

# Coronavirus Disease 2019 Pandemic: Impact Caused by School Closure and National Lockdown on Pediatric Visits and Admissions for Viral and Nonviral Infections—a Time Series Analysis

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A time series analysis of 871 543 pediatric emergency visits revealed that the coronavirus disease 2019 (COVID-19) lockdown and school closures were associated with a significant decrease in infectious diseases disseminated through airborne or fecal–oral transmission: common cold, gastroenteritis, bronchiolitis, and acute otitis. No change was found for urinary tract infections.

**Keywords.** COVID-19; lockdown; epidemic; pediatric; emergency.

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In late December 2019, patients with viral pneumonia due to an unidentified microbial agent were reported in Wuhan, Hubei province, central China. This disease outbreak, coronavirus disease 2019 (COVID-19), then grew substantially and was declared a pandemic by the World Health Organization on 11 March 2020 [1].

In 1995, a major French nationwide strike paralyzed France. For 19 days, from 30 November to 18 December 1995, people stayed at home, including children who normally went to day-care centers, and a significant decrease of bronchiolitis cases was observed. This decline might have been caused by workplace and school absenteeism, and lower attendance to day-care centers [2]. Likewise, during the 2013–2014 measles epidemic, a reduction in contact rate during school vacations was associated with 4900 averted cases in the Netherlands [3].

After reaching France on 24 January 2020, a major progression of COVID-19 from February to March led to public health interventions. Partial lockdown and school closures were initiated in early March, and a national lockdown was officially started on 17 March 2020 [4, 5]. No previous public health intervention can be compared to the extent of the lockdown established for the COVID-19 epidemic. We hypothesized that this unusual situation in France would be associated with a sharp decrease in pediatric infectious diseases that usually disseminate through social contacts, with schools at their center. Being able to prevent these infections, responsible for many pediatric hospitalizations, would be an unwanted direct benefit of the lockdown for children, who seem otherwise significantly more protected than adults from infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [6]. Moreover, this could open the road for future guidelines to control future major health issues once the COVID-19 pandemic is under control.

Therefore, the evolution of several major diseases usually correlated with dissemination through contact, such as gastroenteritis, common cold, and acute otitis media (AOM), were investigated before and after the start of the national lockdown. Urinary tract infections (UTIs), which are not reported to be correlated with contacts in children, were used as a control outcome.

## METHODS

We conducted a quasi-experimental interrupted time series analysis based on multicenter prospective French surveillance data for pediatric emergency department (PED) visits and related hospital admissions. The Regional Center of Observation and Action on Emergencies e-CERVEAU (Agence Régionale de Santé) is an official network of emergency departments

dedicated to public health that automatically transmit a summary of anonymized data from all of their visits to the regional database. The database has been approved by the French data protection authority. These data include discharge diagnoses coded by the physicians in charge of the patient at the end of the PED visit according to the *International Classification of Diseases, Tenth Revision* and hospital admission or discharge. This study covers 6 PEDs from academic hospitals being part of the Assistance Publique–Hôpitaux de Paris, located in and around Paris, gathering 250 000 annual visits that daily transmitted data their from 1 January 2017 to 19 April 2020. We used the e-CERVEAU database for this research. Data are anonymous. Patient informed consent is not required according to current dispositions.

Groups of diagnoses extracted were as follows: gastroenteritis, common cold, bronchiolitis, AOM (all considered as infectious diseases thriving through social contact), and UTI (Supplementary Table 1). Visits were grouped by calendar weeks for each year.

### Outcome Measure

The main outcome was the evolution of the number of hospital admissions following the French decision to close schools and start a lockdown for the whole country [5]. The secondary outcomes were the number of PED visits for gastroenteritis, bronchiolitis, common cold, and AOM. As recommended to prevent potential confusion [7, 8], UTIs were analyzed as a control outcome, given that this common pediatric infectious disease is not expected to be impacted by social distancing, although indirect effects such as stress or diet change cannot be excluded. This outcome was already used as a control concerning previous acute respiratory tract infection studies [9].

### Statistical Analysis

Outcomes were analyzed by quasi-Poisson regression, accounting for seasonality, secular trend before and after lockdown, and overdispersion of data [7, 8, 10, 11]. Seasonality was taken into account by including harmonic terms (sines and cosines) with 12-month and 6-month periods to adjust for the seasonal pattern [11]. The time unit chosen was 1 week to provide optimal precision to the model [8].

