Caring for Heritage Collections During the COVID-19 Pandemic

- Version 3 of this document was released on August 10, 2021.
- Version 2 of this document was released on July 24, 2020, and has since been archived.
- Version 1 of this document was released on April 17, 2020, and has since been archived.

New versions of this document will be released as needed, with the date of their release indicated.

Version 3 (released August 10, 2021)

List of abbreviations

AAM	American Alliance of Museums
AISI	American Iron and Steel Institute
AMM	Association of Manitoba Museums
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CCI	Canadian Conservation Institute
CDC	Centers for Disease Control and Prevention
COVID-19	coronavirus disease of 2019
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
HEPA	high-efficiency particulate air
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
IPM	integrated pest management
MERV	minimum efficiency reporting value
NPS	National Park Service
OCLC	Online Computer Library Center
ppb	parts per billion
PPE	personal protective equipment
QAC	quaternary ammonium compounds
REALM	Reopening Archives, Libraries and Museums (Project)
RH	relative humidity
SARS	severe acute respiratory syndrome
SARS-CoV-2	severe acute respiratory syndrome-related coronavirus 2
WHO	World Health Organization

Key points

Here is a summary of key points to consider:

- Protect people first: follow the advice of your local public health authorities, including practising physical distancing, frequent handwashing or the use of hand sanitizers and the use of personal protective equipment (PPE). Close your institution whenever transmission in the community is high. Provide appropriate ventilation, where possible, to reduce the risks of person-to-person spread.
- Use isolation to prevent or deal with contamination of collection spaces and objects whenever possible. Coming into contact with the virus on surfaces is not thought to be the primary mode of transmission, but the virus can persist on surfaces for some time before naturally deactivating. Existing data indicates that waiting for at least seven days limits the risk on a range of surfaces in a range of conditions. This is preferable to using disinfecting solutions, which can damage many heritage materials.
- If disinfection of non-heritage surfaces in collection spaces is required, use methods that permit controlled application of cleaning solutions and disinfectants. Always use disinfectants that have been approved by authorities (such as Health Canada and the U.S. Environmental Protection Agency [EPA]).
- If your institution needs to close indefinitely, do so in a manner that provides adequate security, fire protection, integrated pest management (IPM) and environmental control. Implement regular exterior and, if possible, interior inspections. Consider how you would respond to other kinds of emergencies, such as water leaks or fires, if needed.
- Upon reopening, integrate physical distancing and assigned workstations, where possible, and appropriate PPE into collections work to keep people safe while limiting collections contamination. Find creative ways to eliminate frequent touching of collection materials or interactive exhibits by multiple people. Implement isolating, cleaning and disinfecting protocols where needed in a manner that does not harm collections.

More detailed information is provided below through answers to frequently asked questions about contamination of heritage materials, disinfection of collection spaces, dealing with a facility closure and reopening safely. Useful resources are listed at the end of this resource.

Contamination of collection materials by the COVID-19 virus

1. Can the COVID-19 virus be transmitted via collection objects or heritage surfaces?

Public health agencies agree that the COVID-19 virus (SARS-CoV-2) is primarily spread from person to person through small droplets and aerosols expelled when an infected person sneezes, coughs, sings, shouts or speaks. Although less likely, people can potentially become infected with COVID-19 by touching contaminated surfaces or objects and then touching their eyes, nose or mouth. If an

infected person coughs or exhales in the direction of collection objects or handles objects with contaminated hands, objects could be contaminated with the virus, which could, in theory, be transmitted to those who handle the objects afterwards. Since collection objects tend to be handled infrequently and the virus deactivates naturally outside of the human body, the chance of transmission is probably low. The risk may be higher where people work in heritage interiors and use heritage furnishings or where books, records or study collections are handled frequently by multiple users, potentially in quick succession. In all contexts, the risk is reduced when people wear masks, when they wash or sanitize their hands regularly and as more people become vaccinated.

2. How long does SARS-CoV-2 persist on surfaces?

The virus SARS-CoV-2, which is responsible for the COVID-19 pandemic, has a finite amount of time that it can reinfect once it is outside the human body. SARS-CoV-2 is a membrane envelope virus with glycoprotein spikes. Membrane viruses are known to be more readily damaged by the environment and disinfectants than other forms of virus. Without disruption by disinfectants, the bilayer lipid membrane degrades by chemical processes tied to drying and exposure to air.

Information on the stability of the SARS-CoV-2 virus has been published in laboratory studies (consult the Appendix). Some of these studies aimed to inform the operation of our critical health care systems, so the choice of materials and test conditions primarily model the functions and surfaces found in hospitals. Given the wide variation in responses by material, initial dose and temperature, extrapolation to other contexts, like museums and collection facilities, requires caution. From June 2020 to February 2021, the Reopening Archives, Libraries and Museums (REALM) Project released the results of eight rounds of testing virus attenuation on library and museum materials. The results provide more specific data on some collection materials.

Persistence does vary with the characteristics of the surface material and the presence of other contaminants (Box 1). Smooth surfaces, like metal and hard plastics, exhibit greater viral persistence and permit more transfer than porous surfaces, like paper and textiles. In addition, the REALM Project determined that the virus survives longer when materials like DVD cases, book covers or plastic covers are stacked, as shelved books would be, for example.

What is clear from published laboratory studies on SARS-CoV-2 is that viruses begin to deactivate as soon as they are outside of the human body. Given enough time, the infection risk from a contaminated surface disappears. Transmission is more likely soon after contamination, which is more likely to occur on surfaces that are frequently touched.

Box 1: Influence of existing contaminants and surface characteristics on viral persistence

In addition to looking at a variety of surface materials, when researchers conduct suspensions and dry surface tests of viruses, they examine how adding materials that could be present on these surfaces may affect persistence. Viruses mixed with contaminants are most often tested on representative hospital surface materials, as there is an elevated cause for concern for infection in

hospital settings. Proteins have stabilized viruses on dry surfaces, which extends the persistence significantly by slowing degradation. Surface material and texture also matter. Metals (stainless steel and copper are common test coupons) exhibit some differences in persistence among themselves and can overlap with organic porous substrates (paper, cardboard, cloth). Metal ions (zinc, in particular) are part of essential virus protein structures, and there is evidence that copper and silver interfere with virus proteins, which is why these two metals are present in a few disinfectants. Hard plastics sometimes stand out with a longer persistence. A high surface texture (fabric) versus a smooth one can reduce transfer from the surface to human skin, but it also makes it harder to see or treat contaminations. Obvious contaminations may attract disinfection activity, leaving less obvious overlooked areas as a possible source of infection.

In the context of heritage collections, which comprise a diversity of materials and structures, a simple, conservative estimate that reflects the outer bounds of viral persistence is useful. Adopt one rule for everything in the same way that a 14-day human quarantine is used to decide that a person without symptoms is not infected and not a risk to others, even though COVID-19 symptoms often appear much earlier. Thus, we recommend an isolation period of at least seven days at room temperature for heritage materials that are suspected to be contaminated with the COVID-19 virus in order to protect people's health by minimizing the possibility of transmission via contaminated surfaces. The period suggested is based on all laboratory research data conducted at room temperature that is available to date, across all materials tested to date. Our guidance remains conservative to add an element of safety as the virus continues to mutate and evolve towards increased levels of infectivity. The minimum number of virus particles that can cause infection is still under research, but it is currently considered to be in the hundreds.

3. Does the environment affect how long the coronavirus persists?

Although research on the COVID-19 virus is limited, studies of other similar coronaviruses indicate that environmental conditions, such as temperature, relative humidity (RH), pH and the presence of ultraviolet (UV) radiation and ozone, do affect how long viruses persist on a surface. The effects are often complex and based on laboratory research (Box 2) that may not reflect conditions in collection spaces.

Box 2: Effects of the environment on viral persistence, in brief

Environmental conditions affect the duration of infectivity of viruses on a surface. The REALM Project examined the COVID-19 virus to extend our knowledge on virus attenuation after deposition and drying onto surfaces associated with library and archive materials. Dry coupon work is one mode of study; two others are retention of viral activity in aerosols or suspension in liquids. Advice on the COVID-19 virus is based in part on the accumulation of knowledge from studying SARS and viruses with similar properties, although many more specific COVID-19 virus studies have appeared since the start of the pandemic.

