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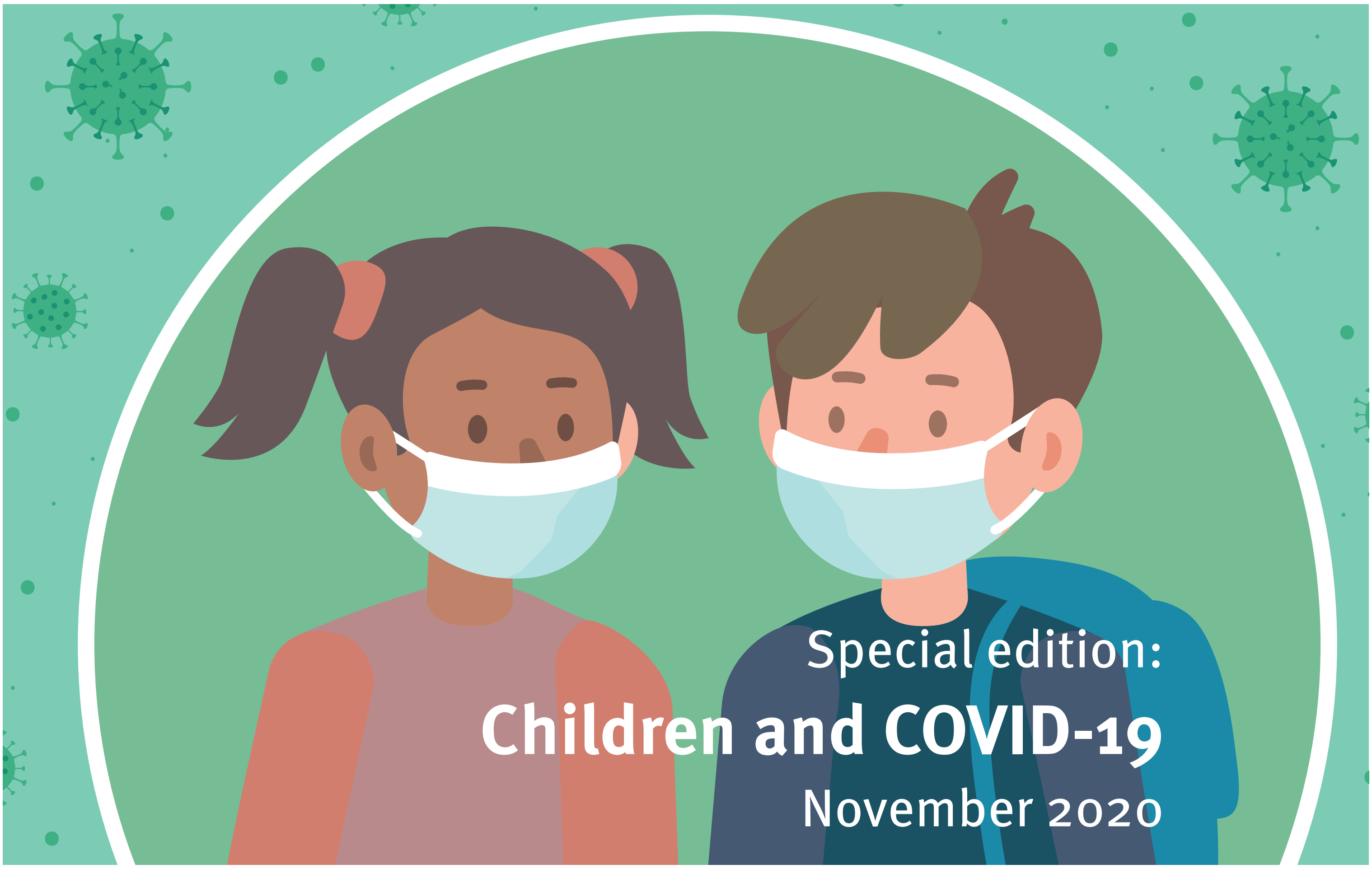

Special edition:

Children and COVID-19

November 2020

Featuring

- COVID-19 school outbreaks
- Transmission of SARS-CoV-2 in children
- Guidelines and considerations for paediatric risk groups
- Impact of unplanned school closure
- and more...

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Editorial team

Based at the European Centre for
Disease Prevention and Control (ECDC),
169 73 Stockholm, Sweden

Telephone number

+46 (0)8 58 60 11 38

E-mail

eurosurveillance@ecdc.europa.eu

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Rapid communication

Surveillance of COVID-19 school outbreaks, Germany, March to August 2020

Eveline Otte im Kampe[1], Ann-Sophie Lehfeld[1] , Silke Buda[1] , Udo Buchholz[1] , Walter Haas[1]
1. Robert Koch Institute, Berlin, Germany

Correspondence: Eveline Otte im Kampe (otte-im-kampee@rki.de)

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Mitigation of the coronavirus disease (COVID-19) pandemic in Germany included school closures in early March 2020. After reopening in April, preventive measures were taken in schools. We analysed national surveillance system data on COVID-19 school outbreaks during different time periods. After reopening, smaller outbreaks (average: 2.2/week) occurred despite low incidence in the general population. School closures might have a detrimental effect on children and should be applied only cautiously and in combination with other measures.

As part of the containment activities for the coronavirus disease (COVID-19) pandemic, Germany's federal states declared closure of primary and secondary schools on 16 March 2020. Within 3 days, schools in all federal states closed except for Saxony and Hesse where schools remained open for students who could not be cared for at home. However, no regular teaching was delivered. Limited reopening of secondary schools was approved on 20 April 2020. Primary schools offered reduced teaching hours only for final year students starting on 4 May 2020 and remained closed for other grades until the end of the summer break. After schools partially reopened, non-pharmaceutical interventions to reduce transmission were decided by each federal state individually [1]. From 22 June 2020, the summer break period started. As the date of the summer break varies from state to state, there was no time period after reopening when all schools were closed again in all states at the same time.

Since closing schools is a severe disruption of children's education [2] it is crucial to better understand the occurrence of school outbreaks during the pandemic as well as the impact of mitigation measures. The aim of our work was to describe COVID-19 school outbreaks in Germany during different periods of the pandemic to provide insights on the possible impact of school closures.

Data source and management

We analysed data on mandatory notifications of laboratory-confirmed COVID-19 infections from the national surveillance system from 28 January 2020 until 31 August 2020. Laboratory confirmation requires detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) nucleic acid by PCR or culture isolation of the pathogen. Physicians and laboratories notify the local public health authorities (PHA) who transfer data through the respective state PHA to the Robert Koch Institute (national public health institute) in Berlin. Notified COVID-19 cases are followed up by the local PHA for contract tracing, isolation, testing and, if applicable, outbreak investigation. All school outbreaks or outbreaks in other settings linked to a school outbreak were analysed if two or more cases were reported for one school outbreak.

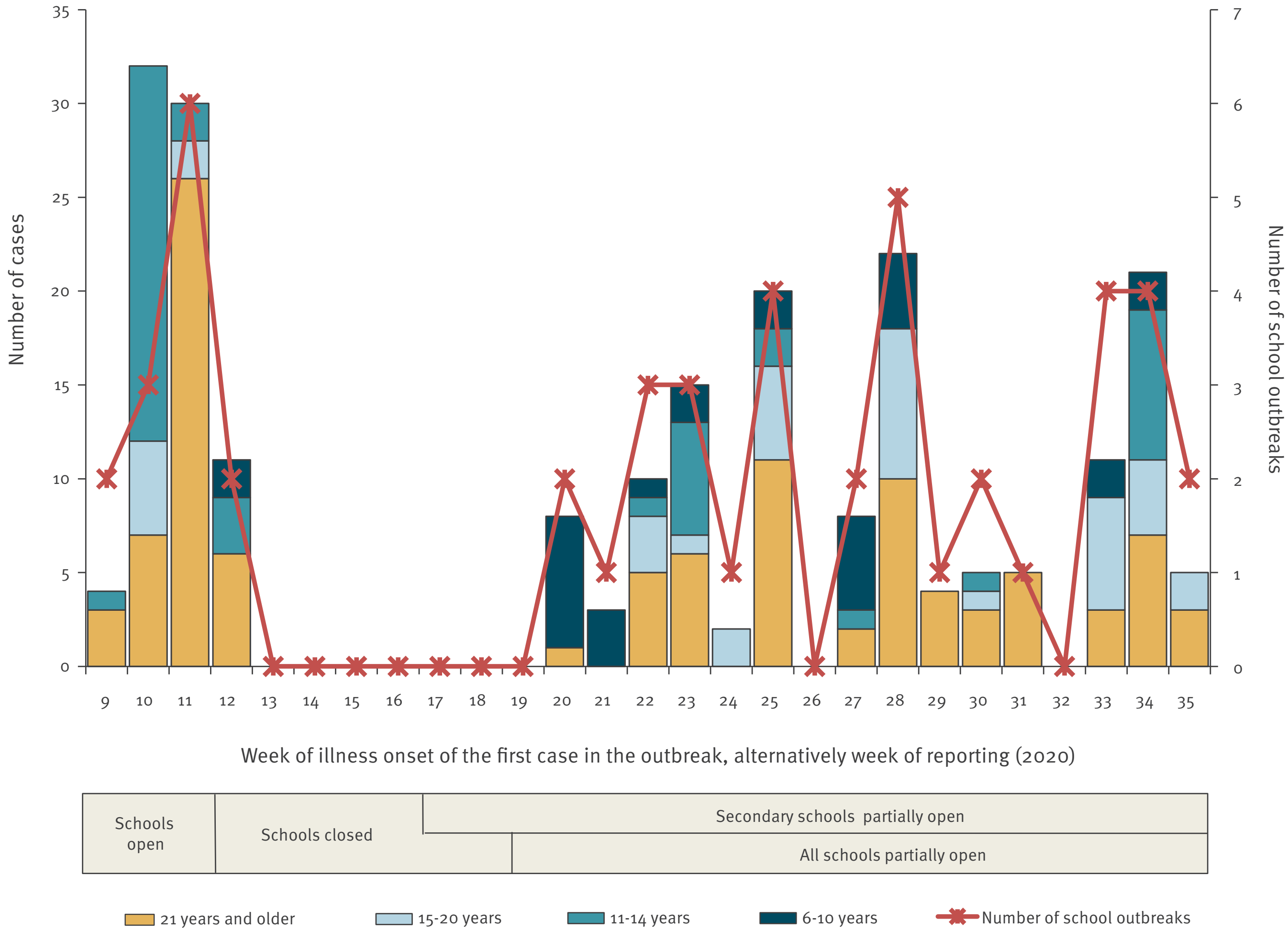
Since school education in Germany usually includes children 6 years and older, we excluded nine cases who were younger than 6 years, one case with unknown age and one outbreak that only had a case younger than 6 years and a 21-year-old case. We considered school outbreak cases up to 20 years of age as students. Except for vocational schools where students of different age groups can attend the same class, we assumed an age range of up to 2 years per school outbreak to represent same grades.

School outbreaks in relation to school closures

Since the start of the COVID-19 pandemic and until 31 August 2020, 8,841 COVID-19 outbreaks comprising a total of 61,540 cases with documentation of the infection setting have been reported; 48 (0.5 %) of these outbreaks occurred in schools and included 216 cases. Almost half of the 216 cases occurred among persons 21 years and older (n = 102) followed by 45 cases among 11–14-year-old children, 39 cases among students aged 15–20 years and 30 cases among children aged 6–10 years.

Figure

Number of school outbreaks (n = 48) and number of laboratory-confirmed COVID-19 cases (n = 216) by age and week of illness onset of the first case in the outbreak, Germany, 28 January–31 August 2020



COVID-19: coronavirus disease.

If data of illness onset were not available (n = 7), week of notification was used.

Data source: mandatory notifications of laboratory-confirmed COVID-19 infections from the German national surveillance system. Outbreaks that occurred during the observation period but reported after 31 August 2020 are not included.

Before schools were closed, school outbreaks were reported in every week, peaking in week 11 (six outbreaks) with a total of 30 of 216 cases and most cases reported in the age group 21 years and older (Figure). After all schools had been at least partially reopened for 1 week (week 20), outbreaks were reported in every week except for 2 weeks. The highest number of outbreaks (five) was reported in week 28, including 22 cases. Overall, the weekly number of outbreaks was lower during the period when the schools were partially open. The difference between the period before school closure and after reopening was small for the average number of outbreaks per week (Kruskal–Wallis p = 0.44) and the average number of cases per outbreak (Kruskal–Wallis p = 0.48). On average 2.2 outbreaks per week and four cases per outbreak were reported after schools reopened. Before school closures were implemented, an average of 3.3 outbreaks per week and six cases per outbreak were reported.

Frequency of symptoms

Clinical data were available for 175 (81%) laboratory-confirmed COVID-19 cases associated with school outbreaks and for 18 of 30 in the youngest age group (Table 1). The proportion of cases with clinical data among the other age groups was similar. Among the 18 cases aged 6–10 years, data on symptoms compatible with COVID-19 were reported for only four. Local PHA reported symptoms suggestive of COVID-19, respectively, for 29 of 37 and for 80 of 90 cases with available clinical data in the group 11–14 years and 21 years and older, whereas such symptoms were reported for only 18 of 30 in the age group 15–20 years.

Table 1

Number and percentage of laboratory-confirmed COVID-19 cases for whom clinical data were collected with symptoms suggestive of COVID-19, overall and by age group, Germany, 28 January–31 August 2020 (n = 216)

	Total		Age groups (years)							
			6–10		11–14		15–20		≥ 21	
	n	%	n	%	n	%	n	%	n	%
Number of cases	216	100	30	100	45	100	39	100	102	100
No clinical data available[a]	41	19	12	40	8	18	9	23	12	12
Clinical data available[b]	175	81	18	60	37	82	30	77	90	88
Cases for whom clinical data were collected[b] …	175	100	18	100	37	100	30	100	90	100
… without symptoms suggesting COVID-19	44	25	14	78	8	22	12	40	10	11
… with symptoms suggesting COVID-19	131	75	4	22	29	78	18	60	80	89

COVID-19: coronavirus disease.

[a] Can include asymptomatic cases or cases for whom no clinical data were collected.

[b] Can include asymptomatic or symptomatic cases with symptoms suggestive of COVID-19 or with symptoms suggestive of diseases other than COVID-19.

Data source: mandatory notifications of laboratory-confirmed COVID-19 infections from the national surveillance system.

Age distribution and linkage to other settings

Five school outbreaks were linked to outbreaks in other settings (Table 2). Two school outbreaks in week 21 and 34 were each linked to an outbreak in a household and two school outbreaks were related to three household outbreaks each. Outbreak number 20 was connected to outbreaks in four different settings.

For 10 of 48 school outbreaks, only cases in the age group 21 years or older were reported. In outbreaks that included cases younger than 21 years, the same grade was affected in 29 of the 48 outbreaks. Except for vocational schools, we observed two outbreaks affecting more than one grade during the period before school closure. After schools reopened partially, nine outbreaks included student cases from different grades. The largest number of cases per outbreak occurred in outbreak number 5 before any mitigation measures were implemented, with 20 cases in students aged 13 to 14 years and five cases among people 21 years or older.

Discussion

By analysing data from Germany's national surveillance system on laboratory-confirmed COVID-19 cases we could show that COVID-19 outbreaks in schools did occur. Most school outbreaks had few cases per outbreak, with more cases among older age groups who could have been staff or other persons epidemiologically linked to school outbreaks. In a minority of school outbreaks we could also find links to outbreaks in other settings, mostly within households, and our data suggest that mostly the same grades in a school were affected. In addition, albeit based on small numbers, we provided estimates of the proportion of symptomatic cases by age indicating that only a small proportion of primary school children were symptomatic.

Non-pharmaceutical interventions and hygiene measures applied after reopening of schools included opening schools for specific grades, staggering timetables, alternating between remote and on-site teaching, restricting class sizes, enhanced hand hygiene, wearing face masks, keeping distance between persons, ventilation of rooms as well as respiratory etiquette and policies for sick students and staff to stay at home [1]. When schools reopened, the incidence of COVID-19 in the general population was low and there was no community transmission [3]. Despite the low-incidence period and enhanced hygiene measures implemented in schools, school outbreaks occurred. The average number of outbreaks and of cases per outbreak was smaller after schools reopened than before school closure, suggesting that containment measures implemented in schools may have some protective effect. However, in some federal states, schools were closed again for summer break from June 2020 onwards, and our data show only weak evidence for a difference between the period before school closure and after reopening.

Our data were collected during outbreak investigations including testing of contacts. This allowed us to estimate the proportion of symptomatic infections among secondary cases, suggesting that four of 18 cases in children aged 6–10 years were asymptomatic. Our result is in agreement with available evidence that children with confirmed COVID-19 are less likely to be symptomatic than older age groups [4]. However, other studies reported asymptomatic proportions among children at around 20% [5-8]. One reason for this difference may be that the number of cases in this age group was small in our analysis and these studies. In addition, our students may have been presymptomatic during testing and for 12 of 30 6–10-year-olds, clinical data were not reported. It is possible that some of these may have been symptomatic cases. Overall, we estimated that 44 of 175 of the cases did not report any symptoms

Table 2

Number and age of laboratory-confirmed COVID-19 cases, connection to outbreaks in other settings, by week of illness onset of the first case in a school outbreak[a], Germany, 28 January–31 August 2020 (n = 216)

Outbreak[b] number	Week of illness onset[a]	Number of cases reported	Age		Other setting linked to school outbreak
			< 21: in years (n)	n ≥ 21	
1	9	2	13 (1)	1	None
2	9	2	0	2	None
3	10	5	15 (1), 16 (1), 17 (1)	2	None
4	10	2	19 (2)	0	None
5	10	25	13 (13), 14 (7)	5	None
6	11	5	0	5	None
7	11	4	0	4	None
8	11[c]	11	20 (1)	10	None
9	11	3	13 (1), 14 (1)	1	None
10	11	2	0	2	None
11	11	5	17 (1)	4	None
12[d]	12	3	12 (2)	1	None
13[d]	12	8	8 (1), 10 (1), 12 (1)	5	None
School closure 16–18 March to 20 April 2020 (calendar weeks 12 to 17)					
14	20	4	7 (2), 8 (1), 10 (1)	0	None
15	20	4	8 (2), 10 (1)	1	None
16	21	3	10 (3)	0	Household
17	22	5	17 (1)	4	None
18	22	2	15 (1), 16 (1)	0	None
19	22	3	10 (1), 12 (1)	1	None
20	23	3	8 (1), 13 (1)	1	Household, accommodation, kindergarten, workplace
21	23	4	14 (1), 15 (1)	2	None
22	23	8	6 (1), 11 (1), 12 (1), 13 (2)	3	None
23	24	2	17 (1), 18 (1)	0	None
24	25	2	12 (1), 13 (1)	0	Household, household, household[e]
25	25	2	0	2	None
26	25[c]	9	17 (1), 18 (1), 20 (2)	5	None
27	25	7	6 (1), 10 (1), 17 (1)	4	None
28	27	2	10 (1), 11 (1)	0	Household, household, household
29	27	6	10 (4)	2	None
30	28	5	15 (1), 17 (1), 18 (1)	2	None
31	28	2	0	2	None
32	28	5	7 (1), 8 (1)	3	None
33	28	3	6 (1), 7 (1)	1	None
34	28[c]	7	16 (2), 17 (1), 18 (1), 19 (1)	2	None
35	29	4	0	4	None
36	30	2	0	2	None
37	30	3	11 (1), 15 (1)	1	None
38	31	5	0	5	None
39	33	2	17 (1), 18 (1)	0	None
40	33	2	10 (2)	0	None
41	33	5	15 (4)	1	None
42	33	2	0	2	None
43	34	9	12 (1), 13 (3), 17 (3), 19 (1)	1	Household[f]
44	34	8	12 (1), 13 (1)	6	None
45	34	2	7 (1), 8 (1)	0	None
46	34	2	11 (2)	0	None
47	35	3	17 (1)	2	None
48	35	2	19 (1)	1	None

COVID-19: coronavirus disease.
[a] Alternatively by week of reporting (n = 7).
[b] An outbreak was defined as at least two cases reported by a local public health authority for the same school.
[c] Vocational school where students might attend teaching only on 2 days per week.
[d] The reported day of illness onset of the first case was 16 March 2020 in both outbreaks.
[e] Further events are associated with this outbreak.
[f] This household outbreak had only one case. Reasons for an outbreak with one case could be contact tracing management or that secondary cases were attributed to another outbreak.
Data source: mandatory notifications of laboratory-confirmed COVID-19 infections from the national surveillance system.

suggestive of a SARS-CoV-2 infection. This might be an underestimation as cases for whom no clinical data were available could have been asymptomatic.

