

Question: What is the evidence for transmission of COVID-19 by children [or in schools]?

Answer:

- Despite librarian-supported duplicate searches by experienced reviewers, no high quality studies directly addressing the study question were identified. This review will continue weekly literature updates to identify any new relevant evidence as it is reported.
- It is widely reported that children can get infected after exposure to confirmed cases, through household or travel contacts. Most paediatric patients have been family-clustered cases and a few have been infected during hospitalisation. Perinatal infection can also occur when the baby is born to a pregnant woman with confirmed infection via vaginal delivery, while vertical transmission from mother to infant or via breastfeeding have not yet been established. There are no reported outbreaks of COVID-19 in schools or nurseries.
- It is estimated that the number of infected children with latent asymptomatic or with mild symptoms of respiratory or gastrointestinal illness is higher than in adults. Available evidence also suggests that children may have more upper respiratory tract (including nasopharyngeal carriage) than lower respiratory tract involvement. Their prognosis is generally better than that in adults.
- There has been no confirmed evidence or reports of paediatric cases as the main source of infection. However, there is risk of transmission by infected children (with virus in nasal secretions and stools) and some evidence of faecal-oral transmission in asymptomatic paediatric cases. This limited evidence may have substantial implications for community spread in day-care centres, schools, and homes.

Extended abstract

Background: There is uncertainty about the risk of COVID-19 transmission by children. Clarity on this issue could help in guiding policies on school closure/opening.

Methods: We searched PubMed on 31/03/2020 to identify relevant studies reporting on the COVID-19 transmission routes among infected (both symptomatic and asymptomatic) children and adolescences. A total of 134 publications were retrieved and 44 studies met the inclusion and exclusion criteria.

Results: It is widely reported that children can get infected after exposure to confirmed adult cases through household or travel contacts. Most paediatric patients were family-clustered cases and a few were infected during hospitalisation. No outbreaks in schools or nurseries were identified. Respiratory droplets and close contact are reported as the main transmission routes, with an additional potential role of faecal-oral transmission for paediatric cases.

Perinatal infection can also occur when the baby is born to a pregnant woman with confirmed infection via vaginal delivery; vertical transmission or transmission through breastfeeding have however not yet been established. The number of infected children with latent asymptomatic disease or with only mild respiratory or gastrointestinal symptoms is estimated to be higher than in adults and their prognosis is generally better.

Conclusions: There is no confirmed evidence or reports of paediatric cases as a source of infection. However, there is risk of transmission by infected children. Therefore, virus in nasal secretions and stools may have substantial implications for community spread in day-care centres, schools, and homes. There is also some evidence of faecal-oral transmission in asymptomatic paediatric cases.

In summary, there appears to be risk of transmission by infected children, especially when considering the evidence of faecal-oral transmission in asymptomatic paediatric cases. The presence of SARS-CoV-2 virus in nasal secretions and stools may have substantial implications for community spread in day-care centres, schools, and homes.

Keywords: COVID-19; coronavirus; SARS-CoV-2; children; newborns; neonatal; transmission; family cluster

Key references

1. Cruz A, Zeichner S. COVID-19 in Children: Initial Characterization of the Pediatric Disease. (2020). *Pediatrics*, e20200834.
2. Cai, J., Xu, J., Lin, D., Yang, Z., Xu, L., Qu, Z., Zhang, Y., Zhang, H., Jia, R., Liu, P., Wang, X., Ge, Y., Xia, A., Tian, H., Chang, H., Wang, C., Li, J., Wang, J., & Zeng, M. (2020). A Case Series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, ciaa198.
3. Cao, Q., Chen, Y. C., Chen, C. L., & Chiu, C. H. (2020). SARS-CoV-2 infection in children: Transmission dynamics and clinical characteristics. *Journal of the Formosan Medical Association = Taiwan yi zhi*, 119(3), 670–673.
4. Chan JF, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 2020;395(10223):514–523.
5. Chen, Z. M., Fu, J. F., Shu, Q., Chen, Y. H., Hua, C. Z., Li, F. B., Lin, R., Tang, L. F., Wang, T. L., Wang, W., Wang, Y. S., Xu, W. Z., Yang, Z. H., Ye, S., Yuan, T. M., Zhang, C. M., & Zhang, Y. Y. (2020). Diagnosis and treatment recommendations for pediatric respiratory infection caused by the 2019 novel coronavirus. *World journal of pediatrics: WJP*, 10.1007/s12519-020-00345-5.
6. Cui, Y., Tian, M., Huang, D., Wang, X., Huang, Y., Fan, L., Wang, L., Chen, Y., Liu, W., Zhang, K., Wu, Y., Yang, Z., Tao, J., Feng, J., Liu, K., Ye, X., Wang, R., Zhang, X., & Zha, Y. (2020). A 55-Day-Old Female Infant infected with COVID 19: presenting with pneumonia, liver injury, and heart damage. *The Journal of infectious diseases*, jiaa113.
7. Fang, F., & Luo, X. P. (2020). Facing the Pandemic of 2019 Novel Coronavirus Infections: The Pediatric Perspectives. *Zhonghua er ke za zhi = Chinese journal of pediatrics*, 58(2), 81–85.

