median number of ED visits declined by 41.6% in 2020 and by 27.4% in 2021. The period of maximum drop in access (-61.9%) was the 2020 12-16th calendar weeks and coincided with the highest rates of COVID-like illness cases (+360%; 22.8% of total ED attendances). About

20% of the variation of the weekly number of ED attendances was explained by the number of COVID-like illness cases. In 2020 and 2021 non-urgent ED codes decreased (-6.7%; -7.3%) and both urgent and emergency ED codes increased (+4.8% and +3.9% the first; +1.9% and +3.5% the second). However, the absolute number of ED access fell drastically for all codes. In particular, the highest increase was registered in 2020 for acute respiratory infections (ARI), including COVID-19 (+3.28%), while traumas and eye diseases saw the highest decrease (-1.02%; -3.80%).

Conclusions. While the reduction in non-urgent visits suggests avoidable pre-pandemic access levels, the decline in non-COVID-19 urgent accesses potentially points to an increase in delayed and missed care.

Introduction

Over the past two decades, the number of visits to emergency departments (ED) has increased overall in almost all the Organization for Economic Co-operation and Development (OECD) countries, switching from 29.3 visits per 100 population in 2001 to 30.8 visits per 100 population in 2011 (+5.2%). Even so, a year-on-year analysis, reveals no consistent growth trend [1]. For instance, while between 2009 and 2010 the number of ED visits increased by 4% in France and 2% in Australia, it also decreased by 12% in Ireland and 1.5% in Italy [1, 2]. More recently, also a report of the United States (US) Department of Health & Human Services indicated that between 2009 and 2018, the proportion of ED visits in the American hospitals remained relatively stable [3].

Variability in ED visits across and within countries over time is associated with various factors. Any occurrence that disrupts normal living conditions within a community (e.g. extremely cold or hot weather conditions, floods, earthquakes, conflicts) has the power to modify people health needs. Likewise, the seasonal circulation of microbes (e.g. epidemic and pandemic influenza) can impact emergency care. Since its first appearance at the end of 2019, the COVID-19

pandemic, caused by the Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2), has drastically transformed the demand for healthcare services. As of May 2023, when the World Health Organization (WHO) has declared the end of the COVID-19 pandemic as a public health emergency, SARS-CoV-2 had caused over 750 million cases of respiratory infections and 6.5 million deaths worldwide [4]. Of these, over 25 million cases of respiratory infections and 190.000 deaths occurred in Italy [5].

Contradicting previous observations of ED overcrowding during seasonal influenza epidemics [6], a systematic review of 81 studies estimated that, in comparison with pre-pandemic levels, health services worldwide have reported a median 37% reduction in services overall. These comprised median reductions for visits of 42%, admissions of 28%, diagnostics of 31%, and therapeutics of 30% [7]. The use of emergency healthcare services, in particular, decreased significantly, with reports of drop in ED admissions up to 50% in England [8] and Italy [9], 42% in USA [10], 41% in Greece [11] and 38% in Germany [12].

Especially during the first wave of the pandemic, Italy was one of the most hard-hit countries [13]. IRCCS San Martino Hospital, Genoa, Liguria Region (Northwest Italy) is the referral tertiary acute-care center in its

region. Although, during the pandemic, San Martino Hospital did not undergo major organizational changes (*e.g.* only limited numbers of healthcare workers were hired or fired; no additional ED opened or closed), except for those necessary for the safe admission of patients with COVID-19 (*e.g.* partition of COVID-19 wards and COVID-19 free wards) the number of ED visits and admissions fell drastically, especially during the months of full lockdown (March-June 2020).

Decline in access to emergency care services can result in missed and delayed diagnoses that, in addition to deaths from COVID-19, have translated, since the beginning of the pandemic, in higher rates of all-cause excess mortality worldwide [14]. An increase in out-of-hospital cardiac arrests, as well as a relative reduction in the execution of primary percutaneous coronary interventions, have been reported in many affected countries [15-17]. Cancer deaths are also expected to increase substantially in the upcoming years [18].

Since the decline in access to in-person health care implies elevated health, social and economic costs, it is vital to describe the effect of the pandemic trends on emergency care services and quantify their impact. To this end, in this study, over 180,000 records of patients accessing San Martino Hospital ED between 2019 and 2021 were analyzed and evaluated.

Materials and methods

STUDY DESIGN, SETTING AND POPULATION

In this study we retrospectively analyzed electronic medical records (EMRs) collected at the emergency department (ED) of IRCCS San Martino Hospital between 2019 (pre-pandemic reference year) and 2020-2021 (two consecutive pandemic years).

San Martino Hospital is a IRCCS or “Scientific Hospital and Care Institute” of national importance with high standards for both scientific production activities and specialized clinical care services. Being the referral tertiary acute-care center in the Liguria region, San Martino Hospital has the largest catchment area in the metropolitan area of Genoa where over 675,000 individuals live. Hosting more than 1,200 beds and 70 medical wards, the average number of accesses to the emergency department is about 78,000 people (range of 56,000-87,000 between 2014 and 2021) per year.

With regards to the pediatric age, San Martino Hospital has a birth center, however, it is not the referral hospital for children. As a consequence, only a small number of individuals under the age of 18 years old are treated here.

DATA SOURCE AND STUDY VARIABLES

EMRs of emergency room visits occurred between January 1st, 2019 and December 31st, 2021 and collected through the hospital information system (HIS) were manually extracted and analyzed. 202,578 records of patients that, during the study period, visited the ED were retrieved. Records of patients which abandoned

or were removed from the ED before receipt of an International Classification of Diseases - 9th revision (ICD-9) code diagnosis (14,429), those diagnosed with either an E or V (external causes of injury and supplemental classification) ICD-9 code (5,087), and those with either an incomplete or incorrect ICD-9 code (2,945) were excluded. Finally, 180,117 records were analyzed.

Each EMR contains demographic, administrative and clinical information (presenting symptoms, medical history, emergency color code, diagnosis and inpatient ward).