There is some indication that transmission occurred within a school. As the number of student cases of the same grade was 25 in outbreak number 5, it is unlikely that no transmission occurred between students. Moreover, in some outbreaks, more than one grade was affected. However, considering class sizes of usually 20 to 25 students per class [9] the low number of cases in each age year suggests rather limited onward transmission within classes. In addition, the very small proportion of school outbreaks among all COVID-19 outbreaks in Germany suggests that schools have not been severely affected. This is in line with a report of COVID-19 school outbreaks in the European Union and European Economic Area region and the United Kingdom stating that only few COVID-19 school outbreaks have been documented [4]. On the other hand, a report from Israel on a major COVID-19 school outbreak indicated considerable SARS-CoV-2 transmission in a school after opening [10]. However, the class size in that school was larger (35–38 students per class) than average class sizes in Germany, and the Israeli outbreak coincided with a heat wave that may have negatively impacted on compliance with wearing face masks or other preventive measures.

There are some limitations to our analysis. Outbreaks, particularly in primary schools, may have been difficult to detect because the children may have been asymptomatic. On the other hand, if major onward transmission had occurred, larger outbreaks with spillover to older age groups would probably have been detected. Household outbreaks epidemiologically linked to schools are not always reported as linked outbreaks or as outbreaks at all. Moreover, we did not know in which class a student had been and can therefore not exclude that cases of similar age may had been in parallel classes. In addition, as the period of reopening schools coincided with relaxing measures in other settings, it is difficult to assess the impact of school reopening on transmission dynamics within a school.

Conclusion

Only few and mostly small COVID-19 school outbreaks had been reported in Germany overall, suggesting that the containment measures are sufficient to reduce spillover into the community.

While schools remain open, well-designed evaluations of the preventive measures are needed to assess effectiveness in terms of reducing SARS-CoV-2 transmission and to guide future decision-making during the COVID-19 pandemic. Moreover, school openings should be accompanied by developing surveillance capability and the ability to rapidly test, trace and isolate suspected COVID-19 cases and their contacts. To avoid detrimental effects on children, school closures should be applied only cautiously and in combination with other control measures.

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Conflict of interest

None declared.

Authors’ contributions

EOiK conceptualised the manuscript, contributed to data analysis and drafted the manuscript. ASL analysed the data. WH initiated the idea of this paper and advised on the analysis. SB and UB contributed to the interpretation of the data. All authors contributed to manuscript conceptualisation, critically revised the manuscript and approved the final version of the manuscript.

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Rapid communication

Transmission of SARS-CoV-2 in children aged 0 to 19 years in childcare facilities and schools after their reopening in May 2020, Baden-Württemberg, Germany

J Ehrhardt[1,2] , A Ekinci[1,2,3] , H Krehl[1,3] , M Meincke[1,4] , I Finci[1,5] , J Klein[1] , B Geisel[6] , C Wagner-Wiening[1] , M Eichner[7] , SO Brockmann[1]

1. Department of Health Protection and Epidemiology, Baden-Wüerttemberg State Health Office, Stuttgart, Germany
2. These authors contributed equally
3. Project Containment Scouts, Federal Office of Administration, Cologne, Germany
4. Postgraduate Training for Applied Epidemiology (PAE), Robert Koch-Institute Berlin, Germany
5. European Programme of Intervention Epidemiology Training (EPIET), Stockholm, Sweden
6. Department of Hygiene and Infection Control, Baden-Wüerttemberg State Health Office, Stuttgart, Germany
7. Institute for Clinical Epidemiology and Applied Biometry, University of Tübingen, Germany

Correspondence: Stefan O. Brockmann (stefan.brockmann@rps.bwl.de)

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We investigated data from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infected 0–19 year olds, who attended schools/childcare facilities, to assess their role in SARS-CoV-2 transmission after these establishments' reopening in May 2020 in Baden-Württemberg, Germany. Child-to-child transmission in schools/childcare facilities appeared very uncommon. We anticipate that, with face mask use and frequent ventilation of rooms, transmission rates in schools/childcare facilities would remain low in the next term, even if classes' group sizes were increased.

To gain further understanding on paediatric transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the school/childcare-facility context, we compiled and analysed data from SARS-CoV-2 infected children (age: 0–19 years), who had been to school/childcare facilities, after such establishments reopened in Baden-Württemberg in May 2020.

Reopening of schools/childcare facilities in Baden-Württemberg

Closure of schools and childcare facilities was part of the German national response and containment strategy of SARS-CoV-2, like in most other European Union countries [1]. In the federal state of Baden-Württemberg in south-west Germany, which has a population of 10.8 million, school and childcare facility closures were mandated on 17 March 2020. From that time, some emergency childcare facilities were nevertheless established for children whose parents both worked in essential services. On 27 April, they were extended to children of persons who could not work from home; for all others, childcare facilities finally reopened on 29 June. Concerning schools, almost 2 months after closing, these reopened in a stepwise manner, beginning on 4 May with the graduating classes of secondary schools, followed on 18 May by the graduating classes of primary schools, and finally, on 15 June, by all remaining classes. The reopening of schools and childcare facilities was accompanied by a series of measures to prevent the spread of SARS-CoV-2 (Table 1).

Data source, study period and epidemiological investigation

To assess the viral transmission role of SARS-CoV-2-infected children who attended schools and childcare facilities after their reopening, we searched all notified (i.e. laboratory-confirmed) coronavirus disease (COVID-19) cases from the state of Baden-Württemberg. Data on all cases aged 0–19 years in the period from 25 May to 5 August 2020 (i.e. from 1 week after school opening in May until 1 week after school closure due to the summer holidays; Figure 1) were compiled.

We contacted the notifying local health offices and reinvestigated school-attendance during the presumed infectious period of these cases, which was according the national standards of the Robert Koch Institute assumed to start 2 days before the onset of symptoms or, in case of an asymptomatic infection, 48 hours before the sampling date of the positive test result [2]. Upon identifying cases, the local health offices had initiated thorough contact investigations in the schools and childcare facilities respectively.

Ethical statement

This analysis was conducted as part of public health usual practice, and was not conducted for research. Ethics approval was, therefore, not needed.

TABLE 1

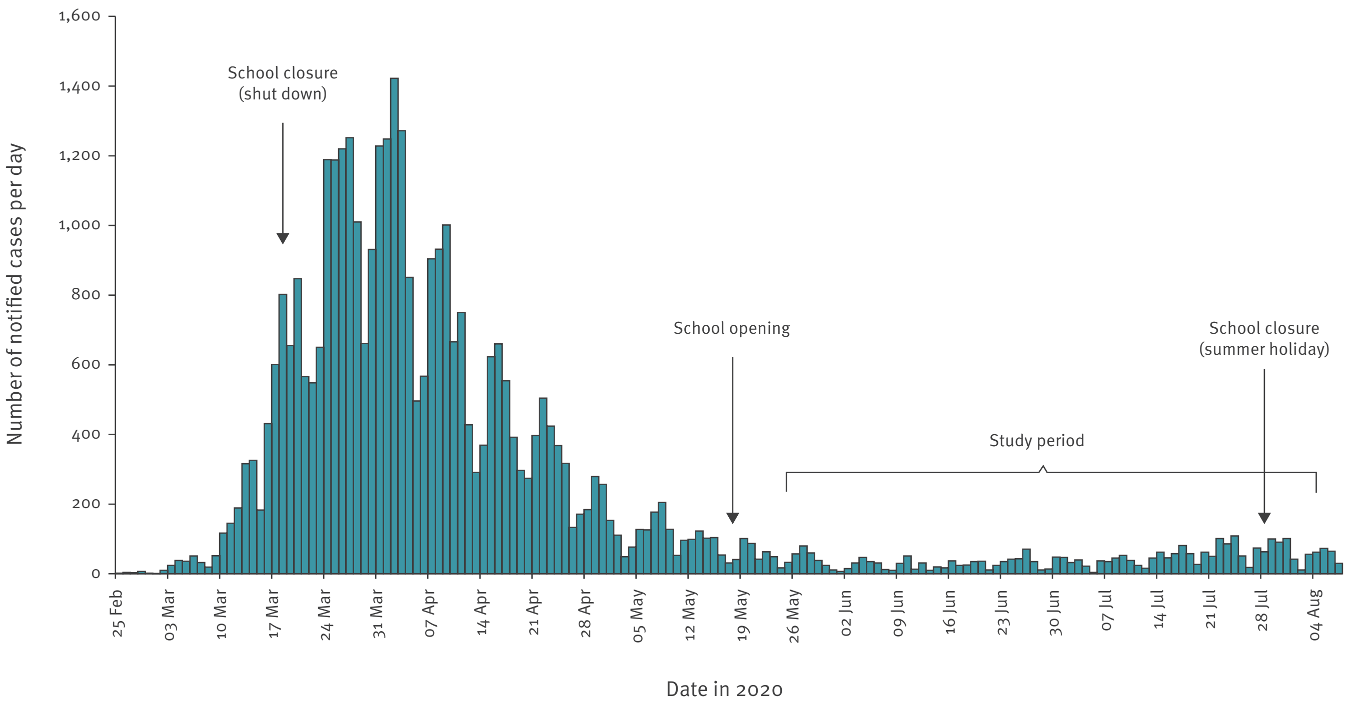
Infection control measures for the prevention of SARS-CoV-2 transmission in schools and childcare facilities in Baden-Württemberg, Germany, May–July 2020

Infection control measure	Childcare facilities	Primary school	Secondary school[a]
Group sizes reduced by 50%	Yes	Yes	Yes
Cleaning of contact surfaces	Yes	Yes	Yes
Regular and interim ventilation of rooms	Yes	Yes	Yes
Exclusion of sick children	Yes	Yes	Yes
Individual hygiene (hand hygiene, cough etiquette)	Yes	Yes	Yes
Face mask in classroom	No	No	No
Face mask outside classroom	No	Some	Some
Physical distancing between children	No	No	Yes
Cancelling singing and use of wind instruments during music lesson	Some	Yes	Yes
Cancelling physical education	NA	Yes	Yes

NA: not applicable; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.
[a] Including vocational school.
White backgrounds indicate measures which will remain unchanged after reopening following the 2020 summer holidays; light blue backgrounds indicate measures that will be cancelled after the 2020 summer holidays; dark blue backgrounds indicate measures that will be established (mask outside classroom) or should be established in the authors' opinion (ventilation and mask in classrooms).

FIGURE 1

Daily number of notified COVID-19 cases in Baden-Württemberg, by date of reporting, Germany, 25 February–07 August 2020 (n = 37,752)

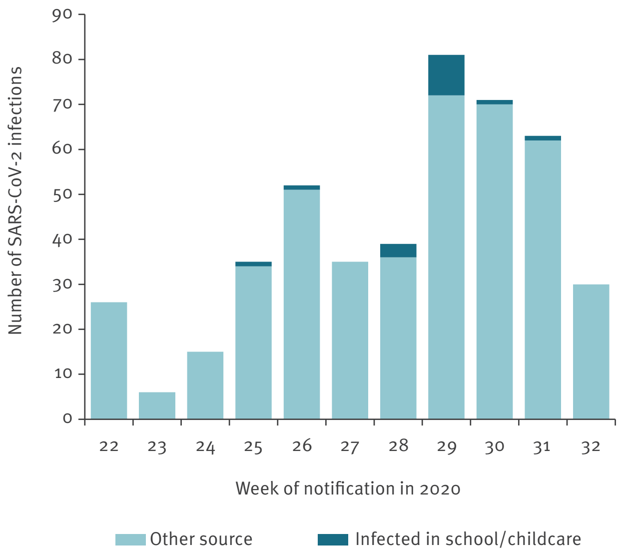


COVID-19: coronavirus disease.

Arrows show the dates of school closing and opening. The bracket indicates the study period, from 1 week after schools had completely reopened (25 May 2020) to 1 week after the beginning of summer holiday (5 August 2020).

Figure 1

Weekly number of notified SARS-CoV-2 infections in the age group 0–19 years by source of infection, Baden-Württemberg, Germany, 25 May–2 August 2020 (n = 453)



SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

Cases infected in school/childcare are shown in dark blue, cases infected by other sources in light blue.

Table 2

Source of SARS-CoV-2 infection in persons aged 0–19 years, Baden-Württemberg, Germany, 25 May–5 August 2020 (n = 453)[a]

Setting/source of infection	Number of infected persons	Percentage
Household	190	41.9%
Parents	93	NA
Grandparents	13	NA
Siblings	7[b]	NA
Not specified	77	NA
Festivity/event[c]	38	8.4%
School/childcare	15	3.3%
By pupil	11	NA
By teacher	4	NA
Church/community of faith	14	3.1%
Travel associated	5	1.1%
Others	4	0.9%
Unknown or not available[d]	187	41.3%

NA: not applicable; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

[a] Of the 557 children aged 0–19 years who were notified with SARS-CoV-2 infection, data on school attendance were available for 453. Information on these 453 children is presented in the table.

[b] Seven children infected in three intra-household clusters.

[c] Birthdays and other parties, weddings, funerals.

[d] As close contacts of the cases were thoroughly examined, it is unlikely that cases in the 'unknown' category were infected in childcare facilities, schools or private households.

Cases and transmission events in schools and childcare settings

In total, 557 cases of age 0–19 years were notified during the study period in Baden-Württemberg (17.9% of all 3,104 notified cases) and for 453 (81.3%) information on school attendance was available; 137 (30%) of these 453 cases attended school or childcare settings for at least 1 day in their infectious period whereas the remaining 316 were at home during their entire infectious period. More than 2,300 nasopharyngeal swabs were taken from the close contacts (teachers and pupils) of the 137 index cases, and from the close contacts of any secondary cases, if identified. Swabbing usually occurred 3 to 5 days after the index cases' diagnosis. Six of the 137 cases were found to have infected a total of 11 additional pupils (one to three pupils per case; see Figure 2; three in childcare facilities, one in primary school, four in secondary school and three in vocational school), whereas no secondary infections could be detected for the remaining cases despite extensive contact tracing and swabbing of school and childcare-facility contacts. To the best of our knowledge, aside from the 11 secondary cases and another four pupils who were infected by two teachers, all remaining cases with information on school attendance (n = 437) were caused by sources outside of school and childcare facilities (Table 2).

Assuming that every one of the 137 index cases spent on average 2 days at school during the infectious period, the 11 secondary cases originated from a cumulative number of 274 infectious days, i.e. one secondary case per roughly 25 infectious school days.

Discussion and conclusion

There is an ongoing discussion in the scientific community regarding the role of children in the transmission of SARS-CoV-2. Recently, the percentage of children and adolescents up to 19 years old among all COVID-19 cases in Germany has increased to 25% [3]. Infected children are more likely to remain asymptomatic or have a mild course of disease and are much less likely than adults to be hospitalised or have fatal outcomes. Thus, their infection may go undetected or undiagnosed. Symptomatic children seem to shed virus in similar quantities as adults and can infect others in a similar way, but it is unknown how infectious asymptomatic children are [1,4,5].

Our investigation suggests that child-to-child transmission in schools and childcare facilities is uncommon and not the primary cause of SARS-CoV-2 infection in children. Based on our estimation there could be one secondary case per roughly 25 infectious school days. This ratio of 1 in 25 might, however, overestimate the transmission risk in schools and childcare facilities, because some of the 104 index cases (i.e. 104 = 557 – 453) for whom no information on school attendance was available, may also have spent some time in school or in a childcare facility while being infectious, yet without further generating any notified COVID-19 cases. While investigations from Ireland concur with our results [6], a report from Israel showed a large outbreak in apparently over-crowded schools where face-mask usage had been discontinued due to a heat wave [7].

The low transmission in schools and childcare facilities found in this current study might be due in part to the infection control measures initiated after school/childcare-facility reopening, yet it is not clear how much the different measures have contributed. In order to gradually return to the regular school and childcare-facility life, larger classes will have to be accepted again. This will require more proximity between pupils. As a countermeasure, strict ventilation of classrooms, not only between lessons but also within, should be implemented [1]. Additionally, face masks should be used in schools, both, inside and outside of classrooms. Based on our current study findings, we anticipate that transmission rates in schools and childcare facilities would remain low under such interventions [8].

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Conflict of interest

None declared.

Authors' contributions

SB, JE, BG, CW and ME designed the study. JE, AE, HK, MM, IF, JK, BG and CW contributed to the acquisition of the data. SB, ME, JE, AE analysed the data. SB, ME, JE, HK and MM interpreted the data. All authors revised the manuscript and approved the final version.

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Rapid communication

A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020

Chen Stein-Zamir[1,2] , Nitza Abramson[1] , Hanna Shoob[1] , Erez Libal[3] , Menachem Bitan[4] , Tanya Cardash[5] , Refael Cayam[6] , Ian Miskin[3]

1. Jerusalem District Health Office, Ministry of Health, Jerusalem, Israel
2. The Hebrew University of Jerusalem, Faculty of Medicine, Braun School of Public and Community Medicine, Jerusalem, Israel
3. Clalit health services, Jerusalem District, Jerusalem, Israel
4. Meuchedet health services, Jerusalem District, Jerusalem, Israel
5. Maccabi Healthcare services, Jerusalem and Shfela Region, Israel
6. Leumit Health Services, Jerusalem District, Jerusalem, Israel

Correspondence: Chen Stein-Zamir (chen.zamir@lbjr.health.gov.il)

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On 13 March 2020, Israel's government declared closure of all schools. Schools fully reopened on 17 May 2020. Ten days later, a major outbreak of coronavirus disease (COVID-19) occurred in a high school. The first case was registered on 26 May, the second on 27 May. They were not epidemiologically linked. Testing of the complete school community revealed 153 students (attack rate: 13.2%) and 25 staff members (attack rate: 16.6%) who were COVID-19 positive.

As part of the coronavirus disease (COVID-19) pandemic containment measures, Israel's government declared complete closure of all educational facilities on 13 March 2020. Limited schools reopening (kindergartens, grades 1–3 and 11–12) only in small groups was approved on 3 May 2020. Subsequently, all school classes reopened on 17 May 2020, with requirement for daily health reports, hygiene, facemasks, social distancing and minimal interaction between classes. Ten days later, the first major COVID-19 school outbreak in Israel emerged in a high school. The first case was registered on 26 May and the second on 27 May. The two cases were not epidemiologically linked. Testing of the complete school community revealed 153 students (attack rate: 13.2%) and 25 staff members (attack rate: 16.6%) who were COVID-19 positive. Overall, some 260 persons were infected (students, staff members, relatives and friends). In this report, we aim to describe the investigation and epidemiological characteristics of the school's outbreak.

Outbreak description and epidemiological investigation

School 1 is a regional public school; students arrive from suburbs and neighbourhoods, by public or school bus. It contains 1,190 students aged 12–18 years (grades 7–12) and 162 staff members. The school reopened after 2 months' closure on Monday, 18 May 2020. Students returned to their previous classrooms and received instructions on preventive procedures. On 19–21 May (Tuesday to Thursday), an extreme heatwave occurred. Hence, the Ministry of Health exempted schoolchildren from facemasks for these 3 days.

The first COVID-19 case (Student A) was notified on 26 May 2020. The source of infection was unknown. Close contacts from household (n = 4), students (n = 50) and teachers (n = 14) were instructed to self-isolate. The second case (Student B) was notified on 27 May 2020. According to the epidemiological investigation, both students attended school during the days of 19–21 May and reported mild symptoms (anosmia, ageusia, fever and headache). They were from different grades and were not epidemiologically linked.

With the emergence of two unrelated cases within 2 days, the district health office declared an 'outbreak status' including school closure, isolation instructions and testing of the school community. During that long weekend (a Jewish holiday, 28–30 May 2020), mass COVID-19 testing was conducted as a joint effort of the school leadership and community, the four Health Funds, Magen David Adom (national emergency services organisation), the local municipality and the district health office.