Temperature: In general, refrigeration temperatures (2ºC–6ºC) prolong viral persistence. Between room temperature and about 37ºC, there is some change in persistence with a minor decrease as temperature rises. Initially, in the range of 37ºC to 56ºC, there was little data to indicate the rate at which structural degradation of the membrane shortens viral persistence. This had been examined more fully by late 2020 on common surfaces, and studies showed reductions in the range from 20ºC to 40ºC. At 60ºC and above, there is a rapid loss of virulence.

Relative humidity: In general, low RH (20–30%) prolongs virulence. Room tests on influenza indicated that dust raised in dry conditions can be problematic because it re-aerosolizes attached viruses. Moderate (40–60%) and high RH (80%) shorten viral persistence. Moderate to high RH rates will also prolong the period in which wet disinfectants stay in contact with surfaces. In tests examining the transfer of bacteria and viruses from materials to skin, moderate humidity was shown to enhance the transfer while low humidity reduced the transfer, with smooth surfaces allowing higher transfer than porous surfaces (factors were two- to ten-fold). The use of proper PPE in handling eliminates the transfer risk. As a separate issue from persistence, some work on aerosolized cold virus indicates high and low RH diminishes infectivity of the aerosol. Epidemiological research has documented reduced incidence of respiratory infections in general at moderate RH levels.

pH: In general, neutral pH prolongs, while the acid and basic regions shorten viral persistence. Low temperature requires more extreme pH (acid or base) to achieve a similar loss of infectivity as at room temperature.

UV: One study assessed UV disinfection of the SARS virus in suspension and demonstrated the loss of virulence after one hour of exposure at 260 nm and more than 90 mW/cm^2. When considered for aircraft disinfection, however, complicating factors such as shadow zones from complex shapes or dust layers reduced efficacy. Application risks seem too high for utility with most heritage material, particularly as sensitive surfaces can also be damaged by UV radiation. Simulated sunlight has been demonstrated to strongly increase the SARS-CoV-2 decay rate over the rate of indoors or in darkness.

Ozone: Ozone can destroy virus activity. It is also an irritant and health concern. Health Canada sets 20 ppb as a guideline for indoor residential exposure and advises against home ozone generators. Average background ozone levels for southern Ontario and Quebec are in the range of 30 to 35 ppb. Ozone causes cumulative harm through oxidation, which museums already try to guard against, to conserve their collections. Examining non-COVID-19 virus response to ozone indicates that virus particles were possibly two to three times more sensitive than the most sensitive colourants to ozone-induced harm. Ozone at a concentration of 2000 ppb for an hour will be equivalent to 60 hours of normal background exposure. Exposure to 25,000 ppb for 20 minutes is equivalent to 10 days of background exposure. Repeating treatments on the same objects will cause significant damage faster than if only exposed to the background level of ozone.

A few observations are possible. In general, cool temperatures (2ºC–6ºC) prolong viral persistence while very warm temperatures (60ºC and above) result in a rapid loss of virulence. The recommendations given in this resource assume normal room temperature conditions. Greater caution is suggested if contamination occurs in cooler collection spaces, such as walk-in freezers or unheated rooms. Low RH (20–30%), which is common in heated museum spaces that are not humidified in winter in Canada, also prolongs virulence, but may reduce surface-to-surface transfer. Dust raised in such dry conditions can be problematic since it re-aerosolizes attached viruses.

4. Should collection objects or heritage materials be disinfected due to the COVID-19 virus?

Disinfecting collection objects or heritage materials is NOT recommended. Disinfecting solutions contain alcohol, bleach or other chemicals that can damage many of the surfaces and materials in heritage collections. Although certain solutions might be appropriate for some materials (for example, 70% ethanol on metal surfaces), inappropriate use can cause permanent damage or may fail to disinfect properly. Always consult a professional conservator before doing any kind of treatment.

While good hand hygiene is the first line of defence (consult question 5), to further reduce the risk of transferring viruses from contaminated objects to people, quarantine objects. Wait until the virus deactivates naturally on surfaces before handling any objects or resuming operations. Consult question 11 and question 18 for mitigation measures related to built heritage and heritage interiors, where isolation strategies are more complex and not always feasible.

5. Should hand-sanitizing products be used by people handling heritage materials?

Handwashing and hand sanitizing are highly recommended for reducing the transfer of the COVID-19 virus. Washing hands with soap and water prior to handling objects and records is an accepted alternative when gloves are not appropriate or if access to gloves is limited. Hand sanitizers provide an alternate way to reduce disease transmission. Hand sanitizers approved for use against the COVID-19 virus in Canada are listed in the List of hand sanitizers authorized by Health Canada. In the U.S., sanitizers and antiseptics are regulated by the Food and Drug Administration (FDA) (consult this FDA resource on Hand sanitizers | COVID-19) and disinfectants are regulated by the EPA [consult About List N: disinfectants for coronavirus (COVID-19)].

Some heritage institutions may provide hand sanitizers to staff and visitors, particularly during pandemics. Hand sanitizers could leave residues on objects or records during handling that could eventually damage some materials. A small study by the Library of Congress on the impact of hand sanitizers on collection materials, in particular on the degradation of paper, indicated the potential for such an effect. However, the testing methods used differ considerably from what would be expected during collection use. In addition, hand sanitizers do not clean dirty or greasy hands. Handwashing or the use of gloves might be preferred for those who handle collection items directly.

Disinfection of collection spaces

6. A person diagnosed with COVID-19 has been working in our facility. What should we do?

Firstly, people who were in close contact with the infected person or who shared workspaces should follow public health guidelines to quarantine or self-isolate. Next, follow official public health guidelines on Cleaning and disinfecting your facility. Close off areas used by the infected person and increase air circulation. Wait at least 24 hours to allow potentially infectious aerosols to settle before cleaning and disinfecting all high-touch, non-heritage surfaces in the spaces accessed by the infected person (consult question 7). If it has been at least seven days since the infected person was in the building, further cleaning and disinfecting is not required. For definitions of cleaning, disinfection and sanitizing, consult Box 3. For more guidance on the special case of heritage interiors, consult question 11.

Box 3: Some useful definitions

Cleaning is a general reduction of dirt and grime, including viral and bacterial loads on surfaces, which makes subsequent disinfection more effective.

Disinfection is the application of a solution or method that kills or deactivates any pathogens that remain after cleaning.

Sanitizing more commonly refers to the practice of using antimicrobial solutions or methods to reduce pathogens on food, surfaces that are in contact with food or pathogens on human skin. This distinguishes them from disinfectant solutions that are not approved for these sensitive uses, particularly on the human body.

The Centers for Disease Control and Prevention (CDC) gives clear guidelines on Cleaning and disinfecting your facility, including a number of surfaces (high-touch hard surfaces, soft surfaces, electronics and items that can be laundered).

7. Can collection workspaces be cleaned and disinfected safely?

Yes, it is possible to safely clean and disinfect non-heritage surfaces (tables, desks and shelves) that are used for working with collection objects or archival records. If these collection workspaces are themselves heritage interiors, consult more specific guidance in question 11.

Heavily touched, hard, non-heritage surfaces may need to be particularly targeted for regular cleaning. Public health resources provide guidance to determine how often to clean and whether additional disinfecting is warranted (consult Cleaning and disinfecting your facility; consult question 6

for the difference between cleaning and disinfecting). Cleaning alone may be sufficient if is known that no infected people have recently been in a space.

Hard surfaces are the easiest surfaces to address; they are also the surfaces on which the virus can persist the longest and with the highest transfer concentration to skin. Cleaning solutions (aqueous surfactants) and disinfecting compounds (alcohols, oxidizing agents, acids and bases, etc.) as well as their application methods (wet spraying, wiping, contact times) have to be appropriate for the surface to which they are applied. Test a small area of each surface type first, and consider the effects of overspray or dripping on any nearby collection items.

Dry cleaning methods (vacuuming, sweeping, dusting) in low RH environments may re-aerosolize virus particles (consult question 3 for the effects of environmental conditions). Therefore, consider using PPE and more contained methods, such as HEPA vacuuming. Note that dry cleaning methods are also not particularly effective at reducing surface grime in high-touch areas.