Attendances were counted by week, year and stratified by several variables: sex (male, female, not known), age group (0-17, 18-64, ≥ 65), triage severity (non-urgent, urgent, emergency), primary diagnosis and ward of admission.

It should be noted that the triage severity categories (non-urgent, urgent, emergency), were established based on the actual color codes used during triage at San Martino Hospital’s Emergency Department. These categories correspond to specific colors: white and green (non-urgent and minor urgency, respectively), orange and blue (urgency and deferrable urgency, respectively), and red (emergency).

Furthermore, considering the communal clinical features among different causes of illness, primary diagnoses identified by ICD-9 codes were grouped into clinically meaningful disease categories during a brainstorming session between four medical residents in Hygiene and Preventive medicine (AF, GI, MP, DS). Finally, 13,844 ICD-9 codes, including special codes later introduced to identify COVID-19 cases (04311, 04312, 04321, 04322, 04331, 04332, 48041, 48042, 51971, 51972, 51891, 51892) were grouped into 23 disease categories. In order to analyze inpatient admissions, 117 hospital units were grouped into 26 main medical wards.

Because of the initial absence, during the first months of 2020, of readily available laboratory diagnostic tests for SARS-CoV-2, as well as specific ICD-9 diagnostic codes for COVID-19, COVID-like illness cases – defined as either influenza-like illness (ILI) or lower respiratory tract infection (LRTI) cases identified through an operator dependent syndromic surveillance system – were preferred to ICD-9 codes as the most accurate proxy to evaluate the pandemic trends.

In the pre-pandemic time, an annual average of 430 cases of ILI and 1200 cases of LRTI were identified at San Martino Hospital through the syndromic surveillance system. This system is based on a two-steps screening procedure: the first is automated and uses catchment keywords such as “cough”, “sore throat”, “fever”, “cold”, “nasal congestion”, “respiratory distress”, “dyspnea” to select potential records of patients presenting with an acute respiratory infection (ARI); the second is carried out, on a daily basis, by a medical provider that by reading the complete ED record, including radiology reports, classifies the event as either “ILI”, “LRTI” or “other”.

Tab. I. Characteristics of emergency department visits across considered years (2019-2021).

	2019 (ref.)	2020	2021
Number of visits, n	76269	50053	53795
Visits per day, n (range)	209 (151-278)	143 (20-246)	151 (36-215)
Visits per week, n (range)	1465 (1371-1623)	1007 (402-1485)	1059 (290-1299)
Number of admissions, n	18290	14833	14294
Sex, n (%)			
Female	40060 (52.52)	25367 (50.68)	27720 (51.52)
Male	36209 (47.47)	24686 (49.31)	26073 (48.46)
Not known	0 (0)	0 (0)	2 (0.003)
Age group, n (%)			
0-17	2394 (3.13)	1150 (2.29)	1579 (2.93)
18-64	43542 (57.09)	28926 (57.79)	31814 (59.13)
≥ 65	30333 (39.77)	19977 (39.91)	20402 (37.92)
Severity at triage, n (%)			
Not urgent	3858 (5.05)	3502 (6.99)	4584 (8.52)
Urgent	47509 (62.29)	27824 (55.58)	29429 (54.70)
Emergency	24902 (32.65)	18727 (37.41)	19578 (36.39)

In our study, we present data related to both the syndromic surveillance of COVID-like illness cases (Section “COVID-like illness”) and data related to ICD-9 codes assigned to patients accessing the ED (Section “Clinical diagnosis”).

STATISTICAL ANALYSIS

Descriptive statistics were reported as median and range for continuous variables, and proportion and percentage for categorical variables.

A linear regression model with the weekly number of COVID-like illness cases as the independent variable and the weekly number of overall ED visits as dependent variable was performed. The results are presented as adjusted R squared (R^2) and p values. When the p-value was < 0.05 , the difference was regarded as statistically significant.

Statistical analyses and data cleaning were performed using KNIME Analytics Platform version 4.6.0 (University of Konstanz, Zurich, Switzerland) and Microsoft Excel version 16.52 (Microsoft Corporation, USA).

Results

In comparison to 2019 (ref.), 2020 e 2021 saw a substantial reduction in the number of ED visits. This reduction in attendances was also seen in subgroups based on sex, age group, triage severity and inpatient admission (Tab. I).

COVID-LIKE ILLNESS

Following the introduction of social distancing measures (March 9th-11th calendar week), in comparison with the pre-pandemic era - during which the median number of ED visits was 208 per day (range of 82-278) - the median number of ED visits declined by 41.6% [median ED visits 121.5 per day (range of 20-214)] in 2020 and

by 27.4% [median ED visits 151 per day (range of 36-215)] in 2021.

The period of maximum drop in accesses (-61.9%) [median ED visits 79 per day (range of 50-110)] corresponded to the 2020 12-16th calendar weeks and coincided with the highest rates of COVID-like illness – defined as either ILI or LRTI cases – identified through an operator dependent syndromic surveillance system (+360%; 22.8% of total ED attendances) [median COVID-like illness cases 18 per day (range of 4-46)].

Figure 1 shows the trends of ED attendances with respect to the total number of ED episodes (blue line), the total number of COVID-like illness cases (orange line) and the proportion of COVID-like illness cases (grey line) registered between November 1st, 2019 and December 31st, 2021.

