An introduction to SARS-CoV-2

The emergence of a novel coronavirus in December 2019, now identified as SARS-CoV-2, has resulted in a global pandemic with an unprecedented public health response. This document provides an introduction to the basic virology and transmission of SARS-CoV-2 to inform the measures taken to mitigate the spread of the virus.

What is COVID-19?

Coronavirus disease (COVID-19) is an illness caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a recently discovered novel coronavirus. Coronaviruses are genetically distinct from viruses that cause influenza. They are enveloped, single-stranded RNA viruses whose surface is covered by a halo of protein spikes, or "corona." Other coronaviruses that have caused significant and lethal outbreaks in the past 20 years include SARS-CoV-1 and MERS-CoV that caused SARS and Middle East respiratory syndrome (MERS), respectively. Like the SARS-CoV-2 virus, these viruses are thought to originate in bats, but may have had an intermediate mammalian host prior to transfer to humans.

COVID-19 can result in symptoms of cough, fever, shortness of breath, tiredness, sore throat, body aches, chills, headache and in some cases result in lethal pneumonia. The elderly and those with pre-existing conditions including diabetes, heart disease or cancer are at the greatest risk of requiring hospitalization or dying from COVID-19. The case fatality rate for COVID-19 differs around the world and fluctuates as the outbreak progresses.[1] The case fatality rate for Canada as of April 21, 2020 was reported as 4.6%.[2]

The basic reproduction number for a contagious disease, or the R_0 value, estimated at the beginning of an outbreak, indicates the number of secondary cases that can be infected by a primary case in a population with no underlying immunity, vaccine or preventive measures. Where R_0 is greater than 1, the number of infected persons is likely to increase. For SARS-CoV-2 the preliminary World Health Organization estimate of R_0 was 1.4-2.5[3] with subsequent research estimating the mean R_0 at 3.28.[4] This suggests that every primary case at the beginning of the outbreak could potentially infect about three others; however, the R_0 is an average and can vary depending on the location and patterns of local transmission.[5] Estimates of R_0 can not easily account for secondary cases that are asymptomatic unless these cases have been detected in the population through widespread testing.[6]

How is the virus transmitted?

Respiratory droplets

The primary mode of human-to-human transmission of SARS-CoV-2 is via direct contact with an infected person and their respiratory droplets.[7] Respiratory droplets are generated by speaking, breathing, coughing and sneezing and exposure is greatest where there are opportunities for prolonged close contact with an infected person. Recommendations for respiratory hygiene to contain large droplets (e.g., covering one's mouth when coughing or sneezing) are intended to reduce the spread of large respiratory droplets (e.g., > 5 µm diameter). These large droplets are thought to travel less than 1 m before dropping to the ground, leading to the 2 m physical distancing practice that has been adopted for limiting the spread in the general public.[7-10] Smaller droplets or aerosols (< 5 µm diameter) produced by speaking,[11] singing or breathing could remain in the air longer than large droplets, and some preliminary evidence under experimental conditions suggests that SARS-CoV-2 may remain viable when airborne over short distances for several hours.[12,13] Dispersal patterns for droplets and aerosols, however, could be affected by environmental conditions (See *Sensitivity to SARS-CoV-2 to environmental factors* below). The relative importance of respiratory transmission via droplets and airborne aerosols requires further investigation and may have implications for public health recommendations for indoor versus outdoor environments.[12,14-16]

Contact with surfaces

Contact with contaminated surfaces (fomites) followed by touching of the eyes, mouth or nose is another recognized mode of SARS-CoV-2 transmission.[7] Fomites can become contaminated by deposition of droplets, aerosols, sputum or feces, either directly or by cross-contamination by touching an object with contaminated hands. The risk of transmission through contact can depend on the concentration of viable virus and its viability on a specific surface for a given time period *(see below for persistence on different surfaces)*. Hand hygiene and routine cleaning and disinfection of surfaces reduces the likelihood of contact transmission.[17] Washing with soap for 20 seconds followed by rinsing can help to emulsify the lipid layer of the virus, rendering it inviable and diffuse virus particles and making spread less likely.[5,18] Using hand sanitizers to inactivate the virus is an alternative to handwashing.[19] Chemical disinfectants can be used to inactivate the virus on surfaces. Both Health Canada[20] and the US EPA[21] have issued a list of disinfectants that are approved for use on hard surfaces against SARS-CoV-2. The Public Health Agency of Canada (PHAC) has also developed guidance on cleaning and disinfection of public spaces for SARS-CoV-2.[22]

