National Collaborating Centre for Methods and Tools
Centre de collaboration nationale des méthodes et outils
School of Nursing
McMaster University

Rapid Review: What is known about how long the virus can survive with potential for infection on surfaces?

Prepared by: The National Collaborating Centre for Methods and Tools

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Executive Summary

Background

As businesses continue to reopen across the country, it is important to understand the role that indirect transmission via surfaces may play in community settings.

This rapid review was produced to support public health decision makers' response to the coronavirus disease 2019 (COVID-19) pandemic. This review seeks to identify, appraise, and summarize emerging research evidence to support evidence-informed decision making.

This rapid review includes evidence available up to July 27, 2020 to answer the question: **What is known about how long the virus can survive with potential for infection on surfaces?**

Key Points

- There is no conclusive evidence on the length of time SARS-CoV-2 can be detected on different surfaces, and the likelihood of infectivity when the virus is detected. Study quality is moderate, and findings are inconsistent.
- Findings from laboratory-based studies indicate SARS-CoV-2 can remain viable longer on smoother surfaces such as plastic or steel than cardboard or cotton. There is wide variation in the length of times reported and study quality was not assessed.

Overview of Evidence and Knowledge Gaps

- A number of real-world studies (not conducted in a laboratory) have identified positive surface samples from a variety of surfaces within hospital wards, isolation rooms, or outbreak settings (such as cruise ships or long-term care). The prevalence of positive samples ranged from 2% to 47%.
  - Variability across studies is related to the type or location of the sample tested (e.g., bed rails, door handles, bathroom, phones and computer equipment other items in a room), the time since a confirmed case was in the setting, the cleaning procedures used and the time since last cleaning.
- Few real-world studies have looked at virus infectivity; two have reported that identified samples were not infective, one reported that the sample may be infective, and one was inconclusive.
- A number of disinfecting procedures were reported, which consistently showed a decrease or elimination of positive RT-PCR samples; however, given the variability in cleaning procedures used, no best practice recommendation can be made based on the evidence.
- Within laboratory studies, the SARS-CoV-2 virus was detectable for up to 7 days on some surfaces. However, given the concentrations used, and testing procedures, the applicability of these findings to real world settings is unknown.

Methods

Research Question

What is known about how long the virus can survive with potential for infection on surfaces?

Search

On July 24 and 27, 2020, the following databases were searched:

- Pubmed's curated COVID-19 literature hub: LitCovid
- Trip Medical Database
- World Health Organization's Global literature on coronavirus disease
- COVID-19 Evidence Alerts from McMaster PLUS™
- Public Health +
- COVID-19 Living Overview of the Evidence (L·OVE)
- McMaster Health Forum
- Prospero Registry of Systematic Reviews
- NCCMT COVID-19 Rapid Evidence Reviews
- MedRxiv preprint server
- NCCEH Environmental Health Resources for the COVID-19 Pandemic
- NCCID Disease Debrief
- Institute national d'excellence en santé et en services sociaux (INESSS)
- Uncover (USHER Network for COVID-19 Evidence Reviews)
- Newfoundland & Labrador Centre for Applied Health Research
- Public Health Ontario

A copy of the search strategy is available on request.

Study Selection Criteria

The search results were first screened for recent guidelines and syntheses. Single studies were included if no syntheses were available, or if single studies were published after the search was conducted in the included syntheses. English-language, peer-reviewed sources and sources published ahead-of-print before peer review were included. Surveillance sources were excluded. English-language, peer-reviewed sources and sources published ahead-of-print before peer review were included. When available, findings from syntheses and clinical practice guidelines are presented first, as these take into account the available body of evidence and, therefore, can be applied broadly to populations and settings.

	Inclusion Criteria	Exclusion Criteria
Population	Inanimate surfaces	
Intervention	SARS-CoV-2 exposure	Exposure through close contact with an infected individual
Comparisons	-	
Outcomes	Detection of SARS-CoV-2 virus or RNA COVID-19 infection	

Data Extraction and Synthesis

Data relevant to the research question, such as study design, setting, location, population characteristics, interventions or exposure and outcomes were extracted when reported. We synthesized the results narratively due to the variation in methodology and outcomes for the included studies.

