The following information resources have been selected by the National Health Library and Knowledge Service Evidence Virtual Team in response to your question. The resources are listed in our estimated order of relevance to practicing healthcare professionals confronted with this scenario in an Irish context. In respect of the evolving global situation and rapidly changing evidence base, it is advised to use hyperlinked sources in this document to ensure that the information you are disseminating to the public or applying in clinical practice is the most current, valid and accurate. For further information on the methodology used in the compilation of this document—including a complete list of sources consulted—please see our National Health Library and Knowledge Service Summary of Evidence Protocol.

YOUR QUESTION

How long can the COVID-19 virus exist on surfaces? What role do contaminated surfaces play in the chain of transmission? What infection control precautions should be implemented?

IN A NUTSHELL

In most instances, coronaviruses are believed to be transmitted through large respiratory droplets from person to person, through inhalation or deposition on mucosal surfaces. Other routes implicated in transmission of coronaviruses include contact with contaminated fomites—ie surfaces or objects which may transmit a disease to a new host—and inhalation of aerosols produced during aerosol generating procedures[4]. According to the Centers for Disease Control (CDC) transmission occurs much more commonly through respiratory droplets than through fomites[8, 9]. They caution that whilst exposure to contaminated surfaces is not thought to be the main way the virus spreads, there is still much to learn about modes of transmission[9].

The viruses and bacteria that cause acute respiratory infections (ARIs) can survive in the environment for variable periods of time: hours to days[2]. Kampf et al reveal that human coronaviruses such as Severe Acute Respiratory Syndrome (SARS) coronavirus, Middle East Respiratory Syndrome (MERS) coronavirus or endemic human coronaviruses (HCoV) can persist on inanimate surfaces such as metal, glass or plastic for up to 9 days[12]. Research reported by Van Doremalen et al showed that SARS-CoV-2 was more stable on plastic and stainless steel than on copper and cardboard, and that viable virus was detected up to 72 hours after application to these surfaces although the virus titer was greatly reduced[15]. The same study indicates that aerosol and fomite transmission of SARS-CoV-2 is plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days[15]. Ren's study adds that the persistence time on inanimate surfaces varied from minutes to up to one month, depending on environmental conditions, and that SARS-CoV-2 can be sustained in air in closed unventilated buses for at least 30 minutes without losing infectivity[20].

It is worth noting that in a Q and A interview, Carolyn Machamer, Professor of Cell Biology, whose lab at the Johns Hopkins School of Medicine has studied the basic biology of coronaviruses for years, states: "What's getting a lot of press and is presented out of context is that the virus can last on plastic for 72 hours—which sounds really scary. But what's more important is the amount of the virus that remains. It's less than 0.1% of the starting virus material. Infection is theoretically possible but unlikely at the levels remaining after a few days. People need to know this[37]."
Furthermore, William Keevil, Professor of Environmental Healthcare at the University of Southampton, states that there is a danger of drawing too many conclusions about the likely progression of the virus on a surface when there are so many different and in some cases unique variables between the materials[38]. Virus particles in the air and on fomites are exposed to a range of environmental conditions that influence their persistence. Relative humidity, fomite material and air temperature can greatly impact enveloped virus inactivation rates[36]. The importance of indirect contact transmission involving contamination of inanimate surfaces is uncertain and warrants further study.

To reduce the risk of infection through fomites, it is essential to establish procedures for the correct disinfection of environments that could have been contaminated with SARS-CoV-2[5]. An effective surface disinfection may help to ensure an early containment and prevention of further viral spread[14]. The CDC recommend cleaning and disinfection of high-touch surfaces daily in household common areas: eg tables, hard-backed chairs, doorknobs, light switches, remotes, handles, desks, toilets, sinks[8].

Lastly, exposure to natural sunlight, the use of antimicrobial copper surfaces, the application of a modified antimicrobial coating on surfaces and sensor taps and no door handles may be effective supplements to standard hygiene practices and present additional opportunities for controlling the transmission of COVID-19 from contaminated fomites[17, 19, 32, 40].

IRISH AND INTERNATIONAL GUIDANCE

What does the Health Protection Surveillance Centre (Ireland) say?

Health Protection Surveillance Centre (June 2020) Interim Public Health, Infection Prevention and Control Guidelines on the Prevention and Management of COVID-19 Cases and Outbreaks in Residential Care Facilities[1]

In general, COVID-19 is spread by respiratory droplets — transmission may be direct, through contact with the respiratory secretions of someone with COVID-19; or indirect, through contact with a contaminated surface/object. Less commonly, airborne spread may occur for example during aerosol generating procedures.