Ten teachers and 26 students who had not attended school since reopening were excluded. Most of the remaining school community was tested, 151 of 152 staff members and 1,161 of 1,164 students. Overall, 153 students and 25 staff members were confirmed as COVID-19-positive. The data from the epidemiological investigation are shown in the Table. The COVID-19 rates differed between groups. Male cases were slightly overrepresented. The rate of cases reporting symptoms, upon meticulous questioning, was 43%

Table

Epidemiological investigation data, COVID-19 outbreak, Israel, May 2020 (n = 1,316[a])

Group	Number of persons	Number tested	Males		Confirmed cases		Males, of confirmed cases		Median age in years (cases)	Symptoms	
			n	%	n	Rate (%)	n	%		n	%
7th grade	197	197	106	53.8	40	20.3	25	62.5	13	19	47.5
8th grade	197	197	102	51.8	34	17.3	19	55.9	14	15	44.1
9th grade	187	187	94	50.3	61	32.6	32	52.5	15	30	49.2
10th grade	200	200	110	55.0	9	4.5	6	66.7	16	2	22.2
11th grade	195	194	98	50.5	6	3.1	3	50.0	17	0	0
12th grade	188	186	87	46.8	3	1.6	1	33.3	18	0	0
All students	1,164	1,161	597	51.4	153	13.2	86	56.2	15	66	43.1
Staff	152	151	51	33.8	25	16.6	9	36.0	40	19	76

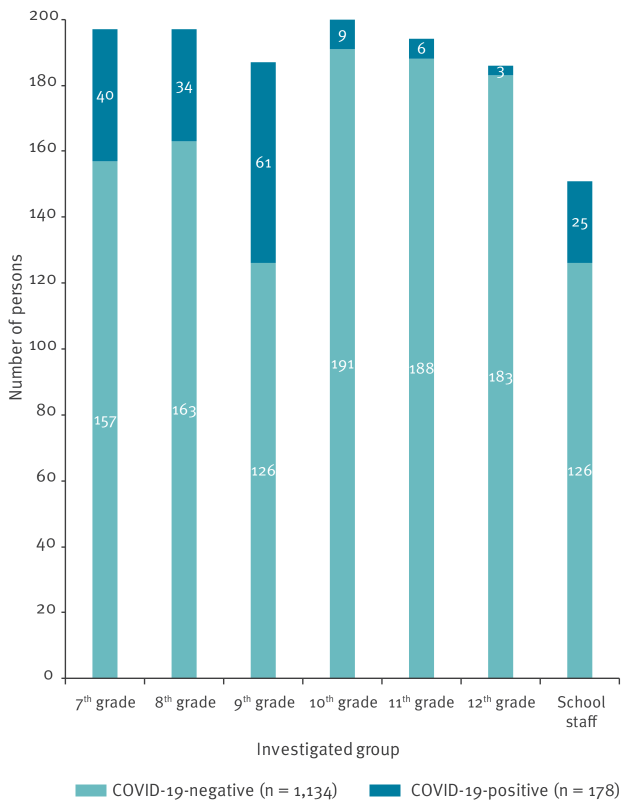
COVID-19: coronavirus disease.

[a] Overall 1,312 members of the school community were tested: 1,161 students and 151 staff.

(66/153) among students and 76% (19/25) among staff. The leading symptoms reported were cough, headache, fever, sore throat and myalgia. One emergency room visit was recorded and no hospitalisations.

Figure 1

Results of COVID-19 testing, school outbreak, Jerusalem, May 2020 (n = 1,312)



COVID-19: coronavirus disease.

COVID-19 rates were higher in junior grades (7–9) than in high grades (10–12) (Figure 1). The peak rates were observed in the 9th grade (20 cases in one class and 13 cases in two other classes) and the 7th grade (14 cases in one class). Of the cases in teachers, four taught all these four classes, two taught three of the four classes and one taught two of these four classes.

An environmental school inspection reported crowded classes: 35–38 students per class, class area 39–49 m², allowing 1.1–1.3 m² per student (below the 1.5 m² standard). Distancing among students and between students and teachers was not possible. Furthermore, during the extreme heatwave, air-conditioning functioned continuously in all classes. The air-conditioning system was separate for each class. The junior grades (7–9) and the high grades (10–12) are situated in one large building, yet in separate wings, and share the schoolyard and public spaces. According to the school schedule, students study 6 days (Sunday to Friday) for 38–40 h weekly (6.3–6.7 h daily on average). Daily travel time to school depends on distance and traffic conditions and lasts 20–45 min. Most students also participate in extracurricular activities such as sports teams or dance classes for an average of 2–4 h per week.

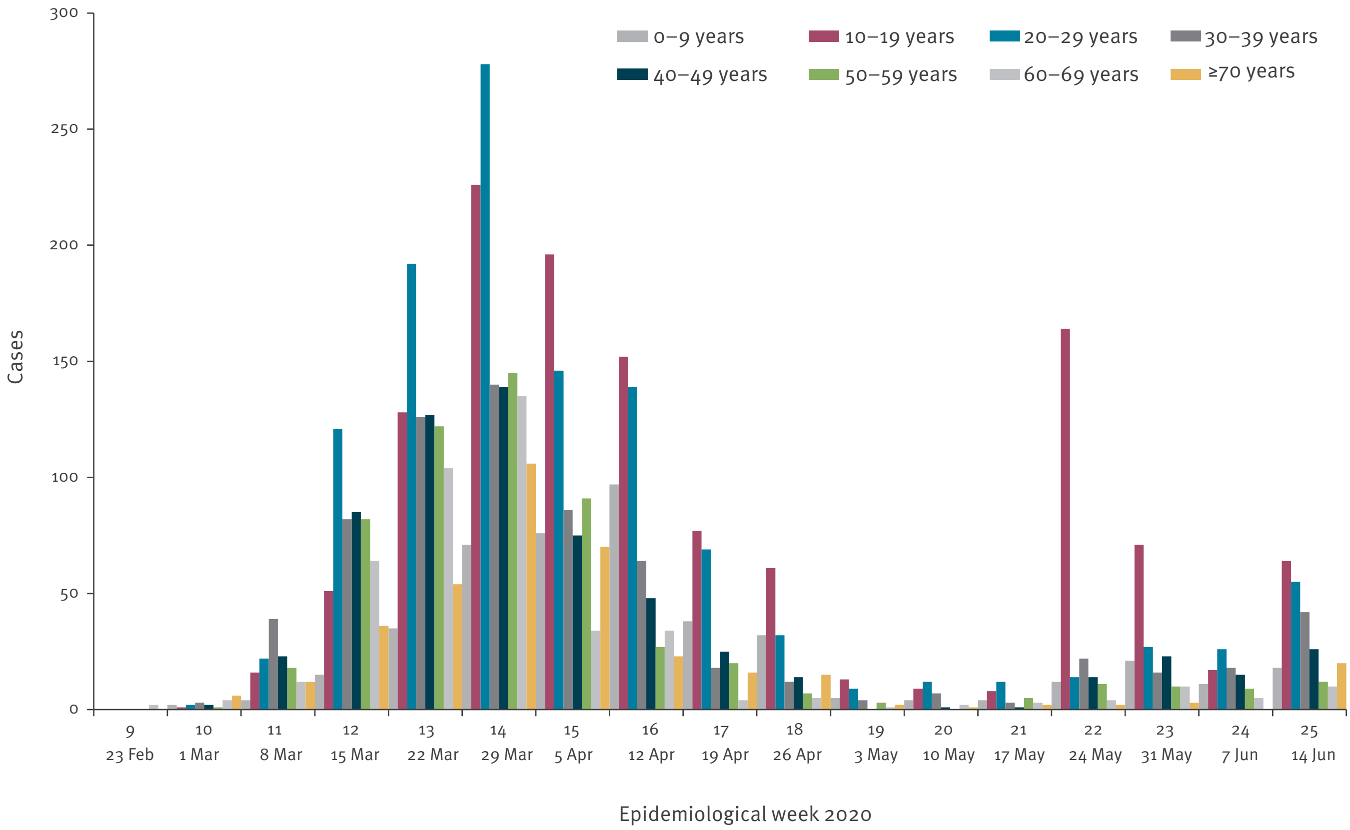
As at 30 June 2020, 100 of 153 (65.4%) students and 16 of 25 (64%) staff members have recovered (with two negative PCR results). Evaluating the recovery period revealed that 60% of asymptomatic cases recovered within 25 days vs only 37% of symptomatic cases.

Cases outside the first affected school

By mid-June 2020, 87 additional confirmed COVID-19 cases had occurred among close contacts of the first school's cases. These included siblings attending

Figure 2

COVID-19 cases, Jerusalem, February–June 2020 (n = 5,519)



COVID-19: coronavirus disease.

other schools, friends and participants in sports and dancing afternoon classes, students' parents and family members of school staff.

COVID-19 cases age distribution in the Jerusalem district

The large school outbreak led us to evaluate the age distribution of COVID-19 cases before and after schools' reopening. From week 9 to week 25 in 2020, 5,519 confirmed COVID-19 cases were reported in the Jerusalem district. As schools reopened on 17 May 2020, the evaluation point selected was 1 week later, on 24 May 2020 (week 22). The evaluation showed that before 24 May 2020, the proportion of the 10–19 years-olds (representing schoolchildren), was 19.8% (938/4,747) of cases in weeks 9–21, increasing to 40.9% (316/772) after 24 May 2020, in weeks 22–25 (Figure 2).

From week 9 to week 24 in 2020, 18,448 confirmed COVID-19 cases were reported nationally, 5,184 cases in the Jerusalem district and 13,264 cases in all the other districts in Israel, excluding Jerusalem. The age pyramid of confirmed COVID-19 cases in the Jerusalem district vs nationally (excluding Jerusalem) showed a prominence of the 10–19 years-olds in Jerusalem, 22.6% vs. 13.9% in all the other districts (Figure 3).

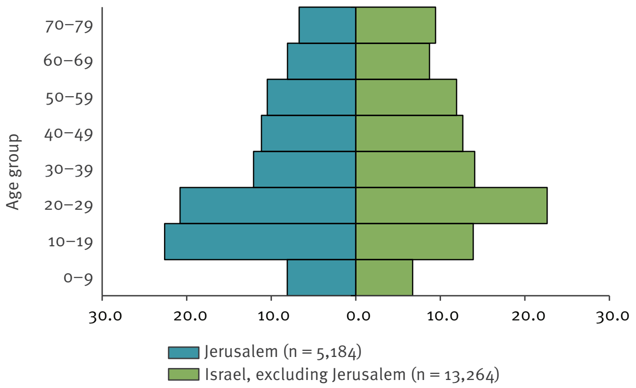
Discussion

On 27 January 2020, Israel's health minister declared COVID-19 infection a notifiable disease requiring immediate reporting. By 21 June 2020, some 20,778 confirmed COVID-19 cases had been reported with 306 fatalities [1]. Israel's population is 9.1 million (median age: 30 years) [2]. Like other countries, Israel implemented diverse containment measures including quarantine. Nationally, there are 1.7 million schoolchildren, 830,000 kindergarten children and 170,000 teachers and staff [3]. Full closure of educational facilities occurred on 13 March 2020. Elsewhere, 107 countries had implemented national school closures by 18 March 2020 [4].

COVID-19 cases are defined clinically (fever > 38 °C, cough, respiratory illness etc.) and epidemiologically. Laboratory confirmation requires detection of SARS-CoV-2 nucleic acid by PCR in nasopharyngeal swabs. The district health offices perform epidemiological investigations and contact tracing and issue isolation instructions and guidance to healthcare, educational and other facilities. The Health Funds, via community clinics, follow patients, refer to hospital if necessary and provide counselling to patients and families. The Jerusalem health office serves 1.25 million residents

Figure 3

Age distribution of COVID-19 cases, Israel, May 2020 (n = 18,448)



COVID-19: coronavirus disease.

(median age: 23.5 years), characterised by moderate to low socioeconomic status and large households [5].

The high school outbreak in Jerusalem displayed mass COVID-19 transmission upon school reopening. The circumstances promoting infection spread involved return of teenage students to their regular classes after a 2-month closure (on 18 May) and an extreme heatwave (on 19 May) with temperatures rising to 40 °C and above [6] that involved exemption from facemasks and continuous air-conditioning. Classes in the first affected school had more than 30 students. Israel's secondary school classes are crowded (average: 29 students in public schools) compared with the Organisation for Economic Cooperation and Development (OECD) average (23 students) [7]. COVID-19 in a school necessitates a prompt response. Classmates and teachers should be considered close contacts (particularly in crowded classes), as should students in groups mixing several classes, extra-curricular activities and school buses. Temporary school closure is prudent (especially in large regional schools) pending investigation results.

Most student cases presented with mild symptoms or were asymptomatic. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in children and adolescents is considered mild compared with adults. A review of 18 studies (1,065 hospitalised paediatric patients) presented overall good prognosis for that age group [8]. A Chinese study of 171 paediatric cases infected with SARS-CoV-2 reported main signs of fever, cough and pharyngitis, 16% were asymptomatic [9]. In a European multicentre study (582 children), COVID-19 was usually mild, a small fraction developed severe disease and mortality was rare [10]. In a study in New York State, Kawasaki-like disease and myocarditis have been linked to COVID-19 infection, with the condition termed multisystem inflammatory syndrome (MIS-C) in children [11]. French paediatric surveillance data also support linkage between SARS-CoV-2 infection and MIS-C [12].

The role of children and adolescents in COVID-19 spread is equivocal; epidemiological data imply insignificance of children in transmission [13]. School closure is a public health tool in influenza pandemic preparedness plans, based on high infectiousness and susceptibility in schoolchildren and high contact rates [14]. School reopening policy after the COVID-19 lockdown varies considerably between nations and therefore requires ongoing assessment [13].

Conclusions and recommendations

COVID-19 prevention in schools involves studying in small groups and minimising student mixing in activities and transportation. Teachers and parents should lead by wearing facemasks, hand hygiene, keeping physical distance etc. School attendance should be avoided at any sign of illness. Learning from home may also reduce the need for class attendance. Outdoors classes should also be considered. COVID-19 prevention encompasses avoiding the 'three Cs': closed spaces with poor ventilation, crowded places and close-contact settings [15]. The European Centre for Disease Prevention and Control's report on air-conditioning and ventilation systems and COVID-19 recommends increasing air exchange rate and outdoor air use and decreasing air recirculation, aiming to reduce spread in indoor spaces [16]. Finally, appropriate planning of COVID-19 prevention for the next school year is essential.

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Conflict of interest

None declared.

Authors' contributions

Chen Stein-Zamir, Nitza Abramson and Hanna Shoob collected data, performed the investigation and data analysis and wrote the manuscript. Erez Libal, Menachem Bitan, Tanya Cardash, Refael Cayam and Ian Miskin performed the patients' follow-up, provided data and reviewed the manuscript.

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Rapid communication

Infection prevention guidelines and considerations for paediatric risk groups when reopening primary schools during COVID-19 pandemic, Norway, April 2020

Tone Bjordal Johansen[1,2] , Elisabeth Astrup[1] , Solveig Jore[1] , Hege Nilssen[3] , Bente Barton Dahlberg[3] , Claus Klingenberg[4,5] , Are Stuwitz Berg[1] , Margrethe Greve-Isdahl[1]

1. The Norwegian Institute of Public Health, Oslo, Norway
2. European Public Health Microbiology Training Programme (EUPHEM), European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden
3. The Norwegian Directorate for Education and Training, Oslo, Norway
4. Paediatric Research Group, Faculty of Health Sciences, University of Tromsø-Arctic University of Norway, Tromsø, Norway
5. Department of Paediatrics and Adolescence Medicine, University Hospital of North Norway, Tromsø, Norway

Correspondence: Tone Bjordal Johansen (tone.johansen@fhi.no)

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In response to the coronavirus disease (COVID-19) pandemic, most countries implemented school closures. In Norway, schools closed on 13 March 2020. The evidence of effect on disease transmission was limited, while negative consequences were evident. Before reopening, risk-assessment for paediatric risk groups was performed, concluding that most children can attend school with few conditions requiring preventative homeschooling. We here present infection prevention and control guidelines for primary schools and recommendations for paediatric risk groups.

In response to the coronavirus disease (COVID-19) pandemic, 185 countries had implemented regional or national school closures by 1 April 2020, affecting 89.4% of the world's children [1]. We here present guidelines developed for the reopening of primary schools in Norway.

COVID-19 epidemic in Norway

Norway reported its first COVID-19 case on 26 February 2020. Quarantine and isolation were implemented for travellers coming to Norway from affected areas and for confirmed COVID-19 cases on 7 March, effective retroactively from 22 February. On 12 March, the government announced a series of restrictive infection control measures after a rapid increase in cases and evidence of community transmission (Figure). These included border control and a travel ban; closure of daycares, schools, universities and businesses; and a ban on mass gatherings. A strict lockdown was never imposed, but the general rule was to work from home and avoid public transportation. The population mobility dropped dramatically overnight [2,3].

On 24 March 2020, the Norwegian Institute of Public Health (NIPH) presented a risk assessment with multiple scenarios based on different target effective reproduction numbers (R_{eff}). The government decided to follow an aggressive strategy aiming for a $R_{eff} < 1$ to avoid overwhelming the healthcare system [2]. The implemented measures proved effective, reaching a R_{eff} of 0.67 by 7 April [4]. However, because of the social and economic consequences, the need to reopen parts of society became urgent.

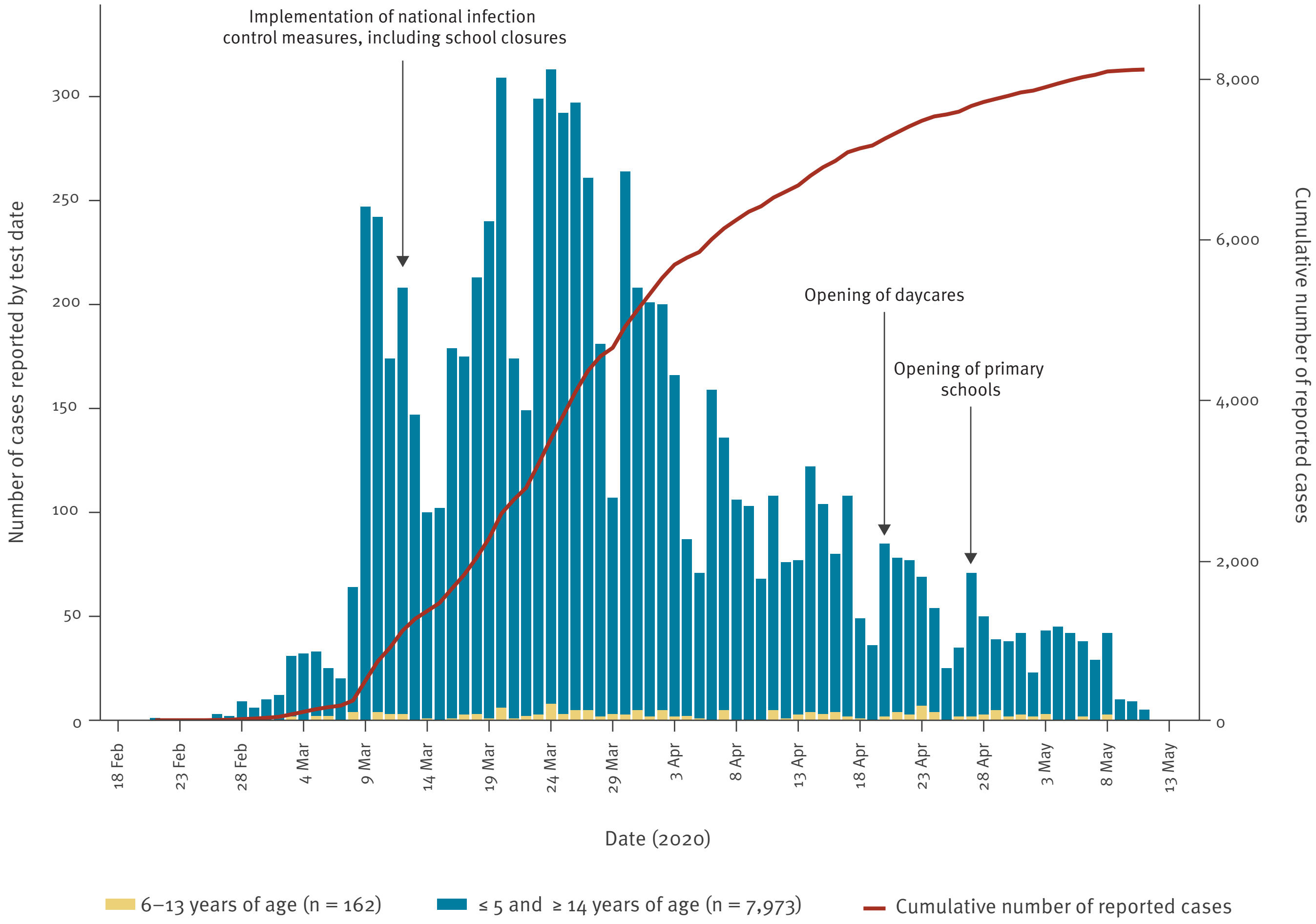
School closures and transmission of SARS-CoV-2

Evidence for the effect of school closures on disease transmission is mainly based on influenza studies. School closures are most likely to be efficient if the virus has a low reproduction number ($R < 2$) and if attack rates are higher in children than in adults [5]. However, although estimates vary widely, the R_0 of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is estimated to be between 2.2 and 3.6 [6-8]. Children are drivers for influenza transmission, but seem to contribute less to the spread of COVID-19 [5,9]. Countries where schools and daycare institutions remained open have not reported outbreaks among children, only sporadic cases [10].

In Norway, as well as globally, the proportion of children with COVID-19 has been low [9,11]. By 11 May, 8,135 COVID-19 cases were reported to the Norwegian Surveillance System for Communicable Diseases (MSIS), of which 72 (0.9%) were aged 0 to 5 years, 162 (2.0%) were aged 6 to 13 years, 341 (4.2%) were aged 14 to 19 years and 7,560 (93.0%) were over 19 years (Figure).

Figure

Number of confirmed COVID-19 cases reported to the Norwegian Surveillance System for Communicable Diseases (MSIS), Norway, 21 February–11 May 2020 (n = 8,135)



The figure illustrates number of confirmed cases reported according to test date among children 6 to 13 years of age and in the population ≤ 5 and ≥ 14 years of age, as well as the cumulative number of reported cases. Dates for implementation of infection control measures, including school closures, are illustrated.

