

## Clinical Features and Follow-Up of SARS-Cov-2 Asymptomatic Carriers

Li Liu<sup>1, #</sup>, Mingjuan Yuan<sup>2, #</sup>, Xiuqin Hong<sup>3</sup>, Yamin Yu<sup>4</sup>, Xin Su<sup>5</sup>, Yan Huang<sup>6</sup>, Xu Wang<sup>6</sup>, Sihai Li<sup>2</sup>, Xiaosong Li<sup>3, \*,</sup> and Yi Shi<sup>5, \*</sup>

<sup>1</sup>Department of Infectious Disease, Hunan Provincial People's Hospital (The First Affiliated Hospital of Hunan Normal University), Changsha, Hunan province, China

<sup>2</sup>Department of Infectious Disease, The First People's Hospital of Yueyang, Yueyang, Hunan province, China

<sup>3</sup>Laboratory of Clinical Epidemiology, Hunan Provincial People's Hospital (The First Affiliated Hospital of Hunan Normal University), Changsha, Hunan province, China

<sup>4</sup>Department of Nephrology, Ningxiang People's Hospital, Changsha, Hunan province, China

<sup>5</sup>Department of Respiratory and Critical Care Medicine, Jinling Hospital, Medical School of Nanjing University, Nanjing, China

<sup>6</sup>Department of Rehabilitation of Traditional Chinese Medicine, The First People's Hospital of Yueyang, Yueyang, Hunan province, China

<sup>#</sup>Equally Contributed

**\*Corresponding authors:** Xiaosong Li, Laboratory of Clinical Epidemiology, Hunan Provincial People's Hospital (The First Affiliated Hospital of Hunan Normal University), Changsha, Hunan province, China, E-mail: lxs0308@sina.com

Yi Shi, Department of Respiratory and Critical Care Medicine, Jinling Hospital, Medical School of Nanjing University, Nanjing, China, E-mail: shiyi56@126.com

**Received:** 23 Jul, 2020 | **Accepted:** 15 Aug, 2020 | **Published:** 20 Aug, 2020

**Citation:** Liu L, Yuan MJ, Hong XQ, Yu Y, Su X, et al. (2020) Clinical Features and Follow-Up of SARS-Cov-2 Asymptomatic Carriers. *J Emerg Dis Virol* 5(3): dx.doi.org/10.16966/2473-1846.156

**Copyright:** © 2020 Liu L, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

In the current global coronavirus disease (COVID-19) pandemic, asymptomatic transmission of the causative agent, severe acute respiratory coronavirus-2 (SARS-CoV-2), poses a considerable challenge for disease control. Furthermore, information on the clinical characteristics of asymptomatic carriers is limited. Here, we aimed to clarify the clinical features and obtain follow-up data of asymptomatic carriers to assist in the clinical management of carriers. This retrospective study included all asymptomatic SARS-CoV-2 carriers diagnosed at the First People's Hospital of Yueyang (Hunan, China) and Hunan Provincial People's Hospital (Changsha, China) between January 22 and March 26, 2020. Data including the epidemiology, clinical characteristics, laboratory test results, and chest computed tomography status were collected, with a follow-up of these cases. A total of 24 asymptomatic carriers were enrolled at the First People's Hospital of Yueyang and Hunan Provincial People's Hospital between 22 January 2020 and 26 March 2020. All patients had previously been exposed to SARS-CoV-2. Over the monitored time, patients experienced no symptoms and most laboratory findings were normal. The median time from contact to diagnosis was 9.6 days (range: 1-38 days), while that from diagnosis to discharge was 14.4 days (range: 6-24 days). Following discharge, all patients remained asymptomatic. However, five patients (20.83%) were re-admitted because a polymerase chain reaction (PCR)-based re-test of their specimens (4 throat swabs and 1 feces) showed that they were positive for SARS-CoV-2. The time to re-testing positively varied from 23 to 53 days post-diagnosis. The time to re-testing negative for SARS-CoV-2 by real-time reverse transcription PCR after re-testing positive was 3 to 11 days. In conclusion, although asymptomatic carriers have favorable outcomes, they should be closely monitored. Also, clear guidelines need to be formulated and close surveillance is required for the management of asymptomatic carriers.

