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Review Article

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Clinical Manifestations, Epidemiologic Characteristics, and Disease Burden of the Coronavirus Disease-19 in Children Ages 5-11 Years Old

Hyun Mi Kang,[1] **Ji Young Park**,[2] **Young June Choe**[3]

[1]Department of Pediatrics, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, the Republic of Korea
[2]Department of Pediatrics, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Seoul, the Republic of Korea
[3]Department of Pediatrics, Korea University Anam Hospital, College of Medicine, Korea University, Seoul, the Republic of Korea

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Correspondence to
Ji Young Park
Department of Pediatrics, Chung-Ang University Hospital, College of Medicine, Chung-Ang University, Seoul, the Republic of Korea.
Email: jypark@caumc.or.kr

ORCID iDs
Hyun Mi Kang
https://orcid.org/0000-0003-0513-8407
Ji Young Park
https://orcid.org/0000-0002-6777-0494
Young June Choe
https://orcid.org/0000-0003-2733-0715

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ABSTRACT

Coronavirus disease 2019 (COVID-19) has been a global pandemic for over 2 years. During the Omicron (B.1.1.529) variant-predominant period in South Korea, confirmed cases among children and adolescents surged. This review found that, although younger children may be less susceptible to COVID-19 than adolescents, more research is needed on the role of children and adolescents in the disease's spread. Detailed epidemiological information about the transmissibility of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) strain in children and adolescents is currently scarce, and more research is needed on the role of children and adolescents in disease's spread. There may be a difference in the proportion of cases with severe disease requiring hospitalization depending on the dominant mutant strain; however, COVID-19 generally presents with a mild-to-moderate course in children aged 5–11 years old.

Keywords: Child; Epidemiology; SARS-CoV-2

INTRODUCTION

Coronavirus disease 2019 (COVID-19), which started in Wuhan, China, in December 2019, has been a global pandemic for over 2 years. As of April 8, 2022, there have been 466,724,014 confirmed cases worldwide and 6,196,177 deaths.[1)] In Korea, 14,983,694 cases have been confirmed, and 18,754 associated deaths have been recorded. Since the pediatric COVID-19 case was confirmed on February 18, 2020,[2)] there have been 1,867,681 confirmed cases and 15 deaths in the 0–9-year-old age group and 2,016,542 confirmed cases and four deaths in the 10–19-year-old age group. Compared to the fatality rate (number of deaths/confirmed cases) of 2.64% in those ≥80 years old, 0.65% in the seventies, and 0.15% in the sixties, the fatality rate in children and adolescents is very low.[3)] However, the fatality rate varies by the pandemic week, and the vaccination percentage of the general population also affects the proportion of confirmed patients with severe or critical COVID-19.

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

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As the Omicron (B.1.1.529) variant became the dominant viral strain causing COVID-19 in South Korea, a surge in confirmed cases within the child and adolescent population has been observed. Thus, concerns about medical response and immunization against COVID-19 are increasing due to the lack of sufficient knowledge on the severity and transmissibility of COVID-19 in children and adolescents. Therefore, this review aimed to examine the susceptibility and transmissibility of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus in children aged 5–11 years old and investigate the clinical characteristics and disease burden of COVID-19 in this age group.

SUSCEPTIBILITY OF COVID-19 IN CHILDREN AGED 5-11 YEARS OLD

SARS-CoV-2 infection in children and adolescents is generally milder and has a lower mortality rate than in adults. In children and adolescents with mild symptoms, most confirmed pediatric infections improve without complications; therefore, there may be fewer cases being tested and confirmed as COVID-19 because of mild symptoms. Thus, if mild or asymptomatic children and adolescents can transmit SARS-CoV-2, they may contribute to community transmission. Thus, it is important to understand the clinical presentation, susceptibility, and transmissibility of SARS-CoV-2 in children and adolescents. It is also important to apply control measures for COVID-19, especially as the vaccination rate in children under 12 years old is lower than that in adults. Furthermore, understanding the susceptibility and transmissibility of SARS-CoV-2 in children and adolescents is key to supporting policies and making decisions to maintain or suspend schools and daycare centers during the COVID-19 pandemic.