What does the World Health Organization say?

World Health Organization (2020) Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care[2]

The viruses and bacteria that cause acute respiratory infections can survive in the environment for variable periods of time: hours to days. The bioburden of such microorganisms can be reduced by cleaning, and infectious agents can be inactivated by the use of standard hospital disinfectants. Environmental cleaning and disinfection is intended to remove pathogens or significantly reduce their numbers on contaminated surfaces and items, thus breaking the chain of transmission. Disinfection is a physical or chemical means of killing microorganisms [but not spores] and should be used for non-critical medical equipment used or shared by patients.

World Health Organization (2020) Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)[3]

Transmission in closed settings: there have been reports of COVID-19 transmission in prisons [Hubei, Shandong, and Zhejiang, China], hospitals and in a long-term living facility. The close proximity and contact among people in these settings and the potential for environmental contamination are important factors, which could amplify transmission. Transmission in these settings warrants further study.

What does the European Centre for Disease Prevention and Control say?

European Centre for Disease Prevention and Control (2020) ECDC Technical Report: Infection prevention and control for COVID-19 in healthcare settings[4]

In most instances, coronaviruses are believed to be transmitted through large respiratory droplets from person to person, through inhalation or deposition on mucosal surfaces. Other routes implicated in transmission of coronaviruses include contact with contaminated fomites and inhalation of aerosols produced during aerosol generating procedures. Regular cleaning followed by disinfection is recommended, using hospital disinfectants active against viruses; cleaning in patient rooms is particularly important for frequently touched surfaces.

European Centre for Disease Prevention and Control (2020) Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2[5]

Contact with contaminated fomites due to persistence of the virus on surfaces is another route implicated in the transmission of SARS-CoV-2 virus. Faecal-oral and airborne modes have also been considered, but their role in the transmission of SARS-CoV-2 is currently unknown. In order to reduce the risk of infection through fomites, it is essential to establish procedures for the correct disinfection of environments that could have been contaminated with SARS-CoV-2.

European Centre for Disease Prevention and Control (2020) Interim guidance for environmental cleaning in non-healthcare facilities exposed to SARS-CoV-2[6]

This document aims to provide guidance about the environmental cleaning in non-healthcare facilities such as rooms, public offices, transports, schools, etc., where confirmed COVID-19 cases have been before being admitted to hospital. This guidance is based on the current knowledge about SARS-CoV-2 and evidence originating from studies on other coronaviruses.

What do the Centers for Disease Control and Prevention (United States) say?

Centers for Disease Control and Prevention (2020) Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings[7]

Routine cleaning and disinfection procedures—eg using cleaners and water to pre-clean surfaces prior to applying an EPA-registered, hospital-grade disinfectant to frequently touched surfaces or objects for appropriate contact times as indicated—are appropriate for SARS-CoV-2 in healthcare settings, including those patient care areas in which aerosol-generating procedures are performed. In general, only essential personnel should enter the room of patients with COVID-19. Healthcare facilities should consider assigning daily cleaning and disinfection of high-touch surfaces to nursing personnel who will already be in the room providing care to the patient.

Centers for Disease Control and Prevention (2020) Interim Recommendations for US Households with Suspected/Confirmed Coronavirus Disease 2019[8]

Based on what is currently known about the novel coronavirus and similar coronaviruses that cause SARS and MERS, spread from person-to-person with these viruses happens most frequently among close contacts within about 6 feet. This type of transmission occurs via respiratory droplets. On the other hand, transmission of novel coronavirus to persons from surfaces contaminated with the virus has not been documented. Transmission of coronavirus occurs much more commonly through respiratory droplets than through fomites. Current evidence suggests that novel coronavirus may remain viable for hours to days on surfaces made from a variety of materials. Cleaning of visibly dirty surfaces followed by disinfection is a best practice measure for prevention of COVID-19 and other viral respiratory illnesses in households and community settings.
Clean and disinfect high-touch surfaces daily in household common areas: eg tables, hard-backed chairs, doorknobs, light switches, remotes, handles, desks, toilets, sinks.

Centers for Disease Control and Prevention (2020) How COVID-19 Spreads[9]

It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes. This is not thought to be the main way the virus spreads, but we are still learning more about how this virus spreads.

Centers for Disease Control and Prevention (2020) Cleaning and Disinfecting Your Facility: Everyday Steps, Steps When Someone is Sick, and Considerations for Employers[10]
Includes information on how to clean various everyday objects and materials and other practical considerations for the workplace.