**Keywords:** COVID-19; Asymptomatic carriers; Clinical features; SARS-CoV-2

**Abbreviations:** CDC: Center for Disease Control and Prevention; SARS-CoV-2: Severe acute respiratory coronavirus-2; COVID-19: Coronavirus disease; 2019-nCoV: 2019-new coronavirus; CT: Computed Tomography; RT-PCR: Real-Time Reverse Transcription Polymerase Chain Reaction; ALT: Alanine Transaminase; AST: Aspartate Transaminase; LDH: Lactate Dehydrogenase; ALB: Albumin; TG: Triglyceride; CHO: Cholesterol; IgM: Immunoglobulin (Ig) M; IgG: Immunoglobulin (Ig) G

### Introduction

The current COVID-19 pandemic has spread rapidly and internationally. As of 29 May 2020 (China Standard Time), more than 5,768,908 cases of COVID-19 have been confirmed worldwide, with 358,490 COVID-19-associated deaths.

COVID-19 has a wide spectrum of disease symptoms ranging from being asymptomatic to mild pneumonia to serious acute respiratory distress syndrome, septic shock, and multiple organ dysfunction syndromes. Extended follow-up and the nature of disease progression indicate that asymptomatic carriers can be further divided into either asymptomatic infection or pre-symptomatic state [1]. A

study conducted by China CDC showed that most patients (80.9%) were considered asymptomatic or had mild pneumonia but shed a large amount of virus during the early phase of infection. This poses enormous challenges for containing the spread of COVID-19 [2]. Asymptomatic and pre-symptomatic individuals are hidden sources of COVID-19 [3,4], and numerous infections may be attributed to asymptomatic transmission.

Although excellent tools exist for the diagnosis of symptomatic patients in well-equipped laboratories, important gaps remain in screening to identify asymptomatic individuals during the incubation phase and for accurate determination of dynamic viral shedding during convalescence which would inform the decision to end isolation [5]. Asymptomatic carriers increase the challenges associated with the prevention and management of COVID-19. Thus, the question of how to manage these patients remains to be addressed. As such, more information regarding asymptomatic carriers must be obtained. In this retrospective study, we analyzed the clinical characteristics and follow-up data of 24 patients who were diagnosed to be asymptomatic carriers at the First People's Hospital of Yueyang (Hunan, China) and Hunan Provincial People's Hospital (Changsha, China). We believe that this information can serve as a reference for the appropriate management of asymptomatic carriers.

## Methods

### Study design and participants

This retrospective study included asymptomatic carriers diagnosed with COVID-19 according to "The Prevention and Control Protocol for Coronavirus Disease 2019 (Third Edition)" issued by the National Health Commission [6]. Patients were diagnosed at the First People's Hospital of Yueyang and Hunan Provincial People's Hospital (Tianxing Hospital and Mawangdui Hospital, Changsha, China) between 22 January and 26 March 2020. Throat swab samples were collected from patients, and SARS-CoV-2 was detected with real-time reverse transcription polymerase chain reaction (RT-PCR). The study protocols were approved by the Ethics Committee of the Hunan Provincial People's Hospital and the Ethics Committee of The First People's Hospital of Yueyang.

### Procedures

Specimens of throat swabs obtained from the upper respiratory tract of all patients were collected every three days during the period of admission and tested using RT-PCR for SARS-CoV-2. A chest computed tomography (CT) scan, laboratory analyses such as routine blood tests, and tests for liver function, blood lipids, and myocardial enzymes were also performed in parallel. The host humoral response to SARS-CoV-2, including responses to immunoglobulin (IgM) and immunoglobulin G (IgG), was examined by an enzyme-linked immunosorbent assay. China's measures for managing asymptomatic carriers include 14 days of centralized quarantine and observation at a designated hospital. In principle, individuals with two consecutive negative nucleic acid tests (spaced at an interval of at least 24 hours) were released from quarantine, following which they were immediately quarantined at a hotel for an additional 4 weeks after discharge [7]. During the additional quarantine period of four weeks, signs and symptoms were monitored and documented. Throat swab specimens were collected from adults and throat swab and feces specimens were collected from teenagers; the specimens were tested for SARS-CoV-2 with RT-PCR.

Epidemiological data, demographic information, laboratory test results, and chest CT images for all asymptomatic patients obtained

from the medical records of the two hospitals were analyzed. Other relevant follow-up data were obtained through regular clinical interviews. The last follow-up interview was conducted on 10 April 2020.

### Statistical analysis

Normally distributed continuous data are expressed as the mean. Non-normally distributed continuous data are expressed as the median. Categorical variables are expressed both as raw data and percentage. Also, results from the laboratory tests were assessed to determine if they were normal or outside the normal range. Statistical analyses were performed using SPSS version 20.0 (IBM Corporation, Armonk, NY, USA).