We evaluated the quality of included evidence using critical appraisal tools as indicated by the study design below. Quality assessment was completed by one reviewer and verified by a second reviewer. Conflicts were resolved through discussion. For some of the included evidence a suitable quality appraisal tool was not found, or the review team did not have the expertise to assess methodological quality. Studies for which quality appraisal has not been conducted are noted within the data tables.

Study Design	Critical Appraisal Tool
Synthesis	Assessing the Methodological Quality of Systematic Reviews (AMSTAR) AMSTAR 1 Tool
Case Report	Joanna Briggs Institute (JBI) Checklist for Case Reports
Prevalence	Joanna Briggs Institute (JBI) Checklist for Prevalence Studies

Completed quality assessments for each included study are available on request.

Findings

Quality of Evidence

This document includes three completed syntheses, two in-progress syntheses and 29 single studies for a total of 34 publications included in this review. The quality of the evidence included in this review is as follows:

		Total	Quality of Evidence
Syntheses	Completed	3	2 Low 1 Moderate
	In Progress	2	---
Single Studies	Completed	29	1 Low 13 Moderate 12 High 3 Not appraised

Warning

Given the need to make emerging COVID-19 evidence quickly available, many emerging studies have not been peer reviewed. As such, we advise caution when using and interpreting the evidence included in this rapid review. We have provided a summary of the quality of the evidence as low, moderate or high to support the process of decision making. Where possible, make decisions using the highest quality evidence available.

Important to this question, we did not assess the methodological quality of laboratory-based studies. Due to the technical nature of these studies, we highly recommend consulting a content-area expert to inform decision making.

Question: What is known about how long the virus can survive with potential for infection on surfaces?

Table 1: Syntheses

Reference	Date Released	Description of Included Studies	Summary of Findings	Quality Rating: Synthesis	Quality Rating: Included Studies
Usher Institute. (2020, May 27). *Summary: What is the evidence for outdoor transmission of SARS-CoV-2?*	May 27, 2020, search completed Apr 30, 2020	This review included: • 3 laboratory-based studies • Descriptive epidemiological studies (number not reported)	Laboratory-based studies suggest the virus may persist longer on smooth surfaces such as plastic and stainless steel and low temperature and wet environments. Real-world applicability is unknown. Epidemiological studies suggest there is potential for fecal-oral transmission through outdoor contaminated surfaces such as fences, gates, gas pumps, pedestrian crossing buttons. The likelihood of this is unknown.	Low	Very low
Fiorillo, L., Cervino, G., Matarese, M., D'Amico, C., Surace, G., Paduano, V., … Cicciù, M. (2020). COVID-19 Surface Persistence: A Recent Data Summary and Its Importance for Medical and Dental Settings. *International Journal of Environmental Research and Public Health*, *17*(9), 3132.	Apr 30, 2020 search date not reported	This review included 4 laboratory-based studies, only one focused on SARS-CoV-2 (also included above).	SARS-CoV-2 persisted longest on plastic and stainless steel. The virus was not detectable after 4h on copper and 24h on cardboard. These findings are consistent with other coronaviruses.	Moderate	Not reported

National Academies of Sciences, Engineering, and Medicine. (2020, March 27). *Rapid expert consultation update on SARS-CoV-2 surface stability and incubation for the covid-19 pandemic*.	Mar 27, 2020	This review included: • Experimental laboratory-based studies • Prevalence studies	Two lab-based studies were described, as well as preliminary results from in-progress studies via personal communication. SARS-CoV-2 showed greater stability on smooth surfaces (glass, banknote, stainless steel, plastic); no infectious virus was detected after 4-7 days. Also, infectious viral levels were detected on the outer layer of a surgical mask after 7 days. Across prevalence studies, there were variable rates of surface samples testing positive for SARS-CoV-2 primarily using reverse transcriptase-polymerase chain reaction (RT-PCR) for testing. Samples across studies were collected both prior to and after cleaning/ disinfection, from different sites (personal rooms, common areas) and across different settings (hospitals, cruise ship).	Low	Not reported

