

COVID-19


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Duration of Isolation and Precautions for Adults with COVID-19

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Summary of Recent Changes

Updates as of October 19, 2020 

As of October 19, 2020

- Added criteria and evidence to address whether people who recovered from COVID-19 and are re-exposed to COVID-19 need to undergo repeat quarantine.

Accumulating evidence supports ending isolation and precautions for persons with COVID-19 using a symptom-based strategy. This update incorporates recent evidence to inform the duration of isolation and precautions recommended to prevent transmission of SARS-CoV-2 to others, while limiting unnecessary prolonged isolation and unnecessary use of laboratory testing resources.

Key findings are summarized here.

1. Concentrations of SARS-CoV-2 RNA measured in upper respiratory specimens decline after onset of symptoms (CDC, unpublished data, 2020; Midgley et al., 2020; Young et al., 2020; Zou et al., 2020; Wölfel et al., 2020; van Kampen et al., 2020).
2. The likelihood of recovering replication-competent virus also declines after onset of symptoms. For patients with mild to moderate COVID-19, replication-competent virus has not been recovered after 10 days following symptom onset (CDC, unpublished data, 2020; Wölfel et al., 2020; Arons et al., 2020; Bullard et al., 2020; Lu et al., 2020; personal communication with Young et al., 2020; Korea CDC, 2020).

Recovery of replication-competent virus between 10 and 20 days after symptom onset has been documented in some persons with severe COVID-19 that, in some cases, was complicated by immunocompromised state (van Kampen et al., 2020). However, in this series of patients, it was estimated that 88% and 95% of their specimens no longer yielded replication-competent virus after 10 and 15 days, respectively, following symptom onset.

3. A large contact tracing study demonstrated that high-risk household and hospital contacts did not develop infection if their exposure to a case patient started 6 days or more after the case patient's illness onset (Cheng et al., 2020).
4. Although replication-competent virus was not isolated 3 weeks after symptom onset, recovered patients can continue to have SARS-CoV-2 RNA detected in their upper respiratory specimens for up to 12 weeks (Korea CDC, 2020; Li et al., 2020; Xiao et al, 2020). Investigation of 285 "persistently positive" persons, which included 126 persons who had developed recurrent symptoms, found no secondary infections among 790 contacts attributable to contact with these case patients. Efforts to isolate replication-competent virus from 108 of these case patients were unsuccessful (Korea CDC, 2020).
5. Specimens from patients who recovered from an initial COVID-19 illness and subsequently developed new symptoms and retested positive by RT-PCR did not have replication-competent virus detected (Korea CDC, 2020; Lu et al., 2020). The risk of reinfection may be lower in the first 3 months after initial infection, based on limited evidence from another betacoronavirus (HCoV-OC43), the genus to which SARS-CoV-2 belongs (Kiyuka et al, 2018).
6. To date, reports of reinfection have been infrequent. Similar to other human coronaviruses where studies have demonstrated reinfection, the probability of SARS-CoV-2 reinfection is expected to increase with time after recovery from initial infection due to waning immunity and possibly genetic drift. Risk of reinfection depends on the likelihood of re-exposure to infectious cases of COVID-19. As the COVID-19 pandemic continues, we expect to see more cases of reinfection.

The current evidence includes the following caveats:

- In a recent study of skilled nursing facility workers followed prospectively for asymptomatic infection, one of 48 infected staff had a nasopharyngeal swab which was weakly positive on a single-passage plaque assay more than 20 days after initial diagnosis; however, the specimen was not subjected to serial passage to demonstrate the presence of replication-competent virus (Quicke et al., 2020).
- In one case report, a person with mild illness provided specimens that yielded replication-competent virus for up to 18 days after symptom onset (Liu et al., 2020).
- Data currently available are derived from adults; equivalent data from children and infants are not presently available.
- More data are needed concerning viral shedding in some situations, including in immunocompromised persons.

