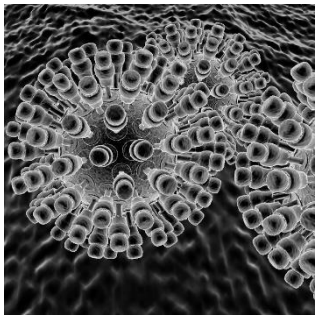
Draft Reference and Guidelines for Post Cleaning Validation of Structures Contaminated with SARS-CoV-2

Indoor Air Quality Association Australia

Incorporated in Victoria, Australia



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SARS-CoV-2 is a very dangerous coronavirus that has become infectious to humans. It has impacted physical and mental health, communication, social fabric and local as well as global businesses and economies, and has strained health systems, their workers and infrastructure throughout the world. COVID-19 has a sufficiently low mortality rate, and a silent start to infection symptoms, promoting its spread by even asymptomatic persons to our most vulnerable. Its evolution from animal hosts has led to a pandemic and a new era of global infection control. These guidelines are designed to provide information and assurance to workers, and those returning to a building to feel safer in those undertakings. I deeply thank the members of Indoor Air Quality Association Australia for their amazing contributions to the IAQ industry through these Guidelines and hope the publication is useful for the many people involved in the recovery from the COVID-19 pandemic. Claire Bird – President IAQAA.

Disclaimer

The Indoor Air Quality Association Australia (IAQAA) has independently developed this draft set of guidelines (the Guidelines) based on commonly employed infection control practices and methodologies. This Guideline is a living document, subject to continuing revision and updating based on the scientific evidence available to the authors at the time of publication. It has been created and compiled for the purpose of disseminating information free of charge and for the sole benefit of its readers.

The rapid release of scientific information into the public domain has been unprecedented from November 2019 to the time of this publication. Much of the scientific data referred to in these Guidelines are awaiting printing and sometimes pending peer review. IAQAA does not assume any liability or responsibility for recommendations based on this developing factual evidence and acknowledges that the recommendations may change on short notice as additional information becomes available to the scientific community. IAQAA is not representing these guidelines as absolute, as it is anticipated that it will be updated from time to time. It is the user's sole responsibility to ensure the accuracy, completeness, and timeliness of information used in their decision-making process.

IAQAA does not guarantee the accuracy of any of the content of this document, and does not accept any liability whatsoever arising from, or connected with factors including the reliability, accuracy, comprehensiveness, completeness or timeliness of the information within these Guidelines, or from documents which are produced based on its contents.

IAQAA recommends that users of these Guidelines exercise their own discretion, knowledge, experience, judgement, and skills in evaluating and utilising the factors contained within this document.

These Guidelines are not a substitute for professional advice, and IAQAA encourages its members and other users to seek direction in interpreting and utilizing these Guidelines.

These Guidelines are not designed to be used for assessing health risks or medical treatment alternatives.

These Guidelines focus on providing the tools for assessment of remediated structures after contamination by a COVID-19 patient(s), caused by the SARS-CoV-2 virus (Coronaviridae Study Group of the International Committee on Taxonomy of Viruses, 2020) to require a similar level of cleaning / disinfection and personal protection. It also provides guidance on cleaning of structures where no infection was reported. This is considered an important consideration as evidence indicates that some infected persons may be asymptomatic, or have not reported symptoms.

There may be a need for property owners, facility managers and others to consider undertaking a risk assessment to minimise risk of exposure to and spread of COVID-19 in their structures, whether occupied or unoccupied. The outcome, utilising a risk hierarchy of control, may involve engineering, administrative and protective systems (personal as well as in-building). These items are not within the scope of this publication.

Assessment of property risk may require services of a Consultant Hygienist or Infection Control specialist. A framework for that assessment is not included as part of these Guidelines.

This guidance is intended for validating adequate cleaning of previously contaminated structures. It does not purport to show that there is no viral particulate matter remaining in a structure, nor that remaining health risks associated with SARS-CoV-2 or other microbial contaminants or pathogens have been ameliorated.

In addition, this publication is designed to assist both employers and workers identify risks in workplace settings and to determine the appropriate control measures to implement around decontamination.

Additional guidance may be needed as COVID-19 outbreak conditions change and new information emerges. IAQAA will endeavour to update this publication as relevant evidence becomes available.