Table 2: In-progress Syntheses

Title	Anticipated Release Date	Setting	Description of Document
Nora, V.D., Azevedo, N. & Rosa, D. (2020). *Survival of SARS-CoV-2 on different surfaces of the dental office and the effective disinfection agents. PROSPERO, CRD42020188152.*	Aug 20, 2020	Dental office	This systematic review aims to explore the survival time of SARS-COV-2 on different surfaces in dental offices and determine decontamination agents and concentration levels for effective disinfection.
Deliga Schroder, A.G., Guariza Filho, O., Neto, J.S., Gonçalves, F.M., Bittencourt Basso, I… Nogueira Cortz Ravazzi, G.M. (2020). *Covid-19 survival time on inanimate surfaces: a systematic review. PROSPERO, CRD42020185643.*	Jun 30, 2020	Multiple	This systematic review aims to explore survival time of COVID-19 on different types of inanimate surfaces.

Table 3: Single Studies

Reference	Date Released	Study Design	Setting	Method of testing and timing	Summary of findings	Quality Rating:
Prevalence Studies						
Yamagishi, T., Ohnishi, M., Matsunaga, N., Kakimoto, K., Kamiya, H., Okamoto, K., … Wakita, T. (2020). Environmental sampling for severe acute respiratory syndrome coronavirus 2 during COVID-19 outbreak in the Diamond Princess cruise ship. *The Journal of Infectious Diseases*. Epub ahead of print.	Jul 21, 2020	Prevalence	Cruise ship Surface samples from vacant cabins of those with confirmed COVID-19 cases, cabins with no confirmed cases, and common areas.	Reverse transcription polymerase chain reaction (RT-PCR) used to detect presence of SARS-CoV-2 RNA. Samples collected 7-9 days after disinfection with 5% hydrogen peroxide.	No viable virus was detected in any of the samples. 58 of 601 (10%) samples tested positive from cabins with confirmed COVID-19 cases 1-17 days after the cabins were vacated, but not from non-case-cabins. The virus was most often detected on the bathroom floor near the toilet and bed pillows.	High
Nelson, A., Kassimatis, J., Estoque, J., Yang, C., McKee, G., Bryce, E., … Schwandt, M. (2020). Environmental detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from medical equipment in long-term care facilities undergoing COVID-19 outbreaks. *American Journal of Infection Control*. Epub ahead of print.	Jul 10, 2020	Prevalence	3 long-term care facilities with confirmed outbreaks Surface samples from high-touch surfaces, communal sites, and mobile medical equipment. Patient rooms and bathrooms were excluded. Canada	RT-PCR Cleaning protocols not reported.	6 of 89 (6.7%) samples tested positive. Positive samples were found on blood pressure cuffs (n = 4), handle of a linen cart, and electronic tablet touchscreen. Infectivity of the virus was inconclusive.	High
Hu, X., Xing, Y., Ni, W., Zhang, F., Lu, S., Wang, Z., … Jiang, F. (2020). Environmental contamination by SARS-CoV-2 of an imported case during incubation period. *Science of The Total Environment*, *742:* 140620.	Jul 9, 2020	Prevalence	Isolation room Samples from rooms with confirmed COVID-19 case. China	RT-PCR Samples collected within 4 hours after case confirmed and 24 hours after disinfection with sodium hypochlorite.	Prior to disinfection, 11 of 23 (47.8%) samples tested positive. After first disinfection, 2 of 23 (8.7%) samples tested positive. Upon third disinfection, all samples tested negative. Highest viral loads were found in the bathroom (toilet bowl and sewer inlet).	High