Based on the current evidence and children's fundamental rights [12], the government announced a gradual reopening of the society, starting with children's daycares 20 April, primary school grades 1 to 4 on 27 April and higher grades (5 to 13) on 11 May. In order to help schools reopen in a secure manner, the NIPH and the Norwegian Directorate for Education and Training (NDET) were asked to develop specific infection prevention and control (IPC) guidelines. Our guidelines consist of practical IPC advice and assessment of paediatric conditions with risk of severe COVID-19 in terms of school attendance.

Guidelines for infection prevention in primary schools

The IPC guidelines were developed for primary schools (grade 1–7, children 6–13 years of age) to apply during the COVID-19 epidemic, and were nationally regulated by law [13]. However, local adaptation was encouraged with assistance of local health authorities.

We reviewed the recommendations from the United Nations Children's Fund (UNICEF), the World Health Organization (WHO) and the International Federation of the Red Cross (IFRC) [14], as well as guidelines developed by public health authorities in Canada, Denmark, the United Kingdom and United States available online [15-18]. The guidelines were all useful. However, they did not specifically address how physical distancing could best be implemented in a school setting while still securing children's need for care and to a certain extent, closer physical contact in the educational setting. Our guidelines also followed the main principles enforcing (i) self-isolation of sick children/staff, (ii) hygiene measures and (iii) physical distancing measures. In addition, schools were required to establish procedures for students or staff who develop symptoms at school. Measures for enforced hand hygiene, respiratory hygiene, cleaning and disinfection will not be further discussed here. For details, see the Supplementary Material.

Table 1

Organisation of cohorts for physical distancing in primary schools during COVID-19 pandemic, Norway, 2020

Grade (age)	Organisation
1 to 4 (6–10 years)	- As a general rule, one staff member should accompany the cohort - The cohorts should minimise changing classrooms - Within a cohort, pupils and staff can socialise and play together - Separate desks 1 m apart recommended - Cohorts should also be maintained in after-school programmes - Cohorts 1 and 2 can work together for practical reasons during the day, preferably outdoors - Staff from cohort 1 can provide relief in cohort 2, and vice versa - Cohorts 3 and 4, and so on, should be organised in a similar way - Cohorts 1 and 2 should generally not mix with cohorts 3 and 4, and so on - Cohorts that are not working together have separate areas or different time points for outdoor activities - Cohorts that are not working together can mind each other and be in the same area for short periods of time (up to 15 min) - Cohorts that are not working together can remain in the same room, provided that a distance of at least 2 m can be maintained between the cohorts over a long period of time - The composition of cohorts can be altered weekly after a weekend
5 to 7 (11–13 years)	The recommendations given above apply, in addition to the following: - Teachers can teach in different classes, but cohorts should remain in the same classroom - Cohorts should move between classrooms as little as possible - Pupils and staff within a cohort must strive to stay 1 m apart wherever possible - Consider in-school teaching combined with digital education at home

We recommended establishing smaller, fixed groups of children and employees, in this setting called 'cohorts' as the key physical distancing measure. Reduced contact with others will limit the risk of transmission from presymptomatic and asymptomatic individuals. Establishment of cohorts takes into account that adhering to physical distancing measures is difficult for children and that physical contact is important for children's development and wellbeing. The cohort strategy ensures physical distancing between cohorts while allowing children's need for care. Within cohorts, the reduced number of children compared with ordinary classes provides more space and limits the number of contacts. Normally, one cohort is present in the classroom at the time.

The cohort strategy additionally enables rapid and easy contact tracing, and reduces the need for home quarantine. The identification of contacts between pupils is of high importance for appropriate screening and implementation of preventive measures for affected families and society [19]. With good management, a positive case will only affect the cohort and not the entire school, thereby preventing full school closure.

Cohort size was based on children's age and the need for care, as well as national regulations for teacher-pupil ratios; up to 15 pupils per teacher in grades 1 to 4 and 20 pupils per teacher in grades 5 to 7. As older pupils can better comply by infection prevention measures, we suggested that groups of older pupils may be somewhat larger. The organisation of cohorts is described in Table 1.

In addition, we recommended to promote outdoor teaching, and to use larger rooms and facilities when possible. We also recommended that areas and situations with potential for crowding receive special attention regarding the possible need for additional measures to maintain distance. School assemblies, sports games and other gatherings were not advised. Other possibilities for reducing the number of pupils present were staggering the beginning and end of the school day or attendance on different days.

To support school administrators in implementing routines for IPC, we developed a checklist tool for school owners and staff (Table 2, Supplementary Material).

Recommendations for children and staff at risk for severe COVID-19

Publications on the COVID-19 pandemic report that most children develop mild disease, even those with severe underlying conditions [20-22]. The typical comorbidities

Table 2

Checklist for school administrators to ensure infection prevention and control in primary schools during COVID-19 pandemic, Norway, 2020

The school owner's overarching responsibility
Train staff regarding infection control measures
Information for parents/guardians concerning new routines at schools/after-school programmes
Prepare plan for hand washing procedures for pupils and staff
Prepare written procedure for cleaning of premises
Prepare plan for establishment and organisation of cohorts
Establish dialogue with any staff who are in a risk group and children who require special provision
Hygiene measures
Ensure sufficient soap and paper towels are available at all handwashing stations and toilets
Training of pupils in handwashing procedures and respiratory hygiene
Put up posters about handwashing procedures and respiratory hygiene
Provide alcohol-based disinfectants where no handwashing facilities are available
Plan hand hygiene measures to be applied outside or on excursions (wet wipes and alcohol-based disinfectants)
Physical distancing measures
Consider the use of rooms relative to the number of pupils in the cohorts
Plan for outdoor activities, including staggered times for different cohorts
Divide outdoor areas so that pupils from different cohorts do not mix insofar as is possible
Avoid large gatherings of pupils
Ensure that sufficient stationery and other equipment/materials is available to limit sharing
Provide a separate desk/chair per pupil with a safe distance between pupils
Provide a separate seat for each pupil during meals and activities, with a safe distance between pupils
Ensure distance between pupils at meals and serving food at the table while children are seated
Plan to reduce crowding in changing rooms, toilets and premise entries and exits
If appropriate, apply markings to floors to ensure safe distances are maintained in areas where crowding may occur
Plan for alternating times for breaks to limit the number of pupils who are outside at the same time
Plan for additional adults to be out at break times in order to help pupils maintain a safe distance from each other
Plan for dispersed places where people can assemble before the start of the school day in order to avoid crowding
Plan school transport (school buses, need for additional capacity)
Avoid using public transport for school trips
Cleaning
Draw up a cleaning plan, which describes the frequency and methods to be used for the various points; the plan must cover toilets, washbasins and frequently touched objects (door handles, stair banisters, light switches, etc)
Draw up a plan for cleaning toys, tablets, etc.; toys and items that cannot be cleaned must be tidied away
Recommendations for staff
Limit physical meetings, arrange video conferencing where appropriate
Maintain social distancing during breaks
Establish procedures for cleaning shared tablets, computers/keyboards
Limit use of public transport

associated with severe COVID-19 in adults, particularly diabetes mellitus and hypertension, are associated with increasing age and are not observed in children [23]. The Norwegian Government requested guidelines for school attendance for children with chronic, severe underlying conditions before reopening schools. For this, the NIPH collaborated with the Norwegian Paediatric Association (NPA). A short background document was prepared, and an inquiry conducted between 8 and 13 April to all Paediatric Department Heads at hospitals and NPA-subspecialist committees. Paediatric conditions were evaluated in terms of risk of severe COVID-19 vs depriving children of education and social development. There was a paucity of experience and peer-reviewed publications on this topic from other countries. However, based on available evidence and expert opinion, NIPH and NPA suggested that most children can and should attend school, and that very few conditions justified preventative homeschooling. The NPA published the list of these conditions on their website [24] (Table 3, Supplementary Material).

School staff with high risk for severe COVID-19 also needed recommendations for when preventive self-isolation was indicated. Knowledge on risk factors was assessed in a rapid literature review by the NIPH [25]. Advanced age (> 65 years) was identified as the main risk factor, especially in combination with comorbidities, with the risk increasing with age. Diabetes mellitus and cardiovascular disease were also considered

Table 3

List of common paediatric conditions where school attendance is encouraged (left column) and severe conditions where preventative homeschooling can be considered (right column) during COVID-19 pandemic, Norway, 2020

Paediatric conditions where school attendance is encouraged	Paediatric conditions where preventative homeschooling can be considered[a]
- Diabetes mellitus - Non-severe asthma - Allergic conditions - Epilepsy - Cardiac conditions without heart failure - Autoimmune conditions in a stable phase - Solid organ transplant patients in a stable phase - Children with Down syndrome	- First months following solid organ transplantation - First 12 months after stem cell transplantation - Cancer patients during active chemotherapy - Severe cardiac conditions with pulmonary hypertension, heart failure or Fontan circulation - Severe lung diseases and/or reduced lung capacity including need for respiratory support - Severe primary immunodeficiency - Autoimmune disease requiring considerable immunosuppression or in unstable phase - Severe liver failure or renal failure - Other rare conditions may also be considered

[a] These conditions may require homeschooling in certain periods or on occasion regardless of the COVID-19 pandemic.

to possibly represent a risk factor in adults < 65 years. The NIPH recommended that individuals above the age of 65 years may continue preventative self-isolation, while other adults needed to consult their physician to assess individual risk. Employees at risk can still contribute to school education by working from home if possible.

Discussion

Education is one of the strongest predictors of a population's health and prosperity, and the impact of long-term school closures has not been evaluated [5]. Children have a right to attend school, which is crucial to their social, physical and psychological wellbeing [12].

The evidence for the effect of school closures on the reduction of COVID-19 disease burden is limited [5], while the negative consequences of school closures include the real risks of deepening social, economic and health inequities [26]. The government therefore decided to reopen schools after 6 weeks of closure. Our guidelines aimed to facilitate the process by providing practical support for schools and information to the public. There was a clear need to evaluate the potential risk for children with severe underlying conditions to ensure safe return to school, and communicate the conclusions to the public. We believe our guidelines may be of value for other countries that plan to reopen schools in the near future.

There was substantial concern about reopening schools among the population, and also among teachers and parents. Based on feedback from teachers' unions and media reports, the guidelines were perceived as reassuring, providing a manageable framework for safe reopening.

There is an urgent need to evaluate the effect of school closures on disease transmission vs the negative effects on children in the context of the COVID-19 pandemic. This is of paramount importance for possible future surges of COVID-19 as well as for future epidemics. In order to evaluate the effects of school opening on SARS-CoV-2 transmission, pupils and teachers will be prioritised for testing as part of the national surveillance strategy. In addition, a study is planned to examine the transmission of SARS-CoV-2 between children in daycare and primary school settings. This will allow us to better evaluate the effect of implementing IPC when reopening schools.

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Conflict of interest

None declared.

Authors' contributions

All authors were involved in developing the national guidelines. TBJ, MGI, EA and SJ together drafted the manuscript. MGI and CK were responsible for risk assessment for children and severe COVID-19. HN and BBD were responsible for adaptation of IPC measures in the educational setting. ASB represents the outbreak response management group at NIPH, and coordinated communication with relevant government bodies. All authors provided critical feedback and helped shape the manuscript.

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Rapid communication

SARS-CoV-2-related paediatric inflammatory multisystem syndrome, an epidemiological study, France, 1 March to 17 May 2020

Alexandre Belot[1] , Denise Antona[2] , Sylvain Renolleau[3] , Etienne Javouhey[3] , Véronique Hentgen[4] , François Angoulvant[4] , Christophe Delacourt[5] , Xavier Iriart[6] , Caroline Ovaert[6] , Brigitte Bader-Meunier[7] , Isabelle Kone-Paut[7] , Daniel Levy-Bruhl[2]

1. Filière de santé des maladies auto-immunes et auto-inflammatoires rares (FAI2R), Lyon, France
2. Santé Publique France, Agence nationale de Santé publique, Saint-Maurice cedex, France
3. Groupe francophone de réanimation et d'urgences pédiatriques (GFRUP), Paris, France
4. Groupe de pathologies infectieuses pédiatriques (GPIP), Nice, France
5. Société Française de Pédiatrie (SFP), Paris, France
6. Société Française de Cardiologie, filiale de Cardiologie pédiatrique et congénitale (FCPC), Paris, France
7. Société francophone dédiée à l'étude des maladies inflammatoires pédiatriques (SOFREMIP), Paris, France

Correspondence: Alexandre Belot (alexandre.belot@chu-lyon.fr)

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End of April 2020, French clinicians observed an increase in cases presenting with paediatric inflammatory multisystem syndrome (PIMS). Nationwide surveillance was set up and demonstrated temporospatial association with the coronavirus disease (COVID-19) epidemic for 156 reported cases as at 17 May: 108 were classified as confirmed (n = 79), probable (n = 16) or possible (n = 13) post-COVID-19 PIMS cases. A continuum of clinical features from Kawasaki-like disease to myocarditis was observed, requiring intensive care in 67% of cases.

On 28 April 2020, French clinicians alerted the French Public Health Agency about an abnormal increase in cases of Kawasaki-like disease (KLD) and myocarditis in children requiring critical care support that occurred during of the ongoing coronavirus disease (COVID-19) epidemic in France. Concomitantly, Riphagen et al. reported eight children displaying characteristics of hyperinflammatory shock, KLD or toxic shock syndrome [1] and an Italian study reported 10 additional children presenting with a KLD [2].

To investigate this emerging inflammatory disease in children, now named paediatric inflammatory multisystem syndrome (PIMS) or multisystem inflammatory syndrome in children (MIS-C), a nationwide surveillance was launched on 30 April, coordinated by the French Public Health Agency and French paediatric scientific societies. All French paediatric departments were asked to report retrospectively and prospectively all cases of this hyperinflammatory syndrome diagnosed since 1 March to Santé Publique France.

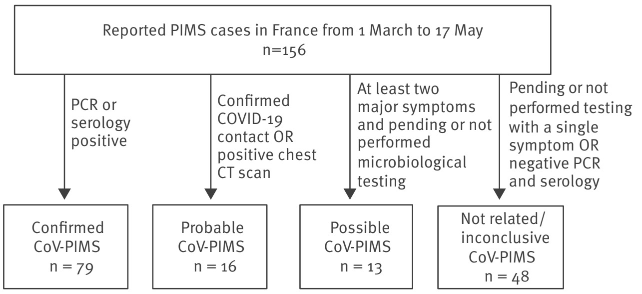
The objectives of this surveillance were to estimate the burden of PIMS in France, to describe the spatial and temporal dynamics of this emergence in order to investigate its link with the COVID-19 epidemic.

Description of the surveillance

A reporting form was developed which included age of the patient, results of either RT-PCR or serology for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), main clinical features (including seritis, attributes of macrophage activation syndrome (MAS), myocarditis or KLD), type of wards (conventional paediatric unit or intermediate/intensive care unit (ICU)) and, for children admitted to ICU, type of care required (including vasopressor, mechanical ventilation and extracorporeal membrane oxygenation) and if relevant, occurrence of death. No follow-up of the child's condition was planned in this initial data collection. Whenever either the PCR or the serology was noted as pending, clinicians were subsequently asked by email to update the questionnaire a few days after initial notification.

Figure 1

Flowchart of paediatric inflammatory multisystem syndrome cases following classification, France, 1 March–17 May (n = 156)



CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome; COVID-19: coronavirus disease; CT: computed tomography; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

Based on the main clinical features and on the available information regarding SARS-CoV-2 status, cases were classified into four categories, according to their link with COVID-19:

• Confirmed/proven cases of SARS-CoV-2-related PIMS (CoV-PIMS) were children presenting with one or more of the following symptoms: seritis, characteristics of MAS, myocarditis and/or KLD and a positive SARS-CoV-2 RT-PCR or serology;

• Probable CoV-PIMS cases were children presenting with any of the above clinical features and either a direct epidemiological link with a confirmed COVID-19 case or a chest computed tomography scan favouring the diagnosis of COVID-19;

• Possible CoV-PIMS cases were children presenting with at least two of the above clinical features with pending or not performed PCR and serology;

• Non-CoV PIMS cases were children with both negative PCR and serology or with pending or not performed PCR and serology and presenting with only one of the above clinical features.

We compared the characteristics of the non-CoV PIMS and CoV-PIMS populations using Mann and Whitney test.

The main analysis for CoV-PIMS was performed on possible, probable and confirmed cases only. A comparison of our own case definition with the case definitions from the World Health Organization (WHO), the United States Centers for Disease Control and Prevention (US CDC) and the Royal College of Paediatrics and Child Health (RCPCH) are reported in the Supplementary Table [3-5].

Findings from the surveillance

By the end of week 20 (17 May 2020), a total of 156 cases had been notified, 79 classified as confirmed, 16 as probable and 13 as possible CoV-PIMS cases. The 48 remaining cases were ruled out based on our case definition (Figure 1).

The epidemic curve of the 108 analysed cases revealed a sharp increase in incidence after 13 April, culminating in week 18, 4–5 weeks after the peak of the COVID-19 epidemic in France and decreasing thereafter (Figure 2). The geographical distribution of cases was comparable to the one of all-ages COVID-19 hospitalisations (Figure 3). Current or past SARS-CoV-2 infection was confirmed by RT-PCR only for 28 cases, by serology only for 42 cases and by both tests for nine cases.

Age distribution showed a median of 8 years and an interquartile range of 5–11 years (Figure 4). The CoV-PIMS and non-CoV PIMS cases followed a significantly different pattern in the two populations, especially in terms of age distribution, clinical presentation and severity (Table). In CoV-PIMS cases, KLD and myocarditis were the most prevalent clinical features and were associated with 61% and 70% of the cases, respectively. Seritis and features of macrophage activation syndrome (MAS) were also overrepresented with a frequency of 22% and 23% (Figure 5). Critical care support was required in 67% of cases and within this group, 73% required vasopressors and 43% mechanical ventilation. One death was recorded.

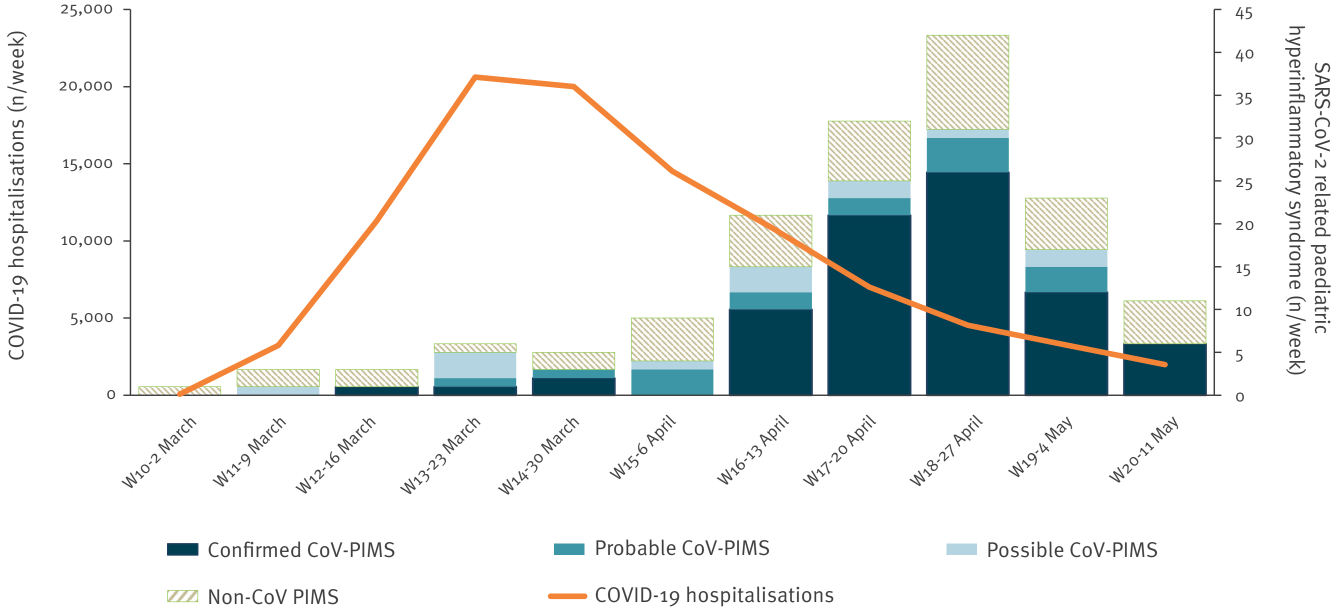
Discussion

This study is, to date, the largest series of published PIMS cases, with more than 100 cases. It supports a causal relationship between SARS-CoV-2 infection and PIMS: 95 of the 156 notified cases were confirmed or probable post-COVID cases. Among the 48 excluded cases, 39 presented with KLD symptoms, probably reflecting the classical Kawasaki disease. Our case definition differed slightly from those proposed later on by the WHO, the RCPCH and the US CDC, mainly because we included as a possible case a patient with a pending or not performed diagnosis of SARS-CoV-2 infections. However, we believe that having classified them as possible PIMS cases reflects the actual likelihood of those cases being real PMS cases. Moreover, possible cases only represented 12% of all cases kept in the analysis and their temporal distribution as well as their age distribution and clinical features (data not shown) did not differ from those of probable and confirmed cases. The significant differences between the CoV2-PIMS and non-CoV2 PIMS cases regarding age distribution and main manifestation support a correct classification. We also highlight that further clinical reporting on all manifestations is required to improve the case definition and disease description.

