Research paper

Pediatric admissions to emergency departments of North-Western Italy during COVID-19 pandemic: A retrospective observational study

Irene Raffaele, Emanuele Castagno, Ilaria Fumi, Claudia Bondone, Fulvio Ricceri, Luigi Besenzoni, Adalberto Brach del Prever, Pina Capalbo, Gianluca Cosi, Enrico Felici, Patrizia Fusco, Maria Rita Gallina, Franco Garofalo, Paola Gianinno, Andrea Gualà, Oscar Haitink, Paolo Manzoni, Antonino Marra, Ivana Rabbone, Luca Roasio, Savino Santovito, Alberto Serra, Eleonora Tappi, Gian Maria Terragni, Fabio S. Timeux, Flaminia Torielli, Alessandro Vigo, Antonio F. Urbino, the ICOPER Study Group

Department of Pediatric Emergency, Regina Margherita Children's Hospital - A.O.U. Città della Salute e della Scienza di Torino, Piazza Polonia 94, 10126 Turin, Italy
Department of Public Health and Pediatrics, University of Turin, Piazza Polonia 94, Turin, Italy
Department of Clinical and Biological Sciences, University of Turin, Regione Gonzolo 10, Orbassano, TO, Italy
Unit of Epidemiology, Regional Health Service, ASL TO3, Via Salseduna 194, Grugliasco, TO, Italy
Division of Pediatrics and Neonatology, P.O. Savigliano, ASL CN1, Via Ospedali 9, Savigliano, CN, Italy
Division of Pediatrics and Neonatology, P.O. Ciriri, ASL TD4, Via Battitore 7/9, Ciriri, TO, Italy
Division of Pediatrics and Neonatology 3, P.O Martini, ASL Città di Torino, Via Tofane 71, Turin, Italy
Pediatric Unit, Sant'Andrea Hospital, ASL VC, Corso Mario Abbiate 21, Vercebi, Italy
Pediatric and Pediatric Emergency Unit, The Children's Hospital, AO SS Antonio e Biagio e C. Arrigo, Via Spatolo Marenco 46, Alessandria, Italy
Pediatric Unit, Monits Regalis Hospital, ASL CN1, Via San Rocchetto 99, Mondovì, CN, Italy
Division of Pediatrics and Neonatology, Beauregard Hospital, Via L. Vaccari 5, Asta, Italy
Pediatric Unit, P.O. Rivoli, ASL TO3, Via Rivolta 29, Rivoli, TO, Italy
Division of Pediatrics, P.O. Cardinal Massaia, ASL AT, Corso Dante Alighieri 202, Asti, Italy
Division of Pediatrics, Ospedale Castelli, Via Fiume 18, Pollenza, Verbania, Italy
Pediatric Department, SS Trinità Hospital, Viale Zoppis 10, Borgomarino, ND, Italy
Division of Pediatrics and Neonatology, Department of Maternal-Infantile Medicine, Nuovo Ospedale Degli Infermi, Via dei Ponderanesi 2, Ponderana, BL, Italy
Pediatric Unit - NICU, S. Croce Hospital, ASL TO5, Piazza Amedeo Ferdinando 3, Moncalieri, TO, Italy
Division of Pediatrics, Department of Health Science, University of Piemonte Orientale, Corso G. Mazzini 18, Novara, Italy
Division of Pediatrics and Neonatology, Division of Pediatrics and Neonatology, Department of Maternal-Infantile Medicine, ASL VC, Corso Vittorio Emanuele 2, Vercelli, Italy
Pediatric Department, SS Vittoria Hospital, Via L. Cibrario 72, Turin, Italy
Division of Pediatrics, Ospedale Michele e Pietro Ferrero, P.O. Alba-Bra ASL CN2, Verdonzo, CN, Italy
Pediatric Unit, A.S.O. S. Croce e Carle, Via M. Coppino 26, Cuneo, Italy
Division of Pediatrics, P.O. Chivasso, ASL TD4, Corso G. Ferrari 3, Chivasso, TO, Italy
Division of Pediatrics and Neonatology, P.O. Ivrea, ASL TD4, Piazza Credenza 2, Ivrea, TO, Italy
Division of Pediatrics, Ospedale Michele e Pietro Ferrero, Via M. Abbiate 21, Vercelli, Italy
Division of Pediatrics, Ospedale San Giovanni Battista, Via M. Collina 1, Biella, BI, Italy
Division of Pediatrics, Ospedale Torino, Via Tofane 71, Turin, Italy
Division of Pediatrics and Neonatology, P.O. Ciri, ASL TO5, Piazza Amedeo Ferdinando 3, Moncalieri, TO, Italy
Division of Pediatrics and Neonatology 3, P.O Martini, ASL Città di Torino, Via Tofane 71, Turin, Italy
Pediatric Unit, S. Croce Hospital, ASL TO5, Via Rivalta 29, Rivoli, TO, Italy
Division of Pediatrics, P.O. Ciriri, ASL TD4, Via Battitore 7/9, Ciriri, TO, Italy
Division of Pediatrics, Ospedale Castelli, Via Fiume 18, Pollenza, Verbania, Italy

Impact of COVID-19 on Pediatric Emergency Room (ICOPER) Study Group:Sonia Aguzzia, MD; Marco Aicardi, MD; Antonella Aimir, MD; Luca Baroero, MD; Michelangelo Barbagnia, MD; Stefania Bezzie, MD; Giulia Calosso, MD; Mario M. Calvo, MD; Roberto Cerchio, MD; Nicoletta Ceschina, MD; Elisa Chiomà, MD; Margherita Conieri, PhD; Elena Coppo, MD; Simona De Francesco, MD; Barbara De Vito, MD; Angelo G. Delmonaco, MD; Valeria Di Giann, MD; Maria E. Donadio, MD; Rachele Gallo, MD; Laura Garassino, MD; Davide Garel, MD; Emanuela Garrone, MD; Marianna Genisi, MD; Elena Giachetti, MD; Giulia Grassò, MD; Barbara Lauria, MD; Cinzia Marciano, MD; Giuseppina Migliore, MD; Maria Angela Milletello, MD; Maria Mussinato, MD; Manuel Pagano, PhD; Francesca Romand, MD; Lorenzo Rossi, MD; Roberta Rossì, MD; Romina Ruffatto, MD; Francesco Tagliaderri, MD; Irene Tardivo, MD; Alberto Testa, MD; Claudia Toppino, MD; Claudia Tortone, MD; Antonella Tuacina, MD; Cristina Vaissa, MD; Maria Paola Vardenz, MD; Antonia Versace, MD; Alice Viano, MD.