Transmission via feces

There is some evidence that the SARS-CoV-2 virus is shed via feces,[23] and the virus has been detected in the toilets of COVID-19 patients.[14,15] Several studies have identified the presence of SARS-CoV-2 RNA in feces but only a few have identified infectious virus.[24] There is currently insufficient evidence to determine whether the fecal-oral pathway (e.g., passing in fecal particles from one person to the mouth, or fecal contamination of food) is significant in the current pandemic.

When is the virus transmitted?

The mean incubation period (time between exposure to the virus and the appearance of symptoms) has been estimated to be around five days,[25,26] with modelling indicating a range of about two to 11 days (2.5th and 97.5th percentiles).[27,28] An infected person can transmit the virus to others both before they show any symptoms (pre-symptomatic) and when they are symptomatic. Current evidence suggests that most transmission occurs during the symptomatic phase, but research is still needed to understand the relative importance of pre-symptomatic and asymptomatic transmission.[29]

Pre-symptomatic and asymptomatic transmission

Research on pre-symptomatic transmission is ongoing, with cases being reported in Washington State,[30] China[31] and Singapore.[32] It is not clear what level of infectious virus is shed during the pre-symptomatic phase, given that the main route of transmission (large respiratory droplets) is limited by the absence of coughing and sneezing.[30] He et al. (2020)[33] estimated that infected persons could be transmitting the virus 0.6-2.5 days before the onset of symptoms. Asymptomatic persons that are infected by the virus yet never show symptoms may also be a source of transmission, but the period of transmission is still being investigated. Current evidence suggests that asymptomatic transmission is more likely to occur following prolonged close contact, such as in family settings where there may be exposure during shared meals, talking, and contact with shared common objects and surfaces.[29,31,32,34]

Symptomatic transmission

Once a person becomes symptomatic, they could be transmitting the virus to others for days to several weeks after symptom onset.[28] The level of viral RNA has been measured to be highest soon after symptom onset and decreases about one week following the peak.[35] The pattern of viral shedding for SARS-CoV-2 has been found to be more similar to influenza as compared to SARS-CoV-1.[29,36]

Research is ongoing to help explain the relationship between viral dose (e.g., the level of exposure to the virus via respiratory droplets, or contact with fomites), the viral load (the quantity of viral particles per unit of bodily fluid in the infected person) and severity of disease.[37] The more viral RNA in the body, the more that can potentially be released by coughs, sneezes, breathing or talking; therefore transmission may be highest in the early stages of the disease, when the viral load has been found to be higher.[35,38]

Patients with a higher viral load appear to experience more severe symptoms and shed more virus over a longer time frame than mild cases.[39] Positive results for viral RNA do not always indicate that infectious virus is being shed but Wolfel et al. (2020)[40] found that viable virus could be isolated at the peak of viral shedding, about four days after symptom onset. Studies of viral load indicate that the amount of viable virus decreases over a much shorter period as compared to viral RNA, which can persist much longer but is not infectious.[28]

Sensitivity of SARS-CoV-2 to environmental factors

Research is ongoing to understand the persistence of SARS-CoV-2 on different surfaces and under various environmental conditions.