The risk of contracting SARS-CoV-2 is a combination of susceptibility (host biological factors), environmental factors related to the type of exposure (including work, within the household or family, or school), and exposure intensity (e.g., community transmission and level of precautions). It is difficult to evaluate the effect of these factors on the risk of SARS-CoV-2 infection separately in children, adolescents, and adults. Therefore, the interpretation of studies reporting age-specific infection levels will depend on the method of the study, as well as the details provided about the context in which the study was conducted.

1. Meta-analyses on population-based SARS-CoV-2 serological prevalence and viral shedding studies

Several population-based SARS-CoV-2 serological prevalence and viral shedding studies have investigated whether children and adolescents are infected at the same rate as adults but have provided mixed results.[4] According to three systematic reviews, children <10 years of age reported lower susceptibility than children aged 10 years and older and adults. The first meta-analysis and systematic review included 32 studies with 41,640 children and 268,945 adults, including 18 contact-tracing studies and 14 population screening studies. In this analysis, the pooled odds ratio of infected contacts in children and adolescents compared to adults was 0.56 (95% confidence interval [CI], 0.37–0.85), showing significant heterogeneity (I^2=94.6%).[5]

The second meta-analysis and systematic review reported household transmission in 54 related studies and 77,758 patients. The household secondary attack rate was 16.6% (95% CI, 14.0–19.3%). The secondary incidence rate at home was higher in symptomatic confirmed

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cases (18.0%, 95% CI, 14.2–22.1%) than in asymptomatic confirmed cases (0.7%; 95% CI, 0–4.9%) and in adult contacts (28.3%; 95% CI, 20.2–37.1%) compared to children and adolescents (16.8%; 95% CI, 12.3–21.7%).[6]

The third meta-analysis on the household SARS-CoV-2 transmission cluster (213 patients, 12 countries) analyzed the susceptibility of children and adolescents to secondary household transmission. The secondary incidence in children and adolescents by household transmission was lower compared to adults (relative risk [RR], 0.62; 95% CI, 0.42–0.91). In further analysis, children <10 years of age were not more or less susceptible to infection than children aged >10 years (RR. 0.69; 95% CI, 0.26–1.82). Data from household transmission cluster studies suggest that children aged <18 years are less susceptible to SARS-CoV-2 infection.[7]

2. Seroprevalence studies

In some serological studies, children are less likely to have detectable antibodies than adolescents or adults. The study on the seroprevalence of SARS-CoV-2 published in Switzerland included 1,339 households and 2,766 participants from April 6 to May 9, 2020. The population distribution in this study had a demographic distribution similar to that in Geneva. This study reported that the seroprevalence in children aged 5–9 years was lower than that in adolescents and adults (5–9 years old, 0.8%; 10–19 years old, 9.6%; 20–49 years old, 9.9%; 50–64 years old, 7.4%; ≥65 years old, 4.1%). Assuming that the presence of immunoglobulin G (IgG) antibodies is associated with immunity, a significantly lower seroprevalence was observed in children aged 5–9 years and adults older than 65 years compared with those aged 10–64 years, meaning that a high proportion of children remained uninfected up to the pre-Delta variant wave; however, indeterminate IgG antibody results were reported in many children, and the rate was significantly higher in the 5–9-years-old age group than in all other age groups.[8] Whether the IgG response in children is delayed or qualitatively different needs to be further investigated to better understand infection and antibody dynamics among young children.