The corresponding author, had full responsibility for the decision to submit for publication.

E-mail address: ecastagno@cittadellasalute.to.it (E. Castagno).

Co-first authors.

https://doi.org/10.1016/j.lanepe.2021.100081
2666-7762/© 2021 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)
The Coronavirus Disease (COVID-19), caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), has provoked a global crisis, leading the World Health Organization to declare the pandemic on March 11th, 2020 [1].

Due to high contagiousness and significant morbidity and mortality rates, many Countries have imposed social distancing, and all public activities have been banned [1]. North-Western Italy was hardly hit by the pandemic. On February 20th, 2020, the first case of COVID-19 has been recorded in a small town of Lombardy, and the lockdown of the whole Country was then imposed between March 9th and May 3rd, 2020.

The burden of the disease involved mainly the older age groups, whereas children were pretty asymptomatic or experienced mild symptoms, resulting in a small number of pediatric COVID-19 visits to the Emergency Department (ED) [2, 3]. On current available Italian surveillance data, 17.3% of reported cases involved children [4]. On the other hand, more concerns arise from the novel Multisystem Inflammatory Syndrome in Children (MIS-C) associated with SARS-CoV-2 infection, which has been increasingly reported, and is characterized by persistent fever, abdominal pain, vomiting, diarrhea, rash, conjunctivitis and other mucocutaneous features [5, 6]. MIS-C is a life-threatening condition that may rapidly progress to cardiac failure.

At the same time, decreasing trend of ED admissions was reported since the very first day of lockdown, mainly in pediatric settings [7]. Compared to the same period of past years, many Italian authors have reported a huge reduction of pediatric admissions to ED, ranging from 72% to 92% [1, 3, 8–13].

The main aim of our multicentre retrospective study was to assess the number and characteristics of pediatric admissions to ED since the outbreak of COVID-19 until the end of lockdown, compared to the same period of 2019. Second, we described the main features of critical children accessing EDs with high priority.

2. Methods

All the children < 18 years admitted to all the 23 Pediatric EDs of Piedmont and Aosta Valley, North-Western Italy, between March 9th and May 3rd, 2020 were included in this multicentre retrospective observational study, and compared to those admitted in the same period of 2019. Among the centres involved, 3 were major Pediatric EDs of hospitals provided with Pediatric Intensive Care Unit (PICU) and 20 were Pediatric EDs of hospitals without PICU.

The medical record databases of each ED were screened for information on the demographic profile of children (age and gender), triage priority code (from lower to higher priority: white, green, yellow and red), and outcome (discharge home, admission to hospital, admission to PICU, transfer to another center). According to age, all the children were stratified in 5 classes: 0–2 years, 3–5 years, 6–10 years, 11–14 years and 15–18 years.

Secondly, we have compared all the children <18 years admitted on March 2019 to those admitted on March 2020, stratified by cause...
of admission (infectious disease, surgical problem, trauma, psychiatric disorder, and others), and priority code.

Last, we have compared all the children with high priority code (yellow and red) admitted on March 2020 to those evaluated on March 2019. Data about this subgroup of children included age, comorbidities, general practitioner visit before admission, symptoms before admission, cause of admission and outcome.

Every participating centre returned two ad hoc report forms to the Coordinating centre. In the first form, every centre reported the total number of children admitted during the study period, stratified by age, gender, priority code, and outcome. In the second form, every centre reported the total number of children admitted on March 2019 and 2020, stratified by cause of admission and priority code, and those admitted in the same period with high priority code, stratified by the variables described above. The Coordinating centre merged all data in the same database before the analysis.

The study protocol was approved by the Ethical Committee of the Coordinating centre of Turin on June 23rd, 2020 (protocol number: 0060387).

2.1. Statistical analysis

All the statistical analysis were made by comparing the 3 major EDs to the 20 EDs of hospitals without PICU and were performed using SAS V9.4.

ED admissions have been described by absolute frequency and percentage and their reduction between 2019 and 2020 was measured using percentages. Comparison between percentage distribution of characteristics at admission and year of admissions (2019 or 2020) and between characteristics at admission and type of hospital (with or without PICU) have been performed using the Chi-square test or the Fisher’s exact test, when the hypothesis for Chi-square test was not met. The significance level was set at alpha=0.05.

To account for multiple comparisons, we estimated the False Discovery Rate (FDR) based on the Benjamini–Hochberg method [14] and we computed the FDR-adjusted p-values at 5% level.

2.2. Role of the funding source

No funding was received for this study.

3. Results

Overall, 16,426 children were admitted to the 23 Pediatric EDs during the study period on 2020, compared to 55,643 admissions recorded on 2019 in the same period (~70.48%). Children aging 0–5 years were 9269 on 2020 (56.43%) and 29,237 on 2019 (52.54%), respectively. Admissions with high priority (yellow and red code) were 1494 (9.09%) on 2020 and 3835 (6.91%) on 2019. Children being discharged home were 14,485 on 2020 (88.18%) and 51,937 on 2019 (93.34%), while those admitted to PICU were 27 (0.16%) and 30 (0.05%), respectively on 2020 and 2019. The distribution of the causes of admission on March of both years is shown in Fig. 1. After stratification by triage priority code, age and outcome, significant reduction of admissions was observed in each class (Table 1).