8. Feng, K., Yun, Y. X., Wang, X. F., Yang, G. D., Zheng, Y. J., Lin, C. M., & Wang, L. F. (2020). Analysis of CT features of 15 Children with 2019 novel coronavirus infection. *Zhonghua er ke za zhi = Chinese journal of pediatrics*, 58(0), E007.
9. Ji, L. N., Chao, S., Wang, Y. J., Li, X. J., Mu, X. D., Lin, M. G., & Jiang, R. M. (2020). Clinical features of pediatric patients with COVID-19: a report of two family cluster cases. *World journal of pediatrics: WJP*, 10.1007/s12519-020-00356-2.
10. Li, Y., Guo, F., Cao, Y., Li, L., & Guo, Y. (2020). Insight into COVID-2019 for pediatricians. *Pediatric pulmonology*, 10.1002/ppul.24734.
11. Li, Y., Zhao, R., Zheng, S., Chen, X., Wang, J., Sheng, X., Zhou, J., Cai, H., Fang, Q., Yu, F., Fan, J., Xu, K., Chen, Y., & Sheng, J. (2020). Lack of Vertical Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, China. *Emerging infectious diseases*, 26(6), 10.3201/eid2606.200287.
12. Liu, M., Song, Z., & Xiao, K. (2020). High-Resolution Computed Tomography Manifestations of 5 Pediatric Patients With 2019 Novel Coronavirus. *Journal of computer assisted tomography*, 10.1097/RCT.0000000000001023.
13. Liu, Y., Yang, Y., Zhang, C., Huang, F., Wang, F., Yuan, J., Wang, Z., Li, J., Li, J., Feng, C., Zhang, Z., Wang, L., Peng, L., Chen, L., Qin, Y., Zhao, D., Tan, S., Yin, L., Xu, J., Zhou, C., ... Liu, L. (2020). Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury. *Science China. Life sciences*, 63(3), 364–374.
14. Lou, X. X., Shi, C. X., Zhou, C. C., & Tian, Y. S. (2020). Three children who recovered from novel coronavirus 2019 pneumonia. *Journal of paediatrics and child health*, 10.1111/jpc.14871.
15. Lu, Q., & Shi, Y. (2020). Coronavirus disease (COVID-19) and neonate: What neonatologist need to know. *Journal of medical virology*, 10.1002/jmv.25740.
16. Lu, X., Zhang, L., Du, H., Zhang, J., Li, Y. Y., Qu, J., Zhang, W., Wang, Y., Bao, S., Li, Y., Wu, C., Liu, H., Liu, D., Shao, J., Peng, X., Yang, Y., Liu, Z., Xiang, Y., Zhang, F., Silva, R. M., ... Chinese Pediatric Novel Coronavirus Study Team (2020). SARS-CoV-2 Infection in Children. *The New England journal of medicine*, 10.1056/NEJMc2005073.
17. Ludvigsson J. F. (2020). Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta paediatrica (Oslo, Norway: 1992)*, 10.1111/apa.15270.
18. Park, J. Y., Han, M. S., Park, K. U., Kim, J. Y., & Choi, E. H. (2020). First Pediatric Case of Coronavirus Disease 2019 in Korea. *Journal of Korean medical science*, 35(11), e124.
19. Qi, H., Luo, X., Zheng, Y., Zhang, H., Li, J., Zou, L., Feng, L., Chen, D., Shi, Y., Tong, C., & Baker, P. N. (2020). Safe Delivery for COVID-19 Infected Pregnancies. *BJOG: an international journal of obstetrics and gynaecology*, 10.1111/1471-0528.16231.
20. Qian, G., Yang, N., Ma, A., Wang, L., Li, G., Chen, X., & Chen, X. (2020). A COVID-19 Transmission within a family cluster by presymptomatic infectors in China. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, ciaa316.
21. Qiu, H., Wu, J., Hong, L., Luo, Y., Song, Q., & Chen, D. (2020). Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. *The Lancet. Infectious diseases*, S1473-3099(20)30198-5.
22. Rothan, H. A., & Byrareddy, S. N. (2020). The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *Journal of autoimmunity*, 102433.
23. Shen, K. L., & Yang, Y. H. (2020). Diagnosis and treatment of 2019 novel coronavirus infection in children: a pressing issue. *World journal of pediatrics: WJP*, 10.1007/s12519-020-00344-6.

