

# Role of children in household transmission of COVID-19

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## ABSTRACT

**Objective** Transmissibility of COVID-19 by children in the household is not clear. Herein, we describe children's role in household transmission of COVID-19.

**Design and setting** All paediatric COVID-19 index cases and their household members reported from 20 January to 6 April 2020 in South Korea were reviewed. The secondary attack rate (SAR) from child index case to household secondary case was calculated.

Epidemiological and clinical findings of child index case-household secondary case pair was assessed.

**Results** A total of 107 paediatric COVID-19 index cases and 248 of their household members were identified. One pair of paediatric index-secondary household case was identified, giving a household SAR of 0.5% (95% CI 0.0% to 2.6%). The index case was self-quarantined at home after international travel, stayed in her room, but shared a meal table with the secondary case.

**Conclusion** The SAR from children to household members was low in the setting of social distancing, underscoring the importance of rigorous contact tracing and early isolation in limiting transmission within households.

## INTRODUCTION

Despite advances in our understanding of the epidemiology of COVID-19, the issue of transmissibility of children is unclear. As children often act as the main drivers of respiratory viral outbreaks, it is important to understand their transmission potential of COVID-19. Nevertheless, ascertaining the role of children in transmission of COVID-19 is challenging due to low numbers of confirmed case in children, which may be secondary to school closure.<sup>1</sup> Furthermore, it has been postulated that children may have less susceptibility to infection or more prone to asymptomatic or subclinical infection compared with adults.<sup>2</sup>

South Korea was among the first countries hit by COVID-19, but has then succeeded flattening the curve. As of June 2020, under the loosened social distancing policy, the country is gradually reopening schools and public facilities. In the setting of comprehensive contact tracing schemes, the available data in South Korea may aid our understanding of children's role in transmission within households.

The objective in this study was to estimate the probability of household secondary attack rate when the index case is a child, and to describe their role in household transmission.

## METHODS

This is a retrospective observational study describing all reported paediatric COVID-19 cases in South Korea. COVID-19 outbreak response policy includes mass screening followed by comprehensive tracing of all identified contacts. All confirmed paediatric cases (by reverse-transcription PCR (RT-PCR)) were isolated in the hospitals or community treatment centres. If a confirmed paediatric case needs direct care by an uninfected guardian on hospitalisation, the guardian should wear a KF94 (N95 equivalent) mask, gloves, full body suit (or waterproof long-sleeve gowns) and goggles. All inbound international travellers were required to get tested and be quarantined at a government-designated facility (foreigners) or at home (nationals) for 14 days. All household contacts were screened with RT-PCR and were put under self-quarantine for 14 days, regardless of symptoms.

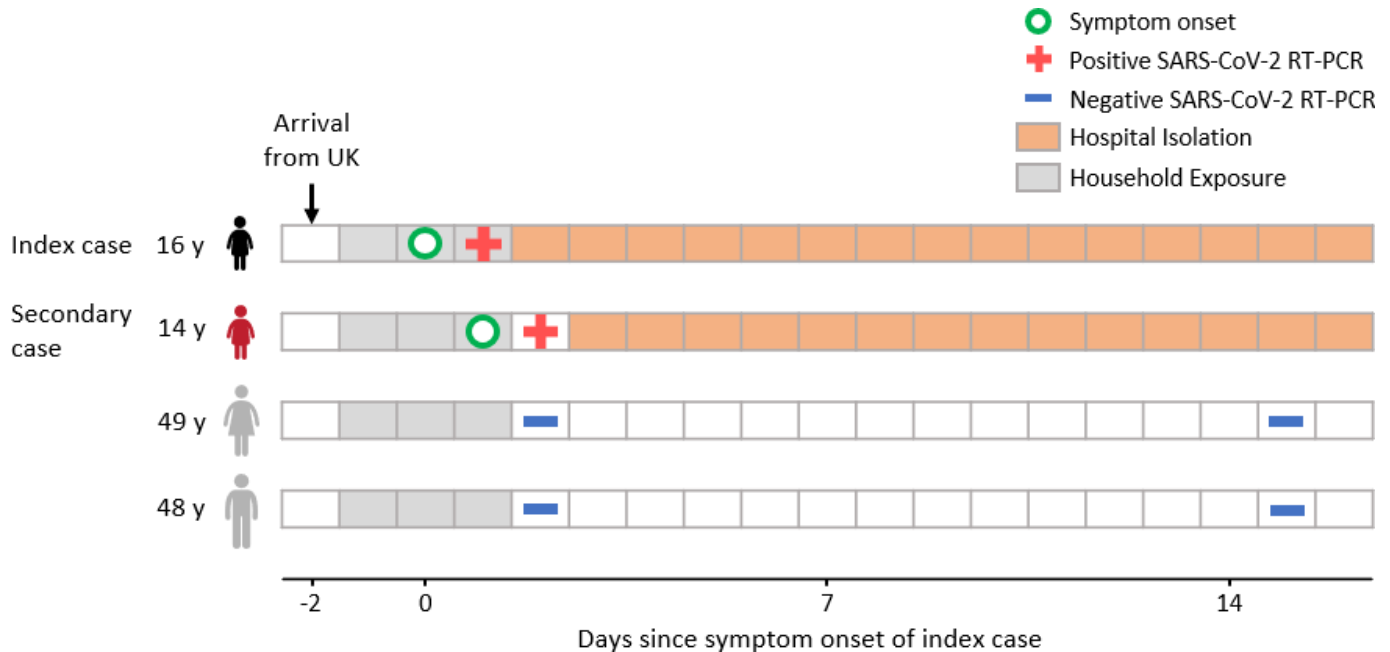
We included all laboratory-confirmed paediatric COVID-19 index cases aged 18 years and under reported to the National Notifiable Disease Surveillance System, the system that collects data on all confirmed COVID-19 cases across the country, from 20 January to 6 April 2020. A paediatric COVID-19 index case was defined as the first identified laboratory-confirmed case, or the first documented patient included in an epidemiological investigation within a cluster. We reviewed the data on household members who were under surveillance after contacting a paediatric COVID-19 index case. Secondary cases were defined as household contact with a paediatric COVID-19 index case, occurring at least 1 day after but within 14 days from the last point of exposure. Age distribution of paediatric COVID-19 index case (median, IQR) and household contacts (10-year scale) were assessed. Number of contacts per index case was calculated. Secondary attack rate (SAR), the probability that an infection occurs among susceptible people within household, was calculated as a single proportion:  $[\text{secondary case } n / (\text{traced } N)] \times 100$ , and two-sided 95% CIs for proportion was generated. Family members infected by a common source with a paediatric COVID-19 index case were excluded from SAR calculation, as performed in previous study.<sup>3</sup>

