



Brief Report

The Impact of the COVID-19 Pandemic Lockdown on Pediatric Infections—A Single-Center Retrospective Study

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Abstract: Since the SARS-CoV-2 outbreak, many countries have introduced measures to limit the transmission. The data based on ICD-10 codes of lower respiratory tract infections and microbiological analysis of respiratory and gastrointestinal infections were collected. The retrospective five-year analysis of the medical records revealed a substantial decrease in respiratory tract infections during the pandemic year (from April 2020 to March 2021). We noted an 81% decline in the LRTI-associated hospital admissions based on the ICD-10 analysis (from a mean of 1170 admissions per year in the previous four years to 225 admissions between April 2020 through March 2021). According to microbiological analysis, there were 100%, 99%, 87%, and 47% drops in influenza virus, respiratory syncytial virus, rotavirus, and norovirus cases reported respectively during the pandemic season until April 2021 in comparison to pre-pandemic years. However, the prevalence of gastrointestinal bacterial infections was stable. Moreover, in August 2021, an unexpected rise in RSV-positive cases was observed. The measures applied during the COVID-19 pandemic turned out to be effective but also had a substantial contribution to the so-far stable epidemiological situation of seasonal infections.

Keywords: pediatrics; SARS-CoV-2; hospitalizations; respiratory tract infection; respiratory viruses; RSV; epidemiology

1. Introduction

It has been about two years since the outbreak of the COVID-19 pandemic [1]. The data reflecting the level of spread of the SARS-CoV-2 (as of 29 December 2021) show as follows: number of confirmed cases worldwide—281,808,270; number of deaths in the world—5,411,759; number of confirmed cases in Poland—4,080,282; number of deaths in Poland—95,707; case fatality rate (CFR) worldwide—1.92; CFR in Poland—2.35 [2]. The clinical manifestation of COVID-19 patients mostly incorporates headache, loss of smell, fever, cough, or myalgia. However, the prevalence of symptoms significantly varies according to age and sex [3,4]. In the pediatric population, the most common course of COVID-19 is usually mild to moderate and presents as fever, cough, diarrhea or vomiting [5]. In response to the rapid escalation of infection cases, many countries have introduced measures to limit the transmission of the new coronavirus, from the recommendation of social distancing and wearing masks to strict lockdown [1]. The pandemic measures provided by the Polish government varied overtime of the study (from the beginning of the

pandemic to August 2021) and included mandatory use of face masks (excluding children under 5 years old) and 1.5 m minimum distance in public spaces, total or at least partial closure of kindergartens/nurseries, primary schools, secondary schools and higher education. The restrictions also concerned the restaurants, sport centers and other services from many sectors [6–8]. Our aim was to investigate how the SARS-CoV-2 pandemic has changed the hospitalizations frequency associated with lower respiratory tract infections (LRTI) in children and the incidence of the most common pediatric pathogens detected from hospitalized patients by microbiological analysis.

2. Materials and Methods

We retrospectively analyzed the results of the routine microbiology tests and the electronic health records of children hospitalized in the Medical University Children's Hospital in Warsaw, one of the two largest pediatric hospitals in the capital of Poland with more than 30,000 annual admissions. This study received an exemption from ethics review at the Medical University of Warsaw (AKBE 138/2021) as it used aggregate prevalence data only, without any patient or clinician identifiers. Data were collected and processed using Microsoft Excel 2019.

Individual medical records involving LRTI-associated hospital admissions (based on ICD-10 codes): (1) viral infections, including bronchiolitis, (2) influenza and flu-like infections, and (3) bacterial infections; and detection rates were collected for the following pathogens: (A) respiratory viruses (*Influenza A*, *B*, *A/H1N1* viruses, and RSV), (B) gastrointestinal (GI) viruses (Rotavirus and Norovirus), (C) gastrointestinal bacteria (*Salmonella* spp., *Campylobacter* spp., *Yersinia* spp., and *Enterohemorrhagic Escherichia coli* (EHEC)), and (D) SARS-CoV-2 and compared between April 2020 to March 2021, and four corresponding previous seasons (2016–2020) with the addition of the summer 2021 period to demonstrate the peak in RSV-positive infections. Children of all ages were, regardless of their length of stay, included in our complete-case analysis.