Wet cleaning methods remove surface grime and can decrease transmission risks by reducing the overall viral load on surfaces. Just as for handwashing, cleaning with water alone is not very effective. In addition to enhanced removal of greasy dirt, surfactants like soaps and detergents are attracted to the fatty membrane that envelopes the COVID-19 virus, thereby disrupting its structure and speeding up degradation, while lessening the attraction to the surface material, making it easier to wipe off (Box 4). Duration, the mechanical action of cleaning (friction) and rinsing influence cleaning effectiveness, as shown in studies of handwashing. This suggests that surfaces should be wiped down with soap and water and then rinsed by wiping with clean water. Proper cleaning with surfactant solutions can reduce the risk of infection if the virus is present on surfaces, but it may not fully eliminate the risk.

Box 4: Cleaning with surfactants

Effective cleaning often relies on surfactants like soaps or detergents. Surfactant cleaning action is associated with a number of factors: lowering of surface tension (wetting), solution pH, amphiphilic structure (hydrophobic/hydrophobic) and the ability to form micelles. Duration, the mechanical action of cleaning (friction) and the rinsing step have also been deemed significant, at least in studies of handwashing. One study has shown that a 0.1% sodium laureth sulphate (SLS) solution can effectively inactivate the COVID-19 virus on a variety of surfaces when used for 60-second durations. Most commercial soap and detergent formulations are surfactant solutions adjusted by emulsifying and chelating agents, pH adjusters, copolymers, colouring agents, perfumes, etc. Cleaning recommendations for heritage applications recommend commercial detergents with as few, if any, of these extra additives as possible to decrease the likelihood of residues or unexpected material interactions. Dilute solutions of these milder detergents are found in the National Park Service's (NPS) COVID 19 Exhibitry Cleaning Guidance: Recommendations for Cleaning and Disinfecting NPS Exhibitry to Combat Novel Coronavirus. Other historic house cleaning guidelines are linked in the Useful resources section. While the recommended surfactant products in these cleaning guidelines carry fewer additives, rinsing is still required, both to ensure effective cleaning and to minimize any surfactant residues.

Disinfecting after cleaning, as deemed necessary by public health guidance, further reduces the risk of viral transmission by eliminating the viability of any remaining viral load. Disinfectants are most effective when surface dirt or grime is removed first by cleaning. PPE should be worn to reduce contact hazards from contaminated surfaces and from the disinfectant solutions.

Cleaning or cleaning and disinfecting should leave no potentially harmful residues on surfaces that will come into direct contact with collection objects (such as reading room tables and shelves for storing objects). The easiest way to avoid residues is to use simple solutions: surfactant solutions, diluted household bleach (solutions that are too concentrated will leave sodium chloride residues; consult Box 5 for concentration information) or alcohol/water solutions that are above 70% (v/v) alcohol in concentration. Although commercial products can also be used, the effects of additives (colourants, scents, foaming agents, etc.) may be problematic. After the required contact time or drying time, make sure to follow any rinsing instructions (usually a clean water wipe-down). Health Canada, in its guidance on Remaining residues and surface compatibility concerns, requires that rinsing instructions, as well as any information on incompatible surfaces be noted on the product label of household cleaners and disinfectants.

In spaces that also house collections, or in which airflow is limited and cleaning needs to be frequent, consider which volatile organic compounds may be released by the chosen cleaner or disinfectant. Mitigating risk through conscientious hand hygiene, by using non-medical masks and by modifying workflows (consult question 17) can help decrease the amount of cleaning or cleaning and disinfecting of surfaces that is necessary.

Box 5: Guidelines for specific disinfectants

Commercial and household disinfectants: For commercial products, Health Canada has generated a List of disinfectants with evidence for use against COVID-19. As contact time information is not listed on the Health Canada site, consult the product label or cross-reference with the EPA's About List N: disinfectants for coronavirus (COVID-19) that indicates recommended contact times (minimum time the surface is visibly wet). Contact times depend on which active disinfecting ingredient is present and its concentration.

Household bleach (sodium hypochlorite): Use only freshly prepared solutions of unexpired bleach, and do not mix with other cleaners (particularly those containing ammonia). Most safety data sheets (SDS) list the concentration of sodium hypochlorite in household bleach as 5–10 wt% (consult section 3 of the SDS, if available, and assume the lower end when calculating concentrations). Both the CDC (Cleaning and disinfecting your facility) and Health Canada [Hard-surface disinfectants and hand sanitizers (COVID-19)] are recommending at least 1000 ppm (0.1%) sodium hypochlorite for disinfecting hard surfaces, ensuring a contact time of at least one minute. The following dilution guidelines assume a starting 5% concentration:

- Metric: 20 mL of bleach per litre of water (1000 mL) or 5 mL per cup (250 mL)
- Imperial: 5 tablespoons (1/3 cup) of bleach per gallon of water; 1 teaspoon per quart

Other recommendations (dilute 1 part bleach in 9 parts water) achieve concentrations as high as 5000–10,000 ppm (0.5–1%) and may be applicable in situations where contact times need to be shorter (30 seconds). Bleach, particularly at higher concentrations, can damage surfaces such as metals. Bleach use also requires good ventilation, protective gloves and eyewear.

Alcohols: Use concentrations of 70:30 (70%) alcohol in water of either ethyl alcohol (ethanol) or isopropyl alcohol (2-propanol, rubbing alcohol, isopropanol). The strength of rubbing alcohol sold at pharmacies is usually either 70% or 90%; 90% rubbing alcohol can be further diluted in water to extend its use. Some liquor stores sell high proof ethanol (for example, grain alcohol of at least 140 proof). Be cautious of denatured alcohol such as that sold at hardware stores, as the denaturing elements (methanol, methyl ethyl ketone, etc.) can be more harmful to human health than ethanol alone. Contact times of 30 seconds appear to be effective against corona-type viruses (consult Table 1 in "Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents"). Products that contain alcohol have been recommended for cleaning electronic surfaces by the CDC (Cleaning and disinfecting your facility); caution is necessary if disinfecting acrylic (such as Plexiglas) surfaces, as cracking can result. Use of alcohols should be avoided on finished wood surfaces, as many finishes are sensitive to alcohols.

Quaternary ammonium compounds (QACs or "quats"): Quaternary ammonium formulations are a large fraction of commercially produced anti-viral disinfectants, so they are readily available. Any QAC can have a variety of organic molecules attached to a central nitrogen atom, which is commonly forming a salt with bromine or chlorine. To improve their efficacy, the QACs are blended with detergents, chelating agents and pH adjusters (strong acids and bases), although some formulations are near neutral. Strongly acidic or basic solutions can have harmful effects on heritage materials. Therefore, careful decisions are required. Quaternary ammonium formulations are more prone to leaving residues than simple solutions like ethanol/water or hydrogen peroxide, and they often require thorough rinsing.

8. Can I follow the same protocols used in mould remediation to clean work surfaces?

No, viruses have their own properties of resistance to disinfectant chemicals. However, similar or identically formulated disinfectants can have strong efficacy against both mould and viruses, such as commonly employed solutions of 70% ethanol in water and appropriately diluted sodium hypochlorite bleach for frequently touched surfaces.

9. What disinfectants are appropriate for non-historic surfaces in collection spaces and heritage interiors?

Many disinfectants can be used on non-collection surfaces in collection spaces (Box 5), when needed. In Canada, check that household and commercial products have been approved by Health Canada for use against the COVID-19 virus (consult List of disinfectants with evidence for use against COVID-19), and follow manufacturer's guidelines for application (pre-cleaning, rinsing,

incompatible surfaces, etc.). Diluted common household bleach and alcohol/water blends can also be prepared in-house.

It is important in all cases to consider contact times (which depend on the concentration and type of active ingredient) as well as incompatible surfaces for each type of disinfectant. Concentrations that are too low will be less effective against the virus, but concentrations that are too high increase both the chemical exposure of the user and the risk of damage to surfaces. Consider both the bulk material and any surface finishes before choosing a disinfectant and test first. Look to public health guidelines, like those from the CDC for cleaning soft surfaces, electronics and for laundering, as described in their guidance Cleaning and disinfecting your facility.

The WHO *Guide to Hygiene and Sanitation in Aviation* (PDF format) discusses the control of infectious agents in public spaces such as airports. The guide advises that carpets can be steam cleaned with machines that can heat to 70ºC, but that some carpets may not tolerate this temperature. Target the use of disinfectants to high-touch, higher-risk transfer points to minimize their overall use.