This document has been prepared by IAQAA members and associates only, and not yet reviewed by other professional bodies or Associations including the Indoor Air Quality Association (United States). We anticipate input and future drafts will be released in conjunction with other organisations in the upcoming period.

Contents

1 Introduction to the SARS-CoV-2 contamination

SARS-CoV-2 is a type of coronavirus called a β-coronavirus. Other β-coronavirus include the virus that caused Sudden Acute Respiratory Syndrome (SARS-CoV / SARS-CoV-1) in November 2002 in China and Middle East Respiratory Syndrome that broke out in Saudi Arabia in 2012. At the time of writing, the disease caused by SARS-CoV-2 (COVID-19) created a global pandemic with universal and vast impact on physical and mental wellbeing, communication, job security, social structures, global movement and travel, and home and overseas trade and economies.

These coronaviruses caused infection of the lower respiratory tract and originated in bats but were transmitted by intermediate animal hosts before infecting humans. MERS was transmitted through camels as a secondary host whilst SARS-CoV was reportedly transmitted through cats. The exact origin of SARS-CoV-2 (referred to in this document also as "the virus") remains subject to investigation but is known to have almost 80% genome similarity to SARS-CoV, and almost identical proteins.

A full introduction to the virus is provided in the Supplementary information in Section 14 of these Guidelines. We recommend referring to this section of the report as research is rapidly changing the testing options and the risk assessment profile for our occupied spaces, and changes to the Guidelines are supported in that supplementary material.

It is vital that we are confident on return to our homes, schools, shops, offices, public transport or other indoor spaces that all reasonably achievable steps have been completed to ensure our safety from infection; to do so we need to understand exposure pathways. The spread of COVID-19 infection is currently understood to stem predominantly from viral movement directly from person-to-person; however, there is increasing evidence of potential for airborne transmission. The Guideline acknowledges that this understanding may change over time, so IAQAA will update this document frequently.

There are numerous National and Jurisdiction-based Australian guidelines, notably from health departments for each Australian State and Territory. This IAQAA publication should be used in conjunction with Government advice, direction, and regulation.

We recommend referring to up to date versions of this Guideline, as research is rapidly changing the testing options and the risk assessment profile for our occupied spaces, and changes to the Guidelines are supported in that supplementary material. This can be downloaded from the IAQAA website at https://www.iaqaaustralia.org.au/downloads or requested from the Association through contact@iaqaaustralia.org.au.

2 Approach taken in this procedure

This set of draft Guidelines does not form part of a Regulatory or agreed set of Guidelines or Standards for validating successful removal and/or inactivation of the SARS-CoV-2 virus which causes the COVID-19 disease in humans. “The virus” for the purpose of this publication is deemed to be the virus known as SARS-CoV-2 at the time of writing.

This document has been prepared in response to sudden unprecedented demand across private and public sectors for advice on ensuring that structures contaminated withSARS-CoV-2 viral particulate are cleaned to a recognised acceptable standard to permit the building to be used for its intended purpose.

This document should only be used in conjunction with relevant State and Federal Guidelines and Standards and in conjunction with industry-specific recommendations for the readers’ particular occupation. It is a Guideline for showing that cleaning has been adequately conducted not that SARS-CoV-2 has been successfully removed from the surface, in accordance with the global direction of site remediation following known or suspected cases of COVID-19 (AIHA, a).

2.1. The concept of remediation of a viral contaminated building

Deeming an environment safe for re-occupancy based on verification and testing requires work protocols to be prepared, and assessment thresholds to be established above which conditions are considered to pose an unacceptable risk to human health. There are currently no such thresholds for microbial contamination of buildings, including for viruses, least of all a novel virus that emerged in recent months. Instead the focus should be on showing on a risk-based approach, the structure may be deemed suitable for its intended purpose as a place of human occupancy and work.

Showing that a surface is free of SARS-CoV-2 particles over an elected surface area would be the gold standard of environmental assessment, and while technology is rapidly developing to conduct such environmental testing, at present such technology is not widely available and requires specialist skills, and has yet to be sufficiently validated for widespread application (for more information refer to Section 14.7 of these Guidelines).

