

Effect of Social Distancing Due to the COVID-19 Pandemic on the Incidence of Viral Respiratory Tract Infections in Children in Finland During Early 2020

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Background: Social distancing measures are used to reduce the spreading of infection. Our aim was to assess the immediate effects of national lockdown orders due to coronavirus disease 2019 (COVID-19) on pediatric emergency room (ER) visits and respiratory tract infections in hospitals and nationwide in Finland.

Methods: This register-based study used hospital patient information systems and the Finnish national infectious disease register. The participants were all patients visiting pediatric ER in 2 Finnish hospitals (Kuopio University Hospital, Mikkeli Central Hospital) covering 1/5th of the Finnish children population, 4 weeks before and 4 weeks after the start of the nationwide lockdown on March 16, 2020. Nationwide weekly numbers of influenza (A + B) and respiratory syncytial virus (RSV) in children were assessed from the infectious disease register from 2015 to 2020.

Results: A major decrease in the rate of daily median pediatric ER visits was detected in both hospitals in the study during the nationwide lockdown compared with the study period before the lockdown (Mikkeli, 19 vs. 7, $P < 0.001$; Kuopio, 9 vs. 2.5, $P < 0.001$). The influenza season was shorter (8 weeks from peak to no cases), and the weekly rate of new cases decreased faster compared with the previous 4 influenza seasons (previously 15–20 weeks from peak to no cases). A similar decrease was also seen in RSV cases. No pediatric cases of COVID-19 were found in participating hospitals during the study period.

Conclusion: These results strongly suggest that social distancing and other lockdown strategies are effective to slow down the spreading of common respiratory viral diseases and decreasing the need for hospitalization among children.

Key Words: Social distancing, influenza, Respiratory syncytial virus, epidemiology

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The World Health Organization (WHO) and the European Centre for Disease Prevention and Control (ECDC) have recommended a series of measures to governments to slow the worldwide spread of the novel severe acute respiratory syndrome coronavirus (SARS-CoV-2) and coronavirus disease 2019 (COVID-19).^{1,2} In

Finland, the government declared the first state of emergency since World War II on March 16, 2020. The following nationwide lockdown acts were ordered: Social gatherings of more than 10 people were prohibited. Universities, high schools, and upper elementary schools were closed. Lower elementary school classes from grades 1 to 3 were kept open but only for the children whose parents were in critical professions. Day care centers remained open, but parents were encouraged to take care of their children at home if possible. For example, in the city of Mikkeli, only 20% of the children attended day care during the lockdown.³ Remote work at home was recommended for employed people whenever possible. Residents aged over 70 were ordered to stay at home, and the borders of Finland were closed.⁴ As part of the state of emergency, the Finnish Institute of Health and Welfare guided residents to stay at home for mild upper respiratory infections and avoid unnecessary visits to a healthcare facility.⁵

These acts were based on the best evidence available at the time of the introduction. The evidence consisted of global experience and previous pandemics.⁶ In some studies, social distancing reduced the spreading of seasonal influenza in workplaces.⁷ The real effect of these broad restrictions on the spreading of diseases is not known, but it appeared to decrease the spreading of the novel coronavirus in China in 2020.⁸ In Japan, the influenza season in 2020 was shorter than normal possibly because of the social restrictions.⁹

The main aim of this study was to describe the immediate effects of the state of emergency and lockdown on the incidence of influenza A, influenza B, and respiratory syncytial virus (RSV) infections among children in Finland. Furthermore, we analyzed the number, age distribution, and reasons for visits in pediatric emergency rooms (ER) and hospitalizations in 2 Finnish hospitals: Kuopio University Hospital (KUH) and Mikkeli Central Hospital (MCH).