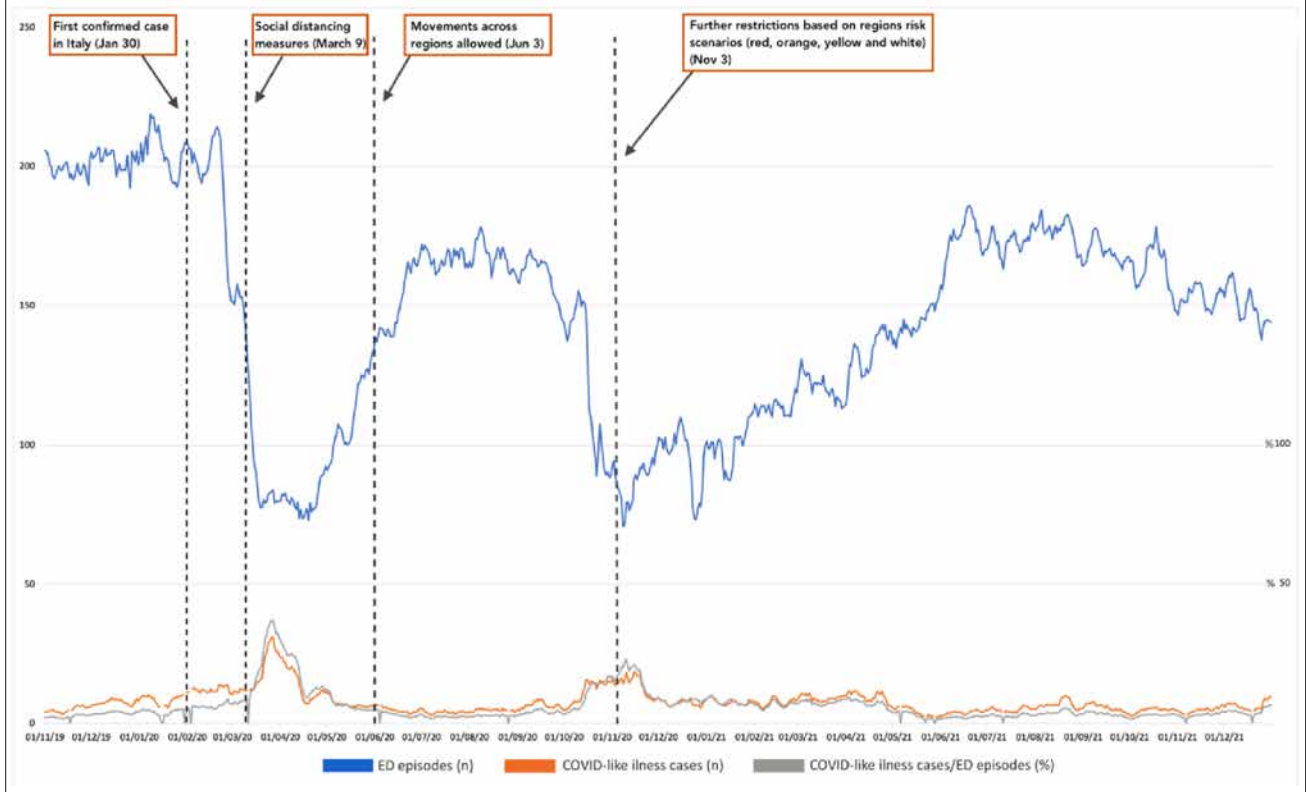
ILI in particular, rose from a median of 2 to 3 cases per day (range 1-14) (+150%), and LRTI rose from a median of 4 to 16 cases per day (range 2-37) (+400%).

Table II shows the characteristics of COVID-like patients that were evaluated as either ILI or LRTI cases during the study period.

In order to describe the relationship between the number of people presenting with COVID-like illness and ED attendances, a linear regression was performed. The model showed that when COVID-like illness cases increased, the overall number of ED visits at San Martino Hospital decreased (negative gradient). Adjusted R squared (R^2) was 0.20 [standard error (SE) 282.09; p value < 0.001]. In other words, about 20% of the variation of the weekly number of ED attendances (dependent variable Y) was explained by the number of COVID-like illness cases (independent variable X) (Fig. 2).

TRIAGE SEVERITY CODES

In terms of relative impact, compared with the total number of ED accesses in 2019, in 2020 and 2021 non-urgent ED codes decreased (-6.7% and -7.3%)

Fig. 1. Trends of ED attendances between November 1st, 2019 and December 31th, 2021 (moving average).**Tab. II.** COVID-like illness (ILI and LRTI) cases stratified by sex and age group, n (%).

COVID-like illness	Sex	Age group	2019 (ref.) (n, %)	2020 (n, %)	2021 (n, %)
ILI	F	0-17	3 (0.15)	2 (0.05)	1 (0.04)
		18-64	210 (10.86)	323 (9.65)	183 (8.20)
		≥ 65	540 (27.93)	712 (21.27)	544 (24.39)
	M	0-17	6 (0.31)	4 (0.11)	2 (0.08)
		18-64	236 (12.20)	479 (14.31)	314 (14.08)
		≥ 65	555 (28.71)	863 (25.79)	604 (27.08)
LRTI	F	0-17	9 (0.46)	11 (0.32)	7 (0.31)
		18-64	139 (7.19)	280 (8.36)	203 (9.10)
		≥ 65	58 (3.00)	165 (4.93)	78 (3.49)
	M	0-17	7 (0.36)	14 (0.41)	7 (0.31)
		18-64	120 (6.20)	302 (9.02)	209 (9.37)
		≥ 65	50 (2.58)	191 (5.70)	78 (3.49)
Tot.			1993 (100)	3346 (100)	2230 (100)

and both urgent and emergency ED codes increased (+4.8% and +3.9% the first; +1.9% and +3.5% the second). Even so, the overall absolute number of ED access fell drastically, especially for non-urgent and urgent codes. The former, in particular, experienced the most severe decrease, shifting from a pre-pandemic value of 47,509 to 27,824 (-19,685) in 2020 and 29,429 (-18,080) in 2021. The latter decreased by 6,175 in 2020 and 5,324 in 2021. Emergency codes decreased by 356 in 2020 and increased by 726 in 2021.