Testing should instead be considered a key part of a quality assurance procedure to demonstrate that the structure has been cleaned in accordance with recommended cleaning (work practices and cleaning agents) and disinfection (suitable for the purpose) procedures. To be effective, these practices must first remove soil using an appropriate detergent. In the case of a vulnerable coronavirus such as SARS-CoV-2, the detergent reportedly disrupts the viral envelope and by extension, begin to deactivate (kill) the virus. However, research indicates that disinfection is required to provide an acceptable level of viral deactivation.

Testing assumes that cleaning has been conducted in accordance with specific training as recommended by qualified persons and/or cognisant public health authorities, and that final disinfection will follow testing. Various trade organisations within the cleaning and disinfectant industry have also issued guidelines for cleaning and disinfection, most often based on the same recommendations.

New technologies for testing may arise in the coming weeks and months which should be assessed based on their scientific merit and the suitability of their application in reducing risks around viral contamination. More description is provided in Section 14.8 of these Guidelines.

Given the anticipated large-scale testing required, a set of easy to use and readily deployable methods both in the field and in the laboratory are needed. Testing needs to focus on providing confidence that the level of cleanliness and hygiene achieved post-remediation is sufficient to return the structure to its intended use with negligible risk to occupant health.

This guideline therefore is designed to ensure the structure or, affected area/s within that structure, have met the hygiene criteria set out for health care settings. Testing should demonstrate that an acceptable and minimal amount of microscopic material, consistent with good cleaning practice, remains on surfaces after testing. Several of the testing modalities discussed have been used in health care settings with acceptable results.

Further discussion around the modes of transmission considered in developing these Guidelines are provided in Section 14.2 which should be read to gain background in the recommended protocols set out in these Guidelines.

It must be noted that whilst maximising where possible energy-effective operation, adequate levels of mechanical or natural ventilation in buildings is vital in reducing risks from airborne exposure. This importance of ensuring that air quality is not excluded is emphasised by recently released comment by world leading figures Morawska and Cao (2020) who stress that airborne transmission of the virus is almost certain. This is further supported by preliminary research publication from Guangzhou, China (Lu *et.al.*, 2020) showing potential spread through air conditioning, and in our understanding of SARS behaviour. It is very reasonable to assume that an airborne viral exposure route is likely (and therefore should be considered under the precautionary principle).

We are advised however globally that the greatest risk of infection is encountered through person-to-person interaction and by disturbance of viral particles from surfaces, especially where those items have heavy viral loads, such as personal protective equipment (PPE) and Personal Protective Clothing (PPC) from health care workers. Toilets and plumbing systems are also a notable area of necessary attention, as there is considerable evidence of viral shedding in stools and of airborne virus in toilets.

The remediation verification approach described in this document verifies delivery of practices designed to successfully clean surfaces to a suitable level to mitigate risks from surface-borne COVID-19. The approach demonstrates that surface cleaning has been successfully achieved through a combination of visual and microscopic inspection and surface testing.

Whilst the term "buildings" is used to describe the structures being cleaned and tested, the principles and procedures may be adapted for other occupied structures such as transport vessels. Occupied structures such as aircraft, buses, cinemas and theatres are characterised as having a high occupation density (i.e. displaying a high seating to surface area or air volume ratio). Advice on cleaning of transport vessels is provided by the American Industrial Hygiene Association (AIHA, 2020b).

These structures may face specific issues such as unique air flow patterns and unsuitability for physical distancing. These differences may mean that a different sampling strategy may be required which may increase testing density. Specific testing may be required, for example around HVAC systems, where air is recirculated in high density occupied spaces. Given the wide-ranging demands globally around the use of surgical masks in public transport, stressing that a case by case basis should be considered for these environments around increased testing density and greater specificity in the sample analysis technologies is vital.

A key consideration during inspection, cleaning, disinfection, and testing is that not all occupied spaces may have had a known case of COVID-19. The role of asymptomatic spread in buildings and other indoor spaces is unknown (AIHA, 2020a) but reports using antibody testing indicate potential for significant community infection, and whilst the guidelines address this to the best of our current understanding, it is likely that the Guideline advice will change in coming months.

IAQAA intends to release a monthly update to this Draft on the first day of each month where changes are considered applicable and it has the capacity to do so with its volunteers and authors.