POINT-OF-CARE TOOLS

What does UpToDate say?

Coronavirus Disease 2019 (COVID-19)[11]
Person-to-person spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is thought to occur mainly via respiratory droplets, resembling the spread of influenza. With droplet transmission, virus released in the respiratory secretions when a person with infection coughs, sneezes, or talks can infect another person if it makes direct contact with the mucous membranes; infection can also occur if a person touches an infected surface and then touches his or her eyes, nose, or mouth.

INTERNATIONAL LITERATURE

What does the international literature say?

KAMPF et al (Mar 2020) Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents[12]
A review of the literature on all available information about the persistence of human and veterinary coronaviruses on inanimate surfaces as well as inactivation strategies with biocidal agents used for chemical disinfection: eg in healthcare facilities. The analysis of 22 studies reveals that human coronaviruses such as Severe Acute Respiratory Syndrome (SARS) coronavirus, Middle East Respiratory Syndrome (MERS) coronavirus or endemic human coronaviruses (HCoV) can persist on inanimate surfaces such as metal, glass or plastic for up to 9 days, but can be efficiently

inactivated by surface disinfection procedures with 62%-71% ethanol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite within 1 minute. Other biocidal agents such as 0.05%-0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate are less effective.

KAMPF et al (June 2020) Corrigendum to "Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents"[13]

KAMPF (June 2020) Potential role of inanimate surfaces for the spread of coronaviruses and their inactivation with disinfectant agents[14]
Human and veterinary coronaviruses can persist on inanimate surfaces such as metal, glass or plastic for up to 9 days. Some disinfectant agents effectively reduce coronavirus infectivity within 1 minute. An effective surface disinfection may help to ensure an early containment and prevention of further viral spread.

VAN DOREMALEN et al (March 2020) [Letter to the editor] Aerosol and Surface Stability of SARS-CoV-2 as compared with SARS-CoV-1[15]
SARS-CoV-2 was more stable on plastic and stainless steel than on copper and cardboard, and viable virus was detected up to 72 hours after application to these surfaces, although the virus titer was greatly reduced from 103.7 to 100.6 TCID50 per milliliter of medium after 72 hours on plastic and from 103.7 to 100.6 TCID50 per milliliter after 48 hours on stainless steel. Our results indicate that aerosol and fomite transmission of SARS-CoV-2 is plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days depending on the inoculum shed.

CHIN et al (May 2020) [Correspondence] Stability of SARS-CoV-2 in different environmental conditions[16]
We first measured the stability of SARS-CoV-2 at different temperatures. The virus is highly stable at 4°C, but sensitive to heat. No infectious virus could be recovered from printing and tissue papers after a 3-hour incubation, whereas no infectious virus could be detected from treated wood and cloth on day 2. By contrast, SARS-CoV-2 was more stable on smooth surfaces. No infectious virus could be detected from treated smooth surfaces on day 4 [glass and banknote] or day 7 [stainless steel and plastic]. Strikingly, a detectable level of infectious virus could still be present on the outer layer of a surgical mask on day 7. Overall, SARS-CoV-2 can be highly stable in a

favourable environment, but it is also susceptible to standard disinfection methods.

RATNESAR-SHUMATE et al (July 2020) Simulated sunlight rapidly inactivates SARS-CoV-2 on surfaces[17]

In the present study, simulated sunlight rapidly inactivated SARS-CoV-2 suspended in either simulated saliva or culture media and dried on stainless steel coupons. Ninety percent of infectious virus was inactivated every 6.8 minutes in simulated saliva and every 14.3 minutes in culture media when exposed to simulated sunlight representative of the summer solstice at 40°N latitude at sea level on a clear day. Significant inactivation also occurred, albeit at a slower rate, under lower simulated sunlight levels. The present study provides the first evidence that sunlight may rapidly inactivate SARS-CoV-2 on surfaces, suggesting that persistence, and subsequently exposure risk, may vary significantly between indoor and outdoor environments. Additionally, these data indicate that natural sunlight may be effective as a disinfectant for contaminated nonporous materials.

YE et al (March 2020) Environmental contamination of the SARS-CoV-2 in healthcare premises: An urgent call for protection for healthcare workers[18]

626 surface samples were collected within the Zhongnan Medical Center in Wuhan, China in the midst of the COVID-19 outbreak between February 7 - February 27, 2020.