Among admissions due to infectious disease, two children had encephalitis and one had sepsis, all on 2019. Overall, four children were admitted for status epilepticus (two on 2020) and nine for the onset of diabetes type I (three on 2020). Among overall children with psychiatric disorders, 12 were suicidal attempts (five on 2020). Admissions for abuse and neglect were 34 (six on 2020). On 2020, two children with MIS-C have been recorded, showing persistent fever, diarrhea, and mucocutaneous involvement (conjunctivitis, fissured lips, skin rash, erythema, and edema of hands and feet). They both had high level of SARS-CoV2 antibody and inflammation markers, lymphopenia, thrombocytopenia, and complement consumption, but negative nasal swabs.

3.1. Comparison between hospitals with and without PICU stratified by priority code, age and outcome

The reduction of admissions was reported in Pediatric EDs of hospitals without PICU (~73.38%) and in those with PICU (~64.08%) with a significant decrease in both of them (p <0.0001). Detailed descriptive analysis by priority code, age, and outcome is shown in Fig. 2 and Table 2.

3.2. Comparison between 2019 and 2020 by cause of admission and priority code

Focusing only on March, we observed 21,846 admissions in 2019, and 4639 in 2020 (~76.76%). After stratification by cause of admission (Figure 1), we observed a significant decrease of the absolute number of admissions for all the subgroups (p <0.0001), especially for infectious disease (~79.29%), and less sharply for surgical and psychiatric disorder (~59.4% and ~66.67%, respectively). Admissions for surgical problems with yellow priority code decreased significantly (p = 0.0002), but less than other admissions with the same priority (Table 3).
that COVID-19 has unveiled previous widespread misuse of admissions already reported in previous epidemics [15, 16]. We could suppose came the anxiety and the need of reassurance of caregivers, as maybe the fear of being infected by SARS-CoV-2 in hospitals over-

PICU (sions with any priority code to hospitals without PICU than with we observed signifi-

and without PICU strati-

Table 1
Decrease of admissions to Pediatric Emergency Departments in all the 23 Centres involved (period: March 9th - May 3rd, 2020 vs. March 9th - May 3rd, 2019), stratified by priority code, age and outcome.

| Outcome                              | 2019       | 2020       | Decrease of admissions (%) | p-value |
|--------------------------------------|------------|------------|-----------------------------|---------|
| Total admissions N (%)               | 55,643     | 16,426     | -70.48                      | <0.0001*|
| Admissions to hospitals with PICU†   | 17,343     | 6230       | -64.08                      |         |
| Admissions to hospitals without PICU†| 38,300     | 10,196     | -73.38                      |         |
| Triage priority code                 |            |            |                             |         |
| White                                | (100.00)   | (100.00)   | -70.48                      | <0.0001*|
| Green                                | (31.17)    | (37.93)    | -64.08                      |         |
| Yellow                               | (38.83)    | (62.07)    | -73.38                      |         |
| Red                                  | (6.67)     | (8.68)     | -61.59                      |         |
| Discharged home                      | (0.22)     | (0.41)     | -44.17                      | <0.0001*|
| Admissions to hospital               | (16.88)    | (13.99)    | -75.53                      |         |
| (6–10)                               | (22.28)    | (22.49)    | -70.20                      |         |
| (11–14)                              | (25.65)    | (24.84)    | -71.42                      |         |
| (15–18)                              | (9390)     | (2298)     | -71.59                      | <0.0001*|
| (4.92)                               | (4.74)     | (4.74)     | -71.59                      |         |
| (9.34)                               | (88.18)    | (88.18)    | -72.11                      |         |
| (6.14)                               | (10.95)    | (10.95)    | -47.35                      |         |
| Transfers to another hospital        | 261        | 116        | -55.56                      | 0.04    |
| Admissions to PICU†                  | 30         | 27         | -55.56                      |         |
| Admissions to other than PICU†       | 3385       | 1771       | -47.68                      |         |

* False Discovery Rate corrected p-value < 0.05.
† PICU: Pediatric Intensive Care Unit.

In the same period, comparing children admitted to hospitals with and without PICU stratified by cause of admission and priority code, we observed significantly higher decrease of all the causes of admissions with any priority code to hospitals without PICU than with PICU (p < 0.0001), except for psychiatric disorders (p = 0.238).

Detailed analysis is reported in Table 4.

3.3. Comparison between 2019 and 2020 by features of critical admissions

Focusing only on critical patients (Table 5), yellow and red codes decreased significantly more in hospitals without PICU, and mild proportional increase of both high priority codes and admissions to PICU has been observed, as reported by Iozzi et al. [11] Anyway, the absolute number of high priority codes and admissions to PICU decreased, as recently noted by the Italian Network of Pediatric Intensive Care Unit Research Group [17]. Interestingly, we did not detect any significant delay in ED referral by caregivers, as previously speculated by other authors [11, 13].

In the same period, comparing children admitted to hospitals with and without PICU stratified by cause of admission and priority code, we observed significantly higher decrease of all the causes of admissions with any priority code to hospitals without PICU than with PICU (p < 0.0001), except for psychiatric disorders (p = 0.238).

Detailed analysis is reported in Table 4.

4. Discussion

This is the first large multicentre study describing how COVID-19 pandemic has changed the referral of children to EDs in hardly hit North-Western Italy. We observed massive reduction of pediatric admissions, as reported in already published subgroups of our population [8–10] and by other Italian centres [1, 11–13]. Non-urgent visits have dropped significantly more than urgent ones, reflecting how maybe the fear of being infected by SARS-CoV-2 in hospitals overcame the anxiety and the need of reassurance of caregivers, as already reported in previous epidemics [15, 16]. We could suppose that COVID-19 has unveiled previous widespread misuse of emergency care facilities, which are often accessed for the management of non-urgent conditions. Children with green and yellow codes decreased significantly more in hospitals without PICU, and mild proportional increase of both high priority codes and admissions to PICU has been observed, as reported by Iozzi et al. [11] Anyway, the absolute number of high priority codes and admissions to PICU decreased, as recently noted by the Italian Network of Pediatric Intensive Care Unit Research Group [17]. Interestingly, we did not detect any significant delay in ED referral by caregivers, as previously speculated by other authors [11, 13].