24. Su, L., Ma, X., Yu, H., Zhang, Z., Bian, P., Han, Y., Sun, J., Liu, Y., Yang, C., Geng, J., Zhang, Z., & Gai, Z. (2020). The different clinical characteristics of corona virus disease cases between children and their families in China - the character of children with COVID-19. *Emerging microbes & infections*, 9(1), 707–713.
25. Sun, D., Li, H., Lu, X. X., Xiao, H., Ren, J., Zhang, F. R., & Liu, Z. S. (2020). Clinical features of severe pediatric patients with coronavirus disease 2019 in Wuhan: a single center's observational study. *World journal of pediatrics: WJP*, 10.1007/s12519-020-00354-4.
26. Sun, W. W., Ling, F., Pan, J. R., Cai, J., Miao, Z. P., Liu, S. L., Cheng, W., & Chen, E. F. (2020). Epidemiological characteristics of 2019 novel coronavirus family clustering in Zhejiang Province. *Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine]*, 54(0), E027.
27. Tang, A., Tong, Z. D., Wang, H. L., Dai, Y. X., Li, K. F., Liu, J. N., Wu, W. J., Yuan, C., Yu, M. L., Li, P., & Yan, J. B. (2020). Detection of Novel Coronavirus by RT-PCR in Stool Specimen from Asymptomatic Child, China. *Emerging infectious diseases*, 26(6), 10.3201/eid2606.200301.
28. Wang, D., Ju, X. L., Xie, F., Lu, Y., Li, F. Y., Huang, H. H., Fang, X. L., Li, Y. J., Wang, J. Y., Yi, B., Yue, J. X., Wang, J., Wang, L. X., Li, B., Wang, Y., Qiu, B. P., Zhou, Z. Y., Li, K. L., Sun, J. H., Liu, X. G., ... Chen, Y. N. (2020). Clinical analysis of 31 cases of 2019 novel coronavirus infection in children from six provinces (autonomous region) of northern China. *Zhonghua er ke za zhi = Chinese journal of pediatrics*, 58(4), E011.
29. Wang, J., Qi, H., Bao, L., Li, F., Shi, Y., & National Clinical Research Center for Child Health and Disorders and Pediatric Committee of Medical Association of Chinese People's Liberation Army (2020). A contingency plan for the management of the 2019 novel coronavirus outbreak in neonatal intensive care units. *The Lancet. Child & adolescent health*, 4(4), 258–259.
30. Wang, J., Wang, D., Chen, G. C., Tao, X. W., & Zeng, L. K. (2020). SARS-CoV-2 infection with gastrointestinal symptoms as the first manifestation in a neonate. *Zhongguo dang dai er ke za zhi = Chinese journal of contemporary pediatrics*, 22(3), 211–214.
31. Wang, L., Shi, Y., Xiao, T., Fu, J., Feng, X., Mu, D., Feng, Q., Hei, M., Hu, X., Li, Z., Lu, G., Tang, Z., Wang, Y., Wang, C., Xia, S., Xu, J., Yang, Y., Yang, J., Zeng, M., Zheng, J., ... Working Committee on Perinatal and Neonatal Management for the Prevention and Control of the 2019 Novel Coronavirus Infection (2020). Chinese expert consensus on the perinatal and neonatal management for the prevention and control of the 2019 novel coronavirus infection (First edition). *Annals of translational medicine*, 8(3), 47.
32. Wang, S., Guo, L., Chen, L., Liu, W., Cao, Y., Zhang, J., & Feng, L. (2020). A case report of neonatal COVID-19 infection in China. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, ciaa225.
33. Wang, S. S., Zhou, X., Lin, X. G., Liu, Y. Y., Wu, J. L., Sharifu, L. M., Hu, X. L., Rong, Z. H., Liu, W., Luo, X. P., Chen, Z., Zeng, W. J., Chen, S. H., Ma, D., Chen, L., & Feng, L. (2020). Experience of Clinical Management for Pregnant Women and Newborns with Novel Coronavirus Pneumonia in Tongji Hospital, China. *Current medical science*, 10.1007/s11596-020-2174-4.
34. Wang, X. F., Yuan, J., Zheng, Y. J., Chen, J., Bao, Y. M., Wang, Y. R., Wang, L. F., Li, H., Zeng, J. X., Zhang, Y. H., Liu, Y. X., & Liu, L. (2020). Retracted: Clinical and epidemiological characteristics of 34 children with 2019 novel coronavirus infection in Shenzhen. *Zhonghua er ke za zhi = Chinese journal of pediatrics*, 58(0), E008.
35. Xia, W., Shao, J., Guo, Y., Peng, X., Li, Z., & Hu, D. (2020). Clinical and CT features in pediatric patients with COVID-19 infection: Different points from adults. *Pediatric pulmonology*, 10.1002/ppul.24718.
36. Xu, X. W., Wu, X. X., Jiang, X. G., Xu, K. J., Ying, L. J., Ma, C. L., Li, S. B., Wang, H. Y., Zhang, S., Gao, H. N., Sheng, J. F., Cai, H. L., Qiu, Y. Q., & Li, L. J. (2020). Clinical findings in a group of patients infected with the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: retrospective case series. *BMJ (Clinical research ed.)*, 368, m606.