The most contaminated objects were self-service printers (20.0%), desktop/keyboard (16.8%), and doorknob (16.0%). Both hand sanitizer dispensers (20.3%) and gloves (15.4%) were most contaminated PPE. These findings emphasize the urgent need to ensure adequate environmental cleaning, strengthen infection prevention training, and improve infection prevention precautions among HCWs during the outbreak of COVID-19.

ECRI (March 2020) Antimicrobial Copper Surfaces for Reducing Healthcare-associated Infection Risk[19]

Antimicrobial copper surfaces—eg countertops, door handles, light switches, bedrails—used in healthcare settings are made from copper alloys or composite materials infused with copper oxides, both of which release copper ions that are toxic to microorganisms. Antimicrobial copper surfaces are intended to supplement standard hygiene practices to reduce healthcare-associated infection (HAI) risks. Antimicrobial copper surfaces may provide sustained antimicrobial effects independent of human activity and pose minimal toxicity risks but cost more than standard surfaces.

REN et al (April 2020) Stability and infectivity of coronaviruses in inanimate environments[20]

Most viruses from the respiratory tract, such as coronaviruses, influenza, SARS-CoV, or rhinovirus, can persist on surfaces for a few days. Persistence time on inanimate surfaces varied from minutes to up to one month, depending on the environmental conditions. SARS-CoV-2 can be sustained in air in closed unventilated buses for at least 30 min without losing infectivity. The most common coronaviruses may well survive or persist on surfaces for up to one month. Viruses in respiratory or faecal specimens can maintain infectivity for quite a long time at room temperature. Absorbent materials like cotton are safer than unabsorbent materials for protection from virus infection. The risk of transmission via touching contaminated paper is low. Preventive strategies such as washing hands and wearing masks are critical to the control of COVID-19.

BLOISE et al (May 2020) [Epub ahead of print] Detection of SARS-CoV-2 on high-touch surfaces in a clinical microbiology laboratory[21]

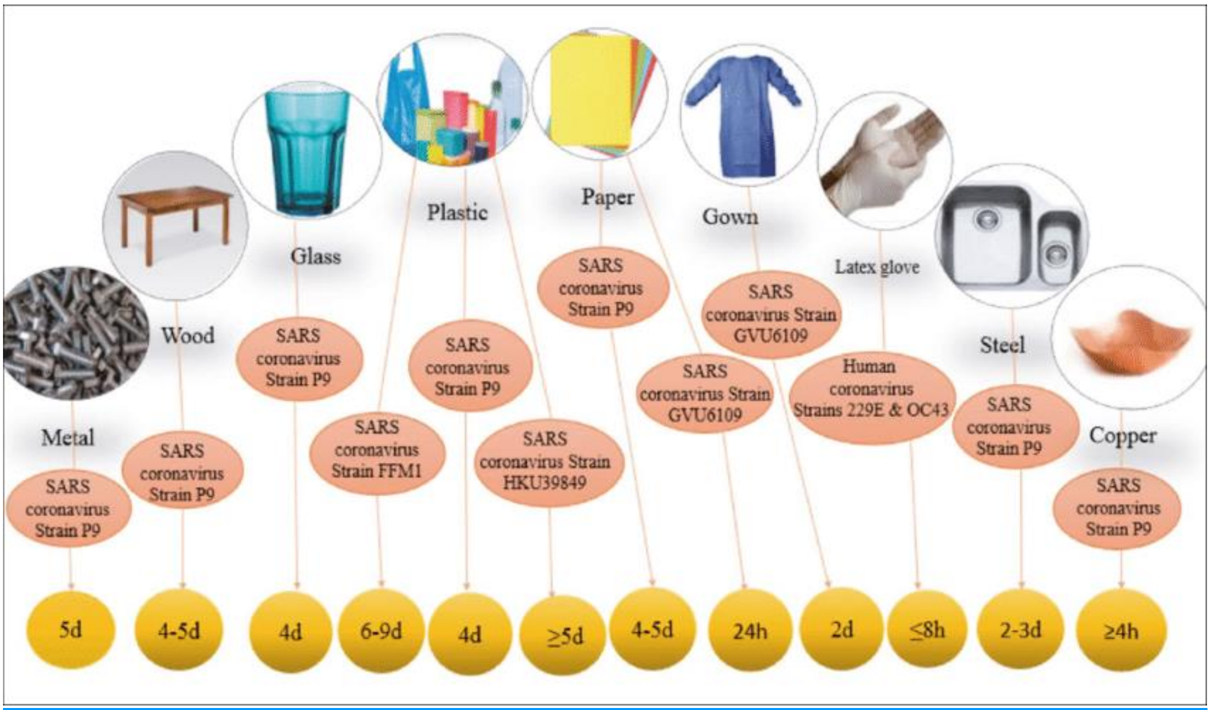
Our aim was to evaluate the presence of viral RNA in fomites in our microbiology laboratory, particularly in the area used for SARS-CoV-2 diagnosis during this pandemic outbreak.
Our data confirm the presence of SARS-CoV-2 on fomites and suggest that environmental contamination might play a role in its transmission among HCWs. In this study, samples were obtained from working areas that are not accessed by patients, but where a high density of respiratory samples were tested for diagnosis of COVID-19. Despite this, the environmental control sample was negative. Samples obtained from personal objects were negative, suggesting that measures in place to avoid transmission [minimum safety distance, handwashing and surface decontamination] are effective. We detected viral RNA on the surfaces of commonly used objects, such as keyboards, telephones and scanners, and they could represent sources of infection for laboratory personnel. These findings highlight the need for frequent disinfection of shared objects for the safety of all HCWs.