We hypothesized that the intervention would have an immediate impact, meaning after 1 time unit, considering the incubation time of most viral diseases. Thus, intervention assessment involved a dummy variable in the model estimating the immediate postintervention change [8, 10]. The preintervention period was from 1 January 2017 to 17 March 2020 and the postintervention period was from 18 March 2020 to 19 April 2020. Intervention impact was estimated by comparing estimates in the postintervention period to expected estimates if the lockdown did not occur, based on quasi-Poisson regression modeling. Validity of the quasi-Poisson regression model was

assessed by visual inspection of the correlograms (auto correlation and partial autocorrelation functions) and residuals analysis. Analysis of acute gastroenteritis was performed on data from 4 hospitals combining 81% of the visits during the study period. All statistical tests were 2-sided, and we considered a result as significant when the *P* value was  $<.05$ . All statistical analyses were done using R version 3.6.1 software (<http://www.R-project.org>).

## RESULTS

A total of 871 543 PED visits in the 6 participating centers from 1 January 2017 to 19 April 2020 were included. Data collected in 2017, 2018, and 2019 were used to generate a model fitting the observed values of the PED visit, allowing us to project the number of PED visits that could have been expected without lockdown.

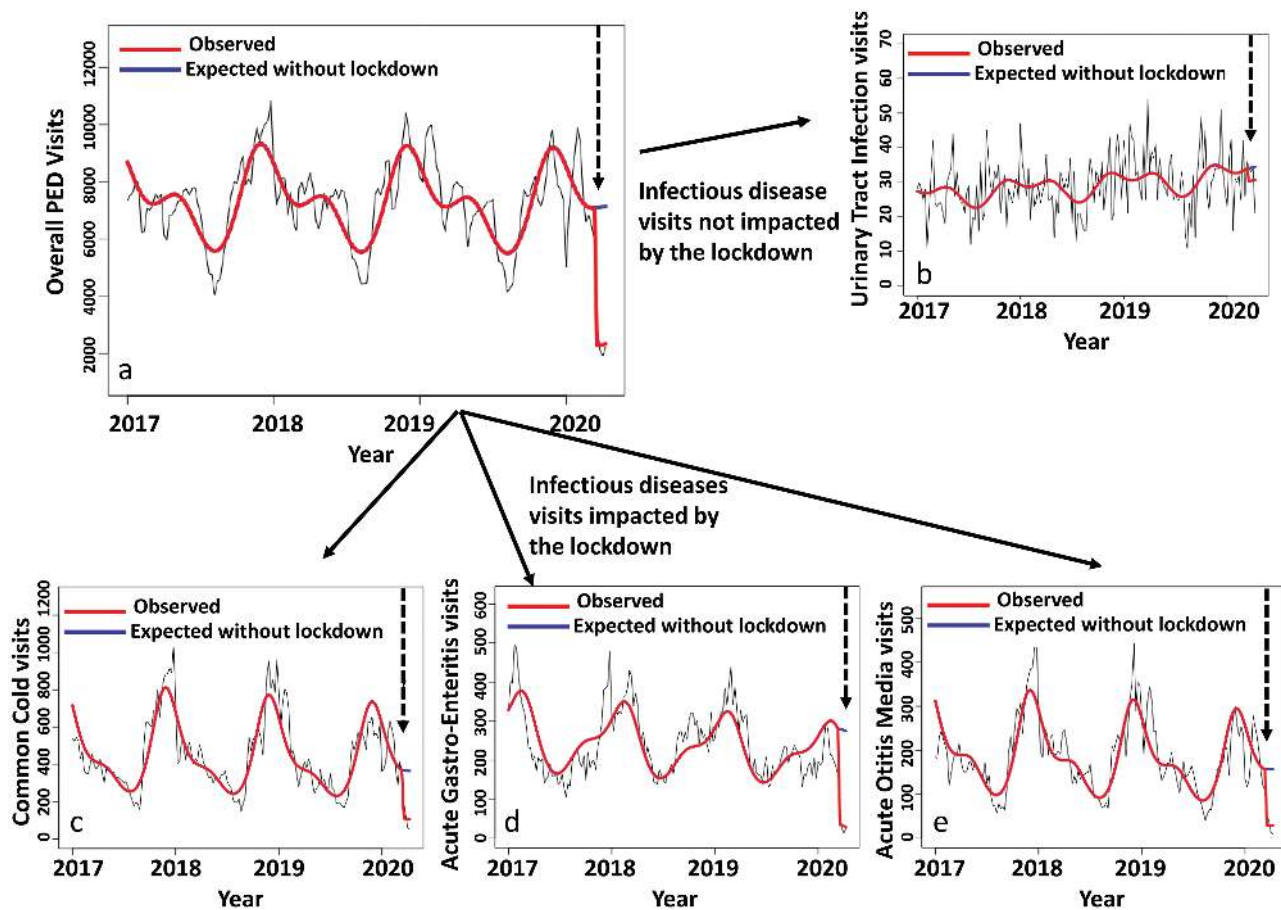
As presented in Figure 1A, a sharp discrepancy was found between expected and observed values after lockdown, reflecting the significant decrease of PED visits ( $-68.0%$  [95% confidence interval {CI},  $-81.2%$  to  $-55.8%$ ]) and hospital admission following PED visits ( $-45.0%$  [95% CI,  $-57.0%$  to  $-32.4%$ ]) in the lockdown period (Figure 1, Supplementary Figure 1, and Supplementary Table 2).