Overall, on 2020 we observed a decrease of pediatric admissions to EDs for all the age groups, but in particular in major hospitals with PICU such reduction was less marked for younger children and patients with comorbidities and high priority code, who are usually more fragile. As already reported, the most evident drop regarded infectious diseases, which usually represent the main reason of Pediatric ED visits [11]. Children did not attend schools or other communities during the lockdown, thus decreasing the spread of both SARS-CoV-2 and other pathogens. Nonetheless, although restrictive measures and mandatory use of facial mask were imposed to all the population, we confirm that most of critical patients were affected by infectious diseases and admissions with high priority due to infections dropped significantly only in hospitals without PICU [11, 12]. This might be the expression of families’ preference to bring their children to major centres rather than to small ones during the lockdown, even if farer from home.

During the study period, only two cases of MIS-C were reported in our centres, and 14 more were recorded between the end of the study period and December 2020. The first reports of COVID-19-associated hyperinflammatory syndromes (including Kawasaki-like
Fig. 2. Admissions to the Pediatric Emergency Department of hospitals with Pediatric Intensive Care Unit (PICU) compared to hospitals without PICU between March 9th and May 3rd, 2019 vs. March 9th and May 3rd, 2020, stratified by: a. priority code b. age c. outcome.
presentation and symptoms mimicking acute appendicitis and peritonitis) have not yet been reached either on diagnostic criteria or on therapy, and many different protocols have been proposed by different Institutions [6]. Based on available evidence and clinical awareness, we designed a dedicated clinical pathway: all the patients identified on clinical criteria underwent laboratory tests including investigations on inflammation, cardiac involvement, coagulation profile, and SARS-CoV2 serology; echocardiogram was always done as soon as possible. Therapy included corticosteroids and intravenous immunoglobulin, along with fluid restriction and strict cardiac and respiratory monitoring.

The considerable reduction of patients discharged home on 2020, especially in hospitals without PICU, was consistent to what reported[11, 13, 22, 23]. Anyway, such perception of pediatric healthcare professionals is not sustained by evidence provided by our study on a large population. In fact, the major part of our critical children arrived within 24 h since the onset of symptoms, suggesting that lockdown and fear of COVID-19 were not responsible for delayed provision of care. On the other hand, the results of an early single center report from Ireland [24] and other recent papers on the need for urgent surgery in large cohorts of children are consistent with our findings [20, 21]. Often, critical patients were not brought to their general practitioners before attending EDs: we might suppose that families preferred to refer directly to hospitals (in particular the major ones) in order not to delay diagnosis and care. Also increased prevalence of patients with comorbidities in major hospitals suggests such hypothesis. During the lockdown, the families of children with special needs felt particularly isolated and stressed [25]: though telemedicine has been implemented also by community medical services, we suppose that caregivers felt more reassured accessing directly the ED of reference centres.

The COVID-19 pandemic shows heavy impact on mental health of both adults and children, in particular those who already suffered from proportional increase of need for urgent surgery only in hospitals without PICU. Anyway, no significant delay in presentation was reported for surgical problems or for any cause of admission with high priority code, as the analysis of the duration of critical patients’ symptoms before they accessed EDs showed no difference between 2019 and 2020.

Delayed access to EDs, due to the fear of contracting COVID-19, has been suggested to cause more severe clinical presentation of some children and adults [11, 13, 22, 23]. Anyway, such perception of pediatric healthcare professionals is not sustained by evidence provided by our study on a large population. In fact, the major part of our critical children arrived within 24 h since the onset of symptoms, suggesting that lockdown and fear of COVID-19 were not responsible for delayed provision of care. On the other hand, the results of an early single center report from Ireland [24] and other recent papers on the need for urgent surgery in large cohorts of children are consistent with our findings [20, 21]. Often, critical patients were not brought to their general practitioners before attending EDs: we might suppose that families preferred to refer directly to hospitals (in particular the major ones) in order not to delay diagnosis and care. Also increased prevalence of patients with comorbidities in major hospitals suggests such hypothesis. During the lockdown, the families of children with special needs felt particularly isolated and stressed [25]: though telemedicine has been implemented also by community medical services, we suppose that caregivers felt more reassured accessing directly the ED of reference centres.

The COVID-19 pandemic shows heavy impact on mental health of both adults and children, in particular those who already suffered from

---

Table 2

Admissions to the Pediatric Emergency Department of hospitals with Pediatric Intensive Care Unit (PICU) compared to hospitals without PICU between March 9th and May 3rd, 2020, stratified by priority code, age and outcome.

|                  | Hospitals with PICU | Hospitals without PICU | p-value | p-value |
|------------------|---------------------|------------------------|---------|---------|
|                  | 2019 | 2020 | Decrease of admissions% | 2019 | 2020 | Decrease of admissions% | 2019 | 2020 |
|                  | 17,343 | 6230 | –64.08 | 38,300 | 10,196 | –73.38 | –0.0001* |
| Triage priority code |       |       |         |       |       |         | 0.942 |
| White            | 1603 | 275 | –82.84 | 4783 | 825 | –73.75 | –0.0001* |
| Green            | 13,377 | 4963 | –62.90 | 32,045 | 8869 | –72.32 | –0.0001* |
| Yellow           | 2296 | 947 | –58.75 | 1419 | 480 | –66.17 | –0.002* |
| Red              | 67 | 45 | –32.84 | (3.70) | (4.71) | –58.49 | 0.130 |
| Age (years)      |       |       |         |       |       |         | 0.002* |
| 0 – 2            | 5,578 | 2,175 | –59.41 | 11,484 | 3,400 | –70.39 | –0.0001* |
| 3 – 5            | 3,518 | 1,344 | –61.80 | 8,877 | 2,350 | –73.53 | –0.0001* |
| 6 – 10           | 4,682 | 1,598 | –65.87 | 9,592 | 2,482 | –74.12 | –0.0001* |
| 11 – 14          | 3,021 | 908 | –71.63 | 6,189 | 1,390 | –77.54 | –0.0001* |
| 15 – 18          | 584 | 205 | –64.90 | 2,158 | 574 | –73.40 | –0.003* |
| Outcome          |       |       |         |       |       |         | 0.002* |
| Discharged home  | 16,179 | 5,420 | –66.50 | 35,758 | 9,065 | –74.65 | –0.0001* |
| Admissions to hospital | 1,139 | 789 | –30.73 | 2,276 | 1,069 | –55.27 | 0.976 |
| Transferrals to another hospital | 3 | 2 | –33.33 | (0.67) | (1.12) | –58.1 | 0.089 |
| Admissions to PICU | 22 | 19 | –13.64 | (0.02) | (0.08) | 0.00 | 0.804 |
| Admissions to other than PICU | 1,117 (644) | 770 (12.36) | –31.66 | 2,268 (5.92) | 1,001 (9.82) | –55.86 | 0.003* |