METHODS

This register-based study was conducted in 2 hospitals, and open national registries for communicable diseases were used. KUH is a tertiary level university hospital located in Eastern Finland. It provides secondary pediatric care for a population of 250,000 and tertiary pediatric care for about one million inhabitants. In Kuopio, the pediatric ER is a 24-hour referral center with approximately 3,000 visits per year, and it is the only pediatric hospital providing secondary and tertiary care in the Northern Savo region. MCH is also located in Eastern Finland and provides secondary care for a population base of 110,000 inhabitants. The pediatric ER serves as both a primary and secondary pediatric 24-hour center with approximately 5,000 visits per year. Of these patients, 700 (14%) are in pediatric care, 500 (10%) in pediatric surgical care, and 3,800 (76%) in general practice care.

The data of pediatric ER visits and hospitalizations were collected from both hospitals 4 weeks before (17.2.2020 to 15.3.2020) and 4 weeks after (16.3.2020 to 12.4.2020), the declaration of the

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Finnish state of emergency on March 16, 2020. The specific interest for the study was the number of visits due to upper or lower respiratory tract infections. The infections were classified as upper or lower by the International Classification of Diseases, 10th revision (ICD-10), diagnosis of the visit (Table 1).

The infectious disease register (IDR) is a nationwide register maintained by the Finnish Institute of Health and Welfare. The IDR was established in 1995 to provide information on contagious diseases in Finland. Reporting infections to the IDR is mandatory by law. The IDR provides an open-access database that is weekly updated, and laboratories notify the findings of listed microbes to the register.¹⁰ For this study, the nationwide weekly numbers of laboratory confirmed cases of influenza A, influenza B, and RSV were collected from the past 5 years (2015–2020) for patients under 15 years of age. We also evaluated the weekly numbers of laboratory confirmed cases and performed tests for pediatric patients from laboratories of both participating hospitals.

Official permissions for the present study were obtained from both participating hospitals. Due to the register-based study design, the present study did not need the statement of the local ethical committee. No personal records were handled during the study.

STATISTICS

The demographics of the patients were analyzed and compared between the groups based on the distribution. The normality of the continuous variables was tested and analyzed based on the distribution. Medians and interquartile ranges were used for the non-normally distributed variables and comparisons, calculated using the Mann-Whitney *U* test. Categorized variables were cross-tabulated and χ^2 tests were used. Fischer’s exact test was used if the number of expected cases was lower than 5. The epidemics were displayed graphically. The nationwide influenza and RSV seasons were compared from the beginning of the season, marked as week 40, until the end of season at week 20. Data were extracted from the patient information system. The data were then inputted into Microsoft Excel 2016 and analyzed by IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY).

RESULTS

During the study period, a total of 816 pediatric ER visits occurred at MCH. Of these visits, 605 (74%) were before the nationwide lockdown, and 211 (26%) occurred after the lockdown. The daily median of visits was 19 before the lockdown and 7 after

the start of the lockdown ($P < 0.001$). This decrease in the number of visits did not occur in 2019 when the daily median rate of ER visits remained constant over the study period (21 vs 19, $P = 0.08$). At KUH, the total number of visits was 358. Of these, 266 (74%) were before and 92 (26%) were after the lockdown. The daily median rate of visits was 9 before and 2.5 after the lockdown in 2020 ($P < 0.001$). In 2019, the daily median rates remained stable at KUH during the corresponding period (11 vs 9, $P = 0.04$). (Figure 1)

The age distribution of patients at both hospitals remained similar before and after the lockdown. The diagnostic characteristics of the patients and the hospitalization rate remained stable during the study period at MCH. At KUH, the proportion of visits due to respiratory infections decreased after the lockdown. There was an overall decrease in the number of hospitalized patients, especially due to respiratory infections after the lockdown (Table 2). No COVID-19 cases were detected in children in either of the participating hospitals.

The annual influenza season in 2020 was shorter and ended more rapidly than the previous 4 influenza seasons. None of the previous four influenza seasons had such a rapid decrease from multiple cases to no cases, which occurred in this current season. In 2020, the epidemic was 8 weeks from the peak to no cases. In previous years, the epidemic lasted longer from its peaks to no cases (13–20 weeks). This rapid decrease was also seen similarly with RSV in 2020. The ongoing RSV season resembled the seasons 2 (2017–2018) and 4 (2015–2016) years ago, but the end of the season arrived more rapidly (Figure 2).