## Results

Patients who were positive for SARS-CoV-2 and experienced an absence of symptoms on the test day were diagnosed as asymptomatic carriers. Asymptomatic carriers can be further divided into either asymptomatic infection or pre-symptomatic state. In the present study, 24 patients (12 (50%) women and 12 (50%) men; mean age: 31 years (range: 2-84 years)) were asymptomatic and had not developed any symptoms during the entire study period. Nineteen (79.17%) patients were aged between 1 and 59 years and accounted for the largest proportion of patients. All patients were infected by prior exposure to patients confirmed as having COVID-19, and all were from family clusters. Eight (33.33%) patients had comorbidities-four had a prior history of pulmonary tuberculosis (mainly fibrosis), two were carriers of the hepatitis B virus, and two had hypertension. The median time from exposure to diagnosis was 9.6 days (range: 1-38 days), and the median time from diagnosis to discharge was 14.4 days (range: 6-24 days). The data are summarized in table 1.

The leukocyte count of most patients was within the normal range and was elevated in one (4.17%) patient, whereas the lymphocyte count ( $0.6 \times 10^9/L$ ) was decreased in four (16.17%) patients; the

**Table 1:** Demographics and baseline characteristics of asymptomatic carriers.

Patients	(n = 24)
<b>Age, years</b>	
Mean range	31 (2-84)
<18	10 (41.67%)
18-60	9 (37.5%)
>60	5 (20.83%)
<b>Sex</b>	
Female	12 (50%)
Male	12 (50%)
<b>Epidemiological history (within 14 days of onset)</b>	
Contact with confirmed patients	24 (100%)
Family cluster	yes
<b>Comorbidities</b>	
History of pulmonary tuberculosis	4 (16.67%)
Hepatitis B	2 (8.33%)
Hypertension	2 (8.33%)
Median time from exposure to diagnosis	9.6 days (1-38 days)
Median time from diagnosis to discharge	14.4 days (6-24 days)

platelet count of all patients was within the normal range. Alanine transaminase (ALT) and Aspartate transaminase (AST) levels were generally found to be within the normal range. However, some patients showed increased lactate dehydrogenase (LDH), triglyceride (TG), and cholesterol (CHO) levels. Some patients exhibited decreased albumin (ALB) levels. Chest CT scans showed that two (8.33%) patients appeared to have pneumonia, whereas the scans of all other patients were normal (Table 2).

We tested eight patients who were SARS-CoV-2-negative via RT-PCR at the time of testing for serum IgM and IgG levels. Two patients were positive for IgM on days 14 and 35 after diagnosis and five were positive for IgG on days 10 (2), 12, 14, and 42; one patient was negative for IgM and IgG on day 12 (Table 3).

**Table 2:** Clinical characteristics of asymptomatic carriers.

Patients	(n = 24)
Asymptomatic infection	24 (100%)
Pre-symptomatic infection	0
<b>LABORATORY TESTS</b>	
<b>Leukocytes (× 10<sup>9</sup> per L; Normal range: 3.5-10)</b>	
Normal range	Increased
Increased	1 (4.17%)
<b>Lymphocytes (× 10<sup>9</sup> per L; Normal range: 1.1-3.2)</b>	
Normal range	16 (66.66%)
Decreased	4 (16.7%)
Increased	4 (16.7%)
<b>Platelets (× 10<sup>9</sup> per L; Normal range: 100-300)</b>	
Normal range	24 (100%)
<b>ALT (× 10<sup>9</sup> per L; Normal range: 100-300)</b>	
Normal range	23 (95.83%)
Increased	1 (4.17%)
<b>AST (ng/mL; Normal range: 0-0.5)</b>	
Normal range	23 (95.83%)
Increased	1 (4.17%)
<b>ALB (mm/h; Normal range: 0-15)</b>	
Decreased	4 (16.7%)
Normal range	20 (83.33%)
<b>LDH (mm/h; Normal range: 0 - 15)</b>	
Increased	2 (8.33%)
Normal range	22 (91.67%)
<b>TG (mm/h; Normal range: 0 - 15)</b>	
Increased	2 (8.33%)
Normal range	22 (91.67%)
<b>CHO (mm/h; Normal range: 0 - 15)</b>	
Increased	3 (12.5%)
Normal range	21 (87.5%)
<b>CT findings</b>	
No pneumonia	22 (91.67%)
Pneumonia	2 (8.33%)