Li, Y.H., Fan, Y.Z., Jiang, L., & Wang, H.B. (2020). Aerosol and environmental surface monitoring for SARS-CoV-2 RNA in a designated hospital for severe COVID-19 patients. *Epidemiology and Infection*, *148*, e154.	Jul 8, 2020	Prevalence	Hospital Samples from 30 sites inside and outside isolation wards. China	RT-PCR Samples collected after routine twice daily cleaning of surfaces and floors with sodium dichloroisocyanurate.	2 of 90 (2.2%) samples tested positive. Positive samples were collected 7 days apart, originating from inside a COVID-19 patient's mask.	High
Zhou, J., Otter, J.A., Price, J.R., Cimpeanu, C., Garcia, D.M., Kinross, J., … Barclay, W.S. (2020). Investigating SARS-CoV-2 surface and air contamination in an acute healthcare setting during the peak of the COVID-19 pandemic in London. *Clinical Infectious Diseases*. Epub ahead of print.	Jul 8, 2020	Prevalence	Hospital Surface samples collected across inpatient and outpatient units, departments and hospital public areas. England	RT-PCR Viral culture All areas were disinfected daily with an additional twice daily disinfection of high touch surfaces using a combined chlorine-based detergent/disinfectant.	91 of 218 (41.7%) samples were suspected and 23 (10.6%) were positive. Positive samples were more frequently detected in areas occupied by COVID-19 patients. The highest positive rates were found on computer, keyboards, mouse, alcohol gel dispensers, and desk surfaces. Viral culturing detected no viable virus from the samples.	High
Marshall, D., Bois, F., Jensen, S. K. S., Linde, S. A., Higby, R., Remy-McCort, Y., … Sudradjat, F. (2020). Sentinel coronavirus environmental monitoring can contribute to detecting asymptomatic SARS-CoV-2 virus spreaders and can verify effectiveness of workplace COVID-19 controls. *Preprint*.	Jun 29, 2020	Prevalence	Workplace 9 office and mixed-used industrial locations Europe USA	RT-PCR Samples were collected near end of work shifts and prior to disinfection and cleaning.	Number or percent of positive samples not reported. Workplaces with positive samples were more likely to have employees with confirmed cases of COVID-19. Highest positive sample rates were found among door handles and shared furniture (break room chairs, workbenches).	Moderate

Razzini, K., Castrica, M., Menchetti, L., Maggi, L., Negroni, L., Orfeo, N. V., ... Balzaretti, C. M. (2020). SARS-CoV-2 RNA detection in the air and on surfaces in the COVID-19 ward of a hospital in Milan, Italy. *Science of The Total Environment*, *742:* 140540.	Jun 26, 2020	Prevalence	Hospital COVID-19 isolation ward Italy	RT-PCR Surfaces and objects were wiped down daily with active chlorine (5–10%) disinfectant. Samples collected prior to cleaning and disinfection.	9 of 37 (24.3%) samples tested positive for SARS-CoV-2. Highest positive rates were found in contaminated (patient and ICU corridor) and semi-contaminated (undressing room) areas compared to clean areas (lockers, dressing room). Positive samples were collected from bedrails, door handles, hand sanitizer dispenser and medical equipment.	High
Lei, H., Ye, F., Liu, X., Huang, Z., Ling, S., Jiang, Z., ... Zanin, M. (2020). SARS-CoV-2 environmental contamination associated with persistently infected COVID-19 patients. *Influenza and Other Respiratory Viruses*, Epub ahead of print.	Jun 24, 2020	Prevalence	Hospital ICU with severely ill COVID-19 patients Isolation ward with recovering COVID-19 patients testing positive for SARS-CoV-2 China	RT-PCR ICU: Floor cleaned twice daily, equipment and furniture cleaned once daily with chlorine-based disinfectant. Cleaning protocols of isolation ward not reported.	None of the 218 surface samples collected in the ICU tested positive despite having patients with high viral loads and prolonged COVID-19. In the isolation ward, samples testing positive for SARS-CoV-2 originated from facemasks, the floor and mobile phones.	High
Wei, L., Lin, J., Duan, X., Huang, W., Lu, X., Zhou, J., & Zong, Z. (2020). Asymptomatic COVID-19 patients can contaminate their surroundings: An environment sampling study. m*Sphere*, *5*(3), e00442-20.	Jun 24, 2020	Prevalence	Hospital Non-ICU isolation rooms Samples were collected on high touch surfaces in patient rooms. China	RT-PCR Cleaning and disinfection by nurses twice daily with chlorine solution. Samples collected within 4-7 hours after first daily cleaning.	Forty-four of 112 (39.3%) samples tested positive. Highest positive sample rates were found for bedrails, pillows, bedsheets, air exhaust outlets, and light switches. Mildly ill or asymptomatic COVID-19 patients have the potential to contaminate surrounding surfaces.	Moderate