We found a significant decrease in acute gastroenteritis, common cold, and AOM (Supplementary Tables 2 and 3) with a sharp decrease of  $>70%$  compared to the expected values (Figure 1B–D). Decrease of bronchiolitis was also significant ( $-63.5%$  [95% CI,  $-101.8%$  to  $-25.9%$ ]) (Supplementary Table 2).

Consistent both with our hypothesis and the incubation time of these different diseases, a dramatic decrease of overall PED visits ( $-68.5%$ ) and hospitalization ( $-44.7%$ ) was observed as soon as 1 week after the start of the lockdown (Supplementary Figure 1). By contrast, UTIs were not impacted by the lockdown, regarding both overall PED visits ( $-16.4%$  [95% CI,  $-40.8%$  to  $+6.4%$ ]) and hospital admissions ( $+20.7%$  [95% CI,  $-27.0$  to  $+58.5$ ]) (Figure 1E, Supplementary Figure 1, and Supplementary Table 2).

## DISCUSSION

In this time series analysis of 871 543 PED visits, the number of PED visits and admissions after the lockdown decreased by  $-68%$  and  $-45%$ , respectively. We found a significant decrease of  $>70%$  of acute gastroenteritis, common cold, bronchiolitis, and AOM compared to the expected values. Unprecedented public health interventions were ordered to reduce the risk of SARS-CoV-2 transmission [4]. Our data suggest that these measures also have a critical impact on the transmission of numerous infectious diseases, more specifically on viral or viral-induced pediatric diseases. This major achievement may also play a critical role in making more health resources with adults admitted to intensive care and healthcare workers available to



**Figure 1.** Impact of lockdown on weekly pediatric emergency department (PED) visits and major pediatric infectious diseases, from 1 January 2017 to 19 April 2020. A, Overall PED visits ( $n = 871\,543$ ). B, PED visits for urinary tract infections ( $n = 5001$ ). C–E, PED visits for common cold ( $n = 67\,210$ ), acute gastroenteritis ( $n = 35\,025$ ), and acute otitis media ( $n = 27\,810$ ), respectively. The black line shows the observed data. The bold red slope shows the model estimates based on observed data (quasi-Poisson regression modeling). The bold blue slope shows the expected values without lockdown in the postintervention period (quasi-Poisson regression modeling). The start of the lockdown is indicated by the vertical black arrows.

fight the COVID-19 pandemic [12]. In the Paris area, children with acute illness could be seen not only in PEDs but also in private offices (general practitioners or pediatricians), general practitioner house calls, and community centers. However, most of these sites of care do not work 24/7 and rarely perform additional tests, especially for the younger children.

Our study has limitations: We cannot exclude a change in clinical management such as avoidance of ear, nose, and throat examination because of COVID-19 fear, which could have influenced diagnosis coding; we did not collect data regarding severity; and so we cannot exclude that reduction in presentations was associated with children presenting later in their illness. While the dramatic decrease in PED visits could be partially due to transportation limitations, a fear of going to the hospital, and increase of telemedicine, the stability in the number of UTI cases that we used as the control outcome and the significant decrease in hospital admissions do not favor this hypothesis. Moreover, visits to private doctors' offices decreased by 40% [13]. While the role of the children in the dissemination of

SARS-CoV-2 is still being discussed, finding that school closure and national lockdown were linked to a dramatic decrease in PED visits concerning gastroenteritis, AOM, bronchiolitis, and other viral diseases could be not only an unexpected benefit for the children but could also raise the question of the impact on the healthcare system of starting to lift the French national lockdown by reopening the schools [14]. Complementary studies using more granular data such as severity could be useful to better understand the lockdown's impact on children's health.

This national-level quasi-experiment is unprecedented in the modern era. It provides unique evidence that could be key in the post-COVID-19 era, to implement new guidelines and new routines in our way of life and to fight past but also potential future infectious disease threats reaching both children and adults.

#### Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

## Note

**Potential conflicts of interest.** The authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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