Figure 3 shows the trend of ED attendances with respect

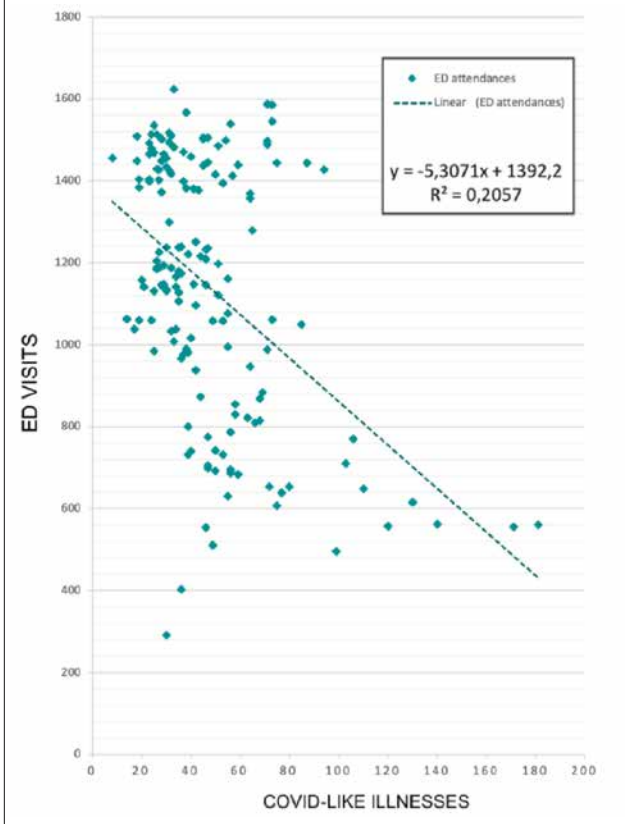
to different triage severity codes registered between 2019 and 2021 at San Martino Hospital.

Table III shows the characteristics of patients that, during the study period, were assigned a triage code.

With regards to patients' characteristics, in 2020 and 2021, elderly aged ≥ 65 and males visiting the ED tended to be assigned more often with severity codes that identify severe conditions.

In particular, in 2020, the rate of urgent codes rose by about 1.60% among both males aged 18-64 and ≥ 65. This trend was partially maintained in 2021, which saw a continuous rise in the proportion of adult males (age 18-

Fig. 2. Relationship between the number of people presenting with COVID-like illness and ED attendances on a weekly basis.



64) assigned with an urgent code (+1.69%). With regards to emergency codes, during the study period their rate saw a considerable increase among both male and female elderly (+0.60% in 2020 and +1.10% in 2021).

CLINICAL DIAGNOSIS

With regards to ICD-9 diagnoses, in 2020, acute respiratory infections (ARI), including COVID-19, saw the highest increase (+3.28%) while traumas and eye diseases saw the highest decrease (-1.02% and -3.80%, respectively).

The rise in ARI was maintained in 2021, during which the percentage of people who received this diagnosis was 1.52% higher than in 2019.

In terms of absolute numbers, ARI went from 1,664 in 2019 to 2,736 in 2020 and 1,995 in 2021. Among them, 1,468 and 1,254 persons, in 2020 and 2021 respectively, were diagnosed with a COVID-19 code.

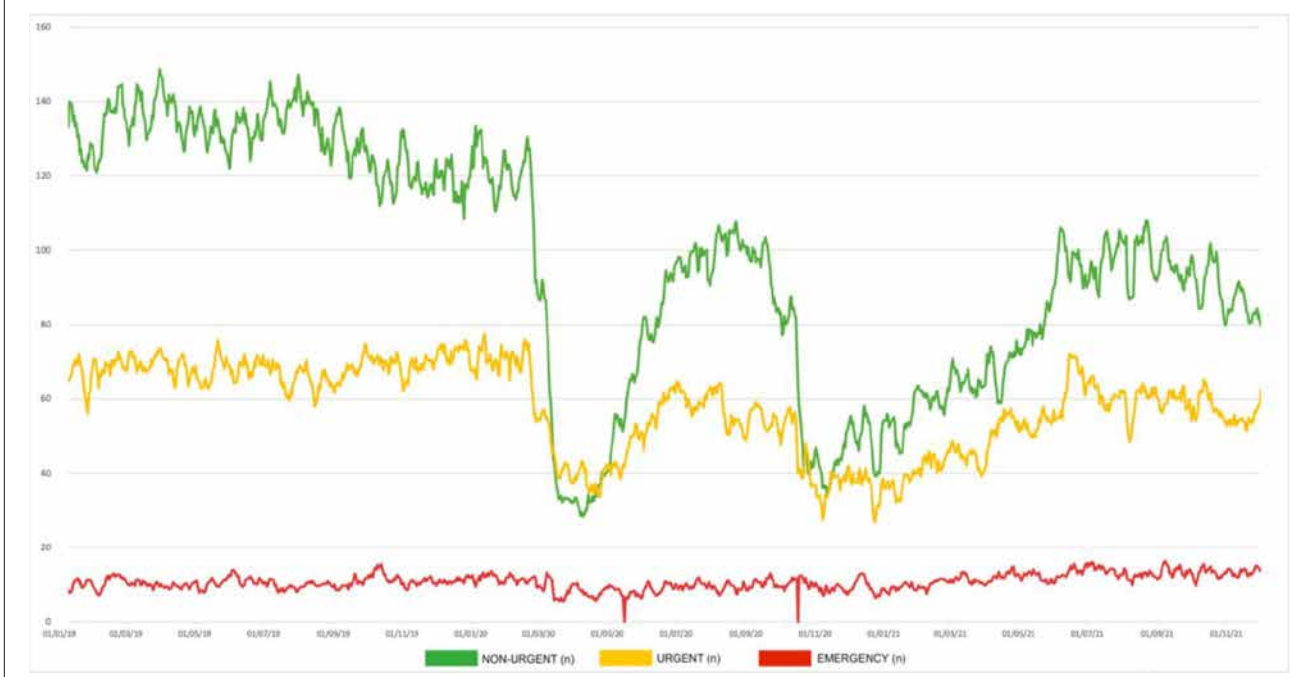
Interestingly, despite not being a referral care center for the pediatric age, the second largest relative increase was observed in the percentage of complications of pregnancy, congenital and growth disease (+1.50% in 2020 and 1.49% in 2021).