DISCUSSION

The decrease in the overall number of pediatric ER visits and visits caused by respiratory tract infections was remarkable after the start of the 2020 national state of emergency and lockdown in Finland. The ongoing annual influenza and RSV seasons ended more rapidly compared with previous seasons among the pediatric population.

The decrease in the rate of visits may be caused by the decrease in incidents of infectious diseases because children lived under social distancing and have not attended school, extracurricular activities, or day care centers. Schools and day care centers have been detected as major sources of common viral infections.^{11,12} Children attending day care have been shown to be at higher risk of having upper or lower respiratory tract infections and acute otitis media than those staying at home.^{13–15} In this study, we focused on the number of visits due to respiratory tract infections and noticed

TABLE 1. Classification of Upper and Lower Respiratory Infections Based on the International Classification of Diseases, 10th Revision (ICD-10)

Upper respiratory infection		Lower respiratory infection	
ICD-10	Class	ICD-10	Class
J00	Acute nasopharyngitis (common cold)	J12	Viral pneumonia, not elsewhere classified
J01	Acute sinusitis	J13	Pneumonia caused by <i>Streptococcus pneumoniae</i>
J02	Acute pharyngitis	J14	Pneumonia caused by <i>Haemophilus influenzae</i>
J03	Acute tonsillitis	J15	Bacterial pneumonia, not elsewhere classified
J04	Acute laryngitis and tracheitis	J16	Pneumonia due to other infectious organisms, not elsewhere classified
J05	Acute obstructive laryngitis (croup) and epiglottitis	J17	Pneumonia in diseases classified elsewhere
J06	Acute upper respiratory infections of multiple and unspecified sites	J18	Pneumonia, organism unspecified
J09	Influenza	J20	Acute bronchitis
J10	Influenza due to identified influenza virus	J21	Acute bronchiolitis
J11	Influenza, virus not identified	J22	Unspecified acute lower respiratory infection
R05	Cough	R06.0	Dyspnea
R07.0	Pain in throat	R06.2	Wheezing