3 Validation of decontamination processes

3.1. The decontamination process for SARS-CoV-2

Different types of pathogens pose different challenges with decontamination. Spore forming bacteria can survive many years in a dormant state, such as anthrax (*Bacillus anthracis*), whilst others are present in biofilms which are notoriously difficult to dislodge and where standard cleaning procedures are inadequate.

These Guidelines focus on coronaviruses, including SARS-CoV-2, as these particular viruses have led to a number of outbreaks in recent years. Where a different emerging or known

pathogen is present, such as MRSA, or a more resistant virus emerges, different approaches may be required, and modifications may be needed to these Guidelines.

Outside the human body, a coronavirus is comparatively easy to disrupt and inactivate. A large number of disinfectants when applied to a cleaned surface at the appropriate concentration and when allowed to dwell for the correct contact time are effective in its inactivation: Examples of proven disinfectants include certain detergents and a range of oxidising agents. Technologies such as germicidal ultraviolet (UV) light of specific wavelengths display effective disruption of DNA and RNA and may be effective when validated to improve sanitation outcomes. Technologies vary in effectiveness, safety, cost, and detrimental surface impacts and could be considered for use, but only when endorsed by public health agencies, and supported by peer-reviewed scientific publications. It is important to check that the product being used is approved by the Therapeutic Goods Administration (TGA) for treating COVID-19 contamination.

Decontamination requires a two-step process, consisting of cleaning followed by disinfection.

In the case of very recent contamination (for example in the previous 72 hours), disinfection may be required prior to cleaning for the safety of workers as the virus has potential to remain viable on a range of surfaces. However, care must be taken as the risk from particle resuspension will be increased when people are moving around and generating air movement during the disinfection process.

Evidence suggests that disinfection is critical in the decontamination process and should usually follow cleaning. Organic debris on the surface may prevent disinfectant working effectively. It is therefore important to show that the surface is clean before disinfecting to avoid organic material interfering with successful treatment (Cremieux *et.al.,* 1991). Therefore, testing prior to disinfection to show residues have been removed is recommended.

The CDC defines separately the role of “cleaning” and of “disinfecting”. It is possible to do one without the other; however, both steps are recommended (Australian Government, 2020).

CDC, 2019a uses the following definitions:

- *Cleaning refers to the removal of dirt and impurities, including germs, from surfaces. Cleaning alone does not kill germs. But by removing the germs, it decreases their number and therefore any risk of spreading infection.*
- *Disinfecting works by using chemicals to kill germs on surfaces. This process does not necessarily clean dirty surfaces or remove germs. But killing germs remaining on a surface after cleaning further reduces any risk of spreading infection.*

Ventilation should be optimised, with a pre-determined number of air changes agreed with the mechanical services operator or based on openable windows that would effectively flush the air in the building fully prior to the entry by cleaning staff or other persons. General advice on

operating air conditioning to minimise risks in buildings is provided by the Federation of European Heating, Ventilation and Air Conditioning Associations guidance document (REHVA, 2020).

When entering the building to set up the ventilation, P100 respiratory protection would be advised to protect the person activating the ventilation.

3.2. Overview of testing methods for successful cleaning

A recent review by Kampf *et.al.,* 2020 indicated that coronaviruses could survive up to 9 days on inanimate surfaces but were deactivated in the order of a minute by employing the correct disinfectant.

The SARS-CoV-2 virus rarely presents in the environment as pure virus, instead being primarily carried in oral or nasal secretions that are expressed by an infected carrier upon sneezing, coughing, exhalation of defaecating. Once these secretions land on a surface, the virus is contained within cells or fluids including the normal array of proteinaceous and carbohydrate materials. These biological fluids are rich sources of cellular forms including human cells and oral bacteria. The challenge for cleaning is therefore to remove all these materials as part of a cleaning process.

Whilst visual inspection and wiping surfaces to ensure dust has been removed visually is critical for showing gross cleaning has been successful, the *South Australia Cleaning Standards for South Australian Healthcare Facilities* (S.A. Health, 2017) states:

"The use of the "white-glove technique" (c.f.) may (also) be used to assess the presence of dust. It is should be noted that micro-organisms are invisible to the naked eye so although a surface may appear clean it may not necessarily be the case."

It was therefore considered essential that validation of cleaning where microbial surface material is of concern requires a more detailed method of assessment than visual inspection alone.