* False Discovery Rate corrected p-value < 0.05.

** PICU: Pediatric Intensive Care Unit.
Decrease of admissions to Pediatric Emergency Departments of all the 23 Centres on March 2020 vs. March 2019, stratified by priority code and cause of admission.

|                        | 2019 | 2020 | Decrease of admissions% | p-value |
|------------------------|------|------|--------------------------|---------|
| **Total admissions N [%]** | 21,846 (100.00) | 4639 (100.00) | –76.76 | <0.0001* |
| **All priority codes** |      |      |                         |         |
| Infectious disease     | 8736 (39.99) | 1809 (39.00) | –79.29 |         |
| Surgical problem       | 596 (2.73) | 242 (5.22) | –59.40 |         |
| Trauma                 | 5753 (26.33) | 1340 (28.89) | –76.71 |         |
| Psychiatric disorder   | 144 (0.66) | 48 (1.02) | –66.67 |         |
| Other disease          | 6617 (30.29) | 1200 (25.87) | –81.86 |         |
| **White code**         |      |      |                         |         |
| Infectious disease     | 969 (4.44) | 124 (2.67) | –87.20 | 0.457   |
| Surgical problem       | 40 (1.80) | 7 (0.15) | –82.50 |         |
| Trauma                 | 283 (13.00) | 35 (0.75) | –87.63 |         |
| Psychiatric disorder   | 2 (0.01) | 1 (0.02) | –50.00 |         |
| Other disease          | 862 (3.95) | 124 (2.67) | –85.61 |         |
| **Green code**         |      |      |                         | <0.0001*|
| Infectious disease     | 7154 (32.75) | 1507 (32.49) | –78.93 |         |
| Surgical problem       | 487 (2.22) | 185 (3.99) | –62.01 |         |
| Trauma                 | 5183 (23.72) | 1220 (26.30) | –74.66 |         |
| Psychiatric disorder   | 90 (4.01) | 27 (0.58) | –70.00 |         |
| Other disease          | 5289 (24.21) | 901 (19.42) | –82.96 |         |
| **Yellow code**        |      |      |                         | 0.0002* |
| Infectious disease     | 583 (2.66) | 165 (3.57) | –71.70 |         |
| Surgical problem       | 69 (0.32) | 48 (1.03) | –30.43 |         |
| Trauma                 | 281 (1.28) | 83 (1.79) | –70.46 |         |
| Psychiatric disorder   | 52 (0.24) | 19 (0.41) | –63.46 |         |
| Other disease          | 447 (2.05) | 165 (3.56) | –63.09 |         |
| **Red code**           |      |      |                         | 0.187   |
| Infectious disease     | 30 (0.14) | 13 (0.28) | –56.57 | Not applicable |
| Surgical problem       | 0 (0.00) | 2 (0.04) | Not applicable |         |
| Trauma                 | 6 (0.03) | 2 (0.04) | –66.67 |         |
| Psychiatric disorder   | 0 (0.00) | 1 (0.02) | Not applicable |         |
| Other disease          | 19 (0.09) | 10 (0.22) | –47.37 |         |

* False Discovery Rate corrected p-value < 0.05.

Our study has some strengths. First, to our knowledge it is the first large multicentre study on the impact of COVID-19 on pediatric admissions to EDs in Europe. This allowed us to discuss previous hypothesis and perceptions based on case series and small studies in the early phase of the pandemic. In particular, we could demonstrate that there was no significant increase in time-to-presentation for care to our centres. Second, we could evaluate the differences between large hospitals and smaller ones: we believe this could be useful to help drawing future strategies. Last, it provides insight on the main causes of admittance to pediatric EDs, again helping eventual remodeling strategies for hospital emergency settings for next challenging times.

Our study has also some limits. Of course, first this is a retrospective study reflecting the experience of 23 EDs of North-Western Italy, which limits the generalizability of our results. However, all the Pediatric EDs of our region have been included and are representative of both urban and rural areas. Second, we did not compare admissions during lockdown to those immediately after its end, therefore we could not compare patients before and after re-opening activities, as reported by other studies [12]. Moreover, our analysis was performed only on aggregate data, so we could not use a time series model, or difference-in-difference approach to better describe the differences between admissions in 2019 and 2020. We are aware that the comparison of two time points using aggregate data might lead to some biases.

In conclusion, in our multicentre retrospective study, we observed massive reduction of pediatric admissions to EDs, but the decrease was higher in hospitals without PICU than in major ones with PICU. Admissions with low priority code decreased significantly more than those with high priority, in particular in hospitals without PICU; we suppose that the fear of being infected by SARS-Cov-2 maybe overcame the concerns of caregivers. Compared to 2019, no significant delay in ED referral by caregivers was reported on 2020. Dedicated strategies for the care of children with comorbidities or mental health disorders should be implemented, involving both hospitals and community medical services.