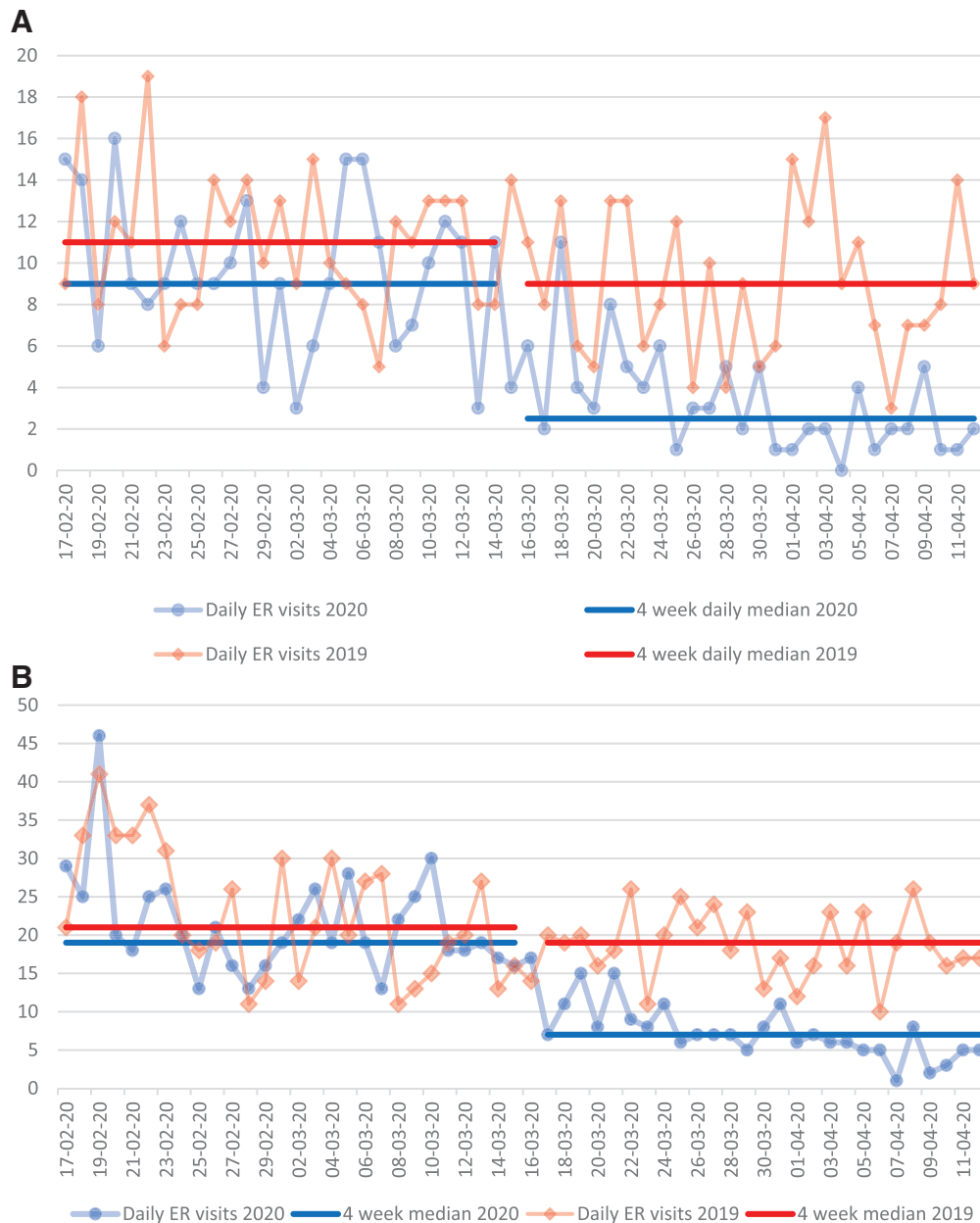


FIGURE 1. The total number of pediatric emergency room (ER) visits per day presented for (A) Kuopio University Hospital and (B) Mikkeli Central Hospital 4 weeks before (February 17, 2020) the state of emergency (March 16, 2020) and 4 weeks after the state of emergency (April 12, 2020) compared with the corresponding period in 2019. The red line represents the median number of daily visits before and after the state of emergency in 2020, and the blue line represents the median number of daily visits in 2019 during the same time period.

that the number of ER visits caused by these symptoms decreased as much as the overall ER visit rate.

The ongoing influenza season had similarities to the season of 2018–2019, but the end of the epidemic was more sudden. The decrease in the number of cases has not been this significant in previous years, and in 2020, there was no remaining burden in the number of new diagnosed cases. This strongly suggests that social restrictions may have decreased the spread of influenza. The closing of schools and the timing of holidays have been shown to decrease the spread of influenza epidemics in previous studies.^{16–18} A previous review reported that workplace social distancing might

reduce the spread of influenza.⁷ In Japan, influenza season in 2020 was shorter than the previous 4 seasons, however, the study was not restricted to pediatric patients. In addition, this study included the suspected influenza (A and B) cases in Japan, and the numbers were extrapolated in the nationwide level from a smaller local sample.⁹

Biennial epidemiological variation of RSV, in which the high season follows the low season, is typical in Nordic countries and Germany.¹⁹ Compared with the high seasons of 2015–2016 and 2017–2018, this RSV season in 2020 was similar until week 10 (1 week prior to the start of the official lockdown) when the decrease in cases

TABLE 2. Patient Characteristics of Pediatric Emergency Room Patients 4 Weeks Before the Start of the State of Emergency and 4 Weeks After the Start of the State of Emergency in Mikkeli Central Hospital and Kuopio University Hospital