Assessment

Available data indicate that persons with mild to moderate COVID-19 remain infectious no longer than 10 days after symptom onset. Persons with more severe to critical illness or severe immunocompromise likely remain infectious no longer than 20 days after symptom onset. Recovered persons can continue to shed detectable SARS-CoV-2 RNA in upper respiratory specimens for up to 3 months after illness onset, albeit at concentrations considerably lower than during illness, in ranges where replication-competent virus has not been reliably recovered and infectiousness is unlikely. The etiology of this persistently detectable SARS-CoV-2 RNA has yet to be determined. Studies have not found evidence that clinically recovered persons with persistence of viral RNA have transmitted SARS-CoV-2 to others. These findings strengthen the justification for relying on a symptom based, rather than test-based strategy for ending isolation of these patients, so that persons who are by current evidence no longer infectious are not kept unnecessarily isolated and excluded from work or other responsibilities.

The duration and robustness of immunity to SARS-CoV-2 remains under investigation. Based on what we know from other related human coronaviruses, people appear to become susceptible to reinfection around 90 days after onset of infection. To date, reinfection appears to be uncommon during the initial 90 days after symptom onset of the preceding infection ([Annex: Quarantine of Persons Recovered from Laboratory-diagnosed SARS-CoV-2 Infection with Subsequent Re-Exposure](#)). Thus, for persons recovered from SARS-CoV-2 infection, a positive PCR without new symptoms during the 90 days after illness onset more likely represents persistent shedding of viral RNA than reinfection.

- If such a person remains *asymptomatic* during this 90-day period, then any re-testing is unlikely to yield useful information, even if the person had close contact with an infected person.
- If such a person becomes *symptomatic* during this 90-day period and an evaluation fails to identify a diagnosis other than SARS-CoV-2 infection (e.g., influenza), then the person may warrant evaluation for SARS-CoV-2 reinfection in consultation with an infectious disease or infection control expert. Isolation may be warranted during this evaluation, particularly if symptoms developed after close contact with an infected person.

Correlates of immunity to SARS-CoV-2 infection have not been established. Specifically, the utility of serologic testing to establish the absence or presence of infection or reinfection remains undefined.

The recommendations below are based on the best information available in mid-July 2020 and reflect the realities of an evolving pandemic. Even for pathogens for which many years of data are available, it may not be possible to establish recommendations that ensure 100% of persons who are shedding replication-competent virus remain isolated. CDC will continue to closely monitor the evolving science for information that would warrant reconsideration of these recommendations.

Recommendations

1. Duration of isolation and precautions

- For most persons with COVID-19 illness, isolation and precautions can generally

be discontinued 10 days *after symptom onset*¹ and resolution of fever for at least 24 hours, without the use of fever-reducing medications, and with improvement of other symptoms.

- A limited number of persons with severe illness may produce replication-competent virus beyond 10 days that may warrant extending duration of isolation and precautions for up to 20 days after symptom onset; consider consultation with infection control experts.
- For persons who never develop symptoms, isolation and other precautions can be discontinued 10 days *after the date of their first positive RT-PCR test for SARS-CoV-2 RNA*.

2. **Role of viral diagnostic testing (PCR or antigen)² to discontinue isolation or precautions**

- For persons who are severely immunocompromised, a test-based strategy could be considered in consultation with infectious diseases experts.
- For all others, a test-based strategy is no longer recommended except to discontinue isolation or precautions earlier than would occur under the strategy outlined in Part 1, above.

3. **Role of viral diagnostic testing (PCR or antigen)² after discontinuation of isolation or precautions**

- For persons previously diagnosed with symptomatic COVID-19 who remain asymptomatic after recovery, retesting is not recommended within 3 months after the date of symptom onset for the initial COVID-19 infection.
- For persons who develop new symptoms consistent with COVID-19 during the 3 months after the date of initial symptom onset, if an alternative etiology cannot be identified by a provider, then the person may warrant retesting. Consultation with infectious disease or infection control experts is recommended, especially in the event symptoms develop within 14 days after close contact with an infected person. Persons being evaluated for reinfection with SARS-CoV-2 should be isolated under recommended precautions while undergoing evaluation. If reinfection is confirmed or remains suspected they should remain under the recommended SARS-CoV-2 isolation until they meet the criteria for discontinuation of precautions – for most persons, this would be 10 days after symptom onset and resolution of fever for at least 24 hours, without the use of fever-reducing medications, and with improvement of other symptoms.
- For persons who never developed symptoms, the date of first positive viral diagnostic test (PCR or antigen) for SARS-CoV-2 RNA should be used in place of the date of symptom onset.

4. **Role of serologic testing**

- Serologic testing should not be used to establish the presence or absence of SARS-CoV-2 infection or reinfection.