Temperature: Experiments have found that high temperatures are better for deactivating the SARS-CoV-2 virus. Experiments using viral suspension found minimal reduction over 14 days at 4°C, but detected no viable particles after four days at 22°C, within one day at 37° C, less than 30 minutes at 56°C and less than five minutes at 70°C.[41,42]

Humidity: Humidity can influence both persistence on surfaces and infectivity of the virus, by affecting spread and susceptibility of respiratory systems to viral infection.[43] There is preliminary evidence that persistence of the virus may decrease with increases in temperature and humidity and the virus may remain infectious under dried conditions.[41,43,44] Further research is needed to better characterise how humidity influences persistence and infectivity of SARS-CoV-2 in indoor and outdoor environments.

Light/Ultraviolet (UV) radiation: UV-radiation has been shown to reduce viral loads of SARS-CoV-1 in clinical and other controlled settings,[45,46] and natural sunlight has been suggested to be effective against influenza virus.[47,48] The effectiveness of sunlight and UV radiation for inactivation of SARS-CoV-2 has not been studied in detail but has been proposed as a decontamination method for personal protective equipment (PPE) contaminated by SARS-CoV-2. Initial results suggest that UV treatment may be more effective on smooth surfaces such as steel as compared to fabrics or porous materials.[49]

Persistence on surfaces

A limited number of studies have specifically examined the persistence of SARS-CoV-2 on common surfaces. A review by Kampf et al. (2020)[50] found that coronaviruses in general (MERS, SARS-CoV-1 and other human coronavirus variants) are detectable on wood, glass, metal and plastic for between four and nine days. A comparison of SARS-CoV-2 to SARS-CoV-1 across a range of surfaces by van Doremalen et al. (2020)[13] shows similar levels of persistence on most surfaces. Both strains were most persistent on stainless steel and plastic surfaces and least persistent on cardboard and copper, however SARS-CoV-2 remained viable for longer than SARS-CoV-1. Chin et al. (2020)[42] found that SARS-CoV-2 was more persistent on smooth, hard surfaces (stainless steel and plastic) than porous materials (wood, cloth, paper and tissue). This work noted a biphasic pattern of viral decay (half-life) on smooth surfaces.

SURFACE	persistence of SARS-CoV-2
Paper/	Paper and tissue: up to three hours**

Cardboard	Cardboard: up to 24 hours*
Stainless Steel	Up to four days (96 hours)** Up to three days (72 hours)* although viability significantly reduced at 48 hours
Copper	Up to four hours*
Plastics	Up to four days (96 hours)** Up to three days (72 hours)*
Wood	Up to two days**
Glass	Up to four days**
Cloth	Up to two days**

* van Doremalen et al. (2020)[13]: research conducted at 21-23 °C and 40% relative humidity over seven days
**Chin et al (2020)[42]: research conducted at 22°C and 65% humidity.

Discussion

This brief review of the properties of SARS-CoV-2 and how it is transmitted outlines some of the evidence that currently forms the basis of our evolving public health response to COVID-19. This information helps to inform measures such as handwashing, surface disinfection, social distancing and PPE. As new evidence and new interpretations evolve, this document will be updated.

Additional COVID-19 related resources to support environmental health can be found on our Environmental Health Resources for the COVID-19 Pandemic topic page.