JONES, Cameron L (April 2020) Environmental surface contamination with SARS Cov2 – a short review[22]

The main takeaway message is that high-touch surfaces, toilets and often overlooked objects and surfaces are virus reservoirs and that transmission almost always occurs indoors. The use of reverse transcriptase polymerase chain reaction surveillance (RT-PCR, qPCR) in combination with careful or improved hand hygiene practice and regular surface disinfection cleaning can reduce the environmental viral burden and should not be overlooked or given preference over social distancing interventions.

FATHIZADEH et al (June 2020) Protection and Disinfection Policies Against SARS-CoV-2 (COVID-19)[23]

The authors collect information on virus stability in the air and on surfaces and discuss ways of preventing its transmission.



Persistence of SARS-COV-2 on surfaces

LIU et al (April 2020) Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals[24]

Here we investigated the aerodynamic nature of SARS-CoV-2 by measuring viral RNA in aerosols in different areas of two Wuhan hospitals during the outbreak of COVID-19 in February and March 2020. The concentration of SARS-CoV-2 RNA in aerosols that was detected in isolation wards and ventilated patient rooms was very low, but it was higher in the toilet areas used by the patients. Levels of airborne SARS-CoV-2 RNA in the most public areas was undetectable, except in two areas that were prone to crowding; this increase was possibly due to individuals infected with SARS-CoV-2 in the crowd. We found that some medical staff areas initially had high concentrations of viral RNA with aerosol size distributions that showed peaks in the submicrometre and/or supermicrometre regions; however, these levels were reduced to undetectable levels after implementation of rigorous sanitization procedures. Although we have not established the infectivity of the virus detected in these hospital areas, we propose that SARS-CoV-2 may have the potential to be transmitted through aerosols. Our results indicate that room ventilation, open space, sanitization of protective apparel and proper use and disinfection of toilet areas can effectively limit the concentration of SARS-CoV-2 RNA in aerosols. Future work should explore the infectivity of aerosolized virus.

LIU et al (May 2020) Stability of SARS-CoV-2 on environmental surfaces and in human excreta[25]

At room temperature, SARS-CoV-2 was stable on environmental surfaces and remained viable up to 7 days on smooth surfaces. This virus could survive for several hours in faeces and 3-4 days in urine.

ONG, Sean et al (March 2020) Air, surface environmental and personal protective equipment contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) from a symptomatic patient[26]

This study documents results of SARS-CoV-2 polymerase chain reaction (PCR) testing of environmental surfaces and personal protective equipment surrounding 3 COVID-19 patients in isolation rooms in a Singapore hospital. There was extensive environmental contamination by one SARS-CoV-2 patient with mild upper respiratory tract involvement. Toilet bowl and sink samples were positive, suggesting that viral shedding in stools could be a potential route of transmission. Post cleaning samples were negative, suggesting that current decontamination measures are sufficient.
Air samples were negative despite the extent of environmental contamination. Swabs taken from the air exhaust outlets tested positive, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents. The positive PPE sample was unsurprising because shoe covers are not part of PPE recommendations. The

risk of transmission from contaminated footwear is likely low as evidenced by negative results in the anteroom and clean corridor.
This study has several limitations. First, viral culture was not done to demonstrate viability. Second, due to operational limitations during an outbreak, methodology was inconsistent and sample size was small. Third, the volume of air sampled represents only a small fraction of total volume, and air exchanges in the room would have diluted the presence of SARS-CoV-2 in the air. Further studies are required to confirm these preliminary results.
Significant environmental contamination by patients with SARS-CoV-2 through respiratory droplets and faecal shedding suggests the environment as a potential medium of transmission and supports the need for strict adherence to environmental and hand hygiene.