2.1. Data Mining Based on ICD-10

For data collection on hospitalization rates, the electronic health record system CGM CLININET (CompuGroup Medical, Lublin, Poland) of the Children's Hospital of the Medical University of Warsaw was used.

All patients, meeting the following criteria, were enrolled:

- The date of hospitalization in one of the following time periods: 1 April 2016–31 March 2017; 1 April 2017–31 March 2018; 1 April 2018–31 March 2019; 1 April 2019–31 March 2020; 1 April 2020–31 March 2021.
- The cause of hospitalization (based on clinical diagnosis and the ICD-10 code) due to one of the clinical subgroups, including lower respiratory tract infections: (1) viral infections (J12 (.0, .1, .2, .8, .9); J20 (.3, .4, .5, .6, .7, .8, .9); J21 (.0, .8, .9); J40], including bronchiolitis (J21 (.0, .8, .9)); (2) influenza or flu-like infection (J10 (.0, .1, .8); J11 (.0, .1, .8)); (3) bacterial infections (J13; J14; J15 (.0, .1, .2, .3, .4, .5, .6, .7, .8, .9); J16 (.0, .8); J18 (.0, .1, .2, .8, .9); J20 (.0, .1, .2)).

2.2. Microbiological Analysis

2.2.1. SARS-CoV-2

Nasopharynx swabs were obtained from examined subjects. Total RNA was extracted from 140 µL specimen with a manual centrifuge column isolation kit (Viral RNA Isolation Kit, ZJ Bio-Tech C, Shanghai, China) according to manufacturer's instruction. Real-time RT-PCR (Liferiver Novel Coronavirus (2019-nCoV) Real-Time Multiplex RT-PCR Kit, Shanghai ZJ Bio-Tech C, Shanghai, China) was performed upon CFX96™ Real-Time PCR Detection System (Bio-Rad, Hercules, CA, USA). The test detects 3 target genes: SARS-CoV-2 gene E, gene N, ORF1ab. The limit of detection is 1×10^3 copies/mL. The specificity of the test is 98.1%, analytical sensitivity 1×10^3 copies/mL. The protocol was

performed according to the manufacturer's instructions. Real-time RT-PCR was performed under the following conditions: 45 °C for 10 min and 95 °C for 15 min, followed by 45 cycles of amplification at 95 °C for 15 s and 60 °C for 1 min. Criteria for judging results: CT value < 43 positive; $43 \leq$ CT value \leq 45 suspicious positive and ≥ 45 negative. The positive should meet at least 2 genes detected. Internal control was added to the extraction mixture in the isolation stage to monitor the whole process. Positive and negative control was included in each run of amplification.

2.2.2. RSV and Influenza A/B

The nasopharyngeal swabs were collected at admission to the hospital. The specimen was tested for the presence of RSV and *Influenza A/B* virus using immune-chromatographic assay according to the manufacturer's instructions (Alere, Scarborough, ME, USA). Some samples were tested with qualitative real-time PCR test Xpert® Xpress Flu/RSV (Cepheid, Sunnyvale, CA, USA) according to the manufacturer's instructions.

2.2.3. Enteric Viruses

Enteric viruses: Rotavirus, Norovirus GI/GII were investigated by the immunochromatographic method according to the manufacturer's instructions (NADAL Rotavirus, Nal von Minden and Simple Norovirus, Operon, Zaragoza, Spain).

2.2.4. EHEC

The presence of stx I, stx II, and eae genes in *E. coli* strains isolated from stool samples was determined by real-time PCR according to EU protocols—identification and characterization of Verotoxin—producing *Escherichia coli* (VTEC) by Real-Time PCR amplification of the main virulence genes and genes associated with serogroups mainly associated with severe human infection. EU-RL VTEC Method 02 Rev of 5 March 2013.

2.2.5. Salmonella, Yersinia, Campylobacter

Stool samples tested for the presence of *Salmonella*, *Yersinia* were plated on five different media: Salmonella Shigella Agar, Selenite -F Broth, MacConkey, Yersinia Selective Agar (Oxoid, Basingstoke, UK) and incubated under aerobic conditions at 37 °C. Stool samples directed to *Campylobacter* were plated on CASA Chromogenic Medium (BioMerieux, Craaponne, France) and incubated under a microaerobic atmosphere at 42 °C. After initial sample processing, colonies were selected for identification using a Microflex LT mass and the MBT Compass IVD Biotyper software (Bruker Daltonics, Bremen, Germany). A score > 1.9 was considered a reliable identification at the species level.