[1] *Symptom onset* is defined as the date on which symptoms first began, including non-respiratory symptoms.

[2] *PCR testing* is defined as the use of an RT-PCR assay to detect the presence of SARS-CoV-2 RNA..

References

- Arons MM, Hatfield KM, Reddy SC, Kimball A, James A, Jacobs JR, *et al.* Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N Engl J Med* 2020 May 28;382(22):2081-2090. doi:10.1056/NEJMoa2008457.
- Bullard J, Durst K, Funk D, Strong JE, Alexander D, Garnett L *et al.* Predicting Infectious SARS-CoV-2 From Diagnostic Samples. *Clin Infect Dis* 2020 May 22. doi: 10.1093/cid/ciaa638.
- Cheng HW, Jian SW, Liu DP, Ng TC, Huang WT, Lin HH, *et al.* Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods Before and After Symptom Onset. *JAMA Intern Med* 2020 May 1; doi:10.1001/jamainternmed.2020.2020.
- Kiyuka PK, Agoti CN, Munywoki PK, Njeru R, Bett A, Otieno JR, *et al.* Human Coronavirus NL63 Molecular Epidemiology and Evolutionary Patterns in Rural Coastal Kenya. *J Infect Dis* 2018 May 5;217(11):1728-1739. doi: 10.1093/infdis/jiy098.
- Korea Centers for Disease Control and Prevention. Findings from Investigation and Analysis of re-positive cases. May 19, 2020. Available at: https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030&act=view&list_no=367267&nPage=1 external icon
- Li N, Wang X, Lv T. Prolonged SARS-CoV-2 RNA Shedding: Not a Rare Phenomenon. *J Med Virol* 2020 Apr 29. doi: 10.1002/jmv.25952.
- Liu WD, Chang SY, Wang JT, Tsai MJ, Hung CC, Hsu CL, *et al.* Prolonged Virus Shedding Even After Seroconversion in a Patient With COVID-19. *J Infect* 2020 Apr 10;S0163-4453(20)30190-0. doi: 10.1016/j.jinf.2020.03.063
- Lu J, Peng J, Xiong Q, Liu Z, Lin H, Tan X, *et al.* Clinical, immunological and virological characterization of COVID-19 patients that test re-positive for SARS-CoV-2 by RT-PCR. (Preprint) Medrxiv. 2020. Available at: <https://www.medrxiv.org/content/10.1101/2020.06.15.20131748v1> external icon doi: <https://doi.org/10.1101/2020.06.15.20131748>
- Midgley CM, Kujawski SA, Wong KK, Collins, JP, Epstein L, Killerby ME *et al.* (2020). Clinical and Virologic Characteristics of the First 12 Patients with Coronavirus Disease 2019 (COVID-19) in the United States. *Nat Med* 2020 Jun;26(6):861-868. doi: 10.1038/s41591-020-0877-5.
- Quicke K, Gallichote E, Sexton N, Young M, Janich A, Gahm G, *et al.* Longitudinal Surveillance for SARS-CoV-2 RNA Among Asymptomatic Staff in Five Colorado Skilled Nursing Facilities: Epidemiologic, Virologic and Sequence Analysis. (Preprint) Medrxiv. 2020. Available at: <https://www.medrxiv.org/content/10.1101/2020.06.08.20125989v1> external icon doi: <https://doi.org/10.1101/2020.06.08.20125989> external icon
- van Kampen J, van de Vijver D, Fraaij P, Haagmans B, Lamers M, Okba N, *et al.* Shedding of infectious virus in hospitalized patients with coronavirus disease-2019 (COVID-19): duration and key determinants. (Preprint) Medrxiv. 2020. Available at: <https://www.medrxiv.org/content/10.1101/2020.06.08.20125310v1> external icon doi: <https://doi.org/10.1101/2020.06.08.20125310>
- Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Müller MA, *et al.* (2020). Virological assessment of hospitalized patients with COVID-2019. *Nature* 2020 May;581(7809):465-469. doi:10.1038/s41586-020-2196-x
- Xiao F, Sun J, Xu Y, Li F, Huang X, Li H, *et al.* Infectious SARS-CoV-2 in Feces of Patient with Severe COVID-19. *Emerg Infect Dis* 2020;26(8):10.3201/eid2608.200681.