3. Household transmission studies

In a study of people who had all household members exposed to a confirmed case of COVID-19, the probability of eventually having a positive polymerase chain reaction test result was about 61% for children aged 5–17 years old and 47% for children aged 0–4 years old.[9] In household transmission studies that narrowed down the age group and analyzed in detail, there are also research results showing that the secondary incidence rate was lower in infants (0–4 years old or 0–5 years old) than in school-age children and adolescents.[10,11]

TRANSMISSIBILITY OF COVID-19 IN CHILDREN AGED 5-11 YEARS OLD

Children and adolescents infected with SARS-CoV-2 can transmit the virus; however, some data show lower rates than in adults. According to reports of the outbreak of COVID-19, where social distancing and mask-wearing were not applied, such as in middle and high schools, summer camps, and daycare centers, the secondary incidence rates were lower in children than in adolescents and adults.[12-14] Another example is Israel's largest school cluster, reported on May 13, 2020, at a high school in Jerusalem, 10 days after the school opened. Screening the entire school community confirmed that 153 of the 1,161 students aged 12–18 years and 25 of the 151 staff members were infected with SARS-CoV-2. The attack rates of these groups were 13.2

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and 16.6%, respectively.[12] In a cross-sectional study of schools in Berlin, 8/24 classes showed at least one student with a confirmed infection. However, there was no major epidemic, and transmission of the infection was related to inconsistent use of masks.[15]

Studies evaluating viral RNA shedding levels by age reported mixed results based on different testing methods.[16,17] The type of sample from which the viral RNA is isolated also affects the determination of the amount of virus, thereby affecting the difference in the result value according to age.[18] A statistical analysis found that the amount of virus shedding increased with age.[19] In 145 patients with mild to moderate illness within 1 week of symptom onset, children below 5 years old, 5–17 years old, and adults aged 18–65 years old were compared. This study showed that young children had significantly lower median (interquartile range) cycle threshold (Ct) values (6.5 [4.8–12.0]) than older children (11.1 [6.3–15.7]) and adults (11.0 [6.9–17.5]), showing that young children have equivalent or more viral nucleic acids in their upper respiratory tract than older children and adults.[20] On the other hand, in another study including 5,544 children and adults, among those tested at the same interval after symptom onset, SARS-CoV-2 virus emissions from the respiratory system were similar in children, adolescents, and adults.[21,22]

Methodological research is difficult because comprehensive data on age, viral shedding volume, and transmission of SARS-CoV-2 infection are lacking, and asymptomatic or mildly symptomatic individuals are rarely tested. In addition, detailed epidemiological information about the transmissibility of the novel SARS-CoV-2 strain in children and adolescents is currently scarce. Furthermore, the transmissibility and susceptibility of a population depend on the control measures applied in the area, the type of mutant causing the outbreak wave (including pre-Delta, Delta [B.1.617.2], and Omicron), and cultural interaction dynamics between age groups in the population, causing limitations in studies. Finally, detecting SAR-CoV-2 RNA does not equal transmissibility; therefore, caution is required when interpreting the data.

CLINICAL MANIFESTATIONS OF CHILDREN WITH COVID-19

In young or school-aged children, COVID-19 infection usually shows asymptomatic or mild courses compared to adults, and the progression to severe COVID-19 infection is rare. Research on the biological mechanism underlying the difference in severity according to age remains lacking and is still in progress. One hypothesis is believed to arise from differences in the function and maturity of the immune system between adults and young children. It has been reported that there is an age-dependent risk of progression to severe disease in the early stages of the COVID-19 pandemic and that there is a possibility that children younger than 1 year are more likely to progress to severe disease than children of other ages. However, the initial reports showed limitations in the research method; therefore, they are perceived to contain a generalization error. In contrast, the majority of newborns also show mild symptoms.[1]

A prospective, multicenter observational cohort study conducted at 260 medical institutions in the United Kingdom from January 17, 2020, to July 3, 2020, analyzed data from 651 children and young adults, of whom 225 were under 1 year of age. When the risk of admission to the intensive care unit (ICU) was evaluated by age, the odds ratio was 3.21 (95% CI, 1.36–7.66) in newborns younger than 1 month than in 15–19-year-olds, and the odds ratio in 10–14-year-olds was 3.23 (95% CI, 1.55–6.99).[23] However, there is still insufficient evidence

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to conclude that young age in children and adolescents infected with COVID-19 is a high-risk factor for severe disease because many case reports have methodological limitations. In addition, even in immunocompromised patients and those with severe underlying diseases such as tumors, many case reports have reported a mild course of COVID-19, and cases without hospitalization are common.