The epidemic curve of the PIMS cases followed that of COVID-19 with a lag time of 4–5 weeks, supporting the hypothesis of PIMS being a post-infectious

Figure 2

Temporal distribution of COVID-19 hospitalisations and SARS-CoV2 hyperinflammatory paediatric cases, France, 2 March–17 May (n = 108)

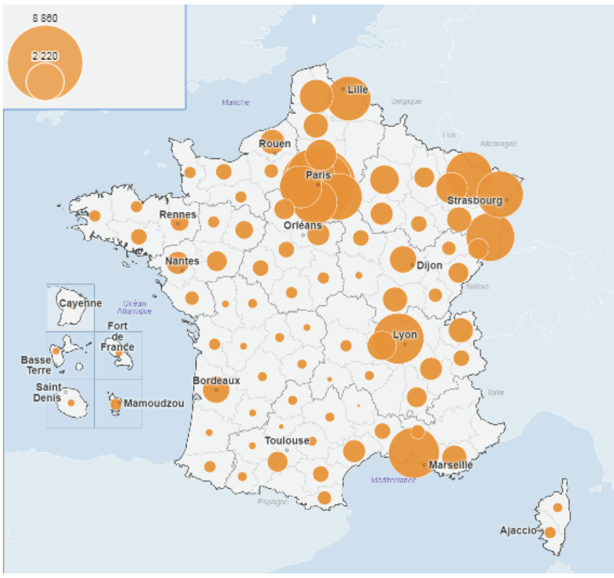


CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome; COVID-19: coronavirus disease; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

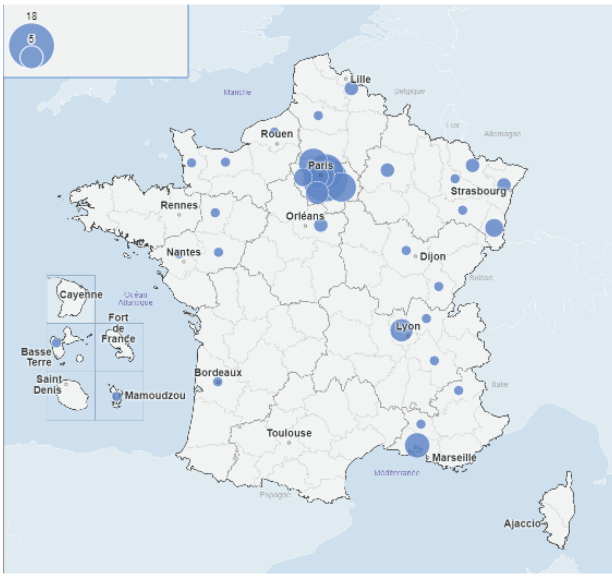
Figure 3

Spatial distribution of COVID-19 hospitalisations and SARS-CoV-2 hyperinflammatory paediatric cases, France, 1 March–17 May (n = 108)

A. COVID-19 hospitalisations (n = 106,500)



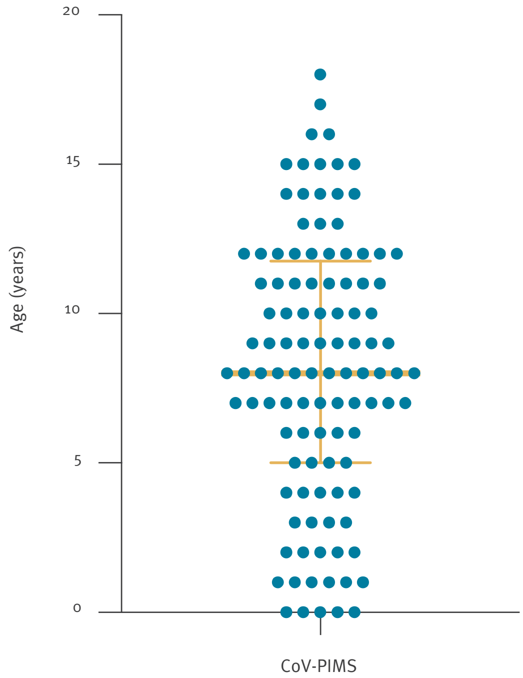
B. CoV-PIMS cases (n = 108)



CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome; COVID-19: coronavirus disease; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

Figure 4

Age distribution of paediatric inflammatory multisystem syndrome patients, France, 1 March–17 May (n = 108)



CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome ; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

Table

Comparison of possible, probable and confirmed CoV-PIMS with non-CoV PIMS following our classification criteria, France, 1 March–17 May (n = 156)

	CoV-PIMS (n = 108)		Unrelated CoV-PIMS (n = 48)		p value
Age in years (median; IQR)	8 (5–11)		3 (1–7)		<0.0005
Sex ratio male/ female	0.96		1		0.99
Clinical presentation	n	%	n	%	
Kawasaki-like disease	66	61	39	81	<0.01
Myocarditis	76	70	5	10	<0.0001
MAS	25	23	1	2	<0.001
Seritis	24	22	5	10	0.11
Intensive care unit	72	67	4	8	<0.0001

CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome;

IQR: interquartile range; MAS: macrophage activation syndrome; NA: not applicable; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

p values were calculated using the Mann-Whitney test for quantitative values and Fisher's exact test for qualitative ones.

manifestation. The geographical distribution of the PIMS cases also correlated with that of the COVID-19 cases. The almost simultaneous detection of PIMS cases in three other places heavily affected by the SARS-CoV-2 epidemic (Italy, the United Kingdom and New York City, US) [6], further reinforces this hypothesis. Conversely, the absence of identified PIMS cases in some countries may reflect (i) a smaller COVID-19 epidemic, (ii) limited awareness of clinicians, (iii) a lack of a specific surveillance system for KLD or other systemic inflammatory symptoms in children, (iv) additional risk factors in our population such as genetic factors or (v) a combination of the above.

Our study gives some insight into the actual risk of PIMS in children with COVID-19. Indeed, with the help of all concerned learned societies, we were able to set up a specific emergency notification system. We believe that the rarity and severity of the disease with frequent ICU admission, in a context of large media coverage of this new syndrome, has most probably led to a high notification rate. In the absence of specific routine Kawasaki disease surveillance, we were unable to compare the number of notified PIMS cases classified as non-CoV PIMS cases with historical classical Kawasaki disease background rates.

Coronaviruses have previously been reported as a possible trigger of classical Kawasaki disease [7] but represent yearly less than 10% of virus infections associated with classical Kawasaki disease [7]. The older age and the balanced sex ratio in SARS-CoV-2-associated KLD were different from the classical Kawasaki disease which rather occur in the youngest and male children [8,9]. MAS and seritis with systemic inflammation are infrequent in Kawasaki disease and reminiscent of other autoinflammatory diseases [9]. A genetic susceptibility for this post-infectious disease has already been hypothesised [10]. Genetic variation of the virus may be also considered for further exploration.

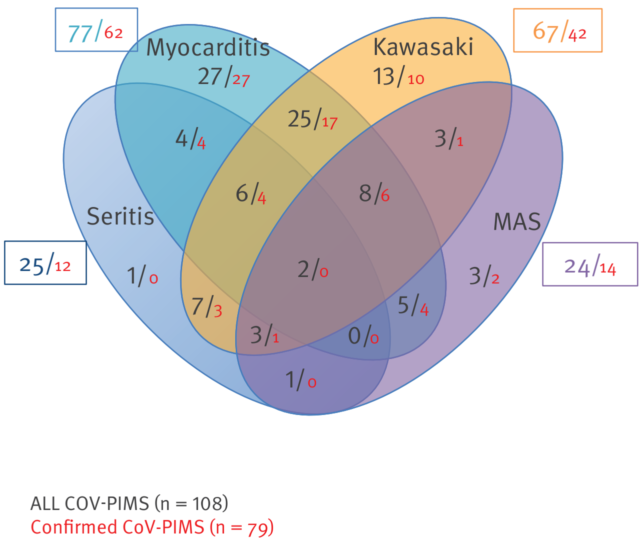
In our report, 73% of patients required vasopressor/inotrope support in the ICU and one case was fatal. The European Centre for Disease Prevention and Control (ECDC) Rapid Risk Assessment from 15 May [6] identified six deaths reported globally including the one in France. Early recognition of this syndrome is critical for careful management, especially regarding the occurrence of myocardial dysfunction and shock as highlighted in a first French study [11]. Additional reports also emphasise an increase of other post-infectious diseases such as Guillain–Barré syndrome [12]. Thus, SARS-CoV-2 represents a potent inflammatory trigger in both children and adults. While interferon defect has been reported in critically ill adult patients with severe outcome of the viral infection [13], specific immunological responses in children need further consideration to explore this delayed inflammatory syndrome.

Conclusion

French surveillance data confirm the signal of the emergence of an inflammatory multisystem syndrome associated with SARS-CoV-2 infection in children. The actual risk of this disease is difficult to estimate, as reliable data on the incidence of COVID-19 infections in children are not yet available. COVID-19 cases

FIGURE 5

Venn diagram of clinical features of SARS-CoV-2-related paediatric inflammatory multisystem syndrome, France, 1 March–17 May (n = 108)



CoV-PIMS: SARS-CoV-2-related paediatric inflammatory multisystem syndrome; MAS: macrophage activation syndrome; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

in children younger than 15 years reported to The European Surveillance System (TESSy) represent only 2.1% of all laboratory-confirmed cases. Under the conservative estimate of no more than only 5% of French children under 15 years having been infected with SARS-CoV-2, the risk of PIMS, based on confirmed, probable and possible cases would be fewer than two per 10,000 children.

In the short term, the risk of new cases of COVID- PIMS is likely to be very low in France, given the low circulation of the virus in France in the past few weeks. More data on this new syndrome will be collected through a research protocol that is currently being implemented. Countries with current high incidence of COVID-19 in the general population should consider this rare but severe delayed syndrome in children.

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Conflict of interest

None declared.

Authors' contributions

DA and DLB have organised the national Surveillance. AB coordonated the consortium, wrote the first draft. SR, EJ, FA, CD, VH, XI, CO, BBM and IKP have collected data, participated to the analyses and reviewed the draft. All authors agreed on the final version of the manuscript.

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Rapid communication

No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020

Laura Heavey[1,2] , Geraldine Casey[1,2] , Ciara Kelly[1,2] , David Kelly[1,2] , Geraldine McDarby[1,2]
1. Public Health Medicine, Health Service Executive, Dublin, Ireland
2. These authors contributed equally to this article and share first authorship

Correspondence: Geraldine Casey (geraldine.casey4@hse.ie)

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As many countries begin to lift some of the restrictions to contain COVID-19 spread, lack of evidence of transmission in the school setting remains. We examined Irish notifications of SARS-CoV2 in the school setting before school closures on 12 March 2020 and identified no paediatric transmission. This adds to current evidence that children do not appear to be drivers of transmission, and we argue that reopening schools should be considered safe accompanied by certain measures.

Coronavirus disease (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was declared a pandemic on 11 March 2020 [1]. Many countries followed the precautionary principle and, to limit the spread of the virus, imposed restrictions on citizens, such as promoting physical distancing, limiting the movement of people, closing educational institutions and/or workplaces. Now countries, while continuing to control the spread of the virus, must plan how to lift some of these restrictions to allow people to resume activities of daily life.

Children are thought to be vectors for transmission of many respiratory diseases including influenza [2]. It was assumed that this would be true for COVID-19 also. To date however, evidence of widespread paediatric transmission has failed to emerge [3]. School closures create childcare issues for parents. This has an impact on the workforce, including the healthcare workforce [4]. There are also concerns about the impact of school closures on children's mental and physical health [5].

We aimed to examine the evidence of paediatric transmission in the Republic of Ireland in the school setting.

Irish school closures

The first Irish case of COVID-19 was notified in a school-going child who had recently returned from Northern Italy at the beginning of March 2020. As the numbers of cases detected in the community in Ireland began to increase, the National Public Health Emergency Team advised the closure of all schools from 12 March 2020 6 p.m., in an effort to contain the spread of COVID-19. [6].

Finding coronavirus disease school-related cases and their contacts

To find evidence in the Republic of Ireland on COVID-19 transmissions related to schools before their closure, all SARS-CoV-2 notifications to Public Health Departments were screened to identify children, under the age of 18 years, and adults who had attended the school setting.

Cases were identified within the Computerised Infectious Disease Reporting (CIDR) system (Ireland's national infectious disease surveillance system). On CIDR, attendance at work or school was routinely recorded for COVID-19 surveillance. Contact-tracing records and records from active surveillance were reviewed to identify cases of secondary transmission.

Case descriptions

Three paediatric cases and three adult cases of COVID-19 with a history of school attendance were identified. The available epidemiological data for all of these cases indicated that they had not been infected with SARS-CoV-2 in the school setting. One case was travel related, while three cases were part of a single household outbreak, also linked to travel. One case was a close contact of a confirmed case in a recreational context, which was outside a school environment. One case was a contact of another case, and transmission occurred in a work environment.

One paediatric case attended a primary school, while the other two cases attended secondary schools. One of the adult cases was a teacher, while the other adult cases conducted educational sessions in schools that were up to 2 hours in duration. All cases except one had symptoms of either cough or fever in line with the European Centre for Disease Prevention and Control (ECDC) case definition for COVID-19 testing at the time

Table

Cases of coronavirus disease with a history of school attendance and contacts, Ireland, 1 March–13 March 2020 (n = 1,160 individuals)

Case	Age group in years	Symptoms	Number of contacts				Number of secondary cases			
			Child		Adult		Child		Adult	
			School	Other[a]	School	Other[a]	School	Other[a]	School	Other[a]
1	10–15	Fever	475	29	30	3	0	0	0	0
2	10–15	None	125	30	25	8	0	0	0	0
3	10–15	Fever	222	14	28	0	0	0	0	0
4	Adult >18	Coryza/cough	52	2	4	38	0	0	0	2
5	Adult >18	Cough	39	2	2	3	0	0	0	0
6	Adult >18	Cough	11	0	12	1	0	0	0	0

[a] Other transmission settings include households of friends and family and recreational activities.

[7]. One paediatric case was asymptomatic and was tested as part of the investigation of a household cluster. Their contacts are summarised in the Table. A total of 1,155 contacts of these six cases were identified. They were exposed at school in the classroom, during sports lessons, music lessons and during choir practice for a religious ceremony, which involved a number of schools mixing in a church environment.

Among 1,001 child contacts of these six cases there were no confirmed cases of COVID-19. In the school setting, among 924 child contacts and 101 adult contacts identified, there were no confirmed cases of COVID-19.

Contact tracing and follow-up

In line with Irish guidelines, contacts were defined as close contacts or casual contacts [8]. Close contacts were advised to restrict movements and underwent active surveillance with daily contact from Public Health monitoring for symptoms until 14 days from last exposure to a case. Casual contacts were advised to monitor for symptoms and given general information on physical distancing, hand hygiene and cough etiquette. Contacts who developed any symptoms consistent with COVID-19 were referred for testing. It was not possible to ascertain exact numbers of symptomatic contacts who were tested from records, however extensive testing was conducted. All symptomatic contacts (close or casual) were tested, even if only reporting mild symptoms of a respiratory tract infection. Although active follow-up of close contacts was conducted for 14 days from last exposure to a case, testing was not limited to this time period. Among all of the cases and contacts, transmission was observed in only one instance, which was outside the school environment, between two of the adult cases and a further adult.

Ethical statement

This analysis was conducted as part of public health usual practice, and was not conducted for research. Ethics approval was therefore not needed.

Discussion

In summary, examination of all Irish paediatric cases of COVID-19 attending school during the pre-symptomatic and symptomatic periods of infection (n = 3) identified no cases of onward transmission to other children or adults within the school and a variety of other settings. These included music lessons (woodwind instruments) and choir practice, both of which are high-risk activities for transmission. Furthermore, no onward transmission from the three identified adult cases to children was identified.

The only documented transmission that occurred from this cohort was between adults in a working environment outside school. Among 1,025 child and adult contacts of these six cases in the school setting there were no confirmed cases of COVID-19 during the follow-up period. Follow-up period was at least one incubation period (14 days) from last contact with a case.

Limitations

This study is limited by small numbers of cases. Not all age ranges are represented since all children are older than 10 years. During this time period there were no reported cases of outbreaks in childcare facilities, however younger children who did not attend school or childcare were not specifically included in this investigation.

Only symptomatic contacts were tested, and so asymptomatic secondary cases were not captured.

Prior to the nationwide closure of schools on 12 March, when a case was identified within a school, either all children and staff within the school or all children and staff involved with an individual case were excluded. This limited the potential for further transmission within the school setting once a case was identified. All contacts listed in the Table had been exposed to the cases before the schools closed however.

Conclusion

While this study, based on small numbers, provides limited evidence in relation to COVID-19 transmission in the school setting, it includes all known cases with school attendance in the Republic of Ireland. The results moreover echo the experience of other countries, where children are not emerging as considerable drivers of transmission of COVID-19. Recent population screening studies from Iceland [9] and Italy [10] identified very few cases of COVID-19 disease in children with PCR testing. A report on school-related transmission in New South Wales, Australia, examining the spread of SARS-CoV-2 from 18 confirmed cases (nine students and nine staff) from 15 schools identified only two potential cases of secondary school-based transmission, despite the identification of 863 close contacts [11].

These findings suggest that schools are not a high risk setting for transmission of COVID-19 between pupils or between staff and pupils. Given the burden of closure outlined by Bayhem [4] and Van Lanker [5], reopening of schools should be considered as an early rather than a late measure in the lifting of restriction. Our report includes both the primary and secondary school setting, with no transmission in either setting. The limited evidence of transmission in school settings supports the re-opening of schools as part of the easing of current restrictions. There are no zero risk approaches, but the school environment appears to be low risk.

On 10 March 2020, the United Nations Children's fund (UNICEF), the International Federation of the Red Cross and the WHO issued a guidance document on re-opening schools [12]. The guidance considers the balance of risks to children's health, well-being, learning and development posed by disease transmission vs not attending school. The document also states that marginalised children are likely to suffer more from school closures. In line with this and ECDC recommendations [13,14], countries can begin to lift restrictions once transmission within the community is controlled, there is surge capacity within the healthcare system and adequate resources are in place for active case finding, testing and contact tracing. Careful attention will still need to be paid to hygiene and respiratory etiquette, both in the classroom and in areas where staff congregate. Monitoring for and exclusion of staff or students with symptoms of respiratory illness and contact tracing would continue as normal. Public Health control measures will be put in place if individual cases within the school are identified, as is usual practice. If this is adhered to there is no reason to believe that the schools cannot be safely reopened.

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Conflict of interest

None declared.

Authors' contributions

All authors contributed equally, this included study design and conception, data retrieval and analysis, compilation of cases reports and writing the final report. LH initiated and co-ordinated study and produced initial report, GC, CK and DK searched case notes and compiled summaries of cases, GMcD compiled and edited first draft of submission. All parties contributed to drafts and edits of report.