A rise was also noticed in the rates of unspecified malaise and fatigue (+1.47% in 2020 and 1.02% in 2021) and thromboembolic and cerebrovascular events (+1.04% in 2020 and 0.60% in 2021).

Being San Martino Hospital an IRCCS with special attention to oncological care, it is interesting to note a slight relative increase in access for oncological conditions of +0.22% in 2020 and +0.25% in 2021. Furthermore, with regards to accesses for mental health, there was a slight increase of +0.09% in access for mental disorders and +0.04% for substance use in 2020, which was not maintained in 2021.

Although the admissions of the elderly, in comparison to adults, being routinely lower, this category experienced the greatest increase in accesses for ARI. Over the total number of patients diagnosed with an acute respiratory infection, in 2020 and 2021, respectively, the rate of ARI

Fig. 3. Trend of ED attendances with respect to the proportion of different triage codes (moving average).



Tab. III. ED attendees stratified by triage severity, sex and age group.

Triage severity	Sex	Age group	2019 (ref.) (n, %)	2020 (n, %)	2021 (n, %)
Non-urgent	F	0-17	809 (1.06)	362 (0.72)	431 (0.80)
		18-64	16582 (21.74)	10042 (20.06)	10934 (20.40)
		≥ 65	7890 (10.34)	4057 (8.10)	3988 (7.44)
	M	0-17	1074 (1.40)	467 (0.93)	754 (1.40)
		18-64	15156 (19.87)	9578 (19.13)	10140 (18.92)
		≥ 65	5998 (7.86)	3318 (6.62)	3182 (5.93)
Urgent	F	0-17	221 (0.28)	137 (0.27)	134 (0.25)
		18-64	5157 (6.76)	3796 (7.58)	4448 (8.29)
		≥ 65	7619 (9.98)	5368 (10.72)	5548 (10.35)
	M	0-17	238 (0.31)	142 (0.28)	202 (0.37)
		18-64	5380 (7.05)	4353 (8.69)	4686 (8.7)
		≥ 65	6287 (8.24)	4931 (9.85)	4558 (8.50)
	NA	≥ 65	0 (0)	0 (0)	2 (0.01)
Emergency	F	0-17	17 (0.02)	15 (0.02)	27 (0.05)
		18-64	485 (0.63)	446 (0.89)	564 (1.05)
		≥ 65	1280 (1.67)	1144 (2.28)	1542 (2.87)
	M	0-17	35 (0.04)	27 (0.05)	29 (0.05)
		18-64	782 (1.02)	711 (1.42)	927 (1.72)
		≥65	1259 (1.65)	1159 (2.31)	1495 (2.78)
Tot.			76269 (100)	50053 (100)	53591 (100)

rose by 6.44% and 3.11% among males ≥65, and by 2.68% and 2.04% among females ≥ 65.

HOSPITAL ADMISSIONS

Out of 180,117 individuals accessing the ED between 2019 and 2021, 47,417 were admitted as inpatients. In comparison with 2019, hospital admissions went from 18646 to 14972 in 2020 and 14308 in 2021 (-19.7% and -23.3% in 2020 and in 2021, respectively).

The most significant reduction was observed in the rate of patients admitted to the emergency medicine ward (-12.05% in 2020 and 18.74% in 2021), which can likely be explained by the overall reduction in the number of people visiting the ED. By contrast, a larger proportion of patients was admitted to the wards of internal medicine (+6.11% in 2020 and 5.95% in 2021), orthopedics and traumatology (+2.13% in 2020 and 1.31% in 2021), obstetrics and gynecology (+1.97% in 2020 and 1.73% in

Fig. 4. Proportion of diagnoses in each disease category between 2019 and 2021.