Author Contributions

IR, EC, IF, CB, FR, AFU have given substantial contribution to conception and design of the work; FR has given contributions to analysis and interpretation of data for the work; LB, AbDP, PC, GC, EF, PF, MRG, FG, PG, AG, OH, PM, AM, IvR, Ly, SS, AS, ET, GMT, FST, FT, AV revised it critically for important intellectual content; SA, MA, AA, LB, MB, SB, GC, MC, RC, NC, EC, MC, EC, SDF, BVD, AGD, VDG, MED, RG, LG, DG, EG, MG, EG, GG, BL, CM, GM, MAM, IM, MF, FR, LR, RR, RoRo, RoRu, FT, IT, AT, CTop, CFor, AnT, CV, MPV, AnV, AV have given contributions to the acquisition of data for the work; furthermore, they have draft, critically revised and finally approved the version to be published.

Declaration of Interests

Nothing to disclose.

Data sharing statement

Individual participant data that underlie the results reported in this article will be available after de-identification (text, tables, figures, and appendices). Other available documents will include the study protocol, the statistical analysis plan, and the analytic code. Data will be available at a third party website for 5 years, beginning 3 months after publication, to those investigators whose aims and types of analysis will be approved by an independent review committee identified for this purpose. The proposals should be directed to ecastagno@cittadellasalute.to.it to gain access, and data requestors will sign a data access agreement.
Table 4
Admissions to the Pediatric Emergency Department of hospitals with Pediatric Intensive Care Unit (PICU) compared to hospitals without PICU on March 2019 vs. March 2020, stratified by priority code and cause of admission.

|                      | Hospitals with PICU |                      | Hospitals without PICU |                      |
|----------------------|---------------------|----------------------|-------------------------|----------------------|
|                      | 2019                | 2020                | Decrease of admissions% | p-value              |
|                      | (100.00)            | (100.00)            |                         |                      |
| **Total admissions N (%)** | 7021                | 1920                | –72.65                  | 14,825               | 2719                | –81.66                  |                      |
|                      | (33,707)            | (33,488)            |                         | (41,377)             | (42,182)            |                         |                      |
| **All priority codes** |                     |                     |                         |                      |
| Infectious disease   | 2603                | 662                 | **-0.0001**             | 6133                 | 1147                | **-0.0001**             |                      |
| (37.07)              | (34.48)             |                      |                         | (41.37)              | (42.18)             |                         |                      |
| Surgical problem     | 212                 | 142                 | –33.02                  | 384                  | 100                 | **-0.0001**             |                      |
| (3.02)               | (7.40)              |                      |                         | (2.59)               | (3.68)              |                         |                      |
| Trauma               | 2050                | 622                 | –69.66                  | 3703                 | 718                 | **-0.0001**             |                      |
| (29.20)              | (32.40)             |                      |                         | (24.98)              | (26.41)             |                         |                      |
| Psychiatric disorder | 58                  | 24                  | –58.62                  | 86                   | 24                  | 0.238                   |                      |
| (0.83)               | (1.25)              |                      |                         | (0.58)               | (0.88)              |                         |                      |
| Other disease        | 2098                | 470                 | –77.60                  | 4519                 | 730                 | **-0.0001**             |                      |
| (29.88)              | (24.48)             |                      |                         | (20.48)              | (20.85)             |                         |                      |
| **White code**       |                     |                     |                         |                      |
| Infectious disease   | 254                 | 21                  | Not applicable          | 715                  | 103                 | 0.595                   | 0.025                |
| (3.50)               | (1.09)              |                      |                         | (4.82)               | (3.79)              |                         |                      |
| Surgical problem     | 22                  | 3                   | –91.73                  | 18                   | 4                   | 0.553                   |                      |
| (0.31)               | (0.15)              |                      |                         | (0.12)               | (0.15)              |                         |                      |
| Trauma               | 47                  | 0                   | 100                     | 236                  | 35                  | **0.009**               |                      |
| (0.61)               | (0.00)              |                      |                         | (1.59)               | (1.28)              |                         |                      |
| Psychiatric disorder | 0                   | 2                   | 0.04                    | 555                  | 84                  | 0.464                   |                      |
| (0.00)               | (0.00)              |                      | Not applicable          | (3.75)               | (3.09)              |                         |                      |
| Other disease        | 307                 | 40                  | –86.97                  | 3748                 | 564                 | **-0.0001**             |                      |
| (4.30)               | (2.08)              |                      |                         | (25.28)              | (20.74)             |                         |                      |
| **Green code**       |                     |                     |                         |                      |
| Infectious disease   | 1923                | 518                 | **-0.0001**             | 5232                 | 989                 | **-0.0001**             | **-0.0001**          |
| (27.32)              | (26.98)             |                      |                         | (35.29)              | (36.38)             |                         |                      |
| Surgical problem     | 146                 | 100                 | –31.51                  | 341                  | 85                  | **-0.0001**             | **-0.0001**          |
| (2.05)               | (2.52)              |                      |                         | (2.30)               | (3.13)              |                         |                      |
| Trauma               | 1833                | 574                 | –68.69                  | 3350                 | 646                 | **-0.0001**             | **-0.0001**          |
| (26.10)              | (28.93)             |                      |                         | (22.61)              | (23.75)             |                         |                      |
| Psychiatric disorder | 25                  | 12                  | –52.00                  | 65                   | 15                  | 0.102                   |                      |
| (0.33)               | (0.63)              |                      |                         | (0.44)               | (0.55)              |                         |                      |
| Other disease        | 1541                | 337                 | –78.33                  | 3748                 | 564                 | **-0.0001**             |                      |
| (21.94)              | (17.55)             |                      |                         | (25.28)              | (20.74)             |                         |                      |
| **Yellow code**      |                     |                     |                         |                      |
| Infectious disease   | 421                 | 111                 | **-0.0001**             | 162                  | 54                  | 0.560                   | 0.216                |
| (6.00)               | (5.78)              |                      |                         | (1.09)               | (1.99)              |                         |                      |
| Surgical problem     | 44                  | 38                  | –60.00                  | 25                   | 10                  | 0.454                   |                      |
| (0.60)               | (1.98)              |                      |                         | (0.17)               | (0.36)              |                         |                      |
| Trauma               | 146                 | 47                  | –63.64                  | 135                  | 36                  | **0.014**               |                      |
| (2.05)               | (2.45)              |                      |                         | (0.91)               | (1.32)              |                         |                      |
| Psychiatric disorder | 33                  | 12                  | –63.64                  | 19                   | 7                   | 0.567                   |                      |
| (0.46)               | (0.63)              |                      |                         | (0.13)               | (0.26)              |                         |                      |
| Other disease        | 250                 | 88                  | –64.80                  | 197                  | 77                  | 0.981                   |                      |
| (3.52)               | (4.58)              |                      |                         | (1.33)               | (2.83)              |                         |                      |
| **Red code**         |                     |                     |                         |                      |
| Infectious disease   | 16                  | 12                  | –25.00                  | 14                   | 1                   | 0.028                   | 0.014*               |
| (0.22)               | (0.63)              |                      |                         | (0.09)               | (0.04)              |                         |                      |
| Surgical problem     | 0                   | 1                   | Not applicable          | 0                    | 1                   | Not applicable           |                      |
| (0.00)               | (0.05)              |                      | Not applicable          | (0.00)               | (0.04)              |                         |                      |
| Trauma               | 4                   | 1                   | Not applicable          | 0                    | 1                   | 0.673                   |                      |
| (0.55)               | (0.05)              |                      | Not applicable          | (0.01)               | (0.04)              |                         |                      |
| Psychiatric disorder | 0                   | 0                   | Not applicable          | 0                    | 5                   | 0.893                   |                      |
| (0.00)               | (0.00)              |                      | Not applicable          | (0.00)               | (0.04)              |                         |                      |
| Other disease        | 10                  | 5                   | –50.00                  | 9                    | 5                   | 0.18                    |                      |
| (0.14)               | (0.26)              |                      |                         | (0.06)               | (0.18)              |                         |                      |