3.3. Testing for biological surface material (bioburden)

The use of Adenosine Triphosphate (ATP) for hygiene status assessment is commonplace and is recommended under this Guideline as an indicator of residual contamination of biological origin remaining on a surface. Use of ATP for this purpose has also been recommended by trade organisations such as the Institute of Inspection, Cleaning and Restoration Certification (IICRC) and the Restoration Industry Association (RIA) in their COVID-19 restoration document released on 19 March 2020 (IICRC/RIA, 2020). Using ATP as a marker for biological materials seems logical and reasonable.

ATP was shown to be suitable as a test for Hospital cleaning practices for high touch areas (for example Boyce *et. al.,* 2009). ATP testing is required for cleaning efficacy validation under the

Danish Standard EN/DS2451-14:10E *Infection Control in the Health Care Sector - Part 10 - Requirements for Cleaning* - 2014 (Dansk Standardiseringsrad (DS) (2014))[1]. Under the Danish Standard, areas are defined as having a Hygiene status defined by their risk to occupants, ranging from Level 1 to Level 5. Level 5 is designed to eliminate / minimise risk of spread of infection whilst Level 3 to 4 is designed to reduce risks.

On general surfaces where an infected person has been present, or on high touch point surfaces in structures without a reported infection but a risk of asymptomatic infection shedding, Level 5 may be deemed a suitable target for cleaning. Level 3 to 4 is likely more applicable to those areas of a building where asymptomatic infection may have been present but risk from exposure is low such as in general use areas. High touch point locations used by an infected person with an emerging disease with unqualified risks, such as COVID-19, may constitute the need for the Precautionary Principle to be applied and further reduce cleaning thresholds for those items or areas.

The CDC discusses the use of ATP for assessing cleaning potential, where it states that pre- and post-cleaning measurement may be used to show cleaning effectiveness (Guh and Carling, 2010) and that ATP is an acceptable method for cleaning effectiveness assessment.

IAQAA supports the use of ATP as one possible method for determining the effectiveness of cleaning, provided consideration is given to the limitations of that technology.

ATP does not test for virus, and it is important that this consideration be recognised.

Research conducted by Sifuentes *et.al.,* (2016) showed that the reduction in MS2 (non-pathogenic *Escherichia coli* bacteriophage) viral concentration on surfaces post-cleaning correlated well with reduction in ATP outputs using a digital luminometer and luciferase enzyme reaction in an onsite test tube. Further, airborne bacterial concentration on plate count agar, and particle count in the droplet nuclei size range (5-10 µm aerodynamic diameter) fell during cleaning with the decline correlating with reductions in ATP on surfaces (Casini *et.al.*, 2018). Cleaning had a much smaller positive impact on aerosol sized particulate matter of the size identified as being a dominant particle size fraction for SARS-Co-2 in hospitals by Y. Liu *et.al.* (2020).

Proper cleaning is required prior to disinfection, and ATP can assist in some, but not all circumstances in determining if proper cleaning has been achieved. Use of ATP as a cleaning metric should be conducted by knowledgeable and experienced persons familiar with the strengths and limitations of the method; IAQAA does not provide a blanket endorsement of ATP as a cleaning metric, particularly by persons absent in appropriate training. ATP thresholds have

[1] Danish Standard EN/DS2451-14:10E *Infection Control in the Health Care Sector - Part 10 - Requirements for Cleaning* - 2014.

been set in this document based on those recommended by manufacturers and on Standard of Care documents for cleaning practices where microbial decontamination is included.

There is widespread Government recommendation that bleach (*i.e.* sodium hypochlorite) be used as an option for disinfection. Bleach and some other disinfectants listed by the US EPA for emerging diseases, and the TGA may interfere with the ATP test, therefore IAQAA has followed the guidance of manufacturers and recommends testing *prior* to disinfection. Where this is not possible, ATP readings should not be utilised, and alternative methodology for quality assurance should be selected.

ATP, whilst providing readings that measure hygiene status of the surface in a matter of seconds, requires careful application to avoid poor reliability and to ensure good reproducibility of test results. ATP measurement is known to be unreliable unless sufficient replicate samples are collected (Whiteley, 2016). Chlorinated disinfectants in particular are rapidly used up by any organic debris on a surface.

These Guidelines therefore direct the user toward methods that prevent underestimating the cleaning effectiveness of a structure.