ONG, Sean et al (March 2020) Absence of contamination of personal protective equipment (PPE) by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)[27]
The authors acknowledge their study had several limitations however it is noteworthy that despite the potential for extensive environmental contamination by SARS-CoV-2 they did not find similar contamination of PPE after patient contact.

XING et al (March 2020) Prolonged Viral Shedding in Feces of Pediatric Patients with Coronavirus Disease 2019[28]
Clearance of SARS-CoV-2 in the respiratory tract occurred within two weeks after abatement of fever, whereas viral RNA remained detectable in stools of paediatric patients for longer than 4 weeks. SARS-CoV-2 may exist in children's gastrointestinal tract for a longer time than the respiratory system. Persistent shedding of SARS-CoV-2 in stools of infected children raises the possibility that the virus might be transmitted through contaminated fomites. Massive efforts should be made at all levels to prevent spreading of the infection among children after reopening of kindergartens and schools.

IDE et al (Jan 2019) What's on your keyboard? A systematic review of the contamination of peripheral computer devices in healthcare settings[29]
To determine the extent and type of microbial contamination of computer peripheral devices used in healthcare settings, evaluate the effectiveness of

interventions to reduce contamination of these devices and establish the risk of patient and healthcare worker infection from contaminated devices. Computer keyboards and peripheral devices are frequently contaminated; however, our findings do not allow us to draw firm conclusions about their relative impact on the transmission of pathogens or nosocomial infection. Additional studies measuring the incidence of healthcare-acquired infections from computer hardware, the relative risk they pose to healthcare and evidence for effective and practical cleaning methods are needed.

OTTER et al (2016) Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination[30]

SARS-CoV, MERS-CoV and influenza virus can survive on surfaces for extended periods, sometimes up to months.
Factors influencing the survival of these viruses on surfaces include:

- Strain variation
- Titre
- Surface type
- Suspending medium
- Temperature and mode of deposition
- Relative Humidity
- The method used to determine the viability of the virus

Environmental sampling has identified contamination in field-settings with SARS-CoV and influenza virus, although the frequent use of molecular detection methods may not necessarily represent the presence of viable virus. The importance of indirect contact transmission involving contamination of inanimate surfaces is uncertain compared with other transmission routes, principally direct contact transmission independent of surface contamination, droplet, and airborne routes. However, influenza virus and SARS-CoV may be shed into the environment and be transferred from environmental surfaces to hands of patients and healthcare providers. Emerging data suggest that MERS-CoV also shares these properties. Once contaminated from the environment, hands can then initiate self-inoculation of mucous membranes of the nose, eyes or mouth. Mathematical and animal models and intervention studies suggest that contact transmission is the most important route in some scenarios. Infection prevention and control implications include the need for hand hygiene and personal protective equipment to minimize self-contamination and to protect against inoculation of mucosal surfaces and the respiratory tract and enhanced surface cleaning and disinfection in healthcare settings.

KRAMER et al (2006) How long do nosocomial pathogens persist on inanimate surfaces? A systematic review[31]

The most relevant nosocomial pathogens can persist on dry inanimate surfaces for months. In addition to the duration of persistence, some studies have also identified factors influencing persistence. A low temperature, such as 4°C or 6°C, was associated with longer persistence for most bacteria, fungi and viruses. High humidity > 70% was also associated with longer persistence for most bacteria, fungi, and viruses, although for some viruses conflicting results were reported. A few studies also suggest that a higher inoculum is associated with longer persistence. The type of surface material and the type of suspension medium, however, reveal inconsistent data. Overall, a high inoculum of the nosocomial pathogen in a cold room with high relative humidity will have the best chance for long persistence.
In hospitals, surfaces with hand contact are often contaminated with nosocomial pathogens and may serve as vectors for cross transmission. A single hand contact with a contaminated surface results in a variable degree of pathogen transfer. Contaminated hands can transfer viruses to 5 more surfaces or 14 other subjects. Contaminated hands can also be the source of re-contaminating the surface. Compliance rates of healthcare workers in hand hygiene are known to be around 50%. Due to the overwhelming evidence of low compliance with hand hygiene, the risk from contaminated surfaces cannot be overlooked.