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Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020

Silvia Garazzino[1] , Carlotta Montagnani[2] , Daniele Donà[3] , Antonella Meini[4] , Enrico Felici[5] , Gianluca Vergine[6] , Stefania Bernardi[7] , Roberta Giacchero[8] , Andrea Lo Vecchio[9] , Paola Marchisio[10] , Giangiacomo Nicolini[11] , Luca Pierantoni[12] , Ivana Rabbone[13] , Giuseppe Banderali[14] , Marco Denina[1] , Elisabetta Venturini[2] , Andrzej Krzysztofiak[7] , Raffaele Badolato[4] , Sonia Bianchini[14] , Luisa Galli[2] , Alberto Villani[7] , Guido Castelli-Gattinara[7] , the Italian SITIP-SIP Pediatric Infection Study Group[15]

1. Paediatric Infectious Diseases Unit, Regina Margherita Children's Hospital, University of Turin, Turin, Italy
2. Infection Disease Unit, Meyer Children's University Hospital, Florence, Italy
3. Division of Paediatric Infectious Diseases, Department for Woman and Child Health, University of Padua, Padua, Italy
4. Pediatrics Clinic, University of Brescia and ASST-Spedali Civili of Brescia,, Brescia, Italy
5. Paediatric and Pediatric Emergency Unit, The Children Hospital, AO SS Antonio e Biagio e Cesare Arrigo, Alessandria, Italy
6. UOC Pediatria, Ospedale degli Infermi di Rimini, Rimini, Italy
7. Universitarian-Hospital Department, Ospedale Bambino Gesù IRCCS, Rome, Italy
8. UOC Pediatria e Patologia Neonatale -ASST Lodi, Lodi, Italy
9. Department of Translational Medical Science, Section of Paediatrics, University of Naples Federico II, Naples, Italy
10. Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milan, Italy
11. UOC Pediatria, San Martino Hospital, Belluno, Italy
12. Paediatric Emergency Unit, Policlinico di Sant'Orsola, Bologna, Italy
13. Division of Paediatrics, Department of Health Sciences, University of Piemonte Orientale, Novara, Italy
14. Department of Paediatrics, ASST Santi Paolo e Carlo, University of Milan, Milan, Italy
15. The members of the Italian SITIP-SIP SARS-CoV-2 paediatric infection study group are listed at the end of this article

Correspondence: Silvia Garazzino (silvia.garazzino@unito.it)

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Data on features of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in children and adolescents are scarce. We report preliminary results of an Italian multicentre study comprising 168 laboratory-confirmed paediatric cases (median: 2.3 years, range: 1 day–17.7 years, 55.9% males), of which 67.9% were hospitalised and 19.6% had comorbidities. Fever was the most common symptom, gastrointestinal manifestations were frequent; two children required intensive care, five had seizures, 49 received experimental treatments and all recovered.

Since the end of December 2019, coronavirus disease (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has rapidly spread worldwide becoming the first pandemic of the 21st century. Despite the high number of people affected, data on clinical features and prognostic factors in children and adolescents are limited.

We report the preliminary results of a national multicentre study, promoted by the Italian Society of Paediatric Infectious Diseases (SITIP), within the Italian Society of Paediatrics (SIP). The study investigates epidemiological, clinical and therapeutic aspects of SARS-CoV-2 infection in infants, children and adolescents, hereafter referred to as paediatric population or children.

Participating physicians, hospitals and patients

The multicentre study involves 11 of 13 exclusively paediatric hospitals and 51 of 390 paediatric units across Italy, but predominantly in central and northern regions. Of approximately 15,900 paediatricians working in the national health system, more than 10,000 are members of SIP. Retrospective data collection started on 25 March 2020.

The presented data include all paediatric patients in whom COVID-19 was documented by at least one nasal/pharyngeal swab specimen positive for SARS-CoV-2 nucleic acid using real-time reverse-transcriptase polymerase-chain-reaction (RT-PCR) assay.

Ethical approval of the ethical committee of the coordinating Centre in Turin (Comitato Etico Interaziendale AOU Città della Salute e della Scienza di Torino – AO Ordine Mauriziano di Torino – ASL Città di Torino) was provided on 24 March 2020, protocol number 0031296.

Table

Characteristics of SARS-CoV-2-infected children, Italy, as at 10 April 2020 (n = 168)

Parameter	Total (n)	Percentage (%)
Age (years)		
Mean, median (IQR)	5, 2.3 (0.3–9.6)	NA
Age groups		
< 1 year[a]	66	39.3
1–5 years	38	22.6
6–10 years	24	14.3
11–17 years	40	23.8
Sex		
Males	94	55.9
Females	74	44.1
Signs and symptoms[b]		
Fever ranging from 37.5–39°C	138	82.1
Cough	82	48.8
Rhinitis	45	26.8
Diarrhoea	22	13.1
Dyspnoea	16	9.5
Pharyngitis	9	5.4
Vomiting	9	5.4
Conjunctivitis	6	3.6
Chest pain	4	2.4
Fatigue	3	1.8
Non-febrile seizures	3	1.8
Febrile seizures	2	1.2
Hospital admission within age groups		
< 1 year	52	78.8
1–5 years	24	63.2
6–10 years	13	54.2
11–17 years	21	52.5
Total	110	65.1

IQR: interquartile range; NA: not applicable; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2.

[a] Of coronavirus disease (COVID-19) cases in this age group, 15 of 66 were less than 4 weeks of age.

[b] Several answers were possible.

Data collection was allowed by written consent of at least one parent; patients' data were de-identified.

Findings

As at 10 April 2020, data for 168 children aged 1 day to 17 years, 94 (55.9%) males and 74 (40.1%) females, with confirmed COVID-19 and an adequate follow-up were available. Adequate follow-up was the period considered necessary by the clinician to define the final outcome, in most instances at least 2 weeks. The mean age was 5 years (median: 2.3 years, interquartile range (IQR): 0.3–9.6 years); 15 were neonates (Table). The majority of children (65.1%) were hospitalised: of these, only 17 (15.5%) were referred to hospital after seeing a paediatrician or family doctor. Hospital admission was inversely related to age ($p < 0.01$; Fisher exact test); among infected children under 1 year of age, 52/66 were hospitalised vs 24/38, 13/24 and 21/40 among the 1 to 5 year-olds, 6 to 10 year-olds and over 10 year-olds, respectively.

Thirty-three children (19.6%) had underlying chronic diseases, such as chronic lung disease (n = 7), congenital malformations or complex genetic syndromes (n = 14), cancer (n = 4), epilepsy (n = 5), gastrointestinal (n = 2) or metabolic disorders (n = 1) and seven were immunosuppressed (n = 4) or immunocompromised (n = 3). The hospitalisation rate was similar between children with comorbidities and those without (23/33 vs 87/135, respectively; p = 0.68, Fisher exact test).

Close contact with a COVID-19 infected person outside the family was rarely reported; conversely, 67.3% (113/168) of children had at least one parent who tested positive for SARS-CoV-2 infection. Symptom onset in relatives frequently (88/113, 77.8%) preceded symptoms in the infected child between 1 to 14 days.

All but four (2.5%) enrolled children were symptomatic. Fever ranging from 37.5 to 39 °C was the most common symptom (82.1%), followed by cough (48.8%) and rhinitis (26.8%). Interestingly, 31 children (18.4%) developed gastrointestinal symptoms (vomiting and/or diarrhoea), while five had seizures; of these, three children had a known history of epilepsy, one child had a past history of febrile seizures and the remaining one had a first episode of febrile seizures as onset of COVID-19e and SARS-CoV-2 encephalitis was ruled out. The mean interval between symptom onset and first medical evaluation was 1.6 days (range: 0–18).

In children who underwent blood investigations, the increase of C-reactive protein above 0.5 mg/dl was the most common finding (47/121, 38.8%), while other alterations frequently encountered in adults, such as leukopenia, neutropenia, lymphopenia, increased CK or LDH values, were rare (data not shown).

Complications and co-infections

Thirty-three children (19.6%) developed complications, such as interstitial pneumonia (n = 26), severe acute respiratory illness (n = 14) and peripheral vasculitis (n = 1); two of the 33, a preterm neonate and a 2-month-old infant with congenital heart disease, required intensive care unit (ICU) admission and treatment with mechanical ventilation. Non-invasive oxygen-treatment was administered to 16 of 168 (9.5%) children. No child underwent chest computed tomography scan; pneumonia was assessed either by X-ray or ultrasound in 75 of the children.

A viral co-infection was documented in 10 children (5.9%), including three respiratory syncytial virus, three rhinovirus, two Epstein-Barr virus, one influenza A virus and one non-SARS coronavirus infection. A bacterial co-infection with *Streptococcus pneumoniae* was also documented.

Antiviral treatment

Experimental treatments for SARS-CoV-2 infection, including lopinavir/ritonavir (lopinavir component: 230 mg/m^2 of body surface area twice daily), hydroxychloroquine (2.5 mg/kg twice daily) and/or azithromycin (10 mg/kg once daily)/clarithromycin (7.5 mg/kg twice daily), were administered to 49 children (29.2%). A systemic steroid was administered only in one case. Antiviral treatments were preferentially given to children who were more severely ill (data not shown).

Discussion

SARS-CoV-2 infection in children differs from adult disease with respect to clinical manifestations and outcome. Our data confirmed that case fatality in children is very low: only a few fatal COVID cases have been reported in the literature thus far [1-3]. In our series, all children, including those with comorbidities, recovered fully, and no sequelae were reported at the time of submission.

Italy has been among of the countries most affected by COVID-19, with more than 140,000 infected cases and around 17,000 deaths as at 10 April 2020 [4]. The number of cases and case-fatality rate in Italian adults with COVID-19 are higher compared with many other countries [5]. This may be because of an older mean population age, higher frequency of comorbidities in the older population, and the limited number of rhinopharyngeal swabs performed on asymptomatic people during the initial phase of the Italian epidemic. In this scenario, data from our paediatric multicentre study confirm the different course of the infection in the paediatric age group: children were a marginal percentage of the Italian infected population admitted to hospital and tended to develop benign, pauci-symptomatic disease.

The contribution of children to disease transmission is still under debate, including whether they might serve as facilitators of viral transmission, being a silent reservoir for the virus. Many hypotheses have been formulated on the mechanisms underlying children's lower susceptibility to severe SARS-CoV-2 infection compared with adults; these include an immature receptor system, specific regulatory mechanisms in the immune respiratory system and cross-protection by antibodies directed towards common viral infections in infancy [6]. However, nearly 40% of the children included in this report were under 1 year of age and the majority of them were hospitalised, suggesting a higher susceptibility to symptomatic COVID-19 in this specific age group: the two children who required ICU admission were a neonate and a 2-month-old infant. However, the high number of children under 1 year of age in our study may also reflect both a higher tendency for families to seek medical advice for younger children and a higher propensity among clinicians to admit them to hospitals. Also in the United States (US), hospitalisation was more common among children under 1 year of age than in other paediatric age groups, including ICU admission [1]. According to the Italian national public health institute's surveillance report of 10 April, SARS-CoV-2 infection affected a total of 1,936 children, of whom 5.2% were hospitalised; the percentage of hospitalised children within the 0 to 1-year-old age group was 10.9%. A rough estimate of the general hospitalisation rate in the Italian paediatric population is 39.6 per 1,000 children [7].

Similar to what was reported in paediatric studies from China and the US, we observed a slightly higher, although not statistically significant, prevalence in males in all age groups (data not shown), supporting the hypothesis that sex-linked genetic factors may influence susceptibility to COVID-19.

Fever was the most common encountered symptom in our cohort: this is in contrast with data reported in Chinese and US American children in whom fever was less common (36–56%) compared with cough or pharyngitis [1,2,8-10]. Conversely, proportions of gastrointestinal symptoms were similar among the three cohorts, ranging from 6.4 to 11% for nausea and vomiting and from 8.8 to 13% for diarrhoea [1,2,8-10]. Neurological manifestations, consisting in febrile and non-febrile seizures, were observed in 3% of children at onset of COVID-19, although none developed SARS-CoV-2-related encephalitis.

Although only preliminary data are presented, our study has several limitations. First, our population includes children and adolescents under 18 years of age: this make some results difficult to compare with other publications that consider children and adolescents up to 15 or 16 years. Secondly, the limited sample size for some analyses does not allow to draw definite conclusions. For example, because of small numbers and differences in demographic conditions between children who did vs did not receive antiviral treatments, clinical progression of treated and untreated children could not be compared. Also, with a wider population, specific comparison and analysis in different age groups should be looked specifically at.

Despite these limitations, this is to our knowledge the largest cohort on the characteristics of laboratory-confirmed COVID-19 in European children. At present, most of the paediatric data are from Chinese studies; of these, many also included children without a laboratory diagnosis and in them, the disease seems to have taken a more severe course than in children with laboratory-confirmed disease [8]. According to some authors, this may be because a number of children improperly categorised as having COVID-19 might have been infected by other aggressive pathogens [11].

In conclusion, our findings show a favourable clinical course of COVID-19 infection in children and adolescents in Italy, where the case-fatality rates observed in adults seem high compared with several other countries. Consequently, the diagnostic, clinical and even therapeutic approach in children might be more conservative than in adults, for example reserving chest computed tomography scan, hospital admission and antiviral treatments (unless more effective and safe drugs will become available) to selected situations.

* Authors' correction

The first name of Luisa Abbagnato was corrected in the Italian SITIP-SIP SARS-CoV-2 paediatric infection study group on 20 July 2020.

The Italian SITIP-SIP SARS-CoV-2 paediatric infection study group

Filippo Salvini, Luisa* Abbagnato, Elio Castagnola, Icilio Dodi, Cesare Ghitti, Paola Lippi, Rino Agostiniani, Simonetta Cherubini, Piero Valentini, Paola Gianino, Angelina Vaccaro, Paolo Manzoni, Paola Verna, Pasquale Comberiati, Paola Di Filippo, Paola Gallia, Gianna Battezzati, Ludovica Fiore, Cristina Dalmazzo, Eleonora Tappi, Marta Lazzerini, Pier-Angelo Tovo, Carlo Scolfaro, Giulia Pruccoli, Ugo Ramenghi, Carlo Giaquinto, Liviana Da Dalt, Gianluca Tornese, Paola Berlese, Alessandro Plebani, Emma Concetta Manno, Veronica Santilli, Laura Lancella, Laura Cursi, Andrea Campana, Elena Bozzola, Samantha Bosis, Marcello Lanari, Carmine Pecoraro, Paolo Del Barba, Emanuele Nicastro, Susanna Esposito, Gian Vincenzo Zuccotti, Giovanni Corsello, Fabio Cardinale, Anna Maria Tocco, Giuseppina Ballardini, Carlo Agostoni, Elena Chiappini, Giuseppe Indolfi, Bussolini Anna, Salvatore Cazzato, Giorgio Zavarise, Claudio Pignata, Federico Marchetti.

Conflict of interest

None declared.

Authors' contributions

SG, CM, DD, AM, EF, GV, SB, RG, ALV, PM, GN, LP, IR, GB, MD, EV, AK, RB, SB, LG, AV, GCG contributed to filling-in the registry forms on patient information. SG and MD were also responsible for data entry and elaboration.

All authors, including those listed in the SITIP-SIP SARS-CoV-2 paediatric infection study group, contributed to the conception of the work, the acquisition of data and critical revision of the intellectual content. They also read and approved the final version.

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The impact of unplanned school closure on children's social contact: rapid evidence review

Samantha K Brooks[1] , Louise E Smith[1] , Rebecca K Webster[1] , Dale Weston[2] , Lisa Woodland[1] , Ian Hall[3] , G James Rubin[1]
1. Department of Psychological Medicine, King's College London, Weston Education Centre, London, United Kingdom
2. Behavioural Science Team, Emergency Response Department Science and Technology, Public Health England, Porton Down, United Kingdom
3. Department of Mathematics and School of Health Sciences, University of Manchester, Manchester, United Kingdom

Correspondence: Samantha K Brooks (samantha.k.brooks@kcl.ac.uk)

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Background: Emergency school closures are often used as public health interventions during infectious disease outbreaks to minimise the spread of infection. However, if children continue mixing with others outside the home during closures, the effect of these measures may be limited. **Aim:** This review aimed to summarise existing literature on children's activities and contacts made outside the home during unplanned school closures. **Methods:** In February 2020, we searched four databases, MEDLINE, PsycInfo, Embase and Web of Science, from inception to 5 February 2020 for papers published in English or Italian in peer-reviewed journals reporting on primary research exploring children's social activities during unplanned school closures. Main findings were extracted. **Results:** A total of 3,343 citations were screened and 19 included in the review. Activities and social contacts appeared to decrease during closures, but contact remained common. All studies reported children leaving the home or being cared for by non-household members. There was some evidence that older child age (two studies) and parental disagreement (two studies) with closure were predictive of children leaving the home, and mixed evidence regarding the relationship between infection status and such. Parental agreement with closure was generally high, but some disagreed because of perceived low risk of infection and issues regarding childcare and financial impact. **Conclusion:** Evidence suggests that many children continue to leave home and mix with others during school closures despite public health recommendations to avoid social contact. This review of behaviour during unplanned school closures could be used to improve infectious disease modelling.

Introduction

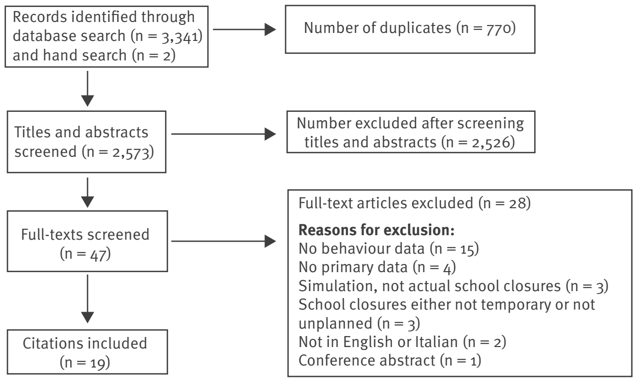
Gaining control of an infectious disease outbreak can require making difficult decisions, particularly when infections are human-to-human transmissible. Children are often in close physical proximity at school, have less-than-perfect hygiene behaviours and have low prior immunity to many infections [1]. For this reason, school closures are often proposed as one way of delaying the spread of infection [2]. There is evidence to suggest that social contacts should reduce when schools are closed. For example, it has been reported that students have contact with fewer people during weekends [3] and that the number of contacts children have with others approximately halves during the holidays [4,5]. Several studies have also examined illness transmission rates during planned school closures, reporting a reduction in illness during school holidays [6-8] and teacher strikes [9].

However, school closure is not a step that can be taken lightly. Clearly, closures can have an impact on the education of the children involved. But they can also have an impact on the healthcare system, on the wider economy if large numbers of the workforce stay home to look after their children, on household incomes, on social policies implemented at school and on the likelihood of children engaging in other risky behaviours if they must be left unattended at home [10*]. Indeed, the secondary economic and social effects of school closures are potentially very large [11].

Understanding whether the effectiveness of school closure in terms of reducing the spread of disease outweighs these impacts is therefore important. One of the key unknowns is what happens to children after a school is closed. The optimum answer from an epidemiological perspective is that children remain in their homes for the duration of the closure, never coming into contact with another person [12,13]. However, this is impractical and from front-line experience of outbreak management, there are many accounts of children continuing to congregate after being sent home from school and sometimes engaging in behaviour likely to increase the risks of infection spreading

Figure

Flowchart of the screening process for the rapid evidence review of the impact of unplanned school closure on children's social contact, February 2020



[14,15]. Any full assessment of the impact of school closures should take this into account.

A related issue is the extent to which children have contact with people, particularly those in vulnerable groups, with whom they would not usually have contact on a typical school day following a school closure. While their number of social contacts may be lower following closures, children may, for example, be taken care of by grandparents which increases the likelihood of older adults who may be at risk coming into contact with the infectious disease in question.

Finally, given that school closures are often accompanied by advice to parents to limit the contact their children have with others, understanding what practical or attitudinal factors affect the likelihood of children mixing during a closure may also be helpful in improving the advice that is given out.

Given these considerations surrounding school closures, we aimed to summarise existing literature on children's activities and contacts made outside the home during unplanned school closures in this rapid evidence review. To expand, we examined: (i) what is currently known about the impact of unplanned school closure on children's interaction with others outside the home, (ii) who provides childcare during a closure, (iii) what factors are associated with children interacting with others outside the home during a closure, and (iv) what affected parents think about closures.

Method

This work was carried out as a rapid evidence review in response to the COVID-19 outbreak that began at the end of 2019, and which has led to policymakers across the world discussing how best to minimise the spread of the disease. Rapid reviews follow the general principles of a systematic review but may be simplified, for example, by not including grey literature or conducting a full quality appraisal, in order to produce information in a shorter period of time with minimal impact on quality. They are essential in circumstances such as the developing situation with COVID-19 as policymakers urgently need synthesised evidence in order to make informed decisions regarding guidelines for the public. As there are no specific guidelines and no standardised methodology for rapid reviews, the PRISMA checklist has not been completed. However, the only Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [16] checklist items that this study lacks relate to the analysis of risk of bias in individual studies; because of time constraints, a quality assessment of each paper was not conducted.

Search strategy and selection criteria

We used the following search strategy to search abstracts and titles in MEDLINE, PsycInfo and Embase:

1. school* ADJ3 close* OR ADJ3 closure* OR ADJ3 closing* OR ADJ3 dismiss*
2. nurser* ADJ3 close* OR ADJ3 closure* OR ADJ3 closing* OR ADJ3 dismiss*
3. kindergar* ADJ3 close* OR ADJ3 closure* OR ADJ3 closing* OR ADJ3 dismiss*
4. playgroup* ADJ3 close* OR ADJ3 closure* OR ADJ3 closing* OR ADJ3 dismiss*
5. play-group* ADJ3 close* OR ADJ3 closure* OR ADJ3 closing* OR ADJ3 dismiss*
6. 1 OR 2 OR 3 OR 4 OR 5
7. behaviour* OR behaviour* OR contact* OR mix* OR social* OR targeted layered containment
8. 6 AND 7

We repeated the same search on Web of Science using NEAR instead of ADJ3. All databases were searched from inception to 5 February 2020.