doi:10.3201/eid2608.200681

- Young BE, Ong SWX, Kalimuddin S, Low JG, Ta, SY, Loh J, et al. Epidemiologic Features and Clinical Course of Patients Infected With SARS-CoV-2 in Singapore. *JAMA* 2020 Mar 3;323(15):1488-1494. doi:10.1001/jama.2020.3204
- Personal communication with Young BE first author of preprint of: Young BE, Ong SW, Ng LF, Anderson DE, Chia WN, Chia PY, et al. Immunological and Viral Correlates of COVID-19 Disease Severity: A Prospective Cohort Study of the First 100 Patients in Singapore. (Preprint) SSRN. 2020. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3576846external icon <http://dx.doi.org/10.2139/ssrn.3576846>
- Zou L, Ruan F, Huang M, Liang L, Huang H, Hong Z, et al. (2020). SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. *N Engl J Med*, 382(12), 1177-1179. doi:10.1056/NEJMc200173

Annex: Quarantine of Persons Recovered from Laboratory-diagnosed SARS-CoV-2 Infection with Subsequent Re-Exposure

Accumulating evidence supports that people who have recovered from COVID-19 do not need to undergo repeat quarantine in the case of another COVID-19 exposure within 3 months of their initial diagnosis. Evidence does not indicate the definitive absence of re-infection during this period, only that risks of potential SARS-CoV-2 transmission from recovered persons are likely outweighed by the personal and societal benefits of avoiding unnecessary quarantine. CDC recommends that all people, regardless of symptoms, and whether or not they have had COVID-19 in the past, continue to take all recommended measures to prevent SARS-CoV-2 transmission (i.e., wear masks, stay 6 feet away from others whenever possible, and wash hands regularly).

Key findings are summarized here.

1. Persons recovered from COVID-19 who have been re-exposed to an active case have not been demonstrated infectious to others. Specifically, Korea CDC conducted an epidemiologic and virologic investigation of persons who tested positive after having clinically recovered and having two negative PCR tests, 170 of whom were exposed to an infectious case of COVID-19. Investigators found no evidence of active infection in these re-exposed persons: no new SARS-CoV-2 infections were attributable to the contacts of these persons during a 14-day quarantine period, and none of the specimens collected from these persons yielded replication competent virus. The positive PCR tests found in this investigation were consistent with persistent shedding of non-infectious viral RNA and not re-infection (Korea CDC).
2. Additional reports of recovered persons have found no evidence of COVID-19 in those who develop symptoms of influenza-like or other illness within 90 days of recovery (Mumoli et al.) including three recovered persons who were intensively re-exposed to COVID-19 in a high transmission setting but were not re-infected (Addetia et al.).
3. The best characterized cases of re-infections to date have occurred at least 90 days after the first illness episode's onset (To et al.; Van Eslande et al). However, additional reports suggest that reinfection is possible as early as 45 days after illness onset or diagnosis of the preceding infection (Abu-Raddad et al; Larson et al; Tillet et al).
4. An increasing number of published studies suggest that >90% of recovered COVID-19 patients develop anti-SARS-CoV-2 antibodies (Wajnberg cohort of 1343; Gudbjartsson et al; Deeks et al; Iyer et al). Additional studies also demonstrate antibody response, including after mild or asymptomatic infection, can be durable for 3 months or more (Wajnberg et al; Isho et al; Gudbjartsson et al). This evidence must be interpreted cautiously as anti-SARS-CoV-2 antibodies have not been definitively correlated with protection of humans from infection.
5. Some studies have also noted lower titers and faster waning of anti-SARS-CoV-2 antibodies in mild or asymptomatic cases of COVID-19 (Long et al; Seow et al; Ibrando et al). It is important to note that plasma antibodies are only one component of human immunity and that immunity may be achieved through other mechanisms such as virus-specific memory T cells (Cervia et al; Kaneko et al; Rodda et al; Sekine et al).
6. Animal challenge studies of SARS-CoV-2 (Deng et al; Chandrashekar et al) and an investigation of seropositive persons in a high transmission setting (Addetia et al) provide initial evidence of protection against re-infection after prior infection with SARS-CoV-2. These studies also provided limited evidence linking antibody presence to protection against re-infection.