* False Discovery Rate corrected p-value < 0.05.

PICU: Pediatric Intensive Care Unit.
Decrease of admissions with high priority codes (yellow and red) to Pediatric Emergency Department (ED) in all the 23 Centres on March 2020 vs. March 2019, stratified by age, comorbidities, cause of ED admission, general practitioner visit before admission, duration of symptoms before admission, and outcome.

| Cause of admission | Total admissions | 2019 | 2020 | p-value |
|--------------------|-----------------|------|------|---------|
| Total admissions N (N) | 1487 | 508 | 504 | 100.00 | 100.00 |
| Age | | | | |
| <12 months | 290 | 114 | 0.4879 |
| 12–23 months | 180 | 73 | |
| 2–5 years | 410 | 139 | |
| 6–9 years | 220 | 57 | |
| 10–14 years | 286 | 90 | |
| 15–18 years | 101 | 35 | |
| Comorbidities | | | | |
| Yes | 293 | 118 | 0.0083* |
| No | 1194 | 390 | |
| General practitioner visit before admission | | | |
| Yes | 237 | 72 | 0.6091 |
| No | 1037 | 369 | |
| Duration of symptoms before admission | | | |
| <24 h | 819 | 291 | 0.2344 |
| 1–3 days | 448 | 127 | |
| 4–7 days | 108 | 46 | |
| >7 days | 65 | 25 | |
| Unknown | 47 | 19 | |
| Cause of ED admission | | | |
| Infectious disease | 608 | 190 | 0.0155* |
| Surgical problem | 61 | 47 | |
| Trauma | 305 | 105 | |
| Psychiatric disorder | 48 | 17 | |
| Neurological disease | 167 | 53 | |
| Other disease | 298 | 96 | |
| Discharge home | 828 | 215 | |
| Outcome | | | |
| Admission to hospital | 372 | 168 | |
| Observation Unit | 198 | 73 | |
| Admission to Short Observation Unit | 17 | 11 | |
| Need for urgent surgery | 18 | 5 | 0.001* |
| Death | 27 | 18 | |
| Transfer to another hospital | 33 | 17 | |
| Spontaneously left the ED | 3 | 1 | |
| Admission refusal | 9 | 5 | |

Reduction of admissions with high priority code (yellow and red) to Pediatric Emergency Departments of hospitals with Pediatric Intensive Care Unit (PICU) on March 2020 vs. March 2019, stratified by age, comorbidities, general practitioner visit before admission, duration of symptoms before admission, cause of admission and outcome.

| Cause of admission | Total admissions | 2019 | 2020 | p-value |
|--------------------|-----------------|------|------|---------|
| Total admissions N (N) | 924 | 15 | 100.00 | 100.00 |
| Age | | | | |
| <12 months | 232 | 74 | 0.3060 |
| 12–23 months | 112 | 38 | |
| 2–5 years | 203 | 86 | |
| 6–9 years | 147 | 43 | |
| 10–14 years | 180 | 52 | |
| 15–18 years | 50 | 22 | |
| Comorbidities | | | |
| Yes | 203 | 92 | |
| No | 721 | 223 | |
| General practitioner visit before admission | | | |
| Yes | 185 | 52 | 0.1208 |
| No | 526 | 200 | |
| Duration of symptoms before admission | | | |
| <24 h | 483 | 169 | 0.5873 |
| 1–3 days | 257 | 74 | |
| 4–7 days | 78 | 30 | |
| >7 days | 61 | 23 | |
| Unknown | 45 | 19 | |
| Cause of admission | | | |
| Infectious disease | 427 | 124 | 0.0043* |
| Surgical problems | 48 | 36 | |
| Trauma | 151 | 52 | |
| Psychiatric disorders | 32 | 12 | |
| Neurological diseases | 81 | 33 | |
| Other diseases | 185 | 58 | |
| Outcome | | | |
| Discharged home | 500 | 131 | 0.0009* |
| Admitted to pediatric ward | 231 | 106 | |
| Admitted to PICU | 152 | 51 | |
| Admitted to Short Observation Unit | 16 (45) | 16 (16.19) | |
| Admitted to PICU | 11 | 9 | |
| Need for urgent surgery | 24 | 15 | |
| Death | 2 (60) | 4 (6.76) | |
| Transferred to another hospital | 0 | 1 | |
| Spontaneously left the ED | 5 (0.11) | 2 (0.06) | |

* False Discovery Rate corrected p-value < 0.05.