According to a meta-analysis conducted in December 2020 of 25 studies published in Europe, the United States, and China, where many studies were reported, 2,446 children infected with COVID-19 were identified. The median age was 1–7 years, and the most common clinical symptom was fever (61.7%), followed by cough (53.2%), and nausea/diarrhea (16.8%). A total of 24.8% were asymptomatic, 40.7% had acute upper respiratory tract infections, 27.0% had mild pneumonia, 5.3% had severe pneumonia, and 3% were reported as severe COVID-19 cases.[23] However, there are insufficient reports of clinical features in children and adolescents after infection with the Delta variant strain. According to the Morbidity and Mortality Weekly Report in the United States, hospitalization rates among children and adolescents in the United States increased approximately tenfold during July and August, when the delta variant strain was the dominant cause of COVID-19, compared to the period before June 2021 according to the Morbidity and Mortality Weekly Report (**Fig. 1**).[24,25]

When investigating by age, the cumulative hospitalization rate was the highest among 0–4 years old (69.2/100,000 patients) and the lowest among 5–11 years old (24.0/100,000 patients). From March 1, 2020, to June 19, 2020, prior to the Delta variant epidemic, of the 3,116 hospitalized children and adolescents in the United States, 26.5% were admitted to the ICU, 6.1% required invasive mechanical ventilation, and 0.7% died. However, from June 20