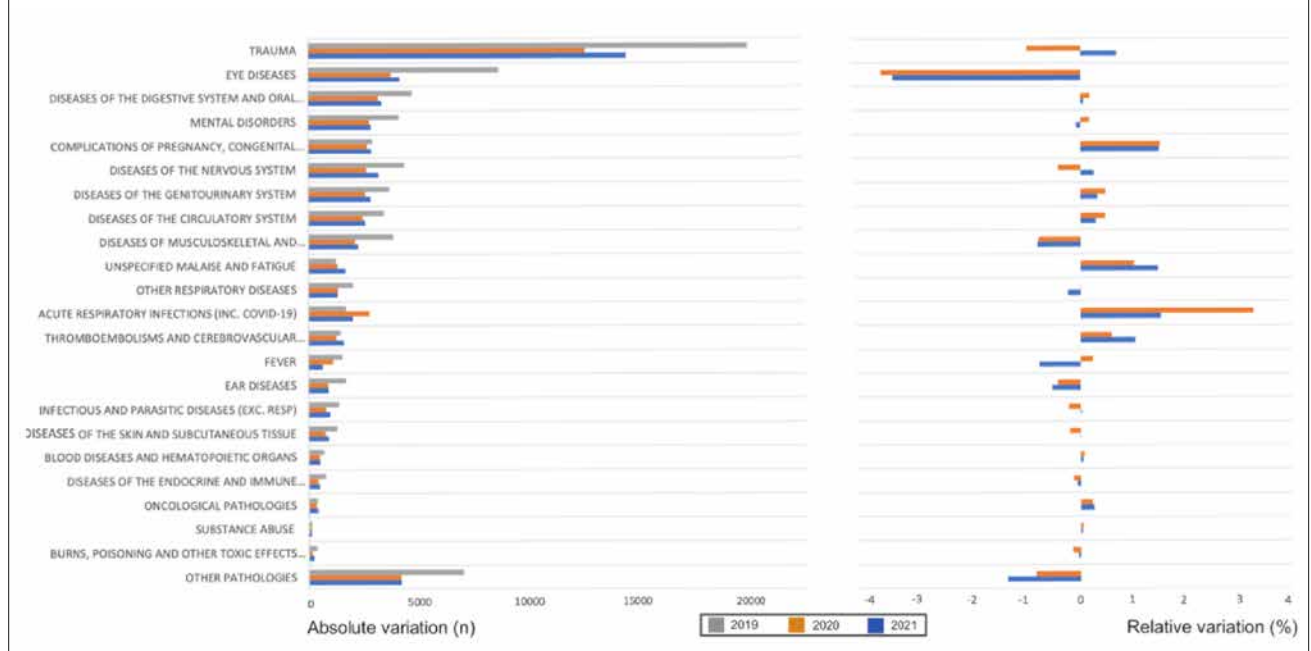
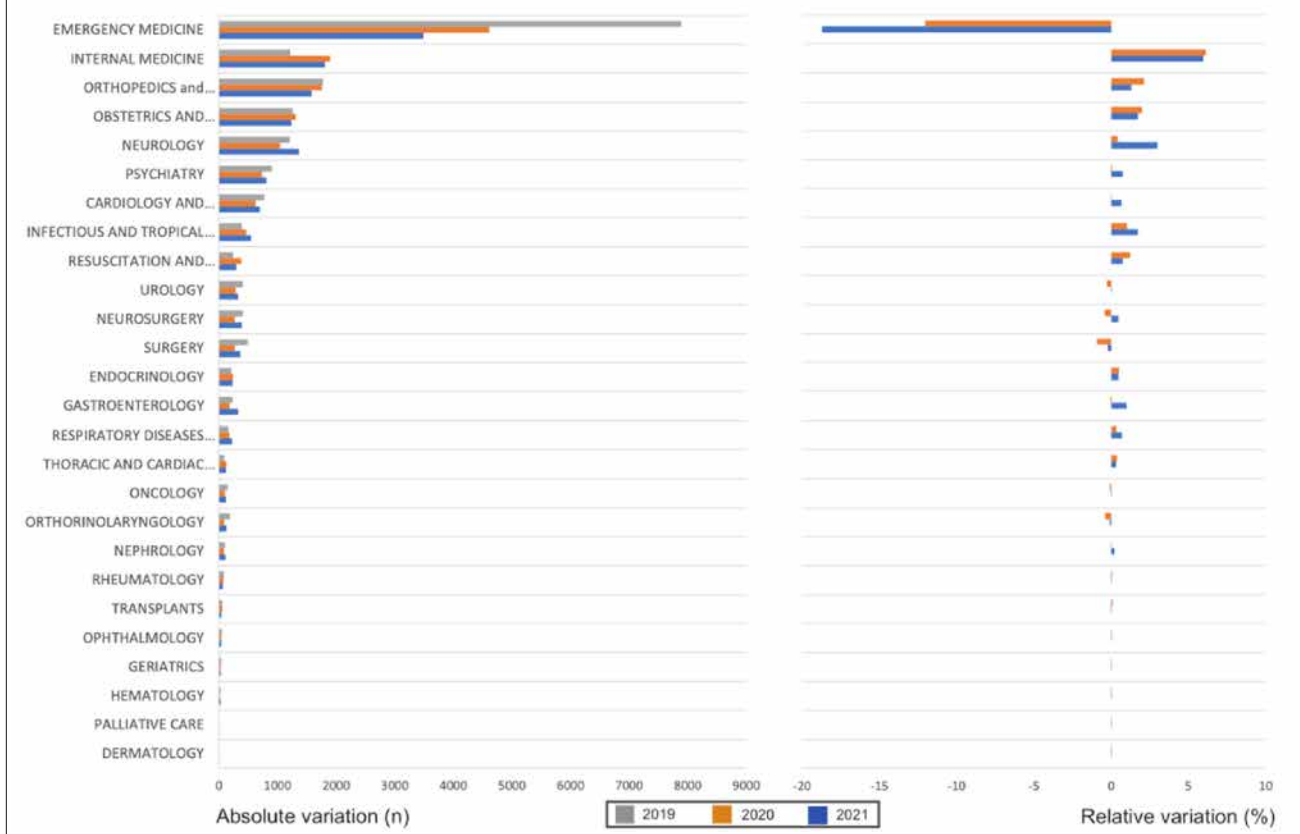


Fig. 5. Proportion of patients admitted to different hospital wards between 2019 and 2021.

2021). Notably, in 2021, the neurology ward recorded a significant increase in the proportion of hospitalizations (+2.96%).

Admissions at infectious and tropical diseases, where a large proportion of COVID-19 patients were treated, increased by 1.03% in 2020 and 1.72% in 2021. Finally, admissions to the resuscitation and intensive care unit grew by 0.31% in 2020 and 1.42% in 2021.

Figure 5 shows the variation in the proportion of patients that, during the study period, were admitted to a hospital ward. The extended figures for Figure 5 are reported in supplementary materials.

Discussion

PRINCIPAL RESULTS

In comparison with the pre-pandemic era, ED visits at San Martino Hospital declined by 41.6% and 27.4% in 2020 and 2021, respectively. During the period of maximum drop in accesses, COVID-like illness cases accounted for 22.8% of total ED attendances. The linear regression model showed that about 20% of the decline in the weekly number of ED attendances was explained by the rise of COVID-like illness cases.

Overall, there were fewer ED visits across all triage severity codes, with non-urgent ED codes decreasing the most. In terms of relative impact, however, non-urgent codes decreased (-6.7% and -7.3%, respectively), while

both urgent and emergency codes increased (+4.8% and +3.9% the former; +1.9% and +3.5% the latter). Elderly and males tended to be assigned more often with triage severity codes that identify severe conditions (urgent and emergency).

In 2020 and 2021, 1,468 and 1,254 individuals were diagnosed with a COVID-19 code. Overall, acute respiratory infections increased by 3.28% in 2020 and 1.52% in 2021 and admissions at infectious and tropical diseases increased by 1.03% in 2020 and 1.72% in 2021.