** PICU: Pediatric Intensive Care Unit.

† ED: Emergency Department.

‡ Pediatric Intensive Care Unit.

§ Emergency Department.
Table 7 Reduction of admissions with high priority code (yellow and red) to Pediatric Emergency Departments (EDs) of hospitals without Pediatric Intensive Care Unit (PICU) on March 2020 vs. March 2019, stratified by age, comorbidities, general practitioner visit before admission, duration of symptoms before admission, cause of admission and outcome.

| Duration of Symptoms before Admission | Age | Total admissions | N (%) | 2019 | 2020 | p-value |
|---------------------------------------|-----|-----------------|-------|------|------|---------|
| <24 h | <12 months | 58 | (10.30) | 40 | (20.73) | 0.0351 |
| 12-23 months | 68 | (12.08) | 35 | (18.13) |
| 2-5 years | 207 | (36.77) | 53 | (27.46) |
| 6-9 years | 73 | (12.96) | 14 | (7.25) |
| 10-14 years | 176 | (31.83) | 38 | (19.69) |
| 15-18 years | 51 | (9.06) | 13 | (6.74) |

| Cause of Admission | Total admissions | N (%) | 2019 | 2020 | p-value |
|--------------------------------|-----------------|-------|------|------|---------|
| Infections | 181 | (32.15) | 66 | (34.20) | 0.8282 |
| Surgical problems | 13 | (2.31) | 11 | (5.70) |
| Trauma | 154 | (27.35) | 53 | (27.46) |
| Psychiatric disorders | 16 | (2.84) | 8 | (4.29) |
| Neurological diseases | 86 | (25.18) | 20 | (10.36) |
| Other diseases | 113 | (20.07) | 38 | (19.69) |
| Outcome | 328 | (58.27) | 84 | (43.53) | 0.0319 |

| Admitted to | Discharged home | 146 | (25.04) | 62 | (32.12) |
|--------------------------------|-----------------|------|------|------|---------|
| Admitted to Short Observation Unit | 46 | (8.17) | 22 | (11.40) |
| Admitted to PICU | 6 | (1.06) | 2 | (1.04) |
| Need for urgent surgery | 0 | (0.00) | 3 | (1.55) |
| Death | 0 | (0.00) | 3 | (1.55) |
| Transferred to another hospital | 33 | (5.87) | 16 | (8.29) |
| Spontaneously left the ED | 2 | (0.35) | 1 | (0.52) |
| Refused admission | 4 | (0.71) | 3 | (1.55) |

* False Discovery Rate corrected p-value < 0.05.
*Pediatric Intensive Care Unit
*Emergency Department.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lanepe.2021.100081.

References

[1] Bellan A, Gavelli F, Hayden E, et al. Pattern of emergency department referral during the Covid-19 outbreak in Italy. Panninvera Med 2020. doi: 10.23736/S0031-0808.202004000-4.
[2] Dong Y, Mo X, Hu Y, et al. Epidemiological characteristics of 2143 pediatric patients with 2019 coronavirus disease in China. Pediatrics 2020;145:e20200702.
[3] Parri N, Lenge M, Buonsenso D, et al. Children with Covid-19 in pediatric emergency departments in Italy. N Engl J Med 2020;383:187-90.
[4] Italian National Health Institute [Istituto Superiore di Sanita’]. COVID-19 epidemic. 20 October 2020 national update. October 23, 2020. (in Italian) https://www.epicentro.iss.it/coronavirus/bollettino/Bollettino-sorveglianza-integrata-COVID-19-20-ottobre-2020.pdf. Accessed October 2020.
[5] Blumberg E, Levin TL, Kuran I, Lee EY, Liszewski MC. Imaging findings in multi-system inflammatory syndrome in children (MIS-C) associated with coronavirus disease (COVID-19). Am J Roentgenol 2021;216:507–17.
[6] Dove ML, Jaggi P, Kelleman M, Abuali M, Ang JY, Ballan W, et al. Multisystem inflammatory syndrome in children: survey of protocols for early hospital evaluation and management. J Pediatr 2021:229:33–40.
[7] Iba R, Edge R, Jenner R, Broughton E, Francis N, Butler J. Where have all the children gone? Decreases in paediatric emergency department attendances at the start of the COVID-19 pandemic of 2020. Arch Dis Child 2020;105:704.
[8] Scaramuzza A, Tagliaferri F, Bonetti L, et al. Changing admission patterns in paediatric emergency departments during the COVID-19 pandemic. Arch Dis Child 2020;105:704-6.
[9] Ciocchi B, Tonoli F, Marciano C, et al. Reluctance to seek pediatric care during the COVID-19 pandemic and the risks of delayed diagnosis. Ital J Pediatr 2020;46:87.
[10] Manzoni P, Mihielma MA, Fiorica L, Cappiello AR, Manzietta M. Impact of COVID-19 epidemics in pediatric morbidity and utilisation of hospital paediatric services in Italy. Acta Paediatr 2020. doi: 10.1111/apa.15435.
[11] Iozzi L, Brambilla I, Foisadelli T, Marsegla G, Cicrindi G. Paediatric emergency department visits fell by more than 70% during the COVID-19 lockdown in Northern Italy. Acta Paediatr 2020. doi: 10.1111/apa.15458.
[12] Cozzi G, Zanchi C, Giangreco M, et al. The impact of the COVID-19 lockdown in Italy on a pediatric emergency setting. Acta Paediatri 2020. doi: 10.1111/apa.15454.
[13] Lazzerini M, Barbi E, Apacella A, Marchetti F, Cardinale F, Trobia G. Delayed access to healthcare during the COVID-19 pandemic. J Health Psychol 2020. doi:10.1177/1359105320966639.