Shin, K.S., Park, H.S., Lee, J., & Lee, J.K. (2020). Environmental surface testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) during prolonged isolation of an asymptomatic carrier. *Infection Control & Hospital Epidemiology*. Epub ahead of print.	Jun 16, 2020	Prevalence	Isolation room of patients who were asymptomatic with high viral load or mildly symptomatic (sore throat only). Korea	RT-PCR Room and bathroom cleaned weekly. No specific cleaning or disinfection protocols discussed. Samples collected 4 days after last cleaning.	None of the 12 surface samples collected in patients' room or bathroom tested positive. The tested surfaces consisted of primarily plastic, stainless steel, and ceramic. Further exploration is needed to investigate risk of transmission for asymptomatic COVID-19 patients via environmental contamination.	Moderate
Zhou, Y., Zeng, Y., & Chen, C. (2020). Presence of SARS-CoV-2 RNA in isolation ward environment 28 days after exposure. *International Journal of Infectious Diseases*, *97:* 258–259.	Jun 14, 2020	Prevalence	Hospital Isolation wards of COVID-19 patients China	RT-PCR Samples were collected prior to and after cleaning and disinfection using chlorine-containing disinfectants or tissues containing peroxyacetic acid and hydrogen peroxide. Electronics were wiped using 75% alcohol or sanitary wipes.	Upon discharge, no disinfection procedures were used. 28 days later, SARS-CoV-2 was detected on pagers and patient room drawers. Following cleaning and disinfection measures, samples tested negative for SARS-CoV-2.	Low
Cheng, V.C.C., Wong, S.C., Chan, V.W.M., So, S.Y.C., Chen, J.H.K., Yip, C.C.Y ... Yuen, K.Y. (2020). Air and environmental sampling for SARS-CoV-2 around hospitalized patients with coronavirus disease 2019 (COVID-19). *Infection Control & Hospital Epidemiology*. Epub ahead of print.	Jun 8, 2020	Prevalence	Hospital China	RT-PCR Daily environmental disinfection with sodium hypochlorite solution. Samples were collected before disinfection.	Nineteen of 377 (5%) samples tested positive. Highest positive sample rates were from patients' mobile phones, bed rails, and toilet door handles. High viral loads among COVID-19 patients were related to increased likelihood of environmental contamination.	Moderate

Ryu, B.H., Cho, Y., Cho, O.H., Hong, S.I., Kim, S., & Lee, S. (2020). Environmental contamination of SARS-CoV-2 during the COVID-19 outbreak in South Korea. *American Journal of Infection Control*, *48*(8), 875–879.	Jun 3, 2020	Prevalence	Hospital Samples collected inside and outside patient rooms. Korea	RT-PCR Standing cleaning conducted with hypochlorite solution. Room cleaning and disinfection was not performed daily.	Positive samples were more frequently found inside patient rooms than outside rooms (anteroom, corridor, nursing station). Severe contamination was observed in samples collected from severely ill patients compared to mild or asymptomatic cases. Positive surface samples originated from medical equipment, furniture, and pillows.	High
Santarpia, J.L., Rivera, D.N., Herrera, V., Morwitzer, M.J., Creager, H., Santarpia, G.W., … Lowe, J.J. (2020). Aerosol and surface transmission potential of SARS-CoV-2. *Preprint.*	Jun 3, 2020	Prevalence	Hospital and isolation rooms at a medical centre. United States	RT-PCR Viral culture test Surface samples collected from common room, personal items, and toilets.	Positive samples were collected from personal items (phones, remote controls), room surfaces (bedside tables, bed rails), medical equipment, and toilets regardless of the degree of symptoms or acuity of illness. Viral replication was observed after 3-8 days of cell culture, indicating potential viral infectivity in a subset of samples.	High
Döhla, M., Wilbring, G., Schulte, B., Kümmerer, B.M., Diegmann, C., Sib, E., … Schmithausen, R.M. (2020). SARS-CoV-2 in environmental samples of quarantined households. *Preprint.*	Jun 2, 2020	Prevalence	Households under quarantine with at least one confirmed COVID-19 case Germany	RT-PCR Viral culture test Surface samples collected from frequently shared objects (e.g., door handles, remote control).	4 of 119 (3.36%) samples tested positive. Positive samples were found on electronic devices, knobs/handles, and furniture. Viral culturing detected no viable virus from the samples.	Moderate