COMPARISON WITH PREVIOUS STUDIES

Our results substantiate with those of several authors [8–10, 12, 19, 20]. For example, Slagman et al. reported that, in 43 emergency departments in Germany, in 2020, calendar week 14th was the period of maximum drop in accesses (-38%) and coincided with the highest number of COVID-19 cases [12]. At San Martino Hospital, the period between the 12th and the 16th calendar week of 2020 represented the period of maximum drop in accesses (-61.9%) and coincided with the highest number of COVID-like illness cases (+360%). A reduction in non-urgent triage codes, in most cases complemented by a shift towards higher priority triage codes, was observed in Northern Italy by Bellan et al. [20] and Giostra et al. [9], in UK by Wyatt et al. [8] and Reschen et al. [19] and in Germany by Slagman et al. [12]. We observed an overall reduction in all severity

triage categories which, in relative terms, translated in a substantial decline in non-urgent codes and a raise in urgent and emergency codes. Analogously to our findings, Reschen et al. observed that traumatic causes of ED visits saw a consistent decline, while respiratory diseases (including COVID-19) were the only clinical category to not fall significantly during the first wave of the pandemic [19]. A substantial decline in traumatic causes of ED visits was also reported by Slagman et al. [12] and Giostra et al. [9]. The overall reduction in ED accesses during the COVID-19 pandemic may partially be explained by fear of acquiring COVID-19 whilst in hospital. This hypothesis is supported by the results of surveys conducted by the Irish Cardiac Society and the British Heart Foundation indicating that fear of being exposed to COVID-19 was the reason mostly frequently reported for the decrease in acute coronary syndromes admissions, followed by concerns of burdening the healthcare system, as well as lockdown measures and movement restrictions [17].

In Italy, during the first wave of the pandemic, strict emergency measures including the closing of all non-essential businesses and industries and the restriction of people's movement have been in place since March 9th and only gradually eased until June 3rd, when movement across regions and other European countries was restored.

In autumn, the second wave of the pandemic also brought the Italian government to introduce further restrictions on movement and social life, which were gradually lifted in mid-2021. These forced changes in lifestyle may also have concurred to a decline in the number of medical emergencies, explaining the reduction in ED visits for non-COVID-19 causes of illness [21].

For instance, it is generally known that unusual physical exertion can frequently lead to myocardial infarction [22]. Occasions for extraordinary physical efforts, however, have appreciably been reduced because of the social distancing measures. Moreover, restrictions of travel reduced road traffic movements. It should also be noted that Liguria is a touristic region, and the pandemic led to a sharp decline in tourist flow [23]. Fewer tourists meant fewer instances of travel-related incidents and health issues requiring emergency attention. In this regard, a recent review on the effects of the pandemic on road traffic collisions (RTCs) has shown that the drop of traffic volume was associated with a significant drop in RTCs globally and a reduction of road deaths up to 50% [24].

On the other hand, it should be considered that the overall reduction in the absolute number of people presenting with severe non-COVID-19 related diseases potentially points to an increase in delayed or missed opportunities to treat conditions leading to avoidable morbidity and mortality. In fact, along with the sudden drop of ED visits and hospitalizations, there was an increase out-of-hospital all-cause mortality, mainly driven by an increase in deaths for neoplasms, cardiovascular diseases and endocrine, nutritional and metabolic diseases [25]. As others have suggested [7], our findings

provide compelling evidence in favor of giving priority to initiatives that cater to the unmet needs of people with non-COVID-19 illnesses. Finally, the important reduction in ED attendances for non-urgent complaints indicates that the high pre-pandemic access levels may have partially been avoidable. This evidence provides an opportunity to inform and implement new paradigms of care that maximize the appropriateness of future ED visits while simultaneously preventing overdiagnosis and overtreatment [26].

STRENGTHS AND LIMITATIONS

This study presents some limitations. First, while for this analysis two pandemic years were considered, these were compared with only one pre-pandemic year. Second, our study is largely based on ICD-9 code diagnoses. Often, the complete diagnosis comprises more than one code. However, for each record only the first code, considered to be the main one, was extracted. Secondly, although other authors have employed laboratory confirmed SARS-CoV-2 to estimate the impact of COVID-19 on emergency care trends, especially during the first wave of the pandemic this information was not available nor complete in a relevant number of ED records. For this reason, we decided to employ a clinical proxy measure, COVID-like illness rates. In general, this is an analysis of aggregated routine administrative data extracted from San Martino Hospital HIS. Even though it is impossible to completely rule out reporting errors or inaccuracies in the filling/reporting of records, given the volume of cases, these can probably be overlooked. In fact, the large number of records considered (over 180,000) represents a strength of our study. In addition, we were able to show directly, by means of a linear regression model, the existence of an inverse relationship between COVID-19 cases and ED accesses. It should also be considered that, because of the employment of a clinical proxy measure for COVID-19 cases (COVID-like illness cases – defined as either ILI or LRTI cases – identified through an operator dependent syndromic surveillance system), the estimation of figures related to our study outcome was not affected by the limitations posed, in early-2020, by the lacking of readily available laboratory diagnostic tests for SARS-CoV-2, as well as specific ICD-9 diagnostic codes for COVID-19. Finally, the utilization of a clinical proxy measure allowed for an accurate comparison with the reference pre-pandemic year.

Conclusions

Further research will be necessary to fully understand the causes and effects of the changes in emergency care utilization described in this article. For example, qualitative studies aimed at assessing the reasons why people seek or neglect to receive care are necessary to comprehend how the pandemic may have differentially affected treatment among vulnerable groups. This information will be crucial to guide systematic changes

in the healthcare systems aimed at reducing unnecessary ED visits and promoting high-value care.

Supplementary materials

The following supporting information can found below: TabS1- Proportion of diagnoses in each disease category between 2019 and 2021; TabS2 - Proportion of patients admitted to different hospital wards between 2019 and 2021.

Funding

This research received no external funding.

Conflict of interest statement

The authors declare no conflicts of interest.

