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Can children be super-spreaders of COVID-19?

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This rapid review summarizes the available evidence on the rate of COVID-19 transmission attributed to children among healthy individuals. This may change as new evidence emerge.

KEY FINDINGS

- There is limited evidence to suggest that children can significantly contribute to the spread of COVID-19.
- **The incidence of COVID-19 is relatively low in the pediatric population based on published data. Nevertheless, children of all ages remain to be susceptible.**
- **The familial household appears to be the main cluster into which children may contract the virus.**
- **Three retrospective reports suggest that children had a limited impact on the potential super-spread of SARS-CoV-2 infection in schools and the community.**
- **At present, it is difficult to determine the rate of COVID-19 transmission attributed to children because of low-quality evidence.**
- **Further epidemiological and surveillance studies must be reported to identify more pediatric index cases.**

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RESULTS

We reviewed 12 articles in this report. The observational studies are composed of six case reports and three case series. Three retrospective cohort studies are included. Seven studies were from China, and the rest were from France, Ireland, South Korea, Vietnam, and Australia. They were published as early as January 2020 and the latest in May 2020. Four studies focused on the transmission dynamics of COVID-19 in family clusters. The case series, retrospective cohort, and case reports were sourced from peer-reviewed journals. The report from the National Center for Immunisation Research and Surveillance in Australia was published in their official online website.

The studies included in this review were deemed of low quality because of the nature of the studies and the relative heterogeneity of all available data presented. Most of the data in this review involved only a few number of children as primary index cases. Despite the few number of index patients, it should be noted that the number of contacts identified was sizeable (a total of 1,784 contacts for 13 index cases). All studies combined involve a wide range of pediatric ages. Two studies (NCIRS, Heavey) did not specify the ages of these index patients and both studies were not able to report the exact periods of exposure to each contact (in hours or days). The average number of contacts per day is not well elucidated, which will be important in determining the transmission rate, which is defined by the average number of people each infectious person spreads the disease to each day.

While most of the studies used symptoms and RT-PCR swabs as a basis for confirmation, the one secondary case was confirmed only through positive antibody results. Viral co-infection was identified by only one study. All three retrospective studies had an adequate contact tracing program with a follow-up period of 14 days from last exposure, and those who presented with COVID-19 symptoms were tested. There was an adequate description of the disease severity in several reports [18-21,24-27]. There were no studies that declared an outbreak of SARS-CoV-2 in schools and the community.

We compiled the disclosed data from the retrospective cohort studies of Danis, et al, the NCIRS, and Heavey, et al to describe the transmission chain in three scenarios where children were determined to be index patients. A tabulation of these details is given in Table 1.

Data	Country	Number of Index Patients	Age of Patients (years)	Location of Contact	Symptoms	Number of Contacts	Number of Confirmed SARS-CoV-2 Secondary Cases
NCIRS (2020)	New South Wales, Australia	2	Not specified	High School	Unknown	211	1
		2	Not specified	High School	Unknown	83	0
		1	Not specified	High School	Unknown	87	0
		1	Not specified	High School	Unknown	79	0
		1	Not specified	High School	Unknown	149	0
		1	Not specified	High School	Unknown	15	0
		1	Not specified	Primary School	Unknown	55	0
Heavey, et al (2020)	Ireland	1	10-15	Primary or Middle School; Home	Fever	537	0
		1	10-15	Primary or Middle School; Home	None	188	0
		1	10-15	Primary or Middle School; Home	Fever	264	0

Data	Country	Number of Index Patients	Age of Patients (years)	Location of Contact	Symptoms	Number of Contacts	Number of Confirmed SARS-CoV-2 Secondary Cases
Danis, et al (2020)	France	1	9	3 different schools	Symptomatic but not specified (had picornavirus and influenza co-infection)	86	0

Table 1. Breakdown of Index Patients, their age, location, symptomatology, exposed contacts and confirmed secondary cases