**Table 3:** Serum IgM and IgG levels in eight patients.

Patients (n=8)	Age	Sex	IgM and IgG	RT-PCR	Time from diagnosis to test (days)
Patient 1	18	Female	IgM(-) IgG(+)	(-)	10
Patient 2	15	Male	IgM(-) IgG(+)	(-)	46
Patient 3	35	Male	IgM(-) IgG(-)	(-)	35
Patient 4	61	Male	IgM(+) IgG(-)	(-)	35
Patient 5	61	Male	IgM(-) IgG(+)	(-)	12
Patient 6	63	Female	IgM(+) IgG(+)	(-)	14
Patient 7	41	Female	IgM(-) IgG(-)	(-)	12
Patient 8	34	Female	IgM(-) IgG(+)	(-)	10

Following discharge, all patients continued to remain asymptomatic. Five (20.83%) patients were readmitted as their specimens (4 throat swab and 1 feces) were re-tested as positive for SARS-CoV-2 by RT-PCR. Four patients were teenagers, and the fifth patient was a 34-year old woman. For these patients, the time to re-testing positive from diagnosis ranged from 23 to 53 days. The time from re-testing positive to re-testing negative by RT-PCR varied from 3 to 11 days. All patients were administered aerosolized interferon-α and Lianhuaqingwen capsules (a traditional Chinese medicine) for 10 days. Simultaneously, three and two patients were administered oseltamivir and arbidol, respectively (Table 4).

## Discussion and Conclusion

The COVID-19 outbreak that started in Wuhan City, Hubei province, China, in December 2019, has since spread globally. The role of asymptomatic carriers of COVID-19 in transmission is a concerning issue. Numerous studies have reported the proportion of asymptomatic carriers among the infected. Arons MM, et al. found that more than half of the patients who tested positive were asymptomatic at the time of testing, a fact that likely contributed to transmission [8]. He G, et al. reported that the prevalence of asymptomatic COVID-19 infection was 5.8% (95% CI: 3.4 - 9.9%), and this figure is notably higher than that reported by the China CDC (1.2%) [9]. In our previous study, we reported that 12.5% of patients had asymptomatic infections [10]. In the present study, all patients remained asymptomatic for the entire duration of the study. All the patients were suspected to be infected based on their epidemiological history, and infection status was confirmed by RT-PCR. A report by Lu S, et al. also found that the identification of the first asymptomatic carrier in a family cluster depends on repeated and comprehensive epidemiological investigation by disease control experts [11].

Data from China have indicated that older adults, particularly those with serious underlying health conditions, are at a higher risk of contracting severe COVID-19-associated illness and death compared to younger individuals [12]. Age and pre-existing conditions (e.g., hypertension and diabetes) were the most important risk factors for death due to COVID-19-associated pneumonia. In this study cohort, more than a third (8, 33.33%) of patients presented with comorbidities, and most patients were young people with a median age of 31 years. This is consistent with the results of Du W, et al., who showed that asymptomatic patients were younger than symptomatic patients [13]. He G, et al. also reported that asymptomatic patients were more likely to be young adults [9]. We observed that up to 42% of children were asymptomatic, and a systematic review showed that children had milder symptoms and better prognosis for COVID-19 than adults [14]. This suggests that age plays a significant role in the COVID-19 prognosis.

**Table 4:** Characteristics of five patients who re-tested positive with RT-PCR.

Patients (n=5)	Age (years)	Sex	Time from diagnosis to re-testing positive (days)	Time from re-testing positive to re-testing negative (days)	Specimen for RT-PCR	Treatment
Patient 1	7	Male	29	3	Throat	Interferon- $\alpha$ +oseltamivir+Lianhuaqingwen capsule
Patient 2	18	Female	27	4	Throat	Interferon- $\alpha$ +arbidol+Lianhuaqingwen capsule
Patient 3	1	Male	27	11	Faeces	Interferon- $\alpha$ +oseltamivir+Lianhuaqingwen capsule
Patient 4	2	Male	53	3	Throat	Interferon- $\alpha$ +oseltamivir+Lianhuaqingwen capsule
Patient 5	34	Female	23	11	Throat	Interferon- $\alpha$ +arbidol+Lianhuaqingwen capsule

The average incubation period of COVID-19 ranges from 2 to 14 days, and most commonly falls between 3 and 7 days. The incubation period may be longer in some patients. We observed some differences between asymptomatic and symptomatic patients. The median time from exposure to diagnosis with an RT-PCR-positive throat swab was 9.6 days (range: 1-38 days), and the median time from diagnosis to discharge was 14.4 days (range: 6-24 days). This is significantly different from previous studies. Song WL, et al. showed that in asymptomatic children, the median time from exposure to a family member with confirmed infection to a positive SARS-CoV-2 nucleic acid test was 15.5 days (range: 10-26 days). The median time to convert to the first negative nucleic acid test was reported to be 5.5 days (range: 1-23 days) [15]. Xu T, et al. showed that from admission, the median time to a negative SARS-CoV-2 test was 7 days (IQR: 4.0 - 9.0 days) [16]. Because there is currently no consensus regarding how to manage asymptomatic carriers, these values could be useful in determining appropriate quarantine duration.