IKNER et al (May 2020) A continuously active antimicrobial coating effective against human coronavirus 229E[32]

The disinfection of high-contact surfaces is seen as an infection control practice to prevent the spread of pathogens by fomites. Unfortunately, recontamination of these surfaces can occur any time after the use of common disinfectants. We recently reported on a novel continuously active antimicrobial coating which was shown to reduce the spread of healthcare acquired infections in hospitals. We evaluated a modified coating that demonstrated a residual efficacy against viruses. The coated surfaces were found to be effective against human coronavirus (HCoV) 229E, reducing the concentration of these viruses by greater than 90% in 10 minutes and by greater than 99.9% after two hours of contact. The coating formulation when tested in suspension yielded a greater than 99.99% reduction of HCoV 229E within ten minutes of contact. This outcome presents an opportunity for controlling the transmission of COVID-19 from contaminated fomites.

DIETZ et al (March/April 2020) 2019 novel coronavirus (COVID-19) pandemic: Built environment considerations to reduce transmission[33]
Over the last decade substantial research into the presence, abundance, diversity, function and transmission of microbes in the BE has taken place and revealed common pathogen exchange pathways and mechanisms. In this paper, we synthesize this microbiology of the BE research and the known information about SARS-CoV-2 to provide actionable and achievable guidance to BE decision makers, building operators and all indoor occupants attempting to minimize infectious disease transmission through environmentally mediated pathways. We believe this information is useful to corporate and public administrators and individuals responsible for building operations and environmental services in their decision-making process about the degree and duration of social-distancing measures during viral epidemics and pandemics.

ESLAMI and JALILI (May 2020) The role of environmental factors to transmission of SARS Cov2 (COVID-19)[34]
Human-to-human transmission of SARS-CoV-2 occurs most often when people are in the incubation stage of the disease or are carriers and have no symptoms. This study discusses the role of various environmental factors and conditions—temperature, humidity, wind speed—on COVID-19 transmission as well as food, water, sewage, air, insects and contamination by inanimate surfaces. The results show that the resistance of this virus on smooth surfaces was higher than others. Temperature increase and sunlight can facilitate the destruction of SARS-COV-2. When the minimum ambient air temperature increases by 1 °C, the cumulative number of cases decreases by 0.86%. There is no evidence that COVID-19 is transmitted through sewage or contaminated drinking water. Transmission through food, food packages and food handlers has not been identified as a risk factor for the disease. The possibility of transmitting SARS-COV-2 bioaerosol through the air has been reported in the internal environment of ophthalmology. The results additionally show that infectious bioaerosols can move up to 6 feet. There have been no reports of SARS-COV-2 transmission by blood-feeding arthropods such as mosquitoes.

KAPOOR and SAHA (2020) Handwashing agents and surface disinfectants in times of coronavirus (COVID-19) outbreak[35]
Many hand sanitizers and surface cleaning agents are being made available which claim to be virucidal and effective against coronavirus. We present a review of handwashing agents and surface disinfectants which have virucidal properties and are effective against coronaviruses.

WIGGINTON and BOEHM (March 2020) Environmental engineers and scientists have important roles to play in stemming outbreaks and pandemics caused by enveloped viruses[36]
Virus particles in the air and on fomites are exposed to a range of environmental conditions that influence their persistence. Relative humidity, fomite material and air temperature can greatly impact enveloped virus inactivation rates. SARS-CoV-2 will certainly not be the last novel virus to emerge and seriously threaten global public health.
We should aim to understand and communicate to our colleagues in medicine and public health the specific characteristics that drive transport and inactivation of enveloped viruses in solutions, on surfaces and in the air. Likewise, we should seek to understand how environmental factors shape possible virus transmission routes. That way, regardless of the identity of the enveloped virus that causes the next major outbreak, we can provide more informed descriptions of its persistence and recommendations on how to mitigate its spread.

OTHER
VOLKIN, S (March 2020) Q and A: How long can the virus that is COVID-19 survive on surfaces? Carolyn Machamer, a cell biologist who specializes in coronaviruses discusses the latest research on the virus that causes COVID-19[37]
Machamer: "What's getting a lot of press and is presented out of context is that the virus can last on plastic for 72 hours — which sounds really scary. But what's more important is the amount of the virus that remains. It's less than 0.1% of the starting virus material. Infection is theoretically possible but unlikely at the levels remaining after a few days. People need to know this. You are more likely to catch the infection through the air if you are next to someone infected than off of a surface. Cleaning surfaces with disinfectant or soap is very effective because once the oily surface coat of the virus is

disabled, there is no way the virus can infect a host cell. However, there cannot be an overabundance of caution. Nothing like this has ever happened before."