10. My institution wants to use electrostatic disinfectant sprayers in all spaces, including collection rooms. Is this appropriate?

Electrostatic spray technology is one method of applying approved disinfectant solutions that is sometimes suggested for efficient application over complex surfaces. These technologies are not recommended by the WHO and the CDC for the COVID-19 virus due to questions about the extent of their efficacy and due to potentially adverse health effects (consult Cleaning and disinfection of environmental surfaces in the context of COVID-19 and Cleaning and disinfecting your facility). These methods also permit less control over where the disinfectant is applied than manual application. Since heritage objects and surfaces could be sprayed inadvertently with disinfectant, the use of this application technique in collection spaces or heritage interiors is not recommended from a collection standpoint.

11. Can heritage interiors or rooms with cultural heritage objects like artworks or furniture be disinfected safely?

As noted in question 4, using disinfectants on heritage objects and interior finishes and fixtures is not recommended. The chance of damaging heritage materials is too great. If an infected person has been working in a room with heritage objects or heritage finishes, it is recommended that you isolate the space for at least seven days to control viral spread, then follow with regular housekeeping and cleaning. For heritage interiors in historic house museums or similar heritage buildings where all finishes and objects have heritage value, this may be the only safe way to respond to a case of known infection.

If faster access to a room is required, it is suggested that you isolate the room for 24 hours to allow aerosols to settle, then follow with cleaning and disinfecting high-touch, non-heritage surfaces using

disinfectant application methods that can be well controlled and with “normal” cleaning of heritage finishes that are likely to have been touched, such as handrails or door knobs. “Normal” cleaning includes the methods that have been part of your routine housekeeping for the surface in question. Instruct cleaners to take care when working around heritage materials. Consult a conservator before undertaking any “enhanced” cleaning of heritage finishes or surfaces; that is, cleaning outside of your housekeeping resource guidelines (consult the Useful resources section). While some material may be compatible with surfactant solutions (consult question 7) or very rarely with some disinfectant solutions, such as alcohols (consult question 9), the risk of damage is high, especially with daily cleaning.

Removal of artworks or heritage furnishings prior to disinfecting spaces due to COVID-19 concerns is not recommended in most cases, even if the room itself has no particular heritage value. Handling and transport of cultural heritage objects brings its own risks. Leaving the objects in situ and addressing the infection risk through controlled cleaning and disinfecting, when appropriate, as described above is recommended.

Further information on routine cleaning protocols for reopening of historic houses and museums housed in historic buildings is provided in question 15 and question 18.

Dealing with a facility closure

12. Our institution is closed indefinitely due to the COVID-19 pandemic. How do we ensure that collections remain safe with few or no staff regularly on site?

Much preventive conservation care of collections depends on the regular presence of collections, security and facilities staff. When this presence is disrupted, some risks to collections may increase, while others may decrease.

Good security is vital during long-term closure (Box 6). Criminals may take advantage of reduced staff presence on site. The economic downturn may motivate criminal behaviour. Ensure that security protocols and monitoring systems are maintained. Document all entry into the facility.

Box 6: A brief security primer for long-term closure

Secure the building: Make sure that all doors and windows are properly closed and locked. Check that the security alarm and fire protection systems are working properly.

Secure valuables: Think beyond the collection to items such as cash boxes, computer screens, laptops and other electronic equipment that may be attractive to thieves.

Secure important documents: Ensure that desks and offices are left clean and that all sensitive documents and information are secure.

Secure the collection: Consider returning vulnerable collection objects in workspaces or galleries to storage if that is more secure. In particular, think about collection items with respect to windows and ensure that no collection items are vulnerable to smash-and-grab thefts.

Maintain a presence: Check the site and perimeter daily to identify problems and initiate corrective action quickly. Demonstrate that the building is being monitored by maintaining walkways and landscaping.

Turning off or blocking light in collection spaces, except for security lighting, will limit the effects of light and UV.

Maintain an appropriate environment in collection spaces. Decreasing the air exchange rate (minimum outside air) when no people are on site can provide a more stable, less dusty environment. If staff are present regularly, however, increasing ventilation may be beneficial (consult question 16). In newer buildings, HVAC systems can probably be monitored and adjusted remotely. If portable equipment, such as humidifiers, is used to maintain environmental conditions, provide ongoing maintenance or consider shutting it down, particularly if it is prone to malfunction or leaks. Consider dropping the temperature set point a few degrees if this can be done without increasing the risk of mould: a lower temperature slows degradation rates, reduces pest activity and saves on heating costs.

Pest risks could be problematic, especially where chronic problems are no longer monitored closely. Remove food from gift shops, cafés and offices unless it is stored in reliable refrigeration or freezer units to curb rodents. Remove all food waste and garbage to outside receptacles. If possible, replace sticky traps prior to closing and monthly thereafter, if site inspections are possible, to remove dead insects that can attract certain museum pests. Keep drains from drying out to prevent sewer fly and cockroach infestations as well as to suppress sewer gas ingress. Since infestations are common in spring, plan for a response in advance.

Review building maintenance tasks and ensure that essential projects are completed. In addition to checking the site and building perimeter, conduct regular inspections inside the building if possible, paying particular attention to areas of concern, such as locations prone to leaks. A checklist is recommended to guide such inspections. If non-collection staff are responsible for inspections, provide virtual collections care training, highlighting key issues, or set up a system for remote reporting and consulting.

Take measures to reduce the likelihood or negative consequences of another kind of emergency, like water leaks. We highly recommend that you check doors, windows and alarm systems to make sure they are working correctly and that you inspect facilities regularly during closure so that other emergencies are detected early. Turn off and unplug non-essential electrical equipment. Cover collections with plastic sheeting in areas prone to leaks. Drain plumbing if there is a risk of freezing. For institutions in areas prone to spring flooding, we suggest moving collections potentially at risk to higher ground prior to indefinite closure.

If your institution has not yet closed or if you are reviewing long-term closure protocols, the Australian guide *Closed by COVID-19 – checklist for GLAMs and historical and heritage sites* or CCI recommendations for seasonal museum closures found in CCI Note 1/3 *Closing a Museum for the Winter* offer useful practical advice.

13. How do we deal with collection objects on loan when we are closed indefinitely?

Many institutions may have collection objects or temporary exhibitions out on loan at other institutions or on loan on their own premises when a closure due to COVID-19 happens. Ensuring good care of loaned objects will require some accommodation by all parties involved as institutions cope with the same challenges. Communicate with borrowers or lenders, should your institution have active loans, and provide them with your long-term closure strategy. Negotiate the extension of the loan and insurance coverage, as necessary. Discuss whether additional precautionary measures are needed, within reason, given the current working restrictions and health concerns. Review the loan agreement and amend as required. Update changes in loan files and the collections database. Consult with your lawyer, if required. Be cognizant of the specific provincial, state or country guidelines, such as travel restrictions, if the return of items during the closure is necessary. Be mindful that additional delays may arise from reduced schedules and services from museum staff and fine art shippers, or from restrictions imposed by museums as part of their business continuity plans. For additional guidance, review the chapters on loans in *Museum Registration Methods 5th Edition*.

14. If our institution has another emergency such as a fire or flood that damages the collection while we are closed, what should we do?

As at any time, quick response to emergencies can limit damage to collections and enhance recovery. Response will be more challenging during the COVID-19 pandemic. Local regulations may prevent gatherings of the number of people needed to respond quickly and effectively. Staff may be ill, self-isolating or laid off. PPE required for responders may have been donated to local hospitals or may be difficult to obtain.

We encourage institutions to review and update emergency plans and discuss options for response by teleconference, email or chat using a simple tabletop exercise. Basic training may be essential if you need to bring new people into your emergency response team. If your plan depends on securing materials and equipment, or on the services of external contractors, check to see if these will still be available. Contact your insurance company to see how the closure might affect your coverage. Document your response to the pandemic, as this could be useful should a similar situation occur in the future.

In the event that an emergency does occur, implement a response as best you can. Inform local authorities of the need to respond and request guidelines for safe working conditions. Use methods to buy time, such as freezing wet materials, wherever possible. Take particular care of responders, since high stress and fatigue can increase the chance of infection. Canadian institutions are encouraged to contact CCI for expert advice at 1-866-998-3721.