Changes in biochemical and inflammatory markers are reported to be limited in asymptomatic patients [17], which is consistent with our findings. Although we observed that most results were normal, interestingly, a small proportion of asymptomatic patients had decreased ALB and increased blood lipid, respectively. Because the sample size of this study was small, further studies with larger patient cohorts are required to confirm our present findings.

The current gold standard for diagnosis of COVID-19 is an RT-PCR test conducted on respiratory tract specimens. Measurement of antibodies (both IgG and IgM) serves as an additional, non-invasive tool for diagnosis and clinical management. Furthermore, it may help diagnose suspected patients who test negative by RT-PCR and identifying asymptomatic carriers [18]. Defining the immunopathological changes in COVID-19 patients is important for clinical management. The kinetics of individual responses to SARS-CoV-2 varies. Zhao R, et al. described an assay that could detect antibodies against SARS-CoV-2 one day after the onset of disease [19], and Rokni M, et al. found that IgM can be detected in serum as early as 4 days after onset, with most patients seroconverting by day 14 [20]. In this study, we found that one patient did not generate SARS-CoV-2-specific antibody responses up to 12 days after diagnosis. IgM was detected on days 14 and 35, and short-term IgG response was detected on day 10, with long-term IgG response detected on day 46 after diagnosis. These findings have significant implications for the identification of asymptomatic carriers.

Among the large number of COVID-19 patients who were discharged from the hospital, some redeveloped fever and re-tested positive by RT-PCR after discharge. Xing et al. found that a small proportion (3.23%) of recovered patients may re-test as positive

after discharge and described two asymptomatic cases that re-tested positive [21]. In the current study, five patients (20.83%) re-tested positive after discharge. Most patients were teenagers, and the longest interval between re-testing positive and original diagnosis was 53 days. All patients had received anti-viral treatment (both Western and Chinese traditional medicine). Because there is no standard drug treatment for COVID-19, treatment mainly comprised symptom management. Drug treatments for COVID-19 remain controversial. In this small study, the patients who re-tested positive indicated that the treatments were not beneficial for COVID-19. After analyzing the data of patients who re-tested positive as well as their IgM and IgG test results, we found a single patient who had re-tested positive by RT-PCR but was negative for serum IgM and positive for IgG. This was similar to the results of Fu W, et al. [22]. Accordingly, the role that these antibodies play in COVID-19 remains unknown.

The present study had certain limitations. First, it was a retrospective study and only examined a small number of asymptomatic patients from two hospitals located in Hunan province (China). Second, because there is still a debate regarding whether asymptomatic patients are considered potential infection transmitters or not, this observation did not refer to this topic, and thus, additional studies and further observations are needed in the future.

In conclusion, asymptomatic carriers have favorable outcomes but should be closely monitored. There is an urgent need for formulating clear guidelines for the management of asymptomatic carriers, and we propose close surveillance of asymptomatic carriers.

## Acknowledgments

None

## Authors' Contributions

YY, YH, SL, and XW collected the epidemiological and clinical data and processed statistical data, XH analyzed all data, and LL and MY drafted and edited the manuscript. YS and XS participated in the design, and XL revised the manuscript.

## Funding

This study was supported by the Scientific Research Fund from the Hunan Provincial Health Committee (NO.20200034), Research and development plan projects in key areas from Hunan Province Science and Technology (2020SK3042).

## Availability of Data and Materials

All data generated or analyses during this study are included in the published article.



## Ethics Approval and Consent to Participate

All procedures performed in this study involving human participants were conducted under the ethical standards of the Ethics Committee of the Hunan Provincial People's Hospital and The First People's Hospital of Yueyang, the 1964 Helsinki declaration and its later amendments, and with comparable ethical standards.

## Consent for Publication

Informed consent was obtained from all participants included in the study.

## Competing Interests

All authors declare no conflict of interest.