References

1. Public Health Ontario. Review of "Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy". Toronto, ON: Queen's Printer for Ontario; 2020 Mar 25. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/research/research-jama-case-fatality-rate-characteristics-patients-dying-covid-19-italy.pdf?la=en.
2. Public Health Agency of Canada. COVID-19 Daily epidemiology update. Ottawa, ON: PHAC; 2020 Apr 21. Available from: https://www.canada.ca/content/dam/phac-aspc/documents/services/diseases/2019-novel-coronavirus-infection/surv-covid19-epi-update-eng.pdf.
3. World Health Organization. Statement on the meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). Geneva, Switzerland: WHO; 2020 Jan 23. Available from: https://www.who.int/news-room/detail/23-01-2020-statement-on-the-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).
4. Liu Y, Gayle AA, Wilder-Smith A, Rocklöv J. The reproductive number of COVID-19 is higher compared to SARS coronavirus. J Travel Med. 2020;27(2). Available from: https://doi.org/10.1093/jtm/taaa021.
5. Elias B, Bar-Yam Y. Could Air Filtration Reduce COVID-19 Severity and Spread? Cambridge, MA: New England Complex Systems Institute; 2020 Mar 9. Available from: https://necsi.edu/could-air-filtration-reduce-covid19-severity-and-spread.
6. Chisholm RH, Campbell PT, Wu Y, Tong SYC, McVernon J, Geard N. Implications of asymptomatic carriers for infectious disease transmission and control. Royal Society Open Science. 2020;5(2). Available from: https://doi.org/10.1098/rsos.172341.
7. World Health Organization. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. Scientific brief. Geneva, Switzerland: WHO; 2020 Mar 29. Available from: https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations.
8. Atkinson J, Chartier Y, Pessoa-Silva CL, Jensen P, Li Y, Seto WH, editors. Natural ventilation for infection control in health-care settings. Annex C. Respiratory droplets. Geneva, Switzerland: World Health Organization; 2009. Available from: https://www.ncbi.nlm.nih.gov/books/NBK143281/.
9. National Academies of Sciences Engineering and Medicine. Rapid expert consultation on social distancing for the COVID-19 pandemic. Washington, DC: The National Academies Press; 2020 Mar 19. Available from: https://www.nap.edu/read/25753/chapter/1.
10. Public Health Agency of Canada. Physical distancing (fact sheet). Ottawa, ON: PHAC; 2020 [updated 2020 Apr 9; cited 2020 Apr 11]; Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/social-distancing.html.
11. Anfinrud P, Bax CE, Stadnytskyi V, Bax A. Could SARS-CoV-2 be transmitted via speech droplets? medRxiv. 2020. Available from: http://medrxiv.org/content/early/2020/04/06/2020.04.02.20051177.abstract.