37. Yang, P., Liu, P., Li, D., & Zhao, D. (2020). Corona Virus Disease 2019, a growing threat to children?. *The Journal of infection*, S0163-4453(20)30105-5.
38. Zeng, L., Xia, S., Yuan, W., Yan, K., Xiao, F., Shao, J., & Zhou, W. (2020). Neonatal Early-Onset Infection With SARS-CoV-2 in 33 Neonates Born to Mothers With COVID-19 in Wuhan, China. *JAMA pediatrics*, e200878.
39. Zhang, G. X., Zhang, A. M., Huang, L., Cheng, L. Y., Liu, Z. X., Peng, X. L., & Wang, H. W. (2020). Twin girls infected with SARS-CoV-2. *Zhongguo dang dai er ke za zhi = Chinese journal of contemporary pediatrics*, 22(3), 221–225.
40. Zhang, T., Cui, X., Zhao, X., Wang, J., Zheng, J., Zheng, G., Guo, W., Cai, C., He, S., & Xu, Y. (2020). Detectable SARS-CoV-2 Viral RNA in Feces of Three Children during Recovery Period of COVID-19 Pneumonia. *Journal of medical virology*, 10.1002/jmv.25795.
41. Zheng, F., Liao, C., Fan, Q. H., Chen, H. B., Zhao, X. G., Xie, Z. G., Li, X. L., Chen, C. X., Lu, X. X., Liu, Z. S., Lu, W., Chen, C. B., Jiao, R., Zhang, A. M., Wang, J. T., Ding, X. W., Zeng, Y. G., Cheng, L. P., Huang, Q. F., Wu, J., ... Jin, R. M. (2020). Clinical Characteristics of Children with Coronavirus Disease 2019 in Hubei, China. *Current medical science*, 10.1007/s11596-020-2172-6.
42. Zhou, Y., Yang, G. D., Feng, K., Huang, H., Yun, Y. X., Mou, X. Y., & Wang, L. F. (2020). Clinical features and chest CT findings of coronavirus disease 2019 in infants and young children. *Zhongguo dang dai er ke za zhi = Chinese journal of contemporary pediatrics*, 22(3), 215–220.
43. Cai, J. H., Wang, X. S., Ge, Y. L., Xia, A. M., Chang, H. L., Tian, H., Zhu, Y. X., Wang, Q. R., & Zeng, J. S. (2020). First case of 2019 novel coronavirus infection in children in Shanghai. *Zhonghua er ke za zhi = Chinese journal of pediatrics*, 58(0), E002.
44. Hong, H., Wang, Y., Chung, H. T., & Chen, C. J. (2020). Clinical characteristics of novel coronavirus disease 2019 (COVID-19) in newborns, infants and children. *Pediatrics and neonatology*, S1875-9572(20)30026-7.