We then described the transmission linkage between identified paediatric COVID-19 index case-household secondary case pairs in terms of days of exposure, days of isolation, symptom onset date and virological findings from various sources.



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**To cite:** Kim J, Choe YJ, Lee J, et al. *Arch Dis Child* 2021;**106**:709–711.



**Figure 1** A family of household transmission of COVID-19 by a child index case. The index child arrived from the UK and stayed home with her parents and younger sister. Two days after her arrival, the index had sore throat and was tested severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)-positive the day after. Her sister was confirmed with COVID-19 1 day after her diagnosis. Her parents remained uninfected until day 14 from the last exposure. RT-PCR, reverse-transcription PCR.

## RESULTS

A total of 107 paediatric COVID-19 index cases and their 248 household members were identified. The median age of paediatric COVID-19 index cases was 15 years (IQR 10–17 years); 35.7% and 23.0% were 16–18 years and 13–15 years, respectively. On average, 4.3 household contacts were followed per paediatric COVID-19 index case (range 1–67), and the average number of monitored days was 10.9 days (median 14 days). Nearly half (48.4%, 101/248) of the household contacts were aged 30–49 years, followed by 31.5% aged 0–19 years (78/248) and 18.1% aged 50–69 years (45/248). Of those, 41 were confirmed to have COVID-19: 40 were assessed to have the same exposure as the paediatric COVID-19 index cases. Of those, one pair of paediatric COVID-19 index case-secondary case were identified, giving an SAR of 0.5% (95% CI 0.0% to 2.6%).

Figure 1 shows the transmission routes within the identified paediatric COVID-19 index case-secondary case pair. The index case, aged 16 years, had returned from the UK to Korea on 19 March, had developed symptom on 21 March, tested positive and isolated on 22 March 2020. Between 19 and 21 March, the index case was self-quarantined in her room, however she shared the same table with the family for meals. Her younger sibling (the secondary case), aged 14 years, reported symptoms on 23 March, and tested positive. The secondary case did not have any other exposure history to COVID-19 other than the index case. The exposure time was 2 days during the presymptomatic period and 1 day during the symptomatic period of the index case. Their parents were not infected at day 14 from the last exposure to the secondary case. Table 1 shows the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) RNA test results within 2 days of COVID-19 diagnosis in the index case and the secondary case. SARS-CoV-2 RNA was detected in the nasopharynx, oropharynx, sputum and saliva from both cases with comparable cycle threshold (Ct) values, but was not isolated from stool or plasma.

## DISCUSSION

Our study summarises the transmission dynamics within the households from the first 107 paediatric COVID-19 index cases in Korea, and estimates a low transmission potential from children to household members. Previously, very few studies have reported family clusters which presented data on the household transmission when the index case was a child. To our knowledge, this is the first study that exclusively assessed the household transmission risk from the paediatric COVID-19 index cases.