Wong, J.C.C., Hapuarachichi, H.C., Arivalan, S., Tien, W.P., Koo, C., Mailepessov, D., … Ng, L.C. (2020). Environmental contamination of SARS-CoV-2 in a non-healthcare setting revealed by sensitive nested RT-PCR. *Preprint*.	Jun 2, 2020	Prevalence	Sites in which persons with confirmed COVID-19 resided or visited Singapore	RT-PCR Samples collected before and after disinfection of high touch areas (rooms, toilets, elevators) 1-3 days after occupancy. Cleaning and disinfection conducted by professional cleaning companies using various agents.	Two of 428 (0.5%) samples tested positive originating from a bedside wall and bed handle prior to disinfection. Following disinfection and cleaning, repeated collected samples tested negative.	Moderate
Zhang, D., Yang, Y., Huang, X., Jiang, J., Li, M., Zhang, X., … Qu, J. (2020). SARS-CoV-2 spillover into hospital outdoor environments. *Preprint.*	May 19, 2020	Prevalence	Hospital China	RT-PCR Samples collected from outdoor hospital areas (wastewater, soil, roads and walls). Cleaning and disinfection not reported.	SARS-CoV-2 was detected in wastewater and soil samples in areas close to hospital departments which received COVID-19 patients. SARS-CoV-2 was not detected on road or wall surfaces which are regularly disinfected.	High
Jiang, F.C., Jiang, X.L., Wang, Z.G., Meng, Z.H., Shao, S.F., Anderson, B.D., & Ma, M.J. (2020). Detection of severe acute respiratory syndrome coronavirus 2 RNA on surfaces in quarantine rooms. *Emerging Infectious Diseases*. Epub ahead of print.	May 18, 2020	Prevalence	Hospital China	RT-PCR Samples collected 3 hours after patients identified positive for SARS-CoV-2 RNA.	8 of 22 (36%) samples tested positive. SARS-CoV-2 was detected in the surface samples of the pillow cover, duvet cover, and sheets.	Moderate

Bloise, I., Gómez-Arroyo, B., & García-Rodríguez, J. (2020). Detection of SARS-CoV-2 on high-touch surfaces in a clinical microbiology laboratory. *The Journal of Hospital Infection*. Epub ahead of print.	May 15, 2020	Prevalence	Clinical microbiology laboratory with high density of samples tested for COVID-19 Samples from high touch surfaces Spain	RT-PCR Cleaning and disinfection protocols not reported.	4 of 22 (18%) samples tested positive. Positive samples were found on commonly used objects, such as keyboards, telephones and computer mouse, representing potential sources of infection for laboratory personnel.	Moderate
Wu, S., Wang, Y., Jin, X., Tian, J., Liu, J., & Mao, Y. (2020). Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. *American Journal of Infection Control*, *48*(8), 910–914.	May 12, 2020	Prevalence	COVID-19 designated hospital Samples collected from high touch surfaces in morning prior to disinfection and cleaning. China	RT-PCR Cleaning protocols included twice daily surface cleaning and disinfection using a chlorine-based spray disinfectant, conducted by trained volunteers.	Thirty-six of 145 (24.8%) samples tested positive. Highest positive sample rates were from the surface of beepers, water machine buttons, elevator buttons, computer mouses, telephones, and keyboards.	Moderate
Abrahao, J.S., Pengo, L.S., Rezende, I.M., Rodrigues, R., Crispim, A.P.C., Moura, C., ... Drumond, B.P. (2020). Detection of SARS-CoV-2 RNA on public surfaces in a densely populated urban area of Brazil. *Preprint*.	May 8, 2020	Prevalence	Public places (near hospital and public transportation areas) in region with highest number of reported COVID-19 cases Brazil	RT-PCR No information on cleaning protocols of public surfaces.	Sixteen of 101 (16.8%) samples tested positive. Positive samples were found on metal and concrete surfaces at hospital bus stations (bench, ground), hospital sidewalks, bus terminals (handrails), and public square seating (table and benches).	High