Assessment

Despite millions of SARS-CoV-2 infections worldwide and in the United States, to date, surveillance and investigations have thus far demonstrated few confirmed cases of re-infection. Currently, it is unknown if recovered persons are definitively immune to SARS-CoV-2 re-infection because biologic markers of immunity have not been correlated with protection from infection in humans. However, available evidence suggests that most recovered individuals would have a degree of immunity for at least 3 months following initial diagnosis of COVID-19. If implemented with current safety measures to prevent SARS-CoV-2 transmission (i.e., wear masks, stay 6 feet away from others whenever possible, and wash hands regularly), the risks of potential SARS-CoV-2 transmission from recovered persons are at this time likely outweighed by the personal and societal benefits of avoiding unnecessary quarantine. However, there could be scenarios in which the risk of re-infection and potential transmission may be deemed high enough to warrant quarantine of the exposed individual who has recovered from confirmed SARS-CoV-2 infection in the past 3 months.

Recommendation

If a person has a new exposure to someone with suspected or confirmed COVID-19 and meets all of the following criteria:

1. Has recovered from laboratory-confirmed (PCR or antigen) SARS-CoV-2 infection and has already met criteria to end isolation
2. Is within the first 3 months following the onset of symptoms of their initial confirmed infection, or within the first 3 months of their first positive viral test if they were asymptomatic during initial infection
3. Has remained asymptomatic since the new exposure

then that person does not require quarantine or repeat testing for SARS-CoV-2 in the context of this new exposure.

If a person has a new exposure to a person with suspected or confirmed COVID-19 and meets the first two above criteria, but has or develops new symptoms consistent with COVID-19 within 14 days of the new exposure, consultation with a health care provider is recommended, and consultation with infectious disease or infection control experts may be necessary. If an alternative cause of the symptoms cannot be identified, retesting for SARS-CoV-2 infection may be warranted. In the absence of clinical evaluation to rule out SARS-CoV-2 reinfection, this person should be isolated for the duration recommended in the memo above – for most persons, this would be 10 days after symptom onset and resolution of fever for at least 24 hours, without the use of fever-reducing medications, and with improvement of other symptoms.

References

- Abu-Raddad LJ, Chemaitelly H, Ayoub HH, Kanaani ZA, Khal AA, Kuwari EA, et al. Assessment of the risk of SARS-CoV-2 reinfection in an intense re-exposure setting. medRxiv. 2020 Aug 26;2020.08.24.20179457.

- Addetia A, Crawford KHD, Dingens A, Zhu H, Roychoudhury P, Huang M-L, et al. Neutralizing antibodies correlate with protection from SARS-CoV-2 in humans during a fishery vessel outbreak with high attack rate. *Journal of Clinical Microbiology* [Internet]. 2020 Aug 21 [cited 2020 Sep 12]; Available from: <https://jcm.asm.org/content/early/2020/08/21/JCM.02107-20>
- Cervia C, Nilsson J, Zurbuchen Y, Valaperti A, Schreiner J, Wolfensberger A, et al. Systemic and mucosal antibody secretion specific to SARS-CoV-2 during mild versus severe COVID-19. *bioRxiv*. 2020 May 23;2020.05.21.108308.
- Chandrashekar A, Liu J, Martinot AJ, McMahan K, Mercado NB, Peter L, et al. SARS-CoV-2 infection protects against rechallenge in rhesus macaques. *Science*. 2020 Aug 14;369(6505):812–7.
- Deeks JJ, Dinnes J, Takwoingi Y, Davenport C, Spijker R, Taylor-Phillips S, et al. Antibody tests for identification of current and past infection with SARS-CoV-2. *Cochrane Database Syst Rev*. 2020 25;6:CD013652.
- Deng W, Bao L, Liu J, Xiao C, Liu J, Xue J, et al. Primary exposure to SARS-CoV-2 protects against reinfection in rhesus macaques. *Science*. 2020 Aug 14;369(6505):818–23.
- Gudbjartsson DF, Norddahl GL, Melsted P, Gunnarsdottir K, Holm H, Eythorsson E, et al. Humoral Immune Response to SARS-CoV-2 in Iceland. *New England Journal of Medicine*. 2020 Sep 1;0(0):null.
- Ibarondo FJ, Fulcher JA, Goodman-Meza D, Elliott J, Hofmann C, Hausner MA, et al. Rapid Decay of Anti-SARS-CoV-2 Antibodies in Persons with Mild Covid-19. *New England Journal of Medicine*. 2020 Sep 10;383(11):1085–7.
- Isho B, Abe KT, Zuo M, Jamal AJ, Rathod B, Wang JH, et al. Mucosal versus systemic antibody responses to SARS-CoV-2 antigens in COVID-19 patients. *medRxiv*. 2020 Aug 29;2020.08.01.20166553.
- Iyer AS, Jones FK, Nodoushani A, Kelly M, Becker M, Slater D, et al. Dynamics and significance of the antibody response to SARS-CoV-2 infection. *medRxiv* [Internet]. 2020 Jul 20 [cited 2020 Sep 12]; Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7386524/>
- Kaneko N, Kuo H-H, Boucau J, Farmer JR, Allard-Chamard H, Mahajan VS, et al. Loss of Bcl-6-Expressing T Follicular Helper Cells and Germinal Centers in COVID-19. *Cell* [Internet]. 2020 Aug 19 [cited 2020 Sep 12]; Available from: <http://www.sciencedirect.com/science/article/pii/S0092867420310679>
- Korea Centers for Disease Control and Prevention. Findings from Investigation and Analysis of re-positive cases. May 19, 2020. Available at: https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030&act=view&list_no=367267&nPage=1
- Larson D, Brodniak SL, Voegtly LJ, Cer RZ, Glang LA, Malagon FJ, et al. A Case of Early Re-infection with SARS-CoV-2. *Clin Infect Dis* [Internet]. [cited 2020 Sep 22]; Available from: <https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1436/5908892>
- Long Q-X, Tang X-J, Shi Q-L, Li Q, Deng H-J, Yuan J, et al. Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections. *Nat Med*. 2020;26(8):1200–4.
- Mumoli N, Vitale J, Mazzone A. Clinical immunity in discharged medical patients with COVID-19. *Int J Infect Dis*. 2020 Oct;99:229–30.