	Four weeks before		Four weeks after		<i>P</i>
	<i>N</i> (%)		<i>N</i> (%)		
Mikkeli Central Hospital					
Total number of ER visits	605 (100)		211 (100)		
Daily visit rate*	19 (7)		7 (3)		< 0.001
Patient age					
0–4 years	315 (52)		114 (54)		0.78
5–9 years	146 (24)		46 (22)		
10–15 years	144 (24)		51 (24)		
Diagnoses of the visit					
upper respiratory tract infection (%)	221 (37)		71 (34)		0.65
lower respiratory tract infection (%)	33 (5.0)		16 (8.0)		
acute otitis media (%)	85 (14)		28 (13)		
other (%)	296 (44)		96 (45)		
Hospitalized	29 (4.7)		16 (7.6)		0.13
Diagnoses for hospitalization					
upper respiratory tract infection (%)	9 (31)		3 (19)		0.30
lower respiratory tract infection (%)	7 (24)		2 (12)		
other (%)	13 (45)		11 (69)		
Kuopio University Hospital					
Total number of ER visits	266	100	92	100	
Daily visit rate*	9	5	2.5	3	<0.001
Patient age					
0–4 years	184	69	56	61	0.08
5–9 years	43	16	13	14	
10–15 years	39	15	23	25	
Diagnose of the visit:					
upper respiratory tract infection (%)	81	30	26	28	0.04
lower respiratory tract infection (%)	58	22	9	10	
acute otitis media (%)	7	3.0	4	4.0	
other (%)	120	45	53	58	
Hospitalized	100	38	40	44	0.32
Diagnoses for hospitalization**					

*Median and interquartile range, tested with Mann–Whitney *U* test.

**Information was not available from Kuopio University Hospital.

started. The decrease was, however, more rapid than previous years, declining straight to no cases instead of plateauing. This finding was probably caused by the nationwide lockdown. RSV mostly spreads among the youngest children, and day care attendance decreased markedly during the lockdown period. This result suggests that social distancing and smaller day care groups among the youngest children may decrease the disease burden and hospitalizations caused by RSV.

One possible reason for the remarkable decrease in ER visits may be fear of going to the hospital. The Finnish media reported that, during the lockdown, many patients avoided ERs and hospitals, even for major health problems, like acute myocardial ischemia.²⁰ The Finnish Institute of Health and Welfare also guided citizens to treat minor infections at home and seek the ER only after first contacting the local emergency number.⁵ The decrease did not exist among patients needing hospitalization because of other reasons than respiratory infections. This may indicate that at least part of the decrease came from unnecessary ER visits caused by mild respiratory infections in normal times.

One possible bias when interpreting these results is the coverage of the seasonal influenza vaccination and the accuracy of the selected seasonal influenza vaccination. In the 2019–2020 season, the vaccinations used were nasal FluenzTetra for children aged 2–6 and intramuscular VaxigripTetra for others in Finland. In 2020, the seasonal influenza vaccines contained the following serotypes: A/

Brisbane/02/2018 (H1N1) pdm09, A/Kansas/14/2017/(H3N2), B/Colorado/06/2017, and B/Phuket/3073/2013. For example, in 2017, the seasonal influenza vaccination was not the most effective.¹⁰ This caused a higher incidence of laboratory confirmed cases in the 2017–2018 season. The coverage of the seasonal influenza vaccinations in Finland is reported to the IDR each year. In 2019, the coverage was 43% in children under 3 and 29% of children age 3–6. The influenza vaccination has been part of the national vaccination program for children under 3 years since 2007. In autumn 2018 children age 3–6 years were for the first time included to this free seasonal influenza vaccination program. As a result, a clear increase was seen in seasonal vaccination coverage among children 3–6 years of age (from 18% to 29%). The specific vaccination coverage among pediatric patients for this 2019–2020 season and the accuracy of the selected seasonal influenza vaccination have not been reported as of date.¹⁰

The main strengths of this study was the nationwide IDR, which provided weekly numbers of laboratory confirmed infectious disease cases. The coverage of the register correlates well with hospital laboratory data, and the completeness of the register was significant due to the mandatory obligation of laboratories, medical doctors, and dentists to report positive findings of notifiable diseases and microbes.¹⁰ This register is an open-access register updated once a week, providing fast and up-to-date information. One of the strengths of our study was that the provided numbers from the IDR were all laboratory confirmed cases, instead of clinically suspected or estimated cases. Additionally, due to our pediatric ERs being separate from other ERs, we were able to analyze pediatric visits only. Furthermore, MCH pediatric ER had a unique system in which both the primary healthcare and pediatric specialized healthcare were provided for pediatric patients in the same ER. The MCH pediatric ER represented the whole scale of pediatric patients inside one region in Finland, whereas the KUH pediatric ER covered only patients needing specialized secondary and tertiary healthcare, although from a larger region. The whole coverage was approximately 1/5th of Finland.