Lee, S.E., Lee, D.Y., Lee, W.G., Kang, B., Jang, Y.S., Ryu, B., ... Lee, E. (2020). Detection of novel coronavirus on the surface of environmental materials contaminated by COVID-19 patients in the Republic of Korea. *Osong Public Health and Research Perspectives*, *11*(3), 128–132.	May 8, 2020	Prevalence	6 hospitals and 2 communal facilities (rehab centre and apartments) with COVID-19 outbreaks Korea	RT-PCR Samples collected from high touch surfaces (e.g., phones, bedrails, chairs, door handles). No information on cleaning protocols was included.	All 68 samples from hospitals tested negative. Samples were collected after disinfection and cleaning. 2 of 12 (16.7%) samples from communal facilities where disinfection and cleaning had not been conducted prior to collection tested positive. Both samples were from a door handle of a COVID-19 positive patient's room.	Moderate
Ye, G., Lin, H., Chen, S., Wang, S., Zeng, Z., Wang, W., ... Wang, X. (2020). Environmental contamination of SARS-CoV-2 in healthcare premises. *Journal of Infection*, *81*(2), e1–e5.	Apr 30, 2020	Prevalence	Hospital Three sets of samples were collected across major hospital function zones, hospital equipment and medical supplies, and healthcare workers' used personal protective equipment. China	RT-PCR No information on cleaning protocols was included.	85 of 626 (13.6%) samples tested positive. Highest positive rates were found in intensive care unit, obstetric isolation ward, and COVID-19 isolation ward. 60 of 431 (13.9%) samples from hospital objects tested positive. Highest positive sample rates were found among self-service printers, desktops/keyboards, and door handles. 25 of 195 (12.8%) samples from personal protective equipment tested positive. Highest rates were found for hand sanitizer dispensers and gloves.	Moderate

Ding, Z., Qian, H., Xu, B., Huang, Y., Miao, T., Yen, H.L, … Li, Y. (2020). Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital. *Preprint*.	Apr 7, 2020	Prevalence	4 occupied isolation rooms housing 10 COVID-19 patients and other non-isolation room areas (nursing station, corridor, storage or cleaner's rooms, change room) China	RT-PCR Samples collected on three separate days in the morning before cleaning. Cleaning protocols included twice daily cleaning of high touch surfaces cleaned with sodium dichloroisocyanurate solution over 1.5 hour.	7 of 107 (6.5%) samples tested positive; 4 tested positive and 3 weakly positive. 5 of 7 positive samples were from surfaces in patient bathrooms (toilet seat, toilet seat cover, door handle, exhaust grille, tap-lever). 2 of 7 positive samples originated from the inside door handles of patients' rooms.	High
Colaneri, M., Seminari, E., Novati, S., Asperges, E., Biscarini, S., Piralla, A., … Vecchia, M. (2020). Severe acute respiratory syndrome coronavirus 2 RNA contamination of inanimate surfaces and virus viability in a health care emergency unit. *Clinical Microbiology and Infection*, *26*(8), 1094.e1-1094.e5.	May 22, 2020	Prevalence	Infectious Disease Emergency Unit, where febrile patients with respiratory symptoms were evaluated Infectious disease sub-intensive care ward for advanced respiratory care Italy	RT-PCR Viral culture test Samples collected ~ 4 hours after cleaning. Ward surfaces cleaned twice daily with sodium hypochlorite; free chlorine (0.5%) after patient discharged.	2 of 26 (7.7%) of samples tested positive with low-levels of SARS-CoV-2 RNA. Both samples were collected on the external plastic surface of continuous positive airway pressure helmets. None of the 26 samples demonstrated viral infectivity. Study limitation includes that swabs were collected relatively close to the cleaning procedures.	Moderate