Reopening safely

15. Do we need to clean and disinfect the building when we reopen?

Given public anxieties, the resurgence of the virus, including variants, and the growing body of research regarding pre-symptomatic and asymptomatic community spread, establishing a good cleaning protocol that incorporates disinfection as needed is essential before reopening your museum. “Deep” cleaning of spaces that have been unoccupied for more than a week is not essential for public health reasons since the virus degrades naturally with time. Once people return to the building, issues of appropriate ventilation (consult question 16), physical distancing and the use of PPE will be central to reducing the risk of further transmission. The chance of new contamination also needs to be addressed in accordance with public health guidelines to alleviate public concern.

Cleaning protocols should focus on frequently touched, hard, non-heritage surfaces in public and staff spaces. Follow Health Canada’s guidelines, Cleaning and disinfecting public spaces during COVID-19, and consult question 7 and question 11 for cleaning recommendations specific to collections workspaces and heritage interiors, respectively. Normal cleaning procedures should be sufficient for lower traffic collection spaces.

Regular cleaning will be a challenge for historic house museums and similar heritage buildings since heritage materials should not be disinfected. Prior to establishing a cleaning regimen for high-touch surfaces, determine whether the heritage material, finish or fixture can sustain repeated daily cleaning, as this is not a typical procedure. Review your housekeeping plan, or if none exists, consider developing one and incorporating plans and schedules related to this pandemic. The COVID 19 Exhibitry Cleaning Guidance: Recommendations for Cleaning and Disinfecting NPS Exhibitry to Combat Novel Coronavirus from NPS and *The National Trust Manual of Housekeeping* are two excellent resources. Cleaning will mostly involve the use of diluted surfactant solutions in tepid water applied to soft cloths or disposable paper towels, followed by rinsing with plain water on another damp cloth. Test first on a small area; even detergent solutions can cause damage. If you are uncertain about what sort of finish you are dealing with, contact a conservator. Launder cleaning cloths after each use.

As the vaccination program in Canada progresses and cases of COVID-19 decline, the need for enhanced cleaning and disinfection should gradually subside. Follow official public health guidance to ensure that museums remain safe for staff, volunteers and visitors.

16. Will recommendations for increased ventilation change how we control the environment in collection spaces?

The highest risk of transmission is still considered to be person-to-person and not surface transfer. Smaller droplets, sometimes called aerosols, can remain in the air for some time, depending on the degree of ventilation. Measures that prevent airborne spread have become more important with the

appearance of new variants that are more transmissible. As a result, facility managers may need to balance indoor environmental control recommendations that benefit collections with those that safeguard public health. In some cases, common preventive conservation practices are good for both collections and the public during this pandemic. The moderate RH range often recommended for the majority of collection objects, between 40% and 60%, also slightly shortens coronavirus persistence (consult question 3), thus reducing the likelihood of aerosol transmission. This RH range has also been associated with a lower incidence of respiratory infections in general. The positive pressure used to help reduce pollutant levels in collection spaces, particularly storage rooms, will also keep out pathogens that are more likely to accumulate in public or office spaces. Higher air filtration levels of at least MERV 13 (minimum efficiency reporting value) reduce the concentration of airborne viral particles from recirculated building air as well as fine particles that contribute to dust build-up on collection objects. Such filtration may already be present in newer HVAC systems in museums. Filter upgrades may not be possible for all HVAC systems, however, due to increased air pressure drop through the filter.

As institutions contemplated reopening after the initial lockdowns, professional associations like the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) suggested increasing outdoor air ventilation as much as the HVAC system could accommodate during occupied hours to reduce the risk of airborne infection. Higher air exchange rates may make it more challenging and more costly to maintain stable environmental conditions in galleries and collection spaces, as would the recommended daily flushing with maximum outside airflows for two hours before and after occupied hours. More recent guidance from ASHRAE (PDF format) favours air filtration and/or air cleaners to achieve at least the equivalent of MERV 13 in recirculated air while maintaining outdoor airflow rates to those required by applicable codes and standards. If air cleaners (for example, ultraviolet germicidal irradiation [UVGI] for upper room or in-duct air treatment) are used, ensure they are proven to be effective and safe. Outdoor air ventilation is still a possible strategy, if it can be done without creating uncomfortable conditions for staff and visitors and without causing other problems. Where HVAC control is not present, windows could be opened to increase ventilation, but this could also increase dust and pollutant levels (depending on the outdoor air quality) as well as IPM or security issues. Display cases and cabinets that buffer against more variable room climates should reduce the risk from temporary changes to building ventilation in collection spaces for some collection items, and they provide protection against surface contamination.

Some advise commercial building managers to leave the doors to rooms open to increase air circulation. This is not likely to be an option for most collection storage rooms or exhibition galleries since it makes maintaining stable environments more challenging and it decreases security.

17. Will continued risk of COVID-19 affect care of collections when we reopen?

Because the risk of COVID-19 transmission will still be present on reopening, even as the number of vaccinated people grows, museum activities, including collections care, may not return to a pre-pandemic normal state immediately. Museums, like other institutions and businesses, will need to

follow public health guidelines in order to keep museums safe for staff, volunteers and visitors. This section reviews suggestions for general collection care. Issues related to heritage interiors and high-use collections will be addressed separately (consult question 18, question 19 and question 20).

Reopening should reduce many of the concerns for collections related to extended closure (consult question 12). Staff will be present to ensure adequate security, environmental control, facilities maintenance, IPM and, when necessary, timely emergency response. However, some public health recommendations may require museum staff to adjust facility and collections care practice, at least for the short term.

Collection workspaces remain at risk of contamination by the COVID-19 virus as long as the risk of community spread is present. All information and recommendations regarding contamination and disinfecting presented in the first part of this resource (consult questions 4 through 11) would apply should an infection be diagnosed in a person working in museum spaces. Upon reopening, however, staff might review collection work arrangements to reduce the need to disinfect surfaces near collection objects. Consider the following measures, if they are not already in place:

- Require the use of non-medical masks in collection spaces when people are working together closely until all staff are fully vaccinated or public health guidelines suggest otherwise.
- Reserve collection storage rooms for object storage, placing workstations in separate, secure compartments to minimize the possible extent of contamination and limit the effects of workspace cleaning and/or disinfecting on collections.
- If alternate space is not available, locate workspaces near the entrance of collection storage rooms in order to limit the amount of traffic through the room.
- Assign worktables to single individuals, if possible, so that the workspace can be isolated rather than disinfected, should the person be diagnosed with COVID-19.
- Dedicate carts, tables or shelves in workrooms for collection objects to facilitate object isolation and reduce the need to disinfect non-heritage surfaces.
- Protect objects within storage cabinets, display cases or under temporary covers to limit touching and exposure to respiratory droplets.
- Plan collection work projects in which an individual is wholly responsible for certain objects or records to limit handling by multiple people.

The principles of physical distancing may need to be respected in order to create safe workspaces for museum staff and volunteers until the risk of COVID-19 transmission is sufficiently reduced. Much collection work can be done safely in this regard and may only require adequate spacing of workstations in shared rooms or alternating work hours in collection spaces, assuming that rooms are well ventilated. Activities that usually require people to work closely, such as the movement of large or heavy objects, the use of elevators or the transport of collections between sites, may need to be postponed or reorganized or be done wearing the appropriate PPE until enough staff are fully vaccinated. Less activity in collection spaces, including galleries when occupancy is limited to lower than normal levels, will slow dust deposition, reducing the need for housekeeping.

Though not considered the primary method of viral transmission, concerns regarding high-touch surfaces may require touch-free zones in public galleries and the careful management of collection handling by staff for the short term. This could be good news for collections, since touching and handling can cause damage. Activities involving collections used for educational purposes may need to be postponed until the infection risk declines further or more visitors are fully vaccinated since most items cannot be sanitized or disinfected safely. Frequent handwashing may be an acceptable alternative for some types of objects, but the handling of sensitive materials like photographs and metals requires gloves. If obtaining disposable gloves is problematic, cotton gloves could be used instead, assuming a safe protocol for laundering the gloves can be implemented (consult CDC guidance in Cleaning and Disinfecting your Home [PDF format]).