## References

1. Wu ZY (2020) Contribution of asymptomatic and pre-symptomatic cases of COVID-19 in spreading virus and targeted control strategies. *Zhonghua Liu Xing Bing Xue Za Zhi* 41: 801-805.
2. Wang YX, Wang YY, Chen Y, Qin QS (2020) Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. *J Med Virol* 92: 568-576.
3. Li GJ, Li WR, He XJ, Cao YX (2020) Asymptomatic and presymptomatic infectors are hidden sources of COVID-19 disease. *Clin Infect Dis*.
4. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, et al. (2020) Presymptomatic Transmission of SARS-CoV-2 - Singapore, January 23-March 16, 2020. *Morb Mortal Wkly Rep* 69: 411-415.
5. Cheng MP, Papenburg J, Desjardins M, Kanjilal S, Quach C, et al. (2020) Diagnostic testing for severe acute respiratory syndrome-related coronavirus-2: a narrative review. *Ann Intern Med* 172: 726-734.
6. National Health Commission of the People's Republic of China (2020) Notice of the General Office of the National Health Commission on Issuing the New Coronavirus Pneumonia Prevention and Control Plan. Third Edition, China.
7. Zhang J, Wu S, Xu L (2020) Asymptomatic carriers of COVID-19 as a concern for disease prevention and control: more testing, more follow-up. *Biosci Trends* 14: 206-208.
8. Arons MM, Hatfield KM, Reddy SC, Kimball A, James A, et al. (2020) Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N Engl J Med* 382: 2081-2090.
9. He G, Sun W, Fang P, Huang J, Gamber M, et al. (2020) The clinical feature of silent infections of novel coronavirus infection (COVID-19) in Wenzhou. *J Med Virol*.
10. Liu L, Hong X, Su X, Chen H, Zhang D, et al. (2020) Optimizing screening strategies for coronavirus disease 2019: A study from middle China. *J Infect Public Health* 13: 868-872.
11. Lu S, Lin J, Zhang Z, Xiao L, Jiang Z, et al. (2020) Alert for non-respiratory symptoms of coronavirus disease 2019 (COVID-19) patients in epidemic period: A case report of familial cluster with three asymptomatic COVID-19 patients. *J Med Virol*.
12. CDC COVID-19 Response Team (2020) Severe outcomes among patients with coronavirus disease 2019 (COVID-United States, February 12-March 16, 2020. *MMWR Morb Mortal Wkly Rep* 69: 343-346.
13. Du W, Yu J, Wang H, Zhang X, Zhang S, et al. (2020) Clinical characteristics of COVID-19 in children compared with adults in Shandong Province, China. *Infection* 48: 445-452.
14. Ludvigsson JF (2020) Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta Paediatr* 109: 1088-1095.
15. Song WL, Li JH, Zou N, Guan W, Pan J, et al. (2020) Clinical features of pediatric patients with coronavirus disease (COVID-19). *J Clin Virol* 127: 104377.
16. Xu T, Huang R, Zhu L, Wang J, Cheng J, et al. (2020) Epidemiological and clinical features of asymptomatic patients with SARS-CoV-2 infection. *J Med Virol*.
17. Pan Y, Yu X, Du X, Li Q, Li X, et al. (2020) Epidemiological and clinical characteristics of 26 asymptomatic SARS-CoV-2 carriers. *J Infect Dis* 221: 1940-1947.
18. Long Q-X, Liu B-Z, Deng H-J, Wu G-C, Deng K, et al. (2020) Antibody responses to SARS-CoV-2 in patients with COVID-19. *Nat Med* 26: 845-848.
19. Zhao R, Li M, Song H, Chen J, Re W, et al. (2020) Early detection of SARS-CoV-2 antibodies in COVID-19 patients as a serologic marker of infection. *Clin Infect Dis*.
20. Rokni M, Ghasemi V, Tavakoli Z (2020) Immune responses and pathogenesis of SARS-CoV-2 during an outbreak in Iran: Comparison with SARS and MERS. *Rev Med Virol* 30: e2107.
21. Xing Y, Mo P, Xiao Y, Zhao O, Zhang Y, et al. (2020) Post-discharge surveillance and positive virus detection in two medical staff recovered from coronavirus disease 2019 (COVID-19), China, January to February 2020. *Euro Surveill* 25: 2000191.
22. Fu W, Chen Q, Wang T (2020) Letter to the Editor: Three cases of re-detectable positive SARS-CoV-2 RNA in recovered COVID-19 patients with antibodies. *J Med Virol*.