3. Results

3.1. General Hospital Admissions

Following previous data, there was a noticeable seasonal distribution among the respiratory and GI viral infections with their peak during winter-spring months before the pandemic [9,10]. The number of total hospital admissions decreased by 25% during the pandemic season from a mean of 35,658 cases annually in the pre-pandemic years to 26,621 (−25%; −2,7 SD) cases in 2020/2021 (Table 1).

Table 1. Annual summary of infections during the 2016–2021 seasons at the Children’s Hospital of the Medical University of Warsaw. LTRIs—lower respiratory tract infections, SD—standard deviation, RSV—respiratory syncytial virus, EHEC—*Enterohemorrhagic Escherichia coli*, NA—not applicable.

| Seasons (in Periods from April to March) | | 2016/17 | 2017/18 | 2018/19 | 2019/20 | Mean (± SD) 2016–2020 | 2020/21 | Change in 2020/21 % of Mean Value (as per SD) in 2016–2020 |
|--|---|---------|---------|---------|---------|-----------------------------|---------|--|
| ICD-10 Results | | | | | | | | |
| 1 | Respiratory viral infections (J12; J20 (apart from .1, .2); J21; J40) | 462 | 414 | 406 | 412 | 424 (±26) | 102 | −76% (−12.4 SD) |
| | (including Bronchiolitis (J21)) | 161 | 202 | 184 | 261 | 202 (±43) | 24 | −88% (−4.2 SD) |
| 2 | Flu (J10; J11) | 65 | 116 | 136 | 127 | 111 (±32) | 0 | −100% (−3.5 SD) |
| 3 | Respiratory bacterial infections (J13; J14; J15; J16; J18; J20 (.0, .1, .2 only)) | 602 | 812 | 661 | 467 | 636 (±143) | 123 | −81% (−3.6 SD) |
| Total LRTIs (ICD-10) | | 1129 | 1342 | 1203 | 1006 | 1170 (±141) | 225 | −81% (−6.7 SD) |
| Microbiological Analysis Results | | | | | | | | |
| A | Influenza viruses (combined) | 47 | 91 | 179 | 210 | 132 (±76) | 0 | −100% (−1.7 SD) |
| | RSV | 157 | 167 | 188 | 124 | 159 (±27) | 1 | −99% (−5.9 SD) |
| B | Rotavirus | 168 | 89 | 161 | 59 | 119 (±54) | 16 | −87% (−1.9 SD) |
| | Norovirus | 2 | 133 | 130 | 100 | 91 (±61) | 55 | −40% (−0.6 SD) |
| C | <i>Salmonella</i> spp | 56 | 65 | 60 | 52 | 58 (±6) | 48 | −18% (−1.8 SD) |
| | <i>Campylobacter</i> spp | 49 | 42 | 52 | 21 | 41 (±14) | 28 | −32% (−0.9 SD) |
| | <i>Yersinia</i> spp | 1 | 9 | 14 | 11 | 9 (±6) | 11 | +26% (+0.4 SD) |
| | EHEC | NA | NA | NA | 7 | 7 | 8 | +14% |
| D | SARS-CoV-2 | NA | NA | NA | 0 | 0 | 380 | NA |
| Total Microbiological Pathogens | | 480 | 596 | 791 | 587 | 614 (±130) | 547 | −11% (−0.5 SD) |
| Total of General Hospital Admissions | | 31,084 | 35,597 | 38,611 | 37,339 | 35 658 (±3290) | 26,621 | −25% (−2.7 SD) |

3.2. Lower Respiratory Tract Infections-Associated Hospital Admissions Frequency

Among registered hospitalizations, those resulting in LRTI-associated hospitalization accounted for a mean 3.3% (1170/35,658) of all admissions annually (with a total of 4905 cases between 2016–2021) and were subsequently classified, according to ICD-10 codes, into the following clinical categories: (1) viral infections, including bronchiolitis, (2) influenza and flu-like infections, and (3) bacterial infections. During the 2016–2020 seasons, the cumulative annual LRTI-associated hospital admission frequency remained steady (mean ± SD: 1170 ± 141 cases). In contrast, this trend was not reflected during the

3.3. Microbiological Analysis of Pathogens from Hospitalized Patients

The figure consists of three vertically stacked line graphs sharing a common x-axis representing time from April 2016 to April 2021. The x-axis is marked with months (IV, V, VI, VII, VIII, IX, X, XI, XII, I, II, III, IV) and years (2016, 2017, 2018, 2019, 2020, 2021). A red arrow at the bottom indicates the lockdown announcement in April 2020, and a green arrow indicates the opening of nurseries and kindergartens in May 2020. A red box highlights RSV cases in August 2020.