Authors' contributions

Conceptualization, AF; SM; AO; methodology, AF; SM; AO; formal analysis, AF; SM; investigation, AF; MO; GI; MP; CM; DS; SM; AO; resources, GI; AO; data curation, AF; SM; AO; writing-original draft preparation, AF; AO; writing-review and editing, AF; GI; MO; MP; CM; DS; SM; AO; GI; visualization, AF; GI; MO; MP; CM; DS; SM; AO; GI; supervision, AO. All authors have read and agreed to the published version of the manuscript.

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Received on May 20, 2024. Accepted on July 9, 2024.

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How to cite this article: Ferrari A, Iudica G, Porretto M, Minet C, Ogliastro M, Simonetta D, Mosca S, Icardi G, Orsi A. The impact of SARS-CoV-2 on emergency health care demand: inverse relationship between COVID-like illnesses and ED accesses in Genoa, Italy. *J Prev Med Hyg* 2024;65:E154-E165. <https://doi.org/10.15167/2421-4248/jpmh2024.65.2.3279>

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Supplementary Materials

The impact of SARS-CoV-2 on emergency health care demand: inverse relationship between COVID-like illnesses and ED accesses.

Tab. S1. Proportion of diagnoses in each disease category between 2019 and 2021.

Diagnoses, n (%)	2019	2020	2021
Burns, poisoning and other toxic effects (e.g. substance abuse)	240 (0.48)	167 (0.33)	372 (0.44)
Substance abuse	116 (0.18)	116 (0.23)	144 (0.21)
Oncological pathologies	404 (0.5)	361 (0.72)	385 (0.75)
Diseases of the endocrine and immune system, nutrition and metabolism	485 (0.97)	420 (0.83)	742 (0.9)
Blood diseases and hematopoietic organs	509 (0.9)	486 (0.97)	692 (0.94)
Diseases of the skin and subcutaneous tissue	896 (1.67)	737 (1.47)	1281 (1.66)
Infectious and parasitic diseases (exc. Resp)	957 (1.76)	768 (1.53)	1343 (1.77)
Ear diseases	877 (2.17)	873 (1.74)	1658 (1.63)
Fever	634 (1.96)	1093 (2.18)	1495 (1.17)
Thromboembolisms and cerebrovascular diseases	1565 (1.87)	1237 (2.47)	1429 (2.9)
Acute respiratory infections (inc. COVID-19)	1995 (2.18)	2736 (5.46)	1664 (3.7)
Other respiratory diseases	1291 (2.64)	1320 (2.63)	2017 (2.4)
Unspecified malaise and fatigue	1642 (1.58)	1303 (2.6)	1210 (3.05)
Diseases of musculoskeletal and connective tissues	2234 (4.97)	2090 (4.17)	3796 (4.15)
Diseases of the circulatory system	2540 (4.43)	2452 (4.89)	3384 (4.72)
Diseases of the genitourinary system	2805 (4.75)	2538 (5.07)	3623 (5.21)
Diseases of the nervous system	3151 (5.61)	2599 (5.19)	4279 (5.85)
Complications of pregnancy, congenital and growth disease	2835 (3.77)	2644 (5.28)	2881 (5.27)
Mental disorders	2815 (5.32)	2745 (5.48)	4059 (5.23)
Diseases of the digestive system and oral cavity	3293 (6.07)	3126 (6.24)	4631 (6.12)
Eye diseases	4099 (11.19)	3698 (7.38)	8538 (7.62)
Trauma	14260 (25.82)	12412 (24.79)	19697 (26.51)
Other pathologies	4146 (9.1)	4128 (8.24)	6942 (7.7)
Total	76262 (100)	50049 (100)	53789 (100)

Tab. S2. Proportion of patients admitted to different hospital wards between 2019 and 2021.

Hospital wards, n (%)	2019	2020	2021
Dermatology	1 (0)	0 (0)	2 (0.01)
Palliative care	0 (0)	6 (0.04)	2 (0.01)
Hematology	34 (0.18)	18 (0.12)	23 (0.16)
Geriatrics	30 (0.16)	49 (0.32)	24 (0.16)
Ophthalmology	42 (0.22)	37 (0.24)	34 (0.23)
Transplants	51 (0.27)	56 (0.37)	39 (0.27)
Rheumatology	79 (0.42)	73 (0.48)	67 (0.46)
Nephrology	102 (0.54)	81 (0.54)	109 (0.76)
Orthorinolaryngology	182 (0.97)	86 (0.57)	124 (0.86)
Oncology	145 (0.77)	99 (0.66)	119 (0.83)
Thoracic and cardiac surgery	92 (0.49)	130 (0.86)	119 (0.83)
Respiratory diseases and allergology	183 (0.98)	176 (1.17)	219 (1.53)
Gastroenterology	232 (1.24)	177 (1.18)	322 (2.25)
Endocrinology	207 (1.11)	243 (1.62)	228 (1.59)
Surgery	582 (3.12)	263 (1.75)	357 (2.49)
Neurosurgery	410 (2.19)	269 (1.79)	385 (2.69)
Urology	407 (2.18)	286 (1.91)	320 (2.23)
Resuscitation and intensive care	327 (1.75)	476 (3.17)	294 (2.05)
Infectious and tropical diseases	387 (2.07)	467 (3.11)	548 (3.83)
Cardiology and vascular surgery	855 (4.58)	624 (4.16)	697 (4.87)
Psychiatry	945 (5.06)	735 (4.9)	808 (5.64)
Neurology	1206 (6.46)	1042 (6.95)	1369 (9.56)
Obstetrics and gynecology	1257 (6.74)	1312 (8.76)	1230 (8.59)
Orthopedics and Traumatology	1776 (9.52)	1757 (11.73)	1585 (11.07)
Internal medicine	1229 (6.59)	1902 (12.7)	1801 (12.58)
Emergency medicine	7885 (42.28)	4608 (30.77)	3483 (24.34)
Total	18646 (100)	14972 (100)	14308 (100)