For all of these index cases, a total of 1,784 close and casual contacts were identified as susceptible cases. Among all contacts, only one secondary case was confirmed through antibody testing. **From this data, it appears that children cannot be super-spreaders of COVID-19.**

The **National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM)** in the Netherlands released a statement saying that children play a minor role in the spread of the virus and that COVID-19 is spread between persons of approximately the same age. They were able to identify that most infections involving children occur inside the household, particularly from a parent to a child, and, despite low incidence, children remain susceptible. In addition, the RIVM demonstrated that the pediatric cases who were monitored in their contact tracing network did not infect others. [30]

A study to determine the national incidence of COVID-19 is being spearheaded by the National Institutes of Health (NIH) and funded by the National Institute of Allergy and Infectious Diseases (NIAID) in the United States. From the news release, the name of the study is called the **Human Epidemiology and Response to SARS-CoV-2 (HEROS)**, and one of its aims is to determine the rate of SARS-CoV-2 infection in children and their family household. They plan to enroll and prospectively follow 6,000 people from 2,000 U.S. households for a total of 6 months. Participants in the study will be swabbed every two weeks coupled with a series of questionnaires regarding symptomatology, activities, recent exposures, and contacts. The study will include healthy children and children with allergic conditions or asthma. [31]

CONCLUSION

There appears to be limited evidence to suggest that children can significantly contribute to the spread of COVID-19, wherein a pediatric index patient was able to advance further to tertiary spread and cause a super-spreader event. We recommend that further epidemiological and surveillance studies be reported to identify more pediatric index cases.

Declaration of Conflict of Interest

No conflict of interest

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Appendix 1. Characteristics of included studies

No.	Title/Author	Study design	Country	Population/Pediatric case	Key findings
1	<p>Clinical features of pediatric patients with COVID-19: a report of two family cluster cases</p> <p>Ji, L.N., et al</p> <p>Published February 24, 2020 <i>World Journal of Pediatrics</i></p>	Case series	China (Hubei Province)	Two family clusters (1 confirmed pediatric case per cluster)	<p>Case 1: "He was previously healthy. History inquiry revealed that he had a travel history to Wuhan City (the epicenter of COVID-19 outbreak) with his parents one week ago. In Wuhan City, the boy's entire family had dinner with several friends, and one of these friends was confirmed with COVID-19 three days later." "His family members displayed similar symptoms. His father had a low fever of 37.8 °C for one day, with no cough or other discomforts. His mother had a mild cough for one week without fever"</p> <p>Case 2: "History inquiry showed that he had traveled with his family to Xiaogan City, China (the subcenter of COVID-19 outbreak neighboring Wuhan City in Hubei Province) 10 days ago. Both the physical and laboratory examinations of the boy were unremarkable." His mother presented with fever and cough two days earlier than the boy. Although her oropharyngeal swab tests for SARS-CoV-2 were negative during two consecutive times, she was still suspected with COVID-19 because she had a travel history and multiple peripheral ground-glass opacities in both lungs on chest CT (Fig. 2b). The boy's father had a mild cough for four days, and his two-year-old sister had a transient low fever for two days."</p> <p>"In conclusion, pediatric patients with COVID-19 are mostly from the family cluster with clear travel histories to Hubei Province, the epicenter of the outbreak. Close contact in the family is the main transmission way of infection in children."</p>
2	<p>Transmission potential of asymptomatic and paucisymptomatic SARS-CoV-2 infections: a three-family cluster study in China</p> <p>Jiang, X., et al</p> <p>Published April 22, 2020 <i>Journal of Infectious Diseases</i></p>	Case Report	China	Three family clusters (8 confirmed cases, 1 confirmed pediatric case, Patient 8)	<p>"Patient 8, a 3-month-old female infant, was the close contact of Patient 7, her father. On January 27, her nasopharyngeal swab was collected and was a weak positive for SARS-CoV-2. A repeat pharyngeal swab was collected on January 29 and was positive for SARS-CoV-2. The infant had no clinical symptoms before, during, or after hospitalization."</p> <p>"Except for contact with her father, patient 8 had no known contact with COVID-19 patients."</p>
3	<p>Asymptomatic cases in a family cluster with SARS-CoV-2 infection</p> <p>Pan, X., et al</p> <p>Published February 19, 2020 <i>The Lancet Infectious Disease</i></p>	Case Series	China (Hubei Province)	3 confirmed cases in a family cluster (1 confirmed pediatric case, Patient 3)	<p>"On Jan 22, 2020, patient 1 traveled from Wuhan (Hubei, China) to Guangzhou (Guangdong, China) with his wife (patient 2) and son (patient 3) by high-speed rail."</p> <p>"Patients 2 and 3 had no signs or clinical symptoms during the same observation period (Jan 27–29), with no decreases in white blood cell or lymphocyte counts"</p> <p>"However, any of the three individuals could have been the first one to become infected and thus transmitted the virus to the other two family members. Importantly, asymptomatic patients (such as patients 2 and 3) might be unaware of their disease and therefore not isolate themselves or seek treatment, or they might be overlooked by health-care professionals and thus unknowingly transmit the virus to others."</p>
4	<p>A Case Series of children with 2019 novel coronavirus infection: clinical and epidemiological features</p> <p>Cai, J. et al</p> <p>Published February 28, 2020 <i>Clinical Infectious Diseases</i></p>	Case Series	China	10 confirmed pediatric cases	<p>"Seven (70%) children were residents 2 (20%) were from Wuhan and 1 (10%) was from Xiaogan (an endemic area 50 kilometers far away from Wuhan). Eight (80%) children had direct contact with adult patients with 2019-nCoV infection who had a history of travel to Wuhan or contact with persons from Wuhan."</p>