- Rodda LB, Netland J, Shehata L, Pruner KB, Morawski PM, Thouvenel C, et al. Functional SARS-CoV-2-specific immune memory persists after mild COVID-19. medRxiv. 2020 Aug 15;2020.08.11.20171843.
- Sekine T, Perez-Potti A, Rivera-Ballesteros O, Strålin K, Gorin J-B, Olsson A, et al. Robust T cell immunity in convalescent individuals with asymptomatic or mild COVID-19. Cell [Internet]. 2020 Aug 14 [cited 2020 Sep 12]; Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7427556/>
- Seow J, Graham C, Merrick B, Acors S, Steel KJA, Hemmings O, et al. Longitudinal evaluation and decline of antibody responses in SARS-CoV-2 infection. medRxiv. 2020 Jul 11;2020.07.09.20148429.
- Tillett R, Sevinsky J, Hartley P, Kerwin H, Crawford N, Gorzalski A, et al. Genomic Evidence for a Case of Reinfection with SARS-CoV-2 [Internet]. Rochester, NY: Social Science Research Network; 2020 Aug [cited 2020 Sep 12]. Report No.: ID 3680955. Available from: <https://papers.ssrn.com/abstract=3680955>
- To KK-W, Hung IF-N, Ip JD, Chu AW-H, Chan W-M, Tam AR, et al. COVID-19 re-infection by a phylogenetically distinct SARS-coronavirus-2 strain confirmed by whole genome sequencing. Clin Infect Dis [Internet]. [cited 2020 Sep 12]; Available from: <https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1275/5897019>
- Van Elslande J, Vermeersch P, Vandervoort K, Wawina-Bokalanga T, Vanmechelen B, Wollants E, et al. Symptomatic SARS-CoV-2 reinfection by a phylogenetically distinct strain. Clin Infect Dis [Internet]. [cited 2020 Sep 12]; Available from: <https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1330/5901661>
- Wajnberg A, Amanat F, Firpo A, Altman D, Bailey M, Mansour M, et al. SARS-CoV-2 infection induces robust, neutralizing antibody responses that are stable for at least three months. medRxiv. 2020 Jul 17;2020.07.14.20151126.
- Wajnberg A, Mansour M, Leven E, Bouvier NM, Patel G, Firpo A, et al. Humoral immune response and prolonged PCR positivity in a cohort of 1343 SARS-CoV 2 patients in the New York City region. medRxiv. 2020 May 5;2020.04.30.20085613.

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