There were some limitations in this study. First, we obtained only group-level data from the IDR for this study because obtaining permits to access individual-level data would require months. Therefore, we were not able to track the vaccinated and unvaccinated children separately. In addition, the serologic analyses of the positive influenza cases during this season will be available in the autumn. The applications have been submitted, and we will continue this study with an individual-level analysis.

The IDR does not track mild or influenza-like illness cases, as it covers only the laboratory confirmed cases. Another limitation of this study was that we obtained data and results from only 2 Finnish hospitals because the registers covering the nationwide hospitalizations will not be available until, at the earliest, September of 2021. However, the selected hospitals should provide the best estimation available from all levels of healthcare.

The state of emergency, social distancing, and other lockdown acts clearly decreased the pediatric ER patient volume in Finland and changed the patient characteristics to fewer visits caused by respiratory infections. The ongoing RSV and influenza seasons ended more rapidly than previous seasons. These findings provide evidence for decision-making in future epidemics. In addition, these results show that decreasing social contact among young children effectively reduces the need for ER visits and hospitalizations because of common respiratory infections.

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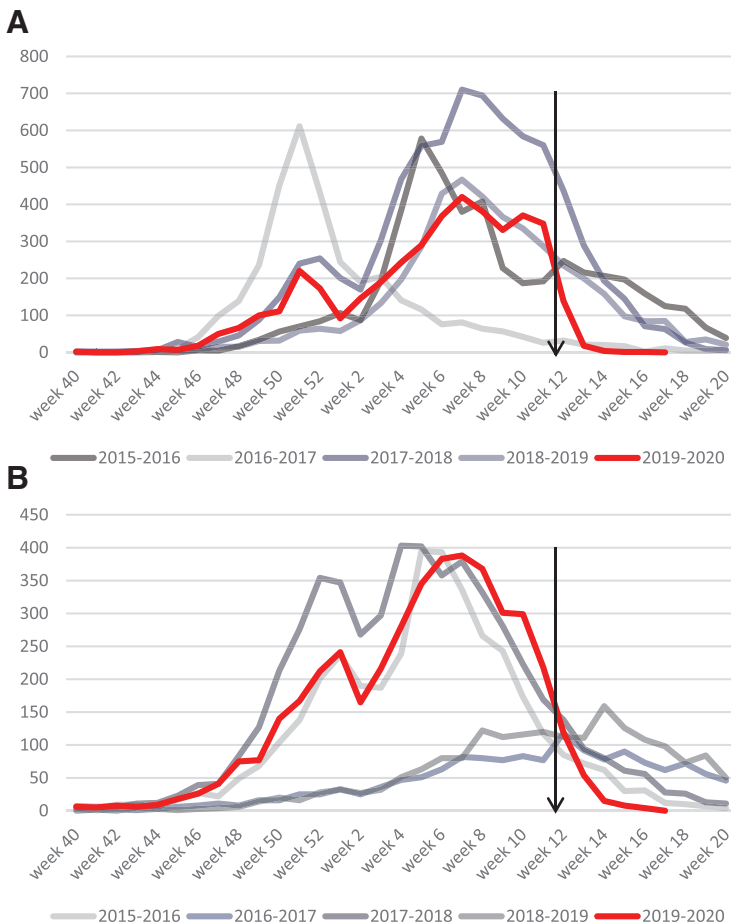


FIGURE 2. The total nationwide weekly numbers of laboratory confirmed cases of (A) influenza A and B and (B) respiratory syncytial virus (RSV) for patients under age 15 for the past five years. Arrow marks the start of the nationwide state of emergency and lockdown at the beginning of week 12 in 2020.

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