DAVIS (2020) How long does coronavirus survive on different surfaces?[38]

A much-discussed study published in the New England Journal of Medicine by researchers in the US looked at the survival of the coronavirus on a variety of surfaces — plastic, stainless steel, copper and cardboard. The results reveal that while viable virus was still detected on plastic and stainless steel after 72 hours, for cardboard and copper it was no longer detectable after 24 hours and four hours respectively.
For all surfaces, the quantity of virus dropped rapidly over time — in the case of plastic, the estimated median half-life of was around 6.8 hours on plastic.
However, another study released this month — not yet peer-reviewed — by researchers in Bejing reported: "SARS-CoV-2 was stable on plastic, stainless steel, glass, ceramics, wood, latex gloves and surgical masks and remained viable for seven days on these seven surfaces."
William Keevil, Professor of Environmental Healthcare at the University of Southampton, said that in the case of copper the US study likely overestimates the time the virus would survive. "I have spent 20 years looking at superbug bacteria and then flu, noravirus and coronavirus 229E [which is a cause of common colds] and they are all killed in minutes." The reason, he said, is that copper ions destroy the genetic material of bacteria and viruses.

YALE ENVIRONMENTAL HEALTH and SAFETY (June 2020) COVID-19: Cleaning computers and electronics for all users[39]

Guidance on how to clean high-touch electronics, examples include computers, computer accessories, touchscreen devices, printers and copiers. All electronics in shared and public locations should be frequently cleaned and disinfected. When cleaning electronics it is important to follow the manufacturer recommendations for specific cleaning requirements.

VISONTAY, E (May 2020) Sensor taps and no door handles: COVID-19 shows it's time to rethink public toilets[40]

Better building codes and some design innovation could greatly improve hygiene, experts say.

Produced by the members of the National Health Library and Knowledge Service Evidence Team[†]. Current as at 06 July 2020.This evidence summary collates the best available evidence at the time of writing and **does not replace clinical judgement or guidance**. Emerging literature or subsequent developments in respect of COVID-19 may require amendment to the information or sources listed in the document. Although all reasonable care has been taken in the compilation of content, the National Health Library and Knowledge Service Evidence Team makes no representations or warranties expressed or implied as to the accuracy or suitability of the information or sources listed in the document. This evidence summary is the property of the National Health Library and Knowledge Service and subsequent re-use or distribution in whole or in part should include acknowledgement of the service.

The following PICO(T) was used as a basis for the evidence summary:

Population (P): person, location, condition/patient characteristic	INANIMATE SURFACE/ FOMITE CONTAMINATION
Intervention (I): length, location, type	SARS-COV-2
Comparison (C): another intervention, no intervention, location of the intervention	
Outcome (O)	HOW LONG CAN THE VIRUS EXIST ON SURFACES, WHAT ROLE DO CONTAMINATED SURFACES PLAY IN THE CHAIN OF TRANSMISSION AND WHAT INFECTION CONTROL PRECAUTIONS SHOULD BE IMPLEMENTED?

The following search strategy was used:

[ABBREVIATED] COVID-19 OR CORONAVIRUS OR "CORONA VIRUS" OR (WUHAN N3 VIRUS) OR (("2019-NCOV" OR "2019 NCOV")) OR "SEVERE RESPIRATORY SYNDROME CORONAVIRUS2" OR (("2019" AND (NEW OR NOVEL) AND CORONAVIRUS))
(HCOV-19) AND (SURFACE OR SURFACES OR TRANSMISSION OR "SURFACE EXPOSURE" OR "ENVIRONMENTAL TRANSMISSION" OR CONTAMINATION OR "INANIMATE SURFACE" OR "HARD SURFACE" OR "SOFT SURFACE" OR "DRY SURFACE") AND (SURVIVAL OR LIFECYCLE OR "LIFE CYCLE" OR EXISTENCE OR SURVIVE OR "LIFE SPAN")

† Emma Quinn, Librarian, St. Luke's General Hospital, Kilkenny [Author]; Pauline Ryan, Librarian, University Hospital Waterford [Author]; Gethin White, Librarian, Dr. Steevens' Hospital, Dublin [Author]; Brendan Leen, Area Library Manager, HSE South [Editor]; Emma Quinn, Librarian, St. Luke's General Hospital Kilkenny [Editor].

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