Ong, S.W.X., Tan, Y.K., Chia, P.Y., Lee, T.H., Ng, O.T., Wong, M.S.Y., & Marimuthu, K. (2020). Air, surface environmental, and personal protective equipment contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA*, *323*(16), 1610–1612.	Mar 4, 2020	Prevalence	Hospital Samples collected from 26 sites on 5 days over a 2-week period after routine cleaning in two patient rooms and before cleaning in one patient room. Samples also taken from personal protective equipment. Singapore	RT-PCR Viral culture test Twice-daily cleaning of high-touch areas and daily cleaning of floors with sodium dichloroisocyanurate.	After routine cleaning: • Patient A's room sampled on days 4 and 10 of symptomatic illness; all samples were negative. • Patient B's room sampled on symptomatic day 8 and asymptomatic day 11; all samples were negative Before routine cleaning: • 13 of 15 (87%) room sites, including air outlet fans were positive • 3 of 5 (60%) toilet sites (toilet bowl, sink, and door handle) were positive Anteroom and corridor samples were negative. Swabs taken from the air exhaust outlets tested positive (number not reported). One swab from personal protective equipment, from the surface of a shoe front, was positive (total number not reported).	Moderate
Laboratory Studies						
Pelisser, M., Thompson, J., Majra, D., Youhanna, S., Stebbing, J., & Davies, P. (2020). Sports balls as potential SARS-CoV-2 transmission vectors. *Public Health in Practice 1:* 100029.	Jul 10, 2020	Laboratory	Sports equipment with inactivated virus pipetted directly onto the surface in a lab UK	Testing protocol not reported.	Surfaces of sports balls were tested before and after disinfection, and after use on a grass field. All samples tested negative. The authors note a limitation to the study may have been the method used to transfer the virus to surfaces using polyester swabs which may not have been effective.	Not appraised

Pastorino, B., Touret, F., Gilles, M., de Lamballerie, X., & Charrel, R.N. (2020). Prolonged infectivity of SARS-CoV-2 in fomites. *Emerging Infectious Diseases*. Epub ahead of print.	Jun 24, 2020	Laboratory	SARS-CoV-2 deposited on polystyrene plastic, aluminum, and glass for 96 hours France	Viral culture test	SARS-CoV-2 demonstrated viral stability for 96 hours on all tested surfaces. Protein mediums increased SARS-CoV-2 infectivity, suggesting that protein-rich mediums such as airway secretions can protect the expelled virus, potentially enhancing persistence and transmission via contaminated surfaces.	Not appraised
Liu, Y., Li, T., Deng, Y., Liu, S., Zhang, D., Li, H., … Li, J. (2020). Stability of SARS-CoV-2 on environmental surfaces and in human excreta. *Preprint*.	May 12, 2020	Laboratory	Steel, plastic, glass, ceramics, paper, cotton, wood, latex gloves, surgical mask deposited and left for 7 days China	Viral culture test	The virus remained stable and viable for seven days on surfaces of plastic, stainless steel, glass, ceramics, wood, latex gloves and surgical mask. The virus did not remain infectious after 4 days on cotton clothes and after 5 days on paper. In both of these materials, rapid loss of virus infectivity was observed within 1 hour after incubation. Across most of the tested conditions, in the initial phase of viral decay, loss of infectivity was rapid, whereas in the terminal phase, viral infectivity decreased slowly.	Not appraised

References

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