					<p>"Exposure setting included household exposure in 7 patients (70%), endemic area exposure in 2 patients (20%), and bus traveling exposure in 1 (10%) patient who had contact with 2 adults travelers from Wuhan who already had mild respiratory symptoms during the bus traveling and were confirmed with COVID after returning to Wuhan."</p> <p>"For the 3-month-old infant (patient 7 in Table), her parents developed symptomatic COVID 7 days after they looked after the sick baby without protection measures. The interval between symptom onset and exposure to index symptomatic case ranged from 2 to 10 days (mean: 6.5 days) and the interval between symptom onset and departure from endemic areas was 1 day and 9 days."</p>
5	<p>A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster</p> <p>Chan, J., et al</p> <p>Published January 24, 2020 <i>The Lancet</i></p>	Case report	China (Wuhan & Shenzhen)	One family cluster including 2 children (1 confirmed pediatric case, Patient 5)	<p>"For the two asymptomatic children (patients 5 and 6), patient 5 had ground-glass lung opacities identified by CT scan. Unlike patient 5, who was aged 10 years and non-compliant to parental guidance, patient 6, who was aged 7 years and reported by her mother to wear a surgical mask for most of the time during the period in Wuhan, was not found to be infected by virological or radiological investigations. The blood tests and CT scans of patient 6 were normal. After they returned to Shenzhen on Jan 4, 2020, patients 3–6 stayed in the same household of patient 7 (mother of patient 4) until Jan 11, 2020."</p> <p>"Dates filled in yellow are the dates on which patients 3–6 stayed with patient 7."</p> <p>"Our study showed that person-to-person transmission in family homes or hospital, and intercity spread of this novel coronavirus are possible, and therefore vigilant control measures are warranted at this early stage of the epidemic."</p>
6	<p>A child with household transmitted COVID- 19</p> <p>Mao, L., et al</p> <p>Published May 7, 2020 BMC Infectious Diseases</p>	Case Report	China	Infant (14-month-old)	<p>"The possible route of transmission was investigated, and the following was revealed. The patient attended a family gathering event together with the patient's mother and grandmother on January 20. One person who also attended the gathering recently went to Wuhan but was asymptomatic at that time. The patient was subsequently diagnosed with COVID-19 on January 28. The child's grandmother started to present symptoms of fever and minor cough at 3 days after the gathering. She tested positive for SARS-CoV-2 by RT-PCR in the nasopharyngeal swab (negative results in urine and stool) on January 29, and was admitted to the hospital for treatment... The patient's mother presented with a symptom of nasal congestion without fever on January 31, and tested positive for SARS-CoV-2 by RT-PCR in the nasopharyngeal swab on February 1."</p> <p>"In summary, the present pediatric case of COVID-19 was acquired through household transmission, and the symptoms were mild."</p>
7	<p>First Pediatric Case of Coronavirus Disease 2019 in Korea</p> <p>Park, J.Y., et al</p> <p>Published March 2016 Journal of Korean Medical Science</p>	Case Report	South Korea	One child (10-year-old girl)	<p>"Within one month of the first case of COVID-19 in Korea, a 10-year-old girl, who had no travel history outside Korea, was diagnosed with COVID-19 on February 18, 2020."</p> <p>"The patient lived with her mother, father, and cousin in a multiplex housing unit, and her uncle and aunt lived upstairs. The patient's uncle, who ran a store in Wuhan, arrived in Korea on January 20, 2020, and had self-</p>