3.4. Inspecting and testing the surface for surface debris

Prior to conducting tests for debris that may be present at microscopic level, it is prudent to examine surfaces for visible evidence of soil. Where this is present, re-cleaning should precede ATP or other surface testing.

3.4.1. Debris observable at the visual scale

If cleaning has progressed satisfactorily, minimal debris should be visible during visual inspection including with the use of the "white-glove" technique or torch to shine an oblique light across the surface (Section 3.3.1).

The surface however should also be clean at a microscopic level.

Therefore, surface measurements designed to detect debris at microscopic level is required.

3.4.2. Microscopic level cleaning effectiveness testing

Adenosine triphosphate (ATP) is found in all living cells. Its measurement allows detection of organic material based on the chemical composition of the debris. However, it does not correlate directly to the extent of soil on the surface. To examine the presence of microscopic soil on surfaces it is necessary to examine the extent of surface debris based on physical transfer of debris from the surface to allow its observation under the field of view of a microscope.

Microscopic surface debris may be physically lifted from the surface using a vacuum onto a filter using methods outlined in ASTM D5755[2] or onto an adhesive tape using tape lift technology in accordance with ASTM D7910:14[3] and examined under a microscope at 400x magnification.

3.4.3. Debris observable at the microscopic scale

As part of validation, alongside successful visual inspection and ATP testing, it is necessary to show that ATP has not missed areas where debris which may contain the virus is persisting. To validate the effectiveness of the ATP swabbing, surface debris samples should be collected.

Only success at this step shows that general environmental particulate matter has been removed at microscopic level. This additional step allows close scrutiny of surface conditions at 400x magnification using standard methods designed to assess such debris. However, given that ATP provides an on-the-spot reading it remains a valuable assessment tool for the extent of surface microbial debris.

Surface debris can provide useful information on the broadscale deposition of environmental particulate matter as well as identify the presence of human-related dander such as skin and hair and therefore possible human contamination. Given debris (as suspended dust) is continually settling out of the air, the surface density of debris indicates the general cleanliness of the surface and allows confirmation that disinfection will likely be successful.

While ATP testing can give false negative results, surface debris samples examined by visual microscopy, when samples are properly taken and analysed, will not give false negative results. The debris method is more prone to false positive results where the person handling the sample has cross-contaminated the sample from a contaminated location, therefore the correct handling process is critical when dealing with low acceptable levels of debris.

Given that the tolerance level for surface debris is low (less than 1%), to avoid false positive results, the correct handling process is critical when collecting and handling samples.

Microscopic surface debris may be physically lifted from the surface to place directly under a microscope by using a vacuum to collect dust onto a filter or lifted from the surface using adhesive tape.

[2] ASTM-D5755:09(2014)e1 - *Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading.*

[3] ASTM D7910:14- *Standard Practice for Collection of Fungal Material from Surfaces by Tape Lift.*

4 Transmission of COVID-19

4.1. Airborne infectivity

Viruses are released into the air attached to, or contained within particles when an infected person coughs, sneezes, talks and breathes. Evidence indicates that infected persons can start shedding viral particles in this manner before symptoms arise, therefore breathing may be a source of the virus, as it is with influenza.

At the time of publication, no research was available showing that airborne, infective SARS-CoV-2 had been successfully recovered from an air sample in a clinical setting.

Furthermore, at the time of publication, the surface or airborne exposure dose required to elicit infection had not been established. It is reasonable to assume however that minimising airborne viral load will provide optimal risk reduction against exposure to viral aerosols in relation to human health. Therefore, in the absence of a reliable testing method, knowledge of the infective dose, and the knowledge of survival rates in air of SARS-CoV-2 of up to 3 hours under ideal conditions, RNA findings (traces of the viral genetic material found in air in several studies) must be taken to indicate possible airborne transmission risk for SARS-CoV-2. This suggests that respiratory protection of workers in a structure during cleaning and disinfection is paramount.

Risk mitigation measures such as the use of PPE, ventilation and ensuring viral-laden air is not migrating through the plumbing or air conditioning system should be included as part of the project risk assessment. Further, faecal-borne viruses have potential to become airborne during toilet flushing and passing stools, so this route should be considered during risk assessments.

At the time of publication, criteria around airborne or surface concentrations of viral particulate matter are not established; therefore, the focus of post-remediation validation of SARS-CoV-2 is on surface cleaning as the first line of defence (Australian Government, 2020, CDC, 2020a).