Inclusion and exclusion criteria

To be included in the review, studies had to: (i) report on primary research, (ii) be published in peer-reviewed journals, (iii) be written in English or Italian, the languages spoken by our team, and (iv) report on social activities of children during unplanned temporary school closures because we speculated that mixing behaviour will likely be different during closures with plenty of notice, giving parents more time to plan what to do.

We excluded papers based on intentions, hypothetical scenarios or simulations.

Screening

One author, SKB, ran the search strategy on all databases and downloaded all resulting citations to EndNote version X9 (Thomson Reuters, New York, United States (US)). Titles and then abstracts were all screened for relevance according to the inclusion criteria by at least two authors (SKB, LES, RKW, DW or LW). The authors compared which texts they had chosen for inclusion and discrepancies were resolved through discussion with the wider team. Full texts of all remaining citations were obtained and reviewed by one author (SKB), excluding any that did not meet all inclusion criteria. Finally, the reference lists of remaining papers were hand-searched by SKB for any additional relevant studies. A flowchart of the screening process is presented in the Figure.

Data extraction

We designed spreadsheets to extract the following data from papers: authors, publication year, country of study, design, participants (including number and demographic information), reason for school closure, length of school closure and key results (i.e. behaviours during school closures, number of children leaving the home during closures and number of children who were cared for by non-household members). With regards to childcare arrangements, we were only interested in arrangements that involved a non-household member, e.g. grandparent, family friend or babysitter, rather than household members, e.g. a parent working from home or an older sibling, in order to explore how many children had contact with people they would not already have contact with by living in the same home. We were also interested in the number of children left home alone. Data extraction was carried out by one author (SKB).

Results

Database searches yielded 3,341 papers and two additional papers were identified via hand-searching; 770 duplicates were removed and the remaining 2,573 were screened for relevance. After this screening, a total of 19 papers remained and were included in the review, 18 of which [17-34] used a cross-sectional design employing questionnaires to assess difficulties during the school closures, activities outside the home during the closures and/or who provided childcare during the closures. The remaining paper [14] used a qualitative design. The majority (n = 10) were from the US [19,21,23-25,27,30,32-34]; four papers were from Australia [14,20,22,29] and the remaining papers were from Argentina [28], Japan [26], Russia [18], Taiwan [31] and the UK [17]. Most papers reported on school closures because of the 2009 influenza A(H1N1) pandemic (n = 12) [14,17,19,20,22,24-26,28,29,31,32] or other influenza or influenza-like outbreaks (n = 6) [18,21,23,27,30,33]. One paper reported on a school closed in preparation for a hurricane [34]. The duration of school closures ranged from 1 day [32] to 2 weeks [28]. The size of the quantitative studies ranged from 35 households (representing 67 children) [21] to 2,229 households (representing 4,171 children) [34]. The Table provides a summary of activities outside the home and childcare arrangements involving non-household members during school closures. See Supplement S1 for more detail on the results of each study.

Interaction with others outside the home

Participation in activities and interactions with others did appear to decrease during school closures compared with regular school days [17-19]. For example, one study of 107 students aged 11 to 15 years in the UK [17] reported that school closure was associated with a 65% reduction in the mean total number of contacts for each student. However, social contact was still common: all 19 studies showed that at least some children took part in activities outside of the home during school closures, even despite health recommendations to remain indoors and isolated from others. In fact, eight studies [17,20,21,23,24,27,28,32] showed that the majority of children (i.e. more than 50%) left the home or took part in activities involving non-household members, including the UK study of school closures during the H1N1 outbreak which found that 98% of children left their homes during that time [17].

Factors associated with contact outside the home

Infection status

Several studies suggested that children who reported illness during a school closure were less likely to take part in activities outside the home [17,20-22]. For example, in a study of 233 Australian households (children with a median age of 11 years), Effler et al. [20] reported a statistically significant difference for the proportion of cases, i.e. students testing positive for influenza A(H1N1) virus, students who had been in close physical proximity to cases, and peers who did not meet case or contact criteria who reported leaving the home more than once during the closure period (42%, 66% and 92%, respectively) ($p < 0.0001$). Cases reported an average of 0.8 out-of-home activities per student per week, compared with 2.9 for contacts and 5.6 for peers. Other studies reported that children who reported illness or lived in households in which influenza-like illness was reported did not participate in the majority of activities reported by other students [21,22] and that their contact with others was reduced [17].

However, other studies reported few differences in out-of-home activities between symptomatic and asymptomatic children [19,23-26]. For example, one American study of 176 children in grades 5 to 12 [19] found that students with illnesses were more likely to report an increase in travel plans; the reasons for this are not clear. Two other American studies found that children with an influenza-like illness were more likely to have visited a healthcare provider (($p<0.01$) [24], statistics not reported [25]) but no other differences in out-of-home activities were found between students with and without symptoms [24,25].

Age

Three American studies noted more activities and contacts among older children [19,23,27]. In the study by Miller et al. [19], grade 12 students, i.e. students aged 16 to 18 years, had more contacts than students in other grades during closures, particularly late in the week. The authors suggest that because many grade 12 students were not regularly attending classes at the school before the outbreak, they may have felt that they or their friends had not been exposed to the infection.

Table A

Studies included in the rapid review and summary of findings about activities outside the home and childcare arrangements involving non-household members during school closures (n = 19)

Study, year and place	Participants	Activities outside the home	Childcare arrangements involving non-household members
Basurto-Davila et al. (2013), Argentina [28]	226 households; children aged 6–15 years from three schools closed for 2 weeks because of influenza A(H1N1).	67% of children visited public places at least once; 45% left the home several times.	Left with a relative or family friend (82%/88% depending on region), hired nanny (13%/5%), other special arrangements (3%/4%), left alone (2%/1%).
Braunack-Mayer et al. (2013), Australia [14]	Four school principals, 25 staff, 14 parents, 13 students aged 12–17 years; schools either partially or fully closed because of H1N1 (length of closure unclear).	Qualitative study indicating most people adhered to advised quarantine, but in the absence of clear instructions, many invented their own rules. Some parents quarantined their children to avoid being seen as irresponsible. However, many parents reported their children were home alone and so it was unclear whether they complied. Others reported seeing the closure as ineffective and did not quarantine their children. One student reported meeting friends regularly even though his parents believed he was at home.	Not reported.
Effler et al. (2010), Australia [20]	233 households; median age of children 11 years (range: 5–13); three schools closed because of H1N1; School A closed entirely 'for the coming week' while Schools B and C cancelled classes for grades 5 and 5–7, respectively.	74% participated in activities outside the home on at least one occasion, reporting a total of 860 out-of-home activities with an average of 3.7 out-of-home activities per student.	Asymptomatic students: with children other than their siblings (19%). Ill students: with children other than their siblings (6%). All students: left alone for at least some time (10%).
McVernon et al. (2011), Australia [29]	314 households; 33 schools; schools with confirmed cases of H1N1 in multiple classes were entirely closed for 7 days while schools with confirmed cases in only one class were instructed to close only that class.	43 households reported that a child spent at least 1 day outside the family home and mixing with other children occurred on almost half of these occasions (48.8%). Contact with children who were not immediate family members was less likely during days spent at home. No child visited a household in which another child was ill, compared with reported child visitors in 15.9% of 226 homes without a case.	Households with influenza: adult from outside the home (44.4% for households that complied with advice to remain in home vs 2.4% for non-compliant households). Households without influenza: adult from outside the home (28.3% for households that complied vs 4.0% for non-compliant households).
van Gemert et al. (2018), Australia [22]	99 students with laboratory confirmed H1N1; age 6–17 years; Seven schools closed for 3–9 days (not including weekends).	26% (21/81) who reported usually taking part in extra-curricular activities (not sports or religious activities) continued to take part in extra-curricular activities.	Not reported.
Mizumoto et al. (2013), Japan [26]	882 households; 25.2% in kindergarten, 24.8% in primary school, 25.1% in junior high school and 24.9% in high school; age range 4–18 years; 'school closure or class suspension at least once' because of H1N1.	20.5% left the home for non-essential reasons.	Another household member (64.3%), left alone (28.5%), special arrangement such as parental absence from work (7.3%).
Litvinova et al. (2019), Russia [18]	450 participants including students and their household members; School A for children aged 6–17 years and School B for children aged 6–15 years; schools closed for 7 days to mitigate spread of seasonal influenza.	There was a reduction in the number of contacts made by students (14.2 contacts/day when open vs 6.5 when closed). Students reduced their number of contacts with individuals under 18 years of age (75% reduction) and 19–59-year-olds (20% reduction), while increasing contacts with individuals aged 60 years and over (52% increase), although the absolute value remained low (less than one contact/day).	Not reported.
Chen et al. (2011), Taiwan [31]	232 households; school for children aged 5–12 years; school closed for 7 days because of H1N1.	13% went to public places or gatherings at least once, 12% visited relatives, 5% went to parents' workplace.	Parents (60%), other relatives (35%), others (4%), left alone (1%).
Jackson et al. (2011), UK [17]	107 students (only 46 reported how many times they visited public places during closures); children aged 11–15 years; school closed for 1 week, reopened for 2 days, then closed for another week because of H1N1.	98% visited more than one place. 73 students provided their typical number of contacts per day during closure and 35 also provided information for a typical school day. Mean totals of reported contacts were 70.3 and 24.8 during typical school days and closure respectively.	Among caregivers for whom information was available, 125/182 (69%) would have seen the student on a typical school day.
Borse et al. (2011), US [25]	554 households; median age of children: 8 years; schools closed for 5–7 days because of H1N1.	30% of students visited at least one locale outside their homes.	Not reported.

IQR: interquartile range; UK: United Kingdom; US: United States.

Table B

Studies included in the rapid review and summary of findings about activities outside the home and childcare arrangements involving non-household members during school closures (n = 19)

Study, year and place	Participants	Activities outside the home	Childcare arrangements involving non-household members
Epson et al. (2015), US [21]	35 households, representing 67 students; one elementary school and one junior and senior high school housed in the same building complex; schools closed between 29 January 2013 and 5 February 2013 because of influenza-like illness.	58% visited at least one outside venue.	Adult from outside the household (9%), work with parents (6%), childcare programme (3%), left alone (9%).
Gift et al. (2010), US [24]	214 households, with 269 children under 18 years of age; elementary school closed for 1 week because of H1N1.	69% visited at least one other location.	Home as main location (77%). The next most common locations were another family member's home, non-family member's home, parents' workplace, vacation, daycare and 'other'.
Johnson et al. (2008), US [23]	220 households, with 355 children; median age of children: 12 years (range: 5–19); schools closed for 12 days because of influenza virus B.	89% visited at least one public location and 47% travelled outside of the county.	Special childcare arrangements including grandparents, other relatives, other adults, taking the child to work, having older siblings watch them or using childcare programs (10%), one or more night spent outside the household (3%).
Miller et al. (2010), US [19]	63 parents of 176 lower school students (grades 5–8); 188 upper school students (grades 9–12); week-long closure because of H1N1.	Upper school: Mean number of days spent on activities: 3.42 any other outdoor activity; 2.44 eating at restaurants; 1.89 using public transport; 1.48 hosting a friend; 1.47 shopping; 1.47 any other indoor activity; 0.44 working at a job. Average number of friends seen per day: 2.53 on Wednesday, 2.06 Thursday, 2.59 Friday, 2.40 Saturday, 1.23 Sunday, 1.02 Monday, 1.05 Tuesday. Lower school: Mean number of days spent on activities: 2.77 any other outdoor activity; 1.34 eating at restaurants; 1.12 any other indoor activity; 1.05 shopping; 0.73 visiting a friend; 0.55 hosting a friend; 0.10 using public transport. Average number of friends seen per day: 0.30 Wednesday, 0.52 Thursday, 0.84 Friday, 0.83 Saturday, 1.17 Sunday, 0.74 Monday, 0.68 Tuesday.	Upper school: Proportion of caregivers: 0.62 parent, 0.24 sibling, 0.07 grandparent, 0.07 other, 0.06 nanny/babysitter, 0.07 friend's caretaker, 0.11 other, 0.88 self. Lower school: Proportion of caregivers: 0.85 parent, 0.30 sibling, 0.09 grandparent, 0.15 other family, 0.27 nanny/babysitter, 0.03 friend's caretaker, 0.06 other, 0.76 self.
Russell et al. (2016), US [27]	99 households, representing 197 children; students in pre-kindergarten up to grade 12; school closed for 4 days because of influenza-like illness.	77% of children went outside the home or visited a non-household member, participating in a mean of two activities (IQR: 1–4).	Adult from outside the household (20%); childcare programme (1%).
Steelfisher et al. (2010), US [32]	523 parents; ages and number of children not reported; childcare centres and schools closed because of H1N1: 10% were closed for 1 day, 19% for 2 days, 29% for 3 days, 15% for 4 days, 17% for 5 days, 9% for more than 5 and 2% didn't know.	56% reported their child participated in at least one activity involving people outside the household.	81% were cared for by an adult in the household, 20% by a family member outside the household, 1% by a friend/neighbour, 3% by a professional care provider, and 10% stayed home alone.
Timperio et al. (2009), US [30]	262 households, representing 480 children; ages not reported. Two schools closed because of seasonal influenza; one closed for 3 days and the other for 4 days.	43.3% visited strip malls or WalMart, the largest store in the area; 42.9% visited family; 38.7% went grocery shopping; 32.6% ate at restaurants; 30.3% either visited friends' homes or had friends visiting their home; 29.1% attended religious services; 23.8% took part in sports activities; 17.6% went to public gatherings such as concerts, movies or festivals; 8.4% went to a part time job.	Not reported.
Tsai et al. (2017), US [33]	208 households with 423 children; school closed for 8 days because of influenza.	Not reported.	Childcare programme (3%), attending work with parents (1%), left alone without supervision (1%), old enough to care for themselves (15%).
Zheteyeva et al. (2017), US [34]	2,229 households with 4,247 students; kindergarten to grade 12; schools closed for 4 days in preparation for Hurricane Isaac.	Not reported.	Old enough to care for themselves (11.6%), went to work with parents (5.3%), childcare programme (2.6%), left alone without supervision (2.5%).

IQR: interquartile range; UK: United Kingdom; US: United States.

One study of 355 children [23] found that children 12 years of age and over were significantly more likely to go to fast food restaurants and parties ($p < 0.05$), but less likely to go grocery shopping than children 12 years of age and under.

Conversely, one Japanese study of 882 households, with children of kindergarten to high school age [26], found that younger children were more likely to leave the home during a closure; 53.2% of kindergarten pupils, 42.5% of primary school pupils, 30.3% of junior high school pupils and 33.2% of high school pupils reporting that they left the home at least once. Primary school pupils were significantly more likely to leave the home to visit a supermarket or convenience store ($p = 0.05$ for the association between school category and shopping), while junior high school pupils and primary school pupils were significantly more likely to leave the home to attend extracurricular studies compared with pupils in other school categories ($p = 0.02$).

District

Evidence from one study of behaviour in children aged 6 to 15 years from 226 households in two different school districts in Argentina [28] suggested that location can affect the out-of-home activities children take part in during school closures. In this study, children in Jujuy were more likely to attend religious events, use public transport, and go to plazas and recreation areas than children in Ushuaia. Meanwhile, children in Ushuaia were more likely to go to the movie theatre and restaurants than children in Jujuy. The study suggested socioeconomic differences may well be the reason for this: Ushuaia has one of the lowest poverty rates in the country, whereas Jujuy has one of the highest.

Employment status of adults in the household

A study of 554 households in the US (median age of children: 8 years) found that if all adults in the home were employed, ill children were less likely to leave the home [25]. The probability of a child visiting any other venue was 34% if the child came from a household where at least one adult was not employed, with annual income less than USD 25,000 and with only one child between kindergarten and fourth grade age who did not have an influenza-like illness before or during the closure. However, if all adults in the household were employed, the probability of children leaving the home decreased to 24%. This was an unexpected finding as we would have expected that children living only with employed adults might have to leave the home for childcare arrangements. The authors did not offer reasons for the association between employed adults and reduced likelihood of children leaving the home.

Perceived appropriateness of school closure

Two studies, one from Australia and one from Japan, found that parental opinion about the appropriateness of the school closure was significantly correlated with student participation in activities outside the home ($p = 0.0006$ and $p = 0.03$ respectively) [20,26]. Students of parents who thought the school closure was not appropriate reported a mean of 4.7 out-of-home activities during the closure, compared with a mean of 4.3 activities for students of parents who were unsure and 2.8 for students of parents who thought the closure was appropriate [20]. This pattern persisted when the analysis was restricted to the 202 students who were asymptomatic. Similarly, Mizumoto et al. [26] found that proportionately fewer children left the home in households that believed the closure was appropriate: 38.8% compared with 53.2% of children in households who felt the closure was inappropriate.

Extent of closure

One Japanese study of 882 households [26] found that extent of school closure was significantly associated with the frequency of children leaving the home: closure of the entire school, closure of a single grade or single class suspension were associated with 47.8%, 32.2% and 40.3% of children leaving the home, respectively ($p = 0.01$).

Length of time advised to isolate

One Australian study of 314 households investigated adherence with reactive school closure attempting to contain the H1N1 pandemic [29]. Participants had been asked to go into voluntary home quarantine ranging from 1 to 14 days in length. Children stayed at home for more than 94% of the days they were advised to be in quarantine. This figure was not associated with the length of quarantine nor did it fluctuate over the course of the quarantine period.

Day of the week

In one American study [19], contact rates of uninfected students at the end of the week were lower than at the beginning. Based on visual inspection of the graph presented in the study, contacts substantially increased for older children, i.e. children in grades 11 and 12, on Friday and Saturday.

Special childcare arrangements

A study of 882 households in Japan found that children in households where special childcare arrangements were needed during closure were significantly more likely to leave the home than households in which children were independent and able to take care of themselves (53.1% vs 35.9%; $p < 0.01$) [26].

Other factors considered

Based on a study of 882 Japanese households, a child's sex, household educational level, household income and household size were not associated with the likelihood of the child leaving the home during school closure [26].

Parental attitudes towards school closure

Perceived benefit of closure

Parents generally agreed with school closures. Several studies reported high rates of parents being at least moderately supportive of the closure: 97% [30], 93% [26], 91% [23], 78% [28], 73% [31] and 71% [32]. The main reasons for agreeing with school closures were believing that it would protect the health of the community, the children themselves and the household. Another main reason was believing that there were too many sick children for the school to remain open [20,23,26,30]. Timperio et al. [30] found that over 90% of parents from 262 households in the US felt it was important to disinfect the schools while closed to reduce the community spread of influenza.

Perceived risk of infection

Several of the main reasons for disagreeing with school closures appeared to be related to perceived risk: parents cited beliefs that closures do not protect against influenza [28], that the illness is only mild [20,26] and that school closure is not an effective measure against infection [26].

Practicalities of school closure

Other main reasons for disagreeing with school closures were related to the practicalities and subsequent impact of the closure. For example, parents were concerned about the impact on the child's education [28], difficulties making childcare arrangements [26] and concerns about the economic impact [20,23]. Parents reported various difficulties associated with school closures, primarily lost income, the effort of arranging alternate childcare and uncertainty about the duration of the closure [33,34]. Some studies also illustrated a lack of consistency by schools regarding the importance of not participating in social activities. For example, 17% of parents reported that after-school activities were not cancelled [32] while others noted that school athletic events were still held on days that school was closed [30].

Discussion

This review of 19 papers found that all studies reported children leaving the home during the closure period and/or being looked after by non-household members, thereby having social contact with others they could potentially infect if they themselves were infected. There was some evidence that continuing to engage in social contact during school closures may be related to older child age, parental disagreement with closure and potentially infection status.

During a major infectious disease outbreak, school closure has the potential to slow the spread of infection. However, the effects of a closure will be attenuated if children continue to mix. Of the 19 papers that we identified, all reported that some degree of mixing continued to occur outside of the home. We should not be surprised at this. Even for adults, self-isolation can be difficult [35] and stressful [36], and children often have wider social circles and feel more social pressure to interact. The precise extent to which contact patterns change during a closure is harder to determine. Only a limited number of studies have attempted to quantify this, reporting reductions in the number of contacts from 70.3 on typical school days to 24.8 [17] and 14.2 to 6.5 [18] during closures. The difference in rates reported are likely because of social and cultural differences as well as differences in definitions of a 'contact' between the papers: there appear to be various definitions of 'social contacts' in addition to what vicinity and duration are necessary for an encounter to be considered a 'contact'.

Complicating matters is that the qualitative nature of contacts also changes. The studies included in this review explored what types of activities children engage in outside of the home during a closure (Table). These include a large range of recreational and social activities, from shopping to meeting friends indoors, using public transport and visiting restaurants. It is likely that the type of activity is important in determining the likelihood of infection spreading. For example, participation in sports events have been noted to be particularly associated with the spread of influenza, as have social events such as parties, whereas visits to a park or beach are reported as being less likely to result in disease spread [20].