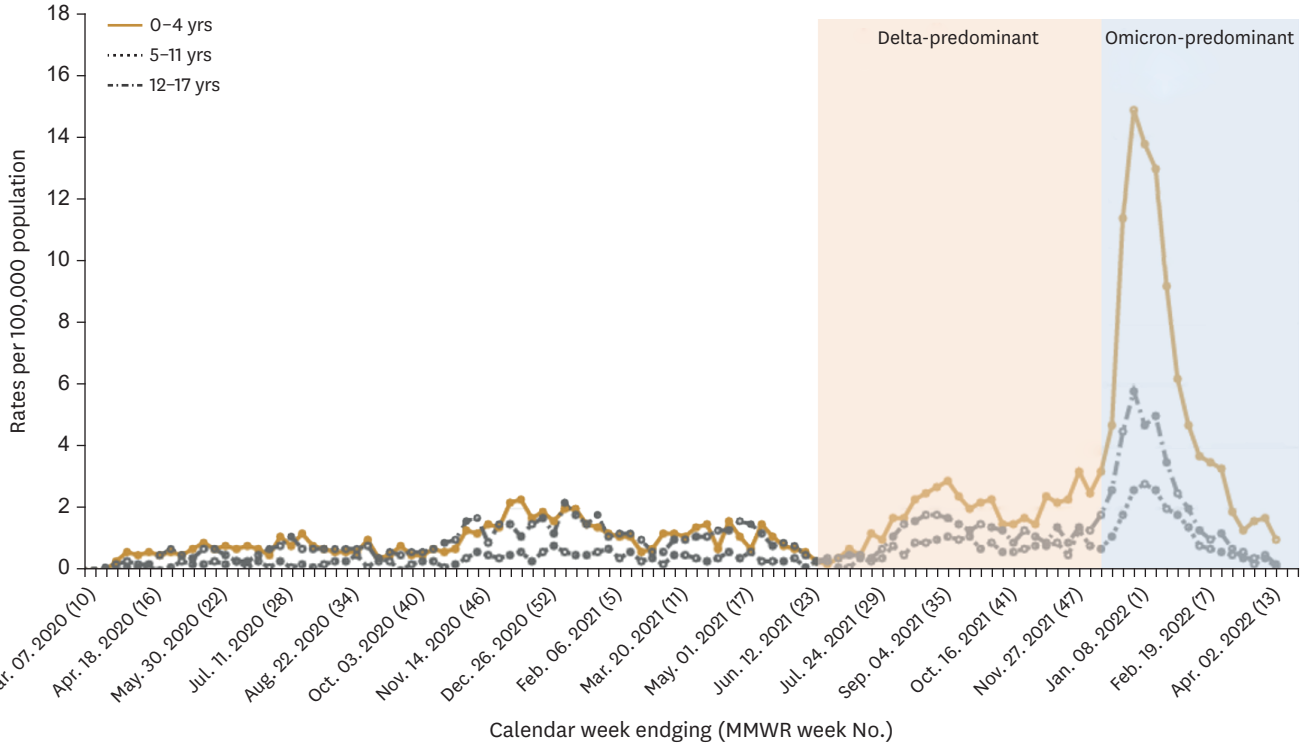

Fig. 1. Coronavirus disease 2019-associated weekly hospitalizations per 100,000 children and adolescents aged 0–17 years, by age group - COVID-NET, 14 states, March 1, 2020–April 02, 2022.[24-26]

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Table 1. Clinical interventions and outcomes among children and adolescents aged 0–17 years during COVID-19–associated hospitalizations — COVID-NET, 14 states, March 1, 2020–June 19, 2021 and June 20–July 31, 2021 and July 1–December 31, 2021[24,26]

Characteristics	No. of hospitalized children and adolescents (%)					
	2020/3/1–2021/6/19 (n=3,116)	2021/6/20–2021/7/30 (n=164)	*P*-value	2021/7/1–2021/12/18 (n=1,834)	2021/12/19–2021/12/31 (n=266)	*P*-value
Length of hospital stay, median (IQR)	3 (2–5)	2 (1–4)	0.01	3 (2–5)	2 (1–5)	0.15
Outcome						
ICU admission	827 (26.5)	38 (23.2)	0.34	510 (27.8)	52 (20.2)	0.01
Invasive mechanical ventilation	190 (6.1)	16 (9.8)	0.06	112 (6.3)	6 (2.3)	0.01
In-hospital death	21 (0.7)	3 (1.8)	0.12	11 (0.5)	0	0.38
Vaccination status (among patients aged 12–17 yrs)						
Fully vaccinated*				53 (8.3)	18 (22.2)	<0.001
Unvaccinated				584 (91.7)	63 (77.8)	

Abbreviations: COVID-19, coronavirus disease 2019; IQR, interquartile range; ICU, intensive care unit.
*Fully vaccinated adolescents were considered as those who had received the final dose in their primary series ≥14 days before the diagnosis of COVID-19. Adolescents who received only 1 vaccine dose ≥14 days or had received a single dose of vaccine <14 days before the diagnosis of COVID-19 were considered partially vaccinated; they were not included in rates.

to July 31, 2021, when the Delta variant epidemic began, 164 children and adolescents were hospitalized, of which 23.2% were admitted to the ICU, 9.8% required invasive mechanical ventilation, and 1.8% died. The degree of need for invasive mechanical ventilation therapy was significantly more common during the Delta variant-predominant period than before the Delta variant-predominant period (**Table 1**).[24,26]

On December 1, 2021, the Omicron variant was first identified in the United States and, as of December 19, it is currently the dominant cause of the current epidemic. Since then, hospitalizations have increased to 7.1 per 100,000, which is about four times higher than the 1.8 per 100,000 for the delta variant. In children aged 0–4 years old, the hospitalization rate was 15.6/10,000, which is 5.4 times higher than the 2.9/100,000 children during the Delta wave, showing the steepest rise in this age group compared to any other age group. This increase was 2.3 times greater in the 5–11 years age group and 3.5 times greater in the 12–17 years age group (**Fig. 1**).[25,26]