Collections work may be affected in surprising ways due to new practices taking place outside heritage institutions in response to COVID-19. Use of acrylic sheeting for transparent barriers in stores and businesses may make it harder to source for exhibit case vitrines and object mounts. PPE such as gloves and respirators may be difficult or more expensive to replace if they were donated to hospitals or care homes early on.

18. How do we manage the reopening of heritage interiors?

It may be challenging for historic house museums and similar heritage properties to meet public health guidelines that keep people safe while also preserving heritage materials. Since the COVID-19 virus spreads primarily from person to person, public hygiene requirements are key to preventing transmission, protecting heritage interiors and protecting visitors and staff.

- Ask that all staff and visitors wear non-medical masks while indoors (consult Health Canada information on non-medical masks), and when required, follow mandatory mask orders in your region or province.
- Provide hand sanitizer in key locations such as upon entry and exit and outside washrooms. Do not attach hand sanitizer dispensers to heritage interior finishes; consider acquiring a foot-operated or touchless dispenser. Consult question 5 on possible hand sanitizer impacts on heritage material.

One of the key elements in protecting staff and the public is to maintain physical distancing. Online ticket sales can be used to limit the number of visitors at any time, but this may not be enough in tight spaces or historic houses with one staircase providing access to upper floors. Marking floors to prevent crowding, as is being done in many institutions, is not recommended for historic floors. The following alternative solutions are required:

- Mark non-heritage floor runners to suggest visitor spacing. Runners of different types or colours can also be used to establish a single visitor path through a heritage building. Bear in mind that long-term use of certain runners is not recommended.
- Alternatively, consider adding stanchions at a distance of 2 m (6 ft.); attach directional signage.
- Attach ribbons or other fabric material at appropriate intervals on stair banisters.

- Control entry to spaces that have only one entry and exit route (for example, upper rooms in houses) to a single group at one time. If this is not feasible, consider blocking access until the contamination risk is lower.
- Integrate outdoor spaces (gardens, courtyards, etc.) into the visitor experience by providing interpretation or activities that can help pace visits while benefiting from the lower risk of transmission in outdoor settings.

Although surface transfer is not the main way the COVID-19 virus spreads, limiting the touching of heritage materials will reduce the likelihood of such transfer and protect heritage interiors at the same time. Untouched surfaces require less frequent cleaning. Thus, encouraging visitors not to touch objects is even more important during this pandemic, but it may not be enough. The need to limit the number of visitors will help as well. Here are some options that may reduce touching further:

- Keep doors open along the visitor route, where possible, to minimize touching of door handles. Ensure that doors are closed at the end of each day as a fire protection measure.
- Add or modify the placement of stanchions or other barriers to limit access to those areas that are easier to clean or to prevent visitors from leaning against or holding onto building elements.
- Rotate access to heritage spaces on a weekly schedule to give the virus time to deactivate naturally, should contamination have occurred. This might be particularly applicable to historic sites with multiple heritage buildings.
- Provide all visitors with gloves as they enter to reduce the need to clean certain heritage elements, such as banisters. If using cotton gloves, a receptacle for used gloves should be placed at the exit so that they can be laundered for reuse (consult CDC guidance in Cleaning and Disinfecting your Home [PDF format]).
- Provide virtual tours of temporarily closed areas that visitors can view on their smartphones or on home computers after their visit. Apps are available that facilitate the creation of such tours.

Disinfecting and sanitizing are inappropriate for all but sanitary areas (such as washrooms and working kitchens) in heritage buildings. Even regular cleaning of high-touch surfaces with mild detergent solutions is complicated (consult question 11 and question 15 for guidance). Normal preservation housekeeping limits cleaning at the best of times to only when necessary. Spaces are often small and/or narrow, so touching of surfaces is an ongoing problem. The measures suggested below balance the need for public health safety with heritage preservation. Each institution will have to determine what is possible at their site based on the characteristics of buildings and spaces open to the public. A phased reopening that protects difficult to clean spaces until the infection risk is very low may be appropriate.

- Review housekeeping procedures and update them to minimize viral spread (consult question 7 and question 11 for cleaning methods for non-heritage and heritage surfaces, respectively):
    - Identify high-touch surfaces and an appropriate cleaning method for each. Refer to the NPS' COVID 19 Exhibitry Cleaning Guidance: Recommendations for Cleaning and Disinfecting NPS Exhibitry to Combat Novel Coronavirus and Historic England's

guidance on Historic surfaces (in good condition and without surface defects). Modify cleaning schedules to meet public health guidelines.

- Protect heritage floors with mats at entrances and floor runners along the visitor path, favouring materials that can be cleaned daily, using a HEPA vacuum for carpets and cleaning solutions for rubber, linoleum or vinyl (consult question 7 and the CDC's guidance Cleaning and disinfecting your facility). Take care not to allow cleaning solutions to come in contact with historic flooring. Also note that the use of rubber and vinyl runners on original wood flooring for long periods of more than three months is not recommended.

Visitors who know what to expect in advance are less likely to be disappointed or concerned by the temporary measures adopted to safeguard people while protecting heritage interiors. Institutions can use social media and websites to explain hygiene and housekeeping measures, as well as any restrictions to public access. Additional signage throughout the museum can reinforce online content. The pandemic offers an opportunity to educate the public on the kind of housekeeping that is appropriate for heritage interiors.

19. How should transport and receiving of incoming collections materials be managed during a pandemic?

During institutional closure, delaying returns and extending loans will minimize risks to objects and people alike. As more institutions reopen, the transport of objects, specimens, records, library books and exhibitions will resume, but not necessarily in the same manner as before the COVID-19 pandemic. Shipping and receiving protocols will need to account for new challenges, such as limitations on international travel, which may also affect couriers, and restrictions on the number of drivers per truck. Shared development of new guidelines by cultural heritage institutions and fine art shipping companies will make the transition easier.

Though viral transmission by surface transfer is not considered the primary mechanism of spread, careful use of PPE, frequent handwashing and refraining from touching the mouth and eyes can limit the risk from contaminated surfaces. In certain contexts, when supported by public health guidelines, these measures may be sufficient and could allow for quicker processing of collection material. Where further caution is warranted, isolating incoming materials postpones handling until the virus deactivates naturally (consult question 2 for recommendations).

For crated collection objects, consider the following:

- The area from which the crate is coming and the current risk level there.
- The length of time the crates will be in transit. For example, a four-day trip will lessen the overall quarantine period. In addition, incoming crates often undergo a 24-hour acclimatization period prior to opening, further reducing the quarantine period.
- Cleaning and disinfecting (consult question 7) the crate exterior would be prudent and, if done while still closed, will prevent any solution from accidentally entering the crate interior. Clean

the metal locks and handles, along the lid edge and any other surfaces likely to be touched. Wear appropriate PPE.
- Remove and transport objects away from the crate for processing.
- Continue with handwashing protocols throughout the process as required, and wear masks when working in shared spaces, particularly in close proximity to others.

If isolation is used, develop a method for tracking when items are ready to be moved, accessed or reintegrated. The packing materials that are removed may require their own isolation period before they can be reused or safely discarded (remembering to care for human health at each stage of disposal).

20. Should our experience with the COVID-19 pandemic change how we manage collection objects and records that are regularly handled by clients and staff?

Frequently used items, like those in library, archival and study collections, may be requested and handled by multiple people in close succession, increasing the risk of viral transmission in a manner similar to frequently touched non-heritage surfaces. Client request, retrieval and return-to-storage protocols may require temporary changes to incorporate the isolation of each item between uses, since collection materials cannot be disinfected. When this is necessary, isolate items for an appropriate period of time (consult question 2) in a designated zone and post a quarantine notification. When space for quarantine is not available, return materials to their permanent storage location. Where possible, identify isolated items in collection databases and indicate the isolation period. Create labels that will accompany the items in storage. Labels should include, at a minimum, the object's unique identifier, the standard quarantine statement, as well as the start and end dates of the isolation period. The labels should be prominent and visible to all staff.

Follow conscientious hand hygiene protocols or use gloves when handling collection materials. Clean and disinfect heavily used carts regularly. If a quarantine space is used, clean and disinfect it (consult question 7) or isolate it (consult question 2) before using it for other purposes. Incorporate new or updated procedures into collections management and emergency plans and procedures.