					<p>quarantined in his room from January 29, 2020. During the quarantine period, he broke self-quarantine by having meals with his family members.</p> <p>Because the patient closely contacted her uncle and her mother, she was screened for COVID-19, and three screening tests for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were all negative on day 1 and 4 since her uncle's diagnosis (February 1) and day 2 from the last exposure (February 5) to her mother. She remained well without subjective symptoms until the 13th day from the last exposure when she developed slightly elevated temperature of 37.3°C, which led to a confirmed diagnosis of her COVID-19 on February 18, 2020.</p> <p>This 10-year old girl took care of herself during the first 7 days spent alone in a negative isolation room. When her mother was discharged from her own negative isolation room, her mother joined her for care. She was transferred to a cohorting facility on the 15th hospital day to allow her isolation room to be used by another confirmed case in a more severe condition.</p>
8	<p>The isolation period should be longer: Lesson from a child infected with SARS-CoV-2 in Chongqing, China</p> <p>Lin, J., et al</p> <p>Published March 2, 2020 Pediatric Pulmonology</p>	Case Report	China	<p>One child (7 year-old girl)</p>	<p>Five days after meeting his daughter, the girl's father presented fever, rhinorrhea, without cough on January 27th. The symptoms did not alleviate after taking Lianhuaqingwen granule (a Chinese herbal medicine) orally. On</p> <p>Although the girl and her father were both infected with SARS-CoV-2, the girl's grandparents, mother, and 2-year-old brother had no clinical manifestation and rRT-PCR tests for SARS-CoV-2 were all negative.</p> <p>First, we speculate that the girl's father may be infected by her because he only had a short stay in Hubei province and did not have close contact with anybody except the family members. More importantly, he became symptomatic and diagnosed with COVID-19 just 5 days (appeared to be the appropriate incubation time) after meeting his daughter. It has been usually ignored that the source of infection could be children, so active monitoring of children back from Hubei province by the local health department should be conducted.</p> <p>In conclusion, this is a case that an adult was infected by a relatively asymptomatic child. It helps us to recognize that children infected with SARS-CoV-2 may be more likely to develop mild symptoms and could be potential sources of infection. The isolation period for suspected child cases should be longer than 14 days. Further research with a large sample size is urgently needed to investigate the feature of children infected with SARS-CoV-2.</p>
9	<p>The first infant case of COVID-19 acquired from a secondary transmission in Vietnam</p> <p>Le, H., et al</p> <p>Published March 23, 2020 The Lancet</p>	Case Report	Vietnam	<p>One child (3 month-old girls)</p>	<p>The grandmother already had direct contact with the infant at her home and when visiting the infant's relative's family on Jan 28 and Jan 29. Because the infant did not travel to the regions where COVID-19 is epidemic, nor did she have close contact with primary sources of infection ie, people who had returned from Wuhan, it could be confirmed that the infant acquired SARS-CoV-2 infection from her grandmother.</p> <p>As of Feb 19, despite close contact with the patient, the infant's mother did not present any symptoms and her repeated nasopharyngeal swabs were negative for SARS-CoV-2. All the other family members, including a</p>