12. Fears AC, Klimstra WB, Duprex P, Hartman A, Weaver SC, Plante KS, et al. Comparative dynamic aerosol efficiencies of three emergent coronaviruses and the unusual persistence of SARS-CoV-2 in aerosol suspensions. medRxiv. 2020. Available from: http://medrxiv.org/content/early/2020/04/18/2020.04.13.20063784.abstract.
13. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as Compared with SARS-CoV-1. N Engl J Med. 2020. Available from: https://doi.org/10.1056/NEJMc2004973.
14. Ong SWX, Tan YK, Chia PY, Lee TH, Ng OT, Wong MSY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. JAMA. 2020 Mar 4. Available from: https://doi.org/10.1001/jama.2020.3227.
15. Santarpia JL, Rivera DN, Herrera V, Morwitzer MJ, Creager H, Santarpia GW, et al. Transmission potential of SARS-CoV-2 in viral shedding observed at the University of Nebraska Medical Center. medRxiv. 2020 Mar 23. Available from: http://medrxiv.org/content/early/2020/03/26/2020.03.23.20039446.1.abstract.
16. Bourouiba L. Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19. JAMA. 2020. Available from: https://doi.org/10.1001/jama.2020.4756.
17. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. MMWR Morb Mortal Wkly Rep. 2002 Oct 25(51(RR16)):1-44. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5116a1.htm.
18. US Centers for Disease Control. Handwashing: clean hands save lives. How to wash your hands. Atlanta, GA: US Department of Health and Human Services; 2020 [updated 2020 Mar 4]; Available from: https://www.cdc.gov/handwashing/show-me-the-science-handwashing.html.
19. US Centers for Disease Control. Handwashing: clean hands save lives. When & how to use hand sanitizer in community settings. Atlanta, GA: US Department of Health and Human Services; 2020 [updated 2020 Mar 3]; Available from: https://www.cdc.gov/handwashing/show-me-the-science-hand-sanitizer.html.
20. Health Canada. Hard surface disinfectants and hand sanitizers: list of hard-surface disinfectants for use against coronavirus (COVID-19). Ottawa, ON: Health Canada; 2020 [updated 2020 Mar 30]; Available from: https://www.canada.ca/en/health-canada/services/drugs-health-products/disinfectants/covid-19/list.html.
21. US Environmental Protection Agency. List N: disinfectants for use against SARS-CoV-2 | Pesticide registration. Washington, DC: US EPA; 2020 [updated 2020 Mar 26]; Available from: https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2.
22. Public Health Agency of Canada. Cleaning and disinfecting public spaces (COVID-19). Ottawa, ON: PHAC; 2020 [updated 2020 Mar 24]; Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/cleaning-disinfecting-public-spaces.html.
23. Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H. Evidence for gastrointestinal infection of SARS-CoV-2. Gastroenterol. 2020 Mar 29. Available from: https://doi.org/10.1053/j.gastro.2020.02.055.
24. Hindson J. COVID-19: faecal–oral transmission? Nature Reviews Gastroenterology & Hepatology. 2020 2020/03/25. Available from: https://doi.org/10.1038/s41575-020-0295-7.
25. Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. Ann Intern Med. 2020 Mar 10. Available from: https://pubmed.ncbi.nlm.nih.gov/32150748/.
26. Public Health Ontario. COVID-19 – what we know so far about… the incubation period Toronto, ON: PHO; 2020 Feb 3. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/what-we-know-feb-04-2020.pdf?la=en.
27. Backer JA, Klinkenberg D, Wallinga J. Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20–28 January 2020. Eurosurveillance. 2020;25(5). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.5.2000062.
28. Public Health Ontario. COVID-19 – what we know so far about… the period of communicability Toronto, ON: PHO; 2020 Mar 30. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/covid-wwksf/what-we-know-communicable-period-mar-27-2020.pdf?la=en.
29. Alberta Health Services. COVID-19 Scientific Advisory Group rapid response report. Key research question: What is the evidence supporting the possibility of asymptomatic transmission of SARS-CoV-2? Edmonton, AB: Government of Alberta; 2020 Apr 13. Available from: https://www.albertahealthservices.ca/assets/info/ppih/if-ppih-covid-19-rapid-response-asymptomatic-transmission.pdf.
30. Kimball A, Hatfield KM, Arons M, James A, Taylor J, Spicer K, et al. Asymptomatic and presymptomatic SARS-CoV-2 infections in residents of a long-term care skilled nursing facility — King County, Washington, March 2020. MMWR Morb Mortal Wkly Rep. 2020 Apr 3;69:377-81. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6913e1.htm?s_cid=mm6913e1_w.
31. Qian G, Yang N, Ma AHY, Wang L, Li G, Chen X, et al. COVID-19 transmission within a family cluster by presymptomatic carriers in China. Clin Infect Dis. 2020. Available from: https://doi.org/10.1093/cid/ciaa316.
32. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic transmission of SARS-CoV-2 - Singapore, January 23-March 16, 2020. MMWR Morb Mortal Wkly Rep. 2020 Apr 10;69(14):411-5. Available from: https://doi.org/10.15585/mmwr.mm6914e1.
33. He X, Lau EHY, Wu P, Deng X, Wang J, Hao X, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. Nat Med. 2020 Apr 15. Available from: https://www.nature.com/articles/s41591-020-0869-5.