4.2. Surface transmission

Once airborne viral particulate matter is released from the body it deposits onto surfaces (Y. Liu *et. al.*, 2020) or is picked up on PPE / PPC of medical staff. These deposits are termed fomites.

Droplet nuclei will settle out of air onto surfaces as fomites at sufficiently high concentrations to generate a high surface load. Touching those surfaces and then touching the face, nose, or mouth can result in exposure. The survival success of SARS-CoV-2 on surfaces depends on the type of surface, temperature, and humidity. Relative Humidities up to 50% and at again very high levels from around 95% are likely to promote growth. Notwithstanding the above the virus has been shown to remain active for several days, notably on steel, hard plastic, and paper-based products (van Doremalen *et.al.*, 2020).

There is some evidence of lasting viral activity on steel (found in air conditioning systems), hard plastic and cardboard surfaces (van Doremalen *et.al.*, 2020) (Figure 1).

The study by van Doremalen *et.al.,* (2020) showed that there is potential for SARS-CoV-2 to remain viable on plastic for up to three days (72 hours). At the time of preparation of these guidelines is it unclear how relative humidity and temperature impacts viral activity, and therefore any measures taken to control it using climate control may be tenuous.

At the time of publication, we do not know what the lowest harmful concentration is on a surface, so achieving a "safe concentration of virus" if we knew the starting concentration based its decay rate over a given time on a particular surface is not possible.

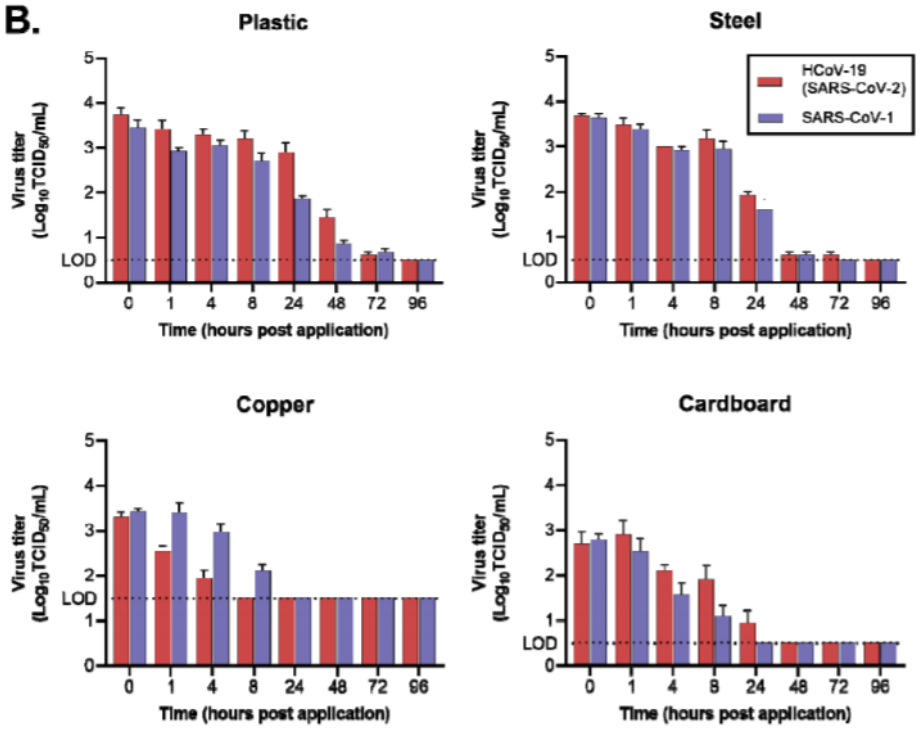

Figure 1: Variability of SARS-CoV-1 and SARS-CoV-2 (HCoV-19) on different surfaces – from van Doremalen *et. al.*, 2020.

Caution is required if entering the building in the first 72 hours post-vacation of an infected person/s. Delaying entry for a period of at least four days, and preferably longer is therefore an important risk management and project operation cost reduction tool.

Where no infections were reported, no time delay is required from vacation of the building prior to entry.

Full air flush of the building remains a recommendation prior to entry without full personal protection even after this time. In tropical climates where relative humidity is typically above 65% for prolonged periods the rate of air flushing should be carefully considered so as to avoid unnecessarily increasing potential for internal condensation which may aid microbial growth.

