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**Disclosure of interest**

The authors declare that they have no competing interest.

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## Epidemiology, clinical features, and outcomes of hospitalized infants with COVID-19 in the Bronx, New York

Novel coronavirus disease 2019 (COVID-19), caused by highly contagious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an ongoing global health emergency. Since its first occurrence in December 2019, SARS-CoV-2 has rapidly spread worldwide, leading to more than five million cases and almost 400,000 deaths [1]. Despite a rapidly growing report on clinical characteristics and outcomes of SARS-CoV-2 patients, there are minimal data on infants. Herein, we discuss the epidemiology, clinical characteristics, and outcomes of infants 1 year of age or younger who had a positive RT-PCR test result for SARS-CoV-2 and were admitted to our hospital before April 26, 2020.

A total of five infants were identified: three (60%) girls and two (40%) boys. The median age of the infants was 3 months (range: 10 days to 10 months). Three (60%) infants were healthy, one infant had congenital heart disease (ventricular septal defects), and one infant was born prematurely and had a history of neonatal respiratory distress syndrome and gastroesophageal reflux. Two (40%) infants were obese, defined as a body mass index greater than the 95th percentile for infants of the same age and sex. Four infants (80%) had a history of contact with someone who was sick, of whom one infant's mother had recently died from suspected SARS-CoV-2 pneumonia. One infant (20%) was exposed to secondhand smoke; two (40%) infants were breastfed.

The most prevalent presenting symptoms were fever (4 infants, 80%) and nasal congestion (3 infants, 60%). One infant presented with a cough (20%). None had diarrhea or vomiting. The median duration from symptom onset to admission was 3 days (range: 1–3 days).

Three (60%) infants had neutropenia with lymphocytosis. None had lymphopenia or thrombocytopenia. Procalcitonin levels were mildly elevated (range: 0.09–0.2 ng/mL) in four (80%) infants and were normal in one (20%) infant. Four (80%) infants had abnormal chest X-ray findings consistent with viral pneumonia, while one (20%) infant had a normal chest X-ray. For all infants, the blood culture, influenza, and respiratory syncytial virus test results were negative.

None required supplemental oxygen nor invasive mechanical ventilation. None of the infants had acute kidney injury or shock. The median length of hospital stay was 5 days (range: 2–11 days). All infants received symptomatic treatment without specific antiviral medications. One infant received steroids for 5 days for possible acute bronchiolitis.

The clinical features and outcomes of infants with COVID-19 in our case series are different from those reported for adults [2,3]. Isolated fever and nasal congestion were common presentations. Obesity was also frequent in infants with COVID-19 but it did not seem to be associated with disease severity. Passive smoking and breastfeeding might not be related to the risk of developing COVID-19 nor impact its clinical course. All of the infants in our report had favorable prognoses and were discharged home safely.

Our study revealed a benign course of COVID-19 in infants, similar to previously published reports [4,5]. The reasons why infants have better prognoses than those of adults remain unknown. We proposed two possible mechanisms underlying the more favorable courses of COVID-19 in infants:

- low expression of angiotensin-converting enzyme (ACE2) receptors in infant lungs;
- immaturity of the infant immune system.

SARS-CoV-2 binds to ACE2 receptors to enter human cells [6]. ACE2 receptors are predominately expressed by type 2 pneumocytes in the lungs explaining why pneumonia is the most prevalent clinical manifestation of COVID-19 [6]. The infant's lungs are not fully developed, with incomplete expression of ACE2 receptors and their underlying pathway. Thus, SARS-CoV-2 may have lower infectivity and virulence in infants than in adults due to the limited entry and functional pathway.

Interestingly, infants with COVID-19 tend to have neutropenia with lymphocytosis. This may be explained by the immaturity of the infant immune system with possibly fewer cytokine responses. The deficit in B-cell function is characteristic of the immature immune development in babies, especially those younger than 6 months. We recently hypothesized that preexisting B-cell suppression has a positive impact on prognosis of COVID-19 [7]. Therefore, favorable COVID-19 outcomes in infants may at least partly be due to their underdeveloped B-cell function.

In conclusion, the clinical course of COVID-19 in infants from our case series seemed more favorable than in adults. However, due to the small number of infants, further research is needed to verify our observation and investigate the underlying causes. Although the clinical outcome of COVID-19 in infants tends to be non-lethal, clinicians should be aware that infants also may

develop life-threatening COVID-19 pneumonia and septic shock as occurs in adults. Therefore, proper supportive intensive care measures should be implemented prompt when indicated. Another concerning issue, which is understudied, is whether SARS-CoV-2 can cause permanent long-term sequelae in infected infants.

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### Disclosure of interest

The authors declare that they have no competing interest.

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