We found that the SAR from children to household members was low in the setting of social distancing in South Korea. Earlier findings on the adult COVID-19 index cases in South Korea showed that the household SAR was 7.6% (95% CI 3.7 to 14.3), which was higher than that of the present study.<sup>3</sup> The low transmission rate of COVID-19 from paediatric index cases may be attributable to intensive outbreak control measures that had been in place since early February. This is in conjunction with a recent systematic review suggesting that

**Table 1** SARS-CoV-2 RNA (RdRp gene) test results from various sources within 2 days of COVID-19 diagnosis of the index case and the secondary case.

Specimens	Index case		Secondary case	
	Qualitative*	Ct*	Qualitative*	Ct*
Nasopharynx	Positive	21.3	Positive	19.1
Oropharynx	Positive	28.0	Positive	30.0
Sputum	Positive	17.7	Positive	18.5
Saliva	Borderline	35.1	Positive	25.0
Stool	Negative	–	Negative	–
Plasma	Negative	–	Negative	–

\*Ct value of  $\leq 35$  is positive and  $> 40$  is negative; value in between is reported as borderline.

Ct, cycle threshold; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

there are no evidence to support that children can become the main drivers of the COVID-19 pandemic, although it should be interpreted with caution as the investigation was carried out in the context of lockdown.<sup>4 5</sup> In this context, our data may provide important baseline information on the role of children in COVID-19 household transmission dynamics in the setting of social distancing, suggesting that children are mainly infected inside household clusters, with limited transmission to household members.

The likelihood of transmission is determined by various factors such as viral kinetics, presence of symptoms, contact rate and duration.<sup>6</sup> From the index-secondary case pair, we found that the exposure time between the child index case and the secondary case was around 3 days, but only 1 day when the index case was symptomatic. A previous study estimated that nearly half of secondary cases were infected during the index cases' presymptomatic stage, in settings with substantial household clustering, active case finding and quarantine outside the home.<sup>7</sup> A paediatric COVID-19 index case may expose household members to a substantial level of infection during the presymptomatic phase. In the setting of low level community transmission in Korea, most cases arise from international travel, as of June 2020. Given the crowded living conditions in South Korea, the present case raises concern on the transmission potential among household contacts during the initial phase of home quarantine after arrival from international travel.

This study has several limitations. First, we used epidemiological information until 6 April 2020, which is a snapshot of the disease dynamics in the setting of school closures, which may have influenced the number of children identified as index cases, but does not reduce the number of household contacts. In fact, school closures may result in more time at home, which would likely increase the SAR among household contacts due to increased exposure to other people within the home. Second, the contact tracing may be incomplete especially in the middle of March (during surge of outbreak) and potential reporting bias may have resulted in under-reporting of household contact information. Third, there is a possibility of underestimation of other positive cases in the households of the positive children, because there were cases excluded from SAR calculation as they had the same initial exposure, but it may be possible that some of them did not acquire the infection at the same time as the child. Lastly, false negatives from PCR test may occur because of low virus quantities, poorly collected specimens, uncooperative children, and other technical reasons, which may have caused misclassification in some cases.

Despite these limitations, this is the largest set of epidemiological findings in children in the early stage of COVID-19 outbreak. With the major global outbreak of COVID-19, further research in the identification of the role of children in transmitting the virus in the community is urgently needed. The available data we present will hopefully facilitate policymaking and development of COVID-19 suppression strategies.

In conclusion, we describe the secondary transmission rate from paediatric COVID-19 index cases, which provides important baseline information in the setting of social distancing. Our data underscore the importance of rigorous contact tracing and early isolation, in limiting transmission within households. The role of children in transmitting COVID-19 in the households and in the community should be monitored and assessed continuously.

**Acknowledgements** The authors would like to thank the relevant ministries, including the Ministry of Interior and Safety, Si/Do and Si/Gun/Gu, medical staffs in health centres and medical facilities for their efforts in responding to COVID-19 outbreak.

**Contributors** JK and YJC conceptualised and designed the study, drafted the initial manuscript and reviewed and revised the manuscript. JL, YJP and OP designed the epidemiological investigation protocols, collected data, carried out the initial analyses and reviewed and revised the manuscript. MSH and J-HK conceptualised and designed the study, coordinated and critically reviewed the manuscript. EHC conceptualised and designed the study and oversaw the study process.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** This investigation was a part of public health response and was not research that was subject to institutional review board approval; written informed consent was not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available on reasonable request. The investigation was a part of public health response and all data are protected under the Personal Information Protection Act, enacted 30 September 2011.

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