34. Hu Z, Song C, Xu C, Jin G, Chen Y, Xu X, et al. Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China. Science China Life Sciences. 2020 May 1;63(5):706-11. Available from: https://doi.org/10.1007/s11427-020-1661-4.
35. To KK-W, Tsang OT-Y, Leung W-S, Tam AR, Wu T-C, Lung DC, et al. Temporal profiles of viral load in posterior oropharyngeal saliva samples and serum antibody responses during infection by SARS-CoV-2: an observational cohort study. Lancet Infect Dis. Available from: https://doi.org/10.1016/S1473-3099(20)30196-1.
36. 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(12):1177-9. Available from: https://www.nejm.org/doi/full/10.1056/NEJMc2001737.
37. Heneghan C, Brassey J, Jefferson T. SARS-CoV-2 viral load and the severity of COVID-19. Oxford, UK: University of Oxford, Centre for Evidence-Based Medicine, Nuffield Department of Primary Care Health Sciences; 2020 Mar 26. Available from: https://www.cebm.net/covid-19/sars-cov-2-viral-load-and-the-severity-of-covid-19/.
38. Pan Y, Zhang D, Yang P, Poon LLM, Wang Q. Viral load of SARS-CoV-2 in clinical samples. Lancet infect Dis. 2020;20(4):411-2. Available from: https://doi.org/10.1016/s1473-3099(20)30113-4.
39. Liu Y, Yan L-M, Wan L, Xiang T-X, Le A, Liu J-M, et al. Viral dynamics in mild and severe cases of COVID-19. Lancet Infect Dis. 2020 Mar 19. Available from: https://doi.org/10.1016/S1473-3099(20)30232-2.
40. Woelfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Mueller MA, et al. Clinical presentation and virological assessment of hospitalized cases of coronavirus disease 2019 in a travel-associated transmission cluster. medRxiv. 2020. Available from: https://www.medrxiv.org/content/medrxiv/early/2020/03/08/2020.03.05.20030502.full.pdf.
41. National Academies of Sciences Engineering Medicine. Rapid expert consultation on SARS-CoV-2 survival in relation to temperature and humidity and potential for seasonality for the COVID-19 pandemic (April 7, 2020). Washington, DC: The National Academies Press; 2020. Available from: https://www.nap.edu/catalog/25771/rapid-expert-consultation-on-sars-cov-2-survival-in-relation-to-temperature-and-humidity-and-potential-for-seasonality-for-the-covid-19-pandemic-april-7-2020.
42. Chin AWH, Chu JTS, Perera MRA, Hui KPY, Yen H-L, Chan MCW, et al. Stability of SARS-CoV-2 in different environmental conditions. Lancet Microbe. 2020 Apr 2. Available from: https://doi.org/10.1016/S2666-5247(20)30003-3.
43. Moriyama M, Hugentobler WJ, Iwasaki A. Seasonality of respiratory viral infections. Ann Rev Virol. 2020;7(1). Available from: https://www.annualreviews.org/doi/abs/10.1146/annurev-virology-012420-022445.
44. Rahman A, Hossain G, Singha AC, Islam S, Islam A. A retrospective analysis of influence of environmental/air temperature and relative humidity on SARS-CoV-2 outbreak. Preprints. 2020 Mar 20. Available from: https://www.preprints.org/manuscript/202003.0325/v1.
45. Duan SM, Zhao XS, Wen RF, Huang JJ, Pi GH, Zhang SX, et al. Stability of SARS coronavirus in human specimens and environment and its sensitivity to heating and UV irradiation. Biomed Environ Sci. 2003 Sep;16(3):246-55. Available from: https://www.ncbi.nlm.nih.gov/pubmed/14631830.
46. International Ultraviolet Association. IUVA Fact sheet on UV disinfection for COVID-19. Chevy Chase, MD: IUVA; 2020 Mar. Available from: http://www.iuva.org/COVID-19.
47. Schuit M, Gardner S, Wood S, Bower K, Williams G, Freeburger D, et al. The influence of simulated sunlight on the inactivation of influenza virus in aerosols. J Infect Dis. 2019;221(3):372-8. Available from: https://doi.org/10.1093/infdis/jiz582.
48. Ianevski A, Zusinaite E, Shtaida N, Kallio-Kokko H, Valkonen M, Kantele A, et al. Low temperature and low UV indexes correlated with peaks of influenza virus activity in Northern Europe during 2010-2018. Viruses. 2019;11(3):207. Available from: https://dx.doi.org/10.3390%2Fv11030207.
49. Fischer R, Morris DH, van Doremalen N, Sarchette S, Matson J, Bushmaker T, et al. Assessment of N95 respirator decontamination and re-use for SARS-CoV-2. medRxiv. 2020:Apr 11. Available from: http://medrxiv.org/content/early/2020/04/15/2020.04.11.20062018.abstract.
50. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. J Hosp Infect. 2020;104(3):246-51. Available from: https://doi.org/10.1016/j.jhin.2020.01.022.

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