					5-year-old boy, were also asymptomatic and tested negative. Thus,
10	<p>A cluster of coronavirus disease 2019 (Covid-19) in the French Alps</p> <p>Danis, K., et al</p> <p>Pre-Publication Release Oxford University Press for the Infectious Diseases Society of America</p>	Retrospective Cohort	France	<p>One index case 15 exposed cases 172 additional contacts (1 confirmed pediatric case, Case 6)</p>	<p><i>"One pediatric case, with picornavirus and influenza A coinfection, visited 3 different schools while symptomatic."</i></p> <p><i>"Because of the large number of contacts of the pediatric case (case 6), particular attention was paid to detect tertiary cases in children in the three schools the child attended while symptomatic. On 08/02, a public meeting was held to inform the parents of two schools (A and B); the parents of school C were informed by telephone. As a precaution, the first two schools were closed for two weeks and the third for one week (end of follow-up period; the pediatric case visited that school on 31/01)."</i></p> <p><i>"On Sunday 09/02, infectious disease specialists 10 and epidemiologists evaluated the risk of 112 school contacts. All children and teachers who were in the same class as the symptomatic pediatric cases considered as high-risk contacts and were isolated at home (Table 2). All hospitals in the region implemented emergency plans to accommodate potential tertiary cases."</i></p> <p><i>"Of those, 98% (N= 169) were contacted; 70 (41%) had respiratory symptoms during the investigation and were thus classified as possible cases; 73 were tested; all tested negative for SARS-CoV-2 except for case 13 who tested positive during hospitalization. No additional cases were identified within the 14-day follow-up period of all contacts."</i></p> <p><i>"Particularly, the infected child, despite interactions with a large number of contacts in different schools, did not transmit the disease, as evidenced by a large number of negative results of his tested contacts. However, the high proportion of picornavirus and influenza infections among his contacts at the schools indicated transmission of those viruses within those settings."</i></p> <p><i>"Similarly, we observed that the family cluster allowed the dissemination of picornaviruses or influenza A in the children, while SARS-CoV-2 was detected in only one child."</i></p>
11	<p>COVID-19 in schools—the experience in NSW Prepared by the National Centre for Immunisation Research and Surveillance (NCIRS)</p> <p>Published April 26, 2020</p>	Retrospective Cohort	New South Wales	<p>18 confirmed cases in 15 schools (9 high school students and 9 staff) 863 close contacts (735 students and 128 staff)</p>	<p><i>"In the 15 schools (10 high school and 5 primary schools) a total of 18 COVID-19 cases (9 students and 9 staff) were identified between 5 March 2020 and 3 April 2020. The public health staff identified 863 close contacts in these 15 schools. Of the 863 close contacts, only two students have been identified as secondary cases. One of these was diagnosed by nose/throat swab testing and one had a positive antibody test 4 weeks after their exposure. A review showed that it was most likely, but not certain, that these two children were infected by transmission in the school environment."</i></p> <p><i>"SARS-CoV-2 transmission in children in schools appears considerably less than seen for other respiratory viruses, such as influenza. In contrast to influenza, data from both virus and antibody testing to date suggest that children are not the primary drivers of COVID-19 spread in schools or the community. This is consistent with data from international studies showing low rates of disease in children and suggesting limited spread among children and from children to adults. Data from the whole of NSW also demonstrate children (aged <19 years) represent</i></p>

					4% of all cases of COVID-19 despite being approximately 23% of the population."
12	<p>No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020</p> <p>Heavey, L., et al</p> <p>Published May 28, 2020 <i>Eurosurveillance</i></p>	Retrospective Cohort	Ireland	<p>6 confirmed cases (3 confirmed pediatric cases – one in primary school, two in secondary school)</p> <p>1,155 total contacts</p>	<p>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.</p> <p>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</p> <p>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.</p>