We conclude that further research is needed to quantify the rates of contact associated with the various activities reported in this review; contacts in households, schools and workplaces are likely of more sustained duration than contacts in more transient social settings such as shopping. However, social gatherings such as parties may form a 'middle ground' in that they likely involve less sustained contact than in a household or school, but more than in a grocery store for example, and the acceptability of such social gatherings is likely to differ across the population. Assuming infection given a contact is a function of duration and type of contact, this can form the basis of more evidence-based modelling and risk assessment.

Reassuringly, our review found that relatively few children required special childcare arrangements that might actively increase the risk of disease transmission, such as being placed into a semi-formal childcare arrangement with other children or being looked after by grandparents. While low, the proportion of children left home alone unsupervised, however, is of concern because unsupervised children could potentially leave the home without their parents knowing thus risking infection spread. If school closures are considered in the future, public health officials should consider how best to support parents and prevent this from occurring.

We found unclear evidence about the majority of the other predictors of out-of-home activities. In particular, there was mixed evidence about whether children showing symptoms of illness or who have been ill during the closure will take part in similar out-of-home activities compared with children who are not ill. We find it particularly concerning that even symptomatic children are participating in out-of-home activities.

Different studies found that both older age and younger age were associated with leaving the home during school closures. It may be that the direction of findings depends on the activity in question. For example, younger children seem to be more likely to go grocery shopping, perhaps because they are too young to be left at home alone when their caregiver goes to the shops, whereas older children are more likely to take part in social activities like parties and going to restaurants. It should be noted that the one study showing younger children were more likely to leave the home [26] was the only study from Japan so the difference in findings may relate to cultural differences.

Parental attitudes associated with agreeing or disagreeing with school closures were similar to those seen in relation to other preventive health behaviours for infectious diseases [37,38]. In particular, two of the studies included in this review suggested there was a strong association between allowing children to socialise outside the home and disagreeing with the school closure [20,26]. Ensuring parents understand why school closure is important will be a key factor determining the success of the measure in any future disease outbreak. In this regard, it was concerning that two studies appeared to highlight a lack of clarity in terms of advice about whether children could take part in social activities and knowing what children were and were not advised to do [30,32]. Advice from schools should be consistent with public health advice; hosting extra-curricular activities and sporting events during a closure sends mixed messages to parents and can be confusing or detrimental [14].

In terms of how our findings fit with the wider literature, one particular discrepancy is worth noting. Evidence from studies in which people are asked how they would react to a hypothetical school closure often find that parents believe they would co-operate with public health advice. For example, one study involving a hypothetical scenario of schools closing for 3 months because of an influenza pandemic found that 85% of parents responsible for children aged between 5 and 17 years of age believed they would be able to keep their children from taking public transport, going to public events and gathering outside the home during this lengthy school closure period [39]. Meanwhile, another found that 96.7% of parents claimed they would keep their children away from others for a month if schools and child-care facilities were closed [40]. Despite these good intentions, our review of real school closures suggests parents are less likely to achieve this, even when schools are closed for much shorter periods of time. Regardless of the conviction with which people answer questions about their likely future actions, much caution is needed in using such data to assume likely behaviours or make decisions about social distancing measures. The duration of planned closure of schools is likely to be important here too; short closures of up to a couple of weeks may be manageable by parents as seen in the studies reviewed but longer closures required for curtailing pandemic waves of the order of months may provide more challenge to them.

Further research is needed to identify how best to ensure that children are incentivised to stay at home during a school closure. The relatively sparse research conducted to date, limited by the real-world occurrence of school closures and the feasibility of conducting rapid research when these do occur, do not allow us to provide a ready answer to this question, but improved communication with both parents and children is likely to be required.

In terms of limitations for this review, the generalisability of the individual studies we identified is unclear. Notably, much may depend on the cultural context, perceptions of the illness in question, length of the closure, socioeconomic status of the families that are affected and information or instructions that are given to them by public health authorities. With relatively few studies in this field, it is difficult to disentangle these effects. The majority of studies examined school closures because of the 2009 H1N1 pandemic and behaviours during this period may not necessarily reflect behaviours during closures for other reasons or even other infectious diseases. Additionally, several studies looked at school closures because of influenza-like illnesses, which may be considered to be mild and not too dangerous in children [41]. Behaviour during closures for this reason may be different to behaviour during closures for diseases perceived as more severe. It must also be noted that the majority of included studies were from the US, perhaps because of our decision to limit the review to English or Italian papers, and thus may not be generalisable to other cultures or countries. Future reviews should consider including papers published in other languages. While we extracted the duration of school closure from studies included in the review (Table), we did not formally analyse whether the length of school closure was associated with children's activities and contacts made outside the home. The closures we identified lasted for less than 2 weeks, limiting our ability to draw conclusions on this. However, we note that practical issues, including difficulties with childcare and economic impact, were identified by several studies. It seems plausible that longer closures would increase these difficulties. Also, while ideally this review would have calculated a mean reduction in contacts based on all studies or an overall percentage of children who left the home across all studies, this kind of calculation was not possible because of the differences in the way studies measured contacts, the time over which they were measured and the different ways of reporting this information.

No standardised quality appraisal of the studies included in this review was carried out because of the rapid nature of this review, which is common for reviews which need to be carried out urgently in order to guide health policy decisions [42]. However, there were some notable limitations to the literature reviewed. Most were convenience samples, often with low response rates, so may not be representative of all households in the wider community [21,28]. It is likely that particularly vulnerable households would experience greater difficulties and would not have prioritised participating in research studies. Because of this, such groups may not be well-represented in the data. Other limitations included different data collection time points, e.g. collecting data for some participants a week after the closure and others 3 months later [28]; comparing fully-closed schools with partially-closed schools, e.g. schools where only some classes were told to remain at home and extra-curricular activities remained open [20]; and potential under-estimation of social contacts because of only asking about specific planned activities and not incidental activities [22].

Current models frequently use planned school closures, e.g. weekends and school holidays, as a proxy for enforced models [43]. Indeed, planned school holidays may be a fair proxy for short-term closures for some parents but we cannot be sure that this can be extrapolated to longer-term closures, e.g. schools potentially closed for months. Human behaviour is complex and understanding how people respond to an evolving and urgent policy is essential. Basing policy on historical patterns may give false confidence in results and not capture uncertainty adequately. Recent reviews of the incorporation of human behaviour into infectious disease models have advocated the use of appropriate, detailed, real-world behavioural data within infectious disease modelling [44,45]. We hope that our identification of real-world data concerning social contact and mixing behaviour during unexpected school closures will help improve existing models and promote rigorous quantitative research in this area.

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Conflict of interest

None declared.

Authors' contributions

Samantha K Brooks undertook the literature searches, data extraction, analysis, writing of the first draft and revisions of the manuscript. Samantha K Brooks, Louise E Smith, Rebecca K Webster, Dale Weston and Lisa Woodland carried out the screening of papers found in the database searches. G James Rubin conceived and led the study, and reviewed and edited manuscript drafts. Ian Hall contributed to planning of the work, and reviewed and edited manuscript drafts. Louise E Smith, Rebecca K Webster, Dale Weston and Lisa Woodland reviewed and edited manuscript drafts.

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Letter to the editor: COVID-19 cases among school-aged children and school-based measures in Hong Kong, July 2020

MW Fong[1] , BJ Cowling[1] , GM Leung[1] , P Wu[1]

1. World Health Organization Collaborating Centre for Infectious Disease Epidemiology and Control, School of Public Health, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China

Correspondence: Peng Wu (pengwu@hku.hk)

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To the editor: We read with interest the recent rapid communication by Stein-Zamir et al. analysing a major outbreak in an Israeli high school, which has been attributed to crowded conditions in classrooms and exemption from wearing face masks [1]. We would like to share our perspective from Hong Kong, where cases among school-aged children have been reported but did not lead to school outbreaks.

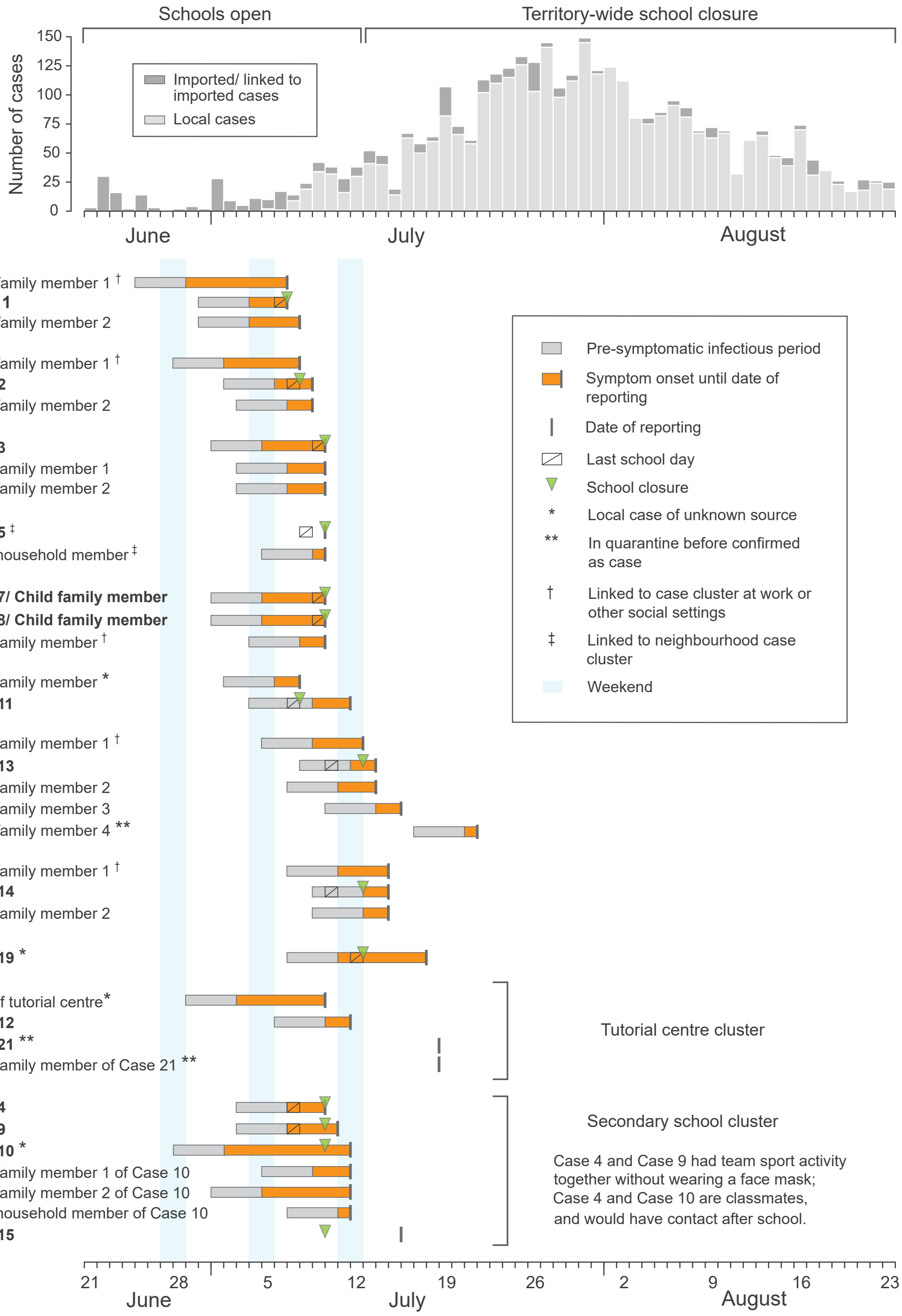
As part of the response to coronavirus disease 2019 (COVID-19), schools in Hong Kong did not resume after the Lunar New Year holiday at the end of January 2020. Classes were instead scheduled online. Following a period without any local infections, secondary schools reopened in late May and primary schools reopened in the subsequent weeks. There were no cases in school-aged children until early July when local transmission resurged [2]. Schools were closed again on 13 July, 1 week before the scheduled summer break. By 18 July, there were 20 cases aged 5–17 years. Fifteen were linked to case clusters within their own household or neighbourhood or had unknown source of infection. The remaining cases included a secondary school cluster and a cluster at a tutorial centre.

Assuming that students were potentially infectious from 4 days before illness onset through 7 days after onset [3], many cases attended school while infectious (Figure). School-wide testing was conducted for schools attended by seven of the 15 cases and for the two clusters, and close contacts were placed under medical surveillance. No other cases related to these 20 cases have been identified in this age group since, suggesting that multiple potential introductions of COVID-19 into schools did not lead to onward transmission. This may be because children, especially young ones, could be less efficient spreaders of COVID-19 [4,5], supplemented by the protective effect of school-based precautionary measures.

Various infection control measures were adopted by local schools during the school resumption. Staff and students underwent daily temperature checks upon arrival at school. Face masks were worn at all times, and schools switched from full-day to half-day mode omitting lunch hours. Students' arrival and dismissal times were staggered or spread out using multiple entrances, desks in classroom were spaced out, and some schools installed transparent partitions between desks. Group work and contact sports were limited as much as possible. To avoid mixing of students from different classes and grades, assemblies, extra-curricular and after-school activities were cancelled, and usage of common facilities was staggered. More efforts to ensure distancing between staff and students will further improve the current strategy in view of the higher infection risk among adults [6]. Previous responses from local schools varied from flexible attendance policies and immediate dismissal to closure for varying durations; this indicated an urgent need to have standardised preparedness plans containing measures to be taken by schools in response to confirmation of cases or contacts of a COVID-19 case among staff and/or students.

FIGURE

School-aged COVID-19 cases identified during school resumption (27 May–12 July) until the 1st week of territory-wide school closure (13–18 July), Hong Kong



Top panel: epidemic curve of daily case numbers from June through August in Hong Kong, with cases shown by date of reporting. Lower panel: information on individual cases by cluster. Cases with no information on school attendance and not linked to other school-aged cases (Cases 16, 17, 18 and 20) are not shown in this figure. Case 6, an asymptomatic case linked only to neighbourhood case cluster is not shown here either. Case 21 was reported after 18 July but included in this figure because the case was linked to the tutorial centre cluster. The pre-symptomatic infectious period was assumed to begin 4 days before symptom onset [3]. Cases were typically isolated on the day of reporting or up to 2 days before reporting, ending any possible transmission. Schools for Cases 1–3, 5, 7–8, 11 and the secondary cluster were closed before the territory-wide school closure, while Cases 13, 14 and 19 were reported after 10 July, therefore these schools were closed with the territory-wide school closure.

Conflict of interest

BJC consults for Roche and Sanofi Pasteur. The authors report no other potential conflicts of interest.

Authors' contributions

MWF initiated and wrote the first draft. All authors commented, revised and approved the manuscript.

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Letter

Letter to the editor: Evidence on school closure and children's social contact: useful for coronavirus disease (COVID-19)?

Michele Poletti[1] , Andrea Raballo[2,3]
1. Department of Mental Health and Pathological Addiction, AUSL-IRCCS of Reggio Emilia, Reggio Emilia, Italy
2. Division of Psychiatry, Clinical Psychology and Rehabilitation, Department of Medicine, University of Perugia, Perugia, Italy
3. Center for Translational, Phenomenological and Developmental Psychopathology, Perugia University Hospital, Perugia, Italy

Correspondence: Michele Poletti (michele.poletti2@ausl.re.it)

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To the editor: We read with interest the recent rapid evidence review by Brooks and colleagues about the impact of unplanned school closure on children's social contact [1]. This review substantially aimed at investigating if children adhere to social isolation or continue to mix with others, limiting the effects of school closure and of quarantine. This is an important topic, the of dark side of which resides on effects of prolonged school closure on well-being of children, poorly considered in the current public debate on management of coronavirus disease (COVID-19) [2]. In this perspective, mental health of children and adolescents undergoes a sudden stress test during school closure, with increased risk of loneliness, addiction to videogames and binge watching, alteration of circadian rhythms, direct or assisted domestic violence, and academic achievement gaps. Especially for the latter, inequalities related to socioeconomic status and differences related to pre-existing vulnerabilities will be further amplified [2-4].

Brooks and colleagues [1] clearly reviewed literature on unplanned school closure to extract potential clues in relation to the management of the current COVID-19 pandemic, but generalisability of findings for this aim is questionable, as acknowledged by authors in the discussion. Two intertwined main obstacles for the generalisability of findings relate to the geographic expansion of the pandemic and to the temporal duration of school closures. Examined studies were almost entirely based on experiences in context with the 2009 influenza A(H1N1) pandemic or other influenza-like outbreaks, that did not have the scale of the COVID-19 pandemic, being geographically limited in some areas. Moreover, duration of previous experiences of school closures ranged from 1 day to 2 weeks, while the current COVID-19 pandemic is causing much longer school closures. For example, in Italy, children and adolescents will be away from schools for almost 6 months (3 months of school closure plus 3 months of usual summer vacation), with the vague possibility of summer camps, in our opinion actually with low probability to be allowed and implemented.

Therefore, findings based on geographically and temporally limited school closures may be poorly informative for a pandemic at the scale of COVID-19 and consequent temporally extended school closures. This is the case because risk perception of children and also of their parents (other factors that Brooks and colleagues found related to the respect of social isolation [1]) is clearly different in the two scenarios and therefore also adherence to social isolation is probably different [5]. In this perspective, one of the main conclusions of the review, i.e. during school closure children continue having social contacts with others, is very poorly informative to predict adherence to social isolation of children during school closure along the COVID-19 pandemic.

Instead, considering how much social isolation may affect mental health of children and adolescents [2-4], we strongly suggest that medical, educational and economical authorities should implement as soon as possible strategic plans for a progressive re-start of school or educational activities. This re-start should ensure a calculated trade-off between risk of COVID-19 infection and reduction of risk for children's well-being, especially for more vulnerable subgroups, as those of families with low socioeconomic status and those with pre-existing mental health problems or learning difficulties.

Conflict of interest

None declared.

Authors' contributions

Conceived the paper: MP, AR; wrote the first draft: MP; revised the paper: AR. Approved the manuscript: all authors.

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Letter

SARS-CoV-2 infection and primary school closure

Philippe Vanhems[1]
1. Hospices Civils de Lyon, Lyon 1 University and International Center for Research in Infectiology (CIRI), Lyon, France

Correspondence: Philippe Vanhems (philippe.vanhems@chu-lyon.fr)

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To the editor: The recent review of Brooks et al. on the impact of unplanned school closure on children's social contact [1] for controlling outbreaks brings interesting information that could apply to coronavirus disease (COVID-19). In addition, a recent case in France of a 9-year-old child infected by SARS-CoV-2 [2] raises the issue of risk assessment for other children at a same school and/or in a same classroom.

Identification of contacts between classmates is of high importance for appropriate screening and implementation of preventive measures at a primary school level but also at a family level. It has been reported that the patterns of contacts strongly differ according to age and school grade. For example, based on radiofrequency identification devices (RFID) technology, it was reported that young French children (age 6 years) in a primary school [3] had a median of 500 contacts per school day and a median of 300 minutes of cumulated contact per day. Older children (age 10–11 years) had a median of 300 contacts per day and a median of 250 minutes of cumulated contact per day. An aggregate analysis emphasised that young children interacted with many schoolmates of the same or similar age (age 7–8 years) while older children restricted their contacts mostly to their own age stratum, like in England [4].

The practical application of such an observation would therefore be to help public health authorities identify the children at higher risk of exposure. The decision to close a school totally or partially according to the age of an index case should be discussed. However, in an emergency context such as the COVID-19 pandemic where scientific knowledge regarding the virus is still lacking, total closure of a school was reasonable and reassuring for parents.

Management of such an event raises two issues in public health decisions. On the one hand, an understandable precautious public health decision for total school closure, and on the other hand, a detailed risk assessment with a potentially different decision. Although SARS-CoV-2 is not influenza or a respiratory syncytial virus, previous studies have identified the major impact of different social contacts of children by age which could have an impact on the spread of respiratory viral infections in schools [5]. Attack rates would differ according to grade or age, which determine the different contact patterns between children and would make it possible to adapt infection control measures [6]. However, a more discriminant risk estimation by age at onset of a public health emergency would appear not to be useful but might be helpful regarding strategies of re-opening schools with sequential access to courses. Nevertheless, at least retrospectively, detailed analysis of inter-individual contact remains a key determinant with viral characteristics in order to understand the dynamic of viral transmission in close environments such as primary schools.

Conflict of interest

None declared.

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European Union

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http://europa.eu

European Commission - Public Health

The website of the European Commission Directorate General for Health and Consumer Protection (DG SANCO).
http://ec.europa.eu/health/

Health-EU Portal

The Health-EU Portal (the official public health portal of the European Union) includes a wide range of information and data on health-related issues and activities at both European and international levels.
http://ec.europa.eu/health-eu/

European Centre for Disease Prevention and Control

European Centre for Disease Prevention and Control (ECDC)
The European Centre for Disease Prevention and Control (ECDC) was established in 2005. It is an EU agency that aims to strengthen Europe's defences against infectious diseases. It is located in Stockholm, Sweden.
http://www.ecdc.europa.eu

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