RESPIRATORY VIRUSES

This graph shows the number of cases for Influenza B virus (green), Influenza A virus (blue), Influenza A/H1N1 virus (light blue), RSV (red), and SARS-CoV-2 (black). The y-axis ranges from 0 to 120. RSV cases show several peaks, with a notable one in August 2020. SARS-CoV-2 cases show a sharp increase starting in April 2020, peaking in late 2020 and early 2021. Influenza cases show seasonal patterns with peaks in late 2016, late 2017, late 2018, and late 2019.

GASTROINTESTINAL VIRUSES

This graph shows the number of cases for Rotavirus (light green) and Norovirus (dark green), along with SARS-CoV-2 (black). The y-axis ranges from 0 to 60. Rotavirus and Norovirus cases show seasonal peaks, typically in late autumn and early winter. SARS-CoV-2 cases show a sharp increase starting in April 2020, peaking in late 2020 and early 2021.

GASTROINTESTINAL BACTERIA

This graph shows the number of cases for Salmonella spp. (yellow), Campylobacter spp. (brown), Yersinia spp. (orange), EHEC (red), and SARS-CoV-2 (black). The y-axis ranges from 0 to 30. Salmonella and Campylobacter cases show seasonal peaks, typically in late summer and early autumn. SARS-CoV-2 cases show a sharp increase starting in April 2020, peaking in late 2020 and early 2021.

4. Discussion

The study demonstrates that a regional epidemiological situation remained stable before the SARS-CoV-2 pandemic, with a plummet of overall hospital admission rates quickly upon the introduction of lockdown in Poland. The decrease was most pronounced in rates of respiratory infections. Atypically, the RSV bronchiolitis season arrived early in 2021, confirming the latest global reports [11]. The incidence of GI viruses, predominantly feco-orally transmitted and requiring direct human contact, was reduced. However, the

prevalence of bacterial GI pathogens, which mainly have food-associated transmission routes, did not fall significantly, similarly to previously reported results [12].

Besides the drastic drop in social interactions and gatherings, these associations may have been related to a fear of mandatory screening testing at admission and a fear of hospitals as the likely sources of the SARS-CoV-2 infection [13]. Interestingly, the opening of daycare centers only (and continuation of the lockdown for the adult population) was not followed by the marked increase in respiratory or gastrointestinal viral infections in children. The fact that in our research, we compared the full pandemic season paralleling with previous years' periods is highly illustrative of the epidemiological situation.

To our knowledge, this is one of the first reports addressing the current pediatric epidemiological situation regarding not only the respiratory viruses but with other most common infections in a hospital setting in Europe [14–16]. The novelty of this paper is in the inclusion of non-respiratory infections covering different gastrointestinal pathogens. However, the present study has some limitations. Firstly, it is a single-center study. Secondly, the sampling bias cannot be excluded as our analysis reflects the group of moderate and severe infections in children who needed to be assessed in a hospital setting. Additionally, the retrospective analyses have often been associated with an increased risk of bias, and it is not possible to definitively prove a cause-effect relationship of the drawn conclusions. We are aware of the fact that the proportion of children has changed since the start of the pandemic, and the reduced attendance to daycare might have affected the observed results. On the other hand, our study has some important strengths. Through a combination of medical records and microbiological data, we provide a complex view of how the SARS-CoV-2 virus has affected the work of one of the regional pediatric hospitals in Europe. It informs further prospective research using more rigorous scientific methods during the COVID-19 pandemic.

5. Conclusions

Our research illustrates that lockdown and social distancing reflect not only in the commonly acknowledged decline of reported SARS-CoV-2 cases but also in the distribution of other common infections in children. Our findings show the effectiveness of restrictions in preventing LRTIs and other common infections among pediatric patients and may imply applicability and future stewardship of public health strategies towards SARS-CoV-2 and other pathogens.

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Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available upon request.

Conflicts of Interest: The authors declare no conflict of interest.

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