During the outbreak of the Omicron variant, the ICU admission rate of children and adolescents was 1.4 times higher. In December 2021, when both the Delta and Omicron variants were circulating simultaneously, vaccinated adolescents 12–17 years of age were hospitalized at 3.8 per 100,000 versus 23.5/100,000 among unvaccinated adolescents, which is 6.3 times higher. Among hospitalized unvaccinated adolescents, 30.3% were admitted to the ICU, which was significantly higher than the 15.5% among vaccinated adolescents. The proportion of hospitalized children and adolescents who required ICU hospitalization was 27.8% during the Delta wave compared to 20.2% during the Omicron wave. Furthermore, the percentage of children who required invasive ventilatory support was 6.3% during the Delta wave compared to 2.3% during the Omicron wave (**Table 1**).[24,26] According to a report on the hospitalization rate in children after the outbreak of the Omicron variant recently reported in South Africa, the number of confirmed cases and hospitalizations in children and adolescents has increased compared with the first, second, and third epidemic waves. Sixty-three percent of hospitalized patients were children aged 0–4, and the manifestations were fever in 61%, cough in 57%, dyspnea in 31%, convulsions in 31%, vomiting in 26%, and diarrhea in 25%. The length of hospitalization was confirmed to be a median of 2 days, and 88% of patients received symptomatic treatment in the ward, but 20% required oxygen therapy. Furthermore, 5% of children were ventilated, 3% died, and all mortality cases occurred in children with underlying medical conditions.[27]

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CLINICAL ASPECTS OF COVID-19 INFECTION IN CHILDREN IN KOREA

In one study, a multicenter retrospective analysis was performed on 900 children and adolescents under the age of 18 years who were hospitalized at 32 medical institutions nationwide due to COVID-19 infections in Korea from January 20 to December 31, 2020. Of the 900 confirmed pediatric cases, 310 were 5–11 years old, accounting for 34.4%. A total of 61.6% of children under 12 years of age were infected via transmission within households. Of the total 900 cases, 34.1% were asymptomatic, 57.5% were symptomatic at the time of diagnosis, and 8.4% of children who were asymptomatic at the time of diagnosis gradually developed symptoms after being diagnosed with COVID-19. Among them, approximately 40% of children aged 2–12 years were asymptomatic up to the time of release from isolation (38.4% of those 2–6 years old and 43.5% of those 7–12 years old), and most of the confirmed children had generalized symptoms such as fever, muscle pain, lethargy, and respiratory symptoms; however, gastrointestinal and neurologic symptoms were rare. The most common systemic symptom was a fever of 38°C or higher (2–6 years old: 35.4%, 7–12 years old: 24.9%), and the respiratory symptoms were cough (2–6 years old: 24.3%, 7–12 years old: 21.1%), sputum (2–6 years old, 11.2%, 7–12 years old, 15.8%), and runny nose (2–6 years old, 19.4%, 7–12 years old, 11.9%). The most common gastrointestinal symptom was diarrhea (2–6 years old: 4.9%, 7–12 years old: 4.6%), and the most common neurological symptom was headache (2–6 years old: 0.5%, 7–12 years old: 8.4%).[28]

In this study, the severity of the disease was categorized into mild cases with mild symptoms but no abnormal findings on chest imaging, moderate cases were defined as those with a lower respiratory tract infection, and severe cases requiring hypoxia with less than 95% oxygen saturation or mechanical ventilation without oxygen treatment. In children aged 2–12 years, asymptomatic infection was confirmed in 41.5%, mild infection in 53.6%, moderate infection in 4.9%, and no serious infection was reported.[28]

In a consecutive study of cases confirmed between January 20 and October 7, 2021, seven children between 10 months and 17 years old (median age of 13 years old) were diagnosed with severe disease and underwent non-invasive or invasive mechanical ventilation that required positive pressure ventilation.[29] In 2020, there were no critically ill children and adolescents, but there were seven critically severe cases for 9 months in 2021. It is hypothesized that there may be a difference in the frequency of occurrence of severe cases, depending on the prevalent mutant strain. Children and adolescents currently account for approximately 25% of all confirmed COVID-19 cases. Omicron dominance is observed, and it is reported to manifest as obstructive laryngitis (croup) in some children, and deaths have been reported in children during the isolation period. Therefore, the severity of the disease in infections caused by the Omicron variant in children and adolescents must be closely monitored.