Digitization provides safe access to collection images and information during a pandemic. The experience of the COVID-19 pandemic could provide the occasion for institutions to review, or in some cases develop, their digitization strategies and projects within the context of their mission and mandate. This is not an easy task given the limited resources, time and technical equipment available and future reformatting considerations; however, there are resources to assist in planning and prioritizing your projects such as the Canadian Heritage Information Network's publications *Capture Your Collections: A Guide for Managers Who Are Planning and Implementing Digitization Projects* and the Digital Preservation Toolkit. In Canada, review Library and Archives Canada's Documentary Heritage Communities Program to determine whether your institution is eligible for funding. There are many reasons that institutions digitize their collections. Digitization is not meant to keep the public away from your institution and viewing the collections first-hand, but rather to provide another manner

in which to engage the community both close and far afield, particularly when in-person visits are restricted during a pandemic.

Appendix: What is the data on the persistence of the COVID-19 virus on surfaces, and why are different times quoted?

As part of public health measures, people have to make personal decisions on safety about the things they touch and the disinfection of everyday items as a precaution, all to protect their health from a novel virus they cannot see. To prevent unnecessary disinfection activity, which can damage heritage objects, suspicion of contamination in mixed collections could be dealt with by a single wait time that is longer than the known range of virus stability across many materials. Hence, CCI previously suggested six to nine days might be needed at room temperature. This recommendation was based on published coronavirus stability research done prior to COVID-19, which included SARS evidence, and incorporated the similar times from SARS-CoV-2 data (notes 1 and 3 in Table 1). The research reported by the authors in note 1 indicates SARS and SARS-CoV-2 viruses are similar in stability even though they differ in epidemiology.

The REALM Project on surface persistence has filled in knowledge gaps on surface materials in libraries and archives that could be handled by staff and visitors. This work has reinforced the initial observations on a shorter length of persistence on paper and metal coupons and a longer persistence on paper materials coated with plastic or other coatings.

There are studies on different coupon substrates that show a longer time of virus activity than the REALM work at room temperatures. In addition, work with human sputum and mucus shows generally shorter times (about 24 hours to limit of detection). To reiterate, while the trends are generally clear on virus decay over time, the absolute numbers across studies and materials differ, depending on the initial concentration of the virus, stabilization effects of the matrix, the effects of surface chemistry and texture on recovery, and the assay method. How well the surface allows fine droplet residues to form, which protects the virus from degradation, significantly affects the timeline of loss of infectious capacity.

CCI is not an organization that offers health advice. We are examining the consequences of COVID-19 on collection care decisions. It is important to note that the times in the table below are not indicative of a certain loss of all virulence. They have, however, been interpreted as such in some media without sufficient explanation, so CCI feels that they must be discussed to convey greater caution within the context of collections.

The research papers on decay of infectious potential from atmospheric or disinfectant exposure publish values as “tissue culture infectious dose,” where 50% of the observed cells will be expected to die. Abbreviated to $TCID_{50}$/mL, this is a concentration term derived by serial dilution of source samples and observing cell death in monolayer test cultures at each dilution. Higher numbers (more dilution required) means more active virus particles were present in the sample. For technical

limitations to have confidence in the values, there are lower limits of what can be measured. These limits can be above some minimal infectious doses of a virus, and this quantity is not known for the COVID-19 virus. Work on the previous SARS virus with mammal species indicates the number of viruses required to cause an infection is very low, and results are still unknown when extended to consider humans. So, in brief, while the direction of safety lies some time beyond the last measurable values in published tests, be cautious and continue to use PPE and handwashing methods to protect staff until community spread is no longer a health authority concern.

Simply waiting the specified amount of time past the last potential contact with an infected individual allows for the natural death of the virus. This can save money and prevent cumulative harms to collections when compared to blanket disinfection by chemical means. There is a significant variation in time required for the virus to degrade on different materials, and there is no overall prediction model for this effect that can be based on material properties. Extrapolation away from the few tested materials and their restricted test environment is potentially perilous at this time.

The encouraging points from the research are that the COVID-19 virus has a limited time that it remains infectious and that the number of viable virus particles decay quickly. Also, as with other virus outbreaks, the potential reservoirs of viruses that might restart a local epidemic cycle are being investigated and published, and this knowledge will also improve our safety.

Table 1 describes the stability of the COVID-19 virus when it is dried on coupon materials. Important: do not use these numbers as a guide for safety. They indicate the variability and unpredictability of virus persistence as an argument for maintaining caution.

Table 1: laboratory determinations of SARS-CoV-2 stability dried on coupon materials

Coupon material with SARS-CoV-2	Initial applied titre	Initial measured titre (0 hour)	Last measured titre	Last measured (hour)	Time first undetected (hour)	Last measured (day)	Time first undetected (day)
Copper [1]	5	3.23	1.82	4	8	0.17	0.33
Copper [2]	5	–	0.00	15	–	0.63	–
Stainless steel (AISI 304) [1]	5	3.65	0.60	72	96	3.00	4.00
Stainless steel [2]	5	–	0.00	90	–	3.75	–
Stainless steel [3]	7.8	5.80	3.26	96	168	4.00	7.00
Plastic [1]	5	3.66	0.60	72	96	3.00	4.00
Plastic [2]	5	–	0.00	100	–	4.17	–

Coupon material with SARS-CoV-2	Initial applied titre	Initial measured titre (0 hour)	Last measured titre	Last measured (hour)	Time first undetected (hour)	Last measured (day)	Time first undetected (day)
Plastic [3]	7.8	5.81	2.27	96	168	4.00	7.00
Cardboard [1]	5	2.74	0.85	24	48	1.00	2.00
Cardboard [2]	5	–	0.00	52	–	2.17	–
Paper [3]	7.8	4.76	2.18	0.5	3	0.02	0.13
Tissue paper [3]	7.8	5.48	2.19	0.5	3	0.02	0.13
Wood [3]	7.8	5.66	2.07	24	48	1.00	2.00
Cloth [3]	7.8	4.84	2.07	24	48	1.00	2.00
Glass [3]	7.8	5.83	2.44	48	96	2.00	4.00
Banknote [3]	7.8	6.05	2.47	48	96	2.00	4.00
Surgical mask, inner face [3]	7.8	5.88	2.47	96	168	4.00	7.00
Surgical mask, outer face [3]	7.8	5.78	2.79	168	ND [4]	7.00	ND [4]

Notes

1

N. van Doremalen et al. "Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1." *The New England Journal of Medicine* (April 2020).

2

These values are taken from the right-hand (higher time) limit at 0 log10 $TCID_{50}$/mL (still some virus activity at no dilution) of the statistical model of stability published by the source in note 1.

3

A.W.H. Chin et al. "Stability of SARS-CoV-2 in Different Environmental Conditions." *The Lancet Microbe* 1 (April 2020).

4

An entry of “ND” means it is not determined.

Viruses are very numerous in human secretions from patients, similar in range to initial titre concentrations used in notes 1 and 3. Viral titres are reported as $\log_{10}$ $TCID_{50}$/mL. This is a unit that represents the number of tenfold serial dilutions from a virus-containing source until the resulting much diluted solution only infects half the cells cultured on the surface of a test container. This method was developed to ensure statistical robustness of the results. So after an action against the virus, be it air exposure or a disinfectant, a 3 $\log_{10}$ decrease from a value of 5 to 2 means a 1000-fold decrease in virus concentration. There is uncertainty attached to published numbers, as individual replicates vary. Because of greater variance, the authors of note 1 caution about their cardboard results. In this table, only the averaged reported value is shown.