CONCLUSION

Although younger children may be less susceptible to COVID-19 than adolescents, more research is needed on the role of children and adolescents in the disease's spread. There may be a difference in the proportion of cases with severe disease requiring hospitalization depending on the dominant mutant strain; however, COVID-19 generally presents with a mild-to-moderate course in children aged 5–11 years old.

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REFERENCES

1. COVID-19 disease in children and adolescents. Scientific brief, 29 September 2021 [Internet]. Geneva: World Health Organization; 2021 [cited 2022 Apr 8]. Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief-Children_and_adolescents-2021.1/.
2. Park JY, Han MS, Park KU, Kim JY, Choi EH. First pediatric case of coronavirus disease 2019 in Korea. J Korean Med Sci 2020;35:e124.
PUBMED | CROSSREF
3. Confirmed domestic cases [Internet]. Sejong: Ministry of Health and Welfare; 2022 [cited 2022 Apr 8]. Available from: http://ncov.mohw.go.kr/bdBoardList_Real.do.
4. Goldstein E, Lipsitch M, Cevik M. On the effect of age on the transmission of SARS-CoV-2 in households, schools, and the community. J Infect Dis 2021;223:362-9.
PUBMED | CROSSREF
5. Viner RM, Mytton OT, Bonell C, Melendez-Torres GJ, Ward J, Hudson L, et al. Susceptibility to SARS-CoV-2 infection among children and adolescents compared with adults: a systematic review and meta-analysis. JAMA Pediatr 2021;175:143-56.
PUBMED | CROSSREF
6. Madewell ZJ, Yang Y, Longini IM Jr, Halloran ME, Dean NE. Household transmission of SARS-CoV-2: a systematic review and meta-analysis. JAMA Netw Open 2020;3:e2031756.
PUBMED | CROSSREF
7. Zhu Y, Bloxham CJ, Hulme KD, Sinclair JE, Tong ZW, Steele LE, et al. A meta-analysis on the role of children in severe acute respiratory syndrome coronavirus 2 in household transmission clusters. Clin Infect Dis 2021;72:e1146-53.
PUBMED | CROSSREF
8. Stringhini S, Wisniak A, Piumatti G, Azman AS, Lauer SA, Baysson H, et al. Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. Lancet 2020;396:313-9.
PUBMED | CROSSREF
9. Somekh E, Gleyzer A, Heller E, Lopian M, Kashani-Ligumski L, Czeiger S, et al. The role of children in the dynamics of intra family coronavirus 2019 spread in densely populated area. Pediatr Infect Dis J 2020;39:e202-4.
PUBMED | CROSSREF
10. Li W, Zhang B, Lu J, Liu S, Chang Z, Peng C, et al. Characteristics of household transmission of COVID-19. Clin Infect Dis 2020;71:1943-6.
PUBMED | CROSSREF
11. Yung CF, Kam KQ, Chong CY, Nadua KD, Li J, Tan NW, et al. Household transmission of severe acute respiratory syndrome coronavirus 2 from adults to children. J Pediatr 2020;225:249-51.
PUBMED | CROSSREF
12. Stein-Zamir C, Abramson N, Shoob H, Libal E, Bitan M, Cardash T, et al. A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020. Euro Surveill 2020;25:2001352.
PUBMED | CROSSREF
13. Szablewski CM, Chang KT, Brown MM, Chu VT, Yousaf AR, Anyalechi N, et al. SARS-CoV-2 transmission and infection among attendees of an overnight camp - Georgia, June 2020. MMWR Morb Mortal Wkly Rep 2020;69:1023-5.
PUBMED | CROSSREF
14. Pray IW, Gibbons-Burgener SN, Rosenberg AZ, Cole D, Borenstein S, Bateman A, et al. COVID-19 outbreak at an overnight summer school retreat - Wisconsin, July-August 2020. MMWR Morb Mortal Wkly Rep 2020;69:1600-4.
PUBMED | CROSSREF
15. Theuring S, Thielecke M, van Loon W, Hommes F, Hülso C, von der Haar A, et al. SARS-CoV-2 infection and transmission in school settings during the second COVID-19 wave: a cross-sectional study, Berlin, Germany, November 2020. Euro Surveill 2021;26:2100184.
PUBMED | CROSSREF
16. Zou L, Ruan F, Huang M, Liang L, Huang H, Hong Z, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. N Engl J Med 2020;382:1177-9.
PUBMED | CROSSREF
17. Yu F, Yan L, Wang N, Yang S, Wang L, Tang Y, et al. Quantitative detection and viral load analysis of SARS-CoV-2 in infected patients. Clin Infect Dis 2020;71:793-8.
PUBMED | CROSSREF

18. Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, et al. Detection of SARS-CoV-2 in different types of clinical specimens. JAMA 2020;323:1843-4.
PUBMED | CROSSREF

19. Held L. A discussion and reanalysis of the results reported in Jones et al. (2020) [Internet]. Charlottesville: Center for Open Science; 2020 [cited 2022 Aug 29]. Available from: https://osf.io/bkuar/.

20. Heald-Sargent T, Muller WJ, Zheng X, Rippe J, Patel AB, Kociolek LK. Age-related differences in nasopharyngeal severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) levels in patients with mild to moderate coronavirus disease 2019 (COVID-19). JAMA Pediatr 2020;174:902-3.
PUBMED | CROSSREF

21. Madera S, Crawford E, Langelier C, Tran NK, Thornborrow E, Miller S, et al. Nasopharyngeal SARS-CoV-2 viral loads in young children do not differ significantly from those in older children and adults. Sci Rep 2021;11:3044.
PUBMED | CROSSREF

22. Baggio S, L'Huillier AG, Yerly S, Bellon M, Wagner N, Rohr M, et al. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viral load in the upper respiratory tract of children and adults with early acute coronavirus disease 2019 (COVID-19). Clin Infect Dis 2021;73:148-50.
PUBMED | CROSSREF

23. Simsek Uzunoglu S, Akca H. Systematic review: clinical symptoms and laboratory and radiology findings in children with COVID-19. Niger J Clin Pract 2021;24:1259-67.
PUBMED

24. Delahoy MJ, Ujamaa D, Whitaker M, O'Halloran A, Anglin O, Burns E, et al. Hospitalizations associated with COVID-19 among children and adolescents - COVID-NET, 14 States, March 1, 2020-August 14, 2021. MMWR Morb Mortal Wkly Rep 2021;70:1255-60.
PUBMED | CROSSREF

25. COVID-NET. A weekly summary of U.S. COVID-19 hospitalization data [Internet]. Atlanta: Centers for Disease Control and Prevention; 2022 [cited 2022 Apr 20]. Available from: https://gis.cdc.gov/grasp/COVIDNet/COVID19_3.html.

26. Marks KJ, Whitaker M, Anglin O, Milucky J, Patel K, Pham H, et al. Hospitalizations of children and adolescents with laboratory-confirmed COVID-19 - COVID-NET, 14 States, July 2021-January 2022. MMWR Morb Mortal Wkly Rep 2022;71:271-8.
PUBMED | CROSSREF

27. Cloete J, Kruger A, Masha M, du Plessis NM, Mawela D, Tshukudu M, et al. Paediatric hospitalisations due to COVID-19 during the first SARS-CoV-2 omicron (B.1.1.529) variant wave in South Africa: a multicentre observational study. Lancet Child Adolesc Health 2022;6:294-302.
PUBMED | CROSSREF

28. Kim DH, Han MS, Kim HS, Lim MS, Choo MA, Lee E, et al. Establishment of multicenter cohort reseasrch system and analysis of clinical epidemiologic chatacteristics for children and adolescents with COVID-19. The 22th Congress of the Korean Society of Pediatric Infectious Diseases; 2021 Nov 20. Seoul: Korean Society of Pediatric Infectious Diseases; 2020.

29. Lee H, Choi S, Park JY, Jo DS, Choi UY, Lee H, et al. Analysis of critical COVID-19 cases among children in Korea. J Korean Med Sci 2022;37:e13.
PUBMED | CROSSREF