There are distinct reasons for caution:

- **Temperature and humidity**: Temperatures tested are chosen to match routine hospital activities. Work on other viruses of similar membrane structure shows a lower temperature can prolong stability when dried or in solutions. The REALM Project has demonstrated that cool temperatures (such as 2°C–4°C) prolong persistence on book covers, plastic protective covers and foam. This is why cooler temperatures are a further reason for employing caution beyond the number of days that people are taking for increasing safety. Humidity conditions also adjust membrane-bound virus deactivation times.
- **Unrecognized differences in materials**: Words like paper and cardboard refer to engineered materials within which there is a wide variation in surfaces and fillers. Cardboard can have surface coatings that enhance wet strength and may contain polymeric printing inks. The surfaces are then possibly closer to plastics, which appear to prolong virus stability more than strict paper cardboard. The limited choice of tested materials to date is tied to common hospital surfaces and supplies since hospital intensive care units are a critical infrastructure to protect and to save lives.
- **Initial amount of contamination**: Compare the results for similar materials in notes 1 and 3. A higher initial titre results in a longer duration until the limit of detection. This concentration effect has been noted for other viruses on materials. This generates some of the confusion in the recommended time-to-wait values when they are directly quoted as a guide for safety. The initial viral titre will be unknown when a contamination event occurs.
- **Experimental design**: The data are “interval censored.” This means the time between measurements are unobserved gaps when the decay curve can cross the limit of detection without a measure of when that happens. The last measured titre and time in the table are the last values determined above the detection limit. The time when viruses become undetectable is governed by the threshold of detection and the choice of sampling interval. Therefore, undetectable is not a guarantee of no virus, although the concentration may be very low and declining.
- **Analysis**: Data requires interpretation. As an example, the values linked to note 2 in Table 1 are taken from the right-hand (higher time) limit at 0 $\log_{10}$ $TCID_{50}$/mL (still some virus activity at no dilution) of the statistical model of stability published by the source in note 1, which incorporated the variances measured in experimental results. This more confident value increases the time for approaching safety compared to the directly measured values being

quoted. The first undetected time is available from the sources in notes 1 and 3. This is a helpful approximation, but its value depends on the chosen time increment and the threshold of detection.

Virology research on the COVID-19 pathogen is exacting and hazardous, requiring highly trained people and careful experimental design. Given the current state of knowledge on SARS-CoV-2 stability, CCI has cautiously recommended waiting as a useful response to a contamination event. The isolation of contaminated collections for at least seven days at room temperature greatly lowers the virus risk, but continue to handle objects with precautions for virus hazard until after community transmission risk is lifted by health authorities.

Useful resources

Alberta Museums Association

- *Guidance for Alberta Museums during the Pandemic: Reopening and Operating Safely* (PDF format)

American Alliance of Museums

- COVID-19 resources & information for the museum field is a compilation of information for the museum sector, which includes a subsection on managing collections care during pandemics.
- *Museum Registration Methods 5th Edition*. Buck, R., and J.A. Gilmore, eds. Washington D.C.: The AAM Press, 2010.

American Industrial Hygiene Association

- *Reopening: Guidance for Museums and Collecting Institutions – Guidance Document* (PDF format)

American Society of Heating, Refrigerating and Air-Conditioning Engineers

- *ASHRAE Position Document on Infectious Aerosols* (PDF format)
- Core recommendations for reducing airborne infectious aerosol exposure (PDF format)
- Coronavirus (COVID-19) response resources from ASHRAE and others

Association of Manitoba Museums

- "Recommendations for Re-opening Your Museum" in the *AMM Messenger* (PDF format)
- Covid-19 pandemic re-opening plan: (DRAFT) addendum to Covid-19 – business continuity plan (PDF format)

BC Museums Association

- The COVID-19 web page includes a section on reopening resources.

Blue Shield Australia & Australian Institute for Conservation of Cultural Material

- *Closed by COVID-19 – checklist for GLAMs and historical and heritage sites* provides guidance for various levels of access (all hands on deck, skeleton staff and evacuation or lockdown) as well as preliminary advice for getting back to normal.

Canadian Conservation Institute

- CCI Note 1/3 *Closing a Museum for the Winter* offers guidelines for a seasonal museum closure.
- *Agent of deterioration: thieves and vandals* offers advice on museum security.
- Video of Tom Strang's presentation "Caring for Heritage Collections During the COVID-19 Pandemic: Focus on Reopening," 9 June 2020 (YouTube)
- Video of Irene Karsten's presentation "Caring for Heritage Collections During the COVID-19 Pandemic," 21 April 2020 (YouTube)
- Video or Janet Kepkiewicz's presentation as part of the National Trust for Canada's webinar "Re-opening Heritage Sites and Historic Places: Heritage Leaders Share Challenges and Solutions," 28 July 2020 (YouTube)

Canadian Heritage Information Network

- *Capture Your Collections: A Guide for Managers Who Are Planning and Implementing Digitization Projects* guides museum managers through the planning and implementation of a digitization project.
- Digital Preservation Toolkit provides resources to help cultural heritage institutions formulate policy and procedures with regards to digital preservation.

Canadian Museums Association

- Reopening resources is a collection of resources from both Canadian and non-Canadian sources pertaining to the reopening of museums during the COVID-19 pandemic.

Centers for Disease Control and Prevention

- Cleaning and disinfecting your facility provides recommendations for cleaning and disinfecting surfaces.
- *Science Brief: SARS-CoV-2 and Surface (Fomite) Transmission for Indoor Community Environments*

Collections Trust (UK)

- Collections in lockdown contains a list of resources pertaining to reopening, collections care and providing guidance for cleaning historic surfaces, among other subjects.

Commission des normes, de l'équité, de la santé et de la sécurité du travail, Quebec

- COVID-19 Toolkit includes a section on museum institutions and libraries.

Environmental Protection Agency

- About List N: disinfectants for coronavirus (COVID-19) includes guidance on contact time.

Health Canada

- Hard-surface disinfectants and hand sanitizers (COVID-19), which includes a List of disinfectants with evidence for use against COVID-19 (consult the EPA "About List N" for guidance on contact time)
- List of disinfectants with evidence for use against COVID-19 (consult the EPA "About List N" for guidance on contact time)
- Coronavirus disease (COVID-19): prevention and risks
- Cleaning and disinfecting public spaces during COVID-19
- Non-medical masks: About
- The facts about COVID-19 vaccines

ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property)

- The Heritage in times of COVID portal includes resources, links and stories of how heritage custodians and institutions around the world are navigating the pandemic.

Institute for Museum and Library Services

- COVID-19 resources for libraries and museums presents links in the museum and library worlds.

International Council of Museums

- Conservation of museum collections provides general recommendations for museums as well as targeted recommendations for storage spaces and exhibitions.

Library of Congress

- Research project "The Impact of Hand Sanitizers on Collection Materials"

Museums Association of Saskatchewan

- *Considerations When Re-Opening Museums* (PDF format)

National Center for Preservation Technology and Training

- *Cultural Resources and COVID-19*
- "Covid-19 Basics: Disinfecting Cultural Resources" presentation

National Collaborating Centre for Environmental Health (NCCEH)

- Environmental health resources for the COVID-19 pandemic
- *Fomites and the COVID-19 Pandemic: An Evidence Review on its Role in Viral Transmission*
- Webinar "Surface Cleaning and Disinfection in the Context of the COVID-19 Pandemic"

National Collaborating Centre for Infectious Diseases (NCCID)

- *Updates on COVID-19 Variants of Concern*

National Park Service

- *Museum Handbook* devotes an entire chapter to "Museum Housekeeping" (PDF format).
- COVID 19 Exhibitry Cleaning Guidance: Recommendations for Cleaning and Disinfecting NPS Exhibitry to Combat Novel Coronavirus

Reopening Archives, Libraries, and Museums (REALM) Project

- Reopening Archives, Libraries, and Museums (REALM) Project information hub for the REALM COVID-19 research project by OCLC (Online Computer Library Center), the Institute of Museum and Library Services, and Battelle. The project, launched in May 2020, collects data on surface persistence on collection materials and aggregates resources related to pandemic policies and decision making.

Smithsonian Cultural Rescue Initiative

- Collections care during a pandemic aggregates relevant links.

The National Trust (UK)

- *The National Trust Manual of Housekeeping: Care and Conservation of Collections in Historic Houses*. Wiltshire, United Kingdom: National Trust, 2011. The manual covers a wide range of conservation practices, guidelines, tools, challenges, health and safety concerns, etc., related

to the routine, scheduled care of objects and interiors (architectural surfaces, fixtures and fittings).

World Health Organization

- *Cleaning and Disinfection of Environmental Surfaces in the Context of COVID-19* offers practical recommendations in hospital and non-hospital settings.
- *Guide to Hygiene and Sanitation in Aviation* (PDF format), 3rd ed., 2009. Annex E provides guidance for cleaning public areas in airports.

Cat. No.: CH57-4/14-2021E-PDF
ISBN 978-0-660-39537-1