On entry after the time delay, appropriate personal protection, reduction in debris resuspension, and ventilation will remain the governing factor to facilitate safe work.

The following control over indoor air quality is therefore recommended by IAQAA based on advice given by the U.K. Government (Public Health England, 2020):

- **Avoid entry to a building if possible after the infectious person has been removed for at least 72 hours. The longer the building can be left prior to entry the safer it will be.**
- **Ventilate the building well for several hours prior to entry. IAQAA recommends operating mechanically ventilated air intakes on maximum fresh air where possible for this duration, and opening windows and doors wherever possible to naturally ventilate the space before cleaning or testing begins. The building should be fully flushed prior to the start of works.**

Similar recommendations were made by the Singapore National Environment Agency (2020a, 2020b, 2020c).

4.3. Risks from inactive virus

It is important to note that there are no known health effects from exposure to a viral particle that is no longer "viable" or "active", meaning when it is no longer capable of causing an infection. This is different to other microbial contaminants (bacteria and fungi / mould) whose cell walls and fragments can contain a range of inflammatory compounds and/or allergenic / asthmatogenic agents which remain even after the organism has lost viability. Therefore, disinfection remains a vital step after cleaning.

Decontamination of a building after a viral contamination event is therefore not identical to that used for other microbial contaminants where source removal is the focus of risk management.

5 Project documentation

It is vital that the history of known infection cases is documented. Where no cases were reported, understanding the risk areas of the structure from asymptomatic individuals is important.

5.1. No reported cases of COVID-19

Where there is no recorded case of infection, it is reasonable to consider the possibility that there may have been an asymptomatic person present. Depending on the number of known and expected cases in a given geographical region, a risk assessment can be made to determine the significance of this risk. At the time of publication in Australia, the risk would be considered low. However, this may change as new information becomes available.

Research using a small pilot study in Santa Clara (US) is providing early indication that the extent of unreported infection from asymptomatic people or those with mild symptoms are many times greater than anticipated (Bendavid *et.al.,* 2020). Testing for antibodies in New York State in the US has identified that potentially around 24.7% of City occupants are positive for the antibody[4]. This suggests that either the virus is highly airborne but with a lower mortality rate resulting in lower rates of medical care and of hospitalisation, or that the antibody test (which are often prone to false positive readings) are highly inaccurate. In either situation, it seems likely that there are a significant number of individuals who may have been infected or continue to carry the virus. Given the passage of combined sewers that collect both sewage and rainwater in the streets of New York City, this may at least present a possible exposure route however this has not been reported.

A very recent publication further confirms the potential spread of the virus through sewerage plumbing systems (Gormley *et.al.* 2020) with tracing RNA signatures in sewerage networks being the tool of choice for tracking COVID-19 spread (CSIRO, 2020).

Therefore, this version of the Guidelines assumes that high-touch-point areas in all buildings have at least a low risk of contamination with potential of harm based on fomite and faecal contamination spread, and therefore require cleaning of these items to the level that is higher than that normally required during a routine clean. For this reason, the Guidelines assume any high touch areas and Toilets are treated as Hygiene Level 5: under the Danish Standards EN/DS2451-14:10E Hygiene Level 5 surfaces that require microbial risk reduction in relation to infection control are classed as Hygiene Level 5.

5.2. Reported case/s of COVID-19

Previous epidemiological studies have proved that there are three occupant and structure related conditions for widespread growth of viruses, being:

- The source of infection.
- The route of transmission.
- The susceptibility of the infected person.

It is vital to document information around each of these three key factors following an outbreak of one or more cases of COVID-19 in an occupied structure or building.

[4] CBSN New York News (2020*) Coronavirus Antibodies Present in Nearly 25% Of All NYC Residents, Cuomo Says; Un-PAUSE in Certain Regions of NY Might Begin In May*. Reported by CBSN New York News, April 27, 2020 at 11:30 pm. Accessed at:

https://newyork.cbslocal.com/2020/04/27/coronavirus-antibodies-present-in-nearly-25-of-all-nyc-residents/ on 29 April 2020.

5.3. Recording infected person/persons movements and activities

It is critical that full documentation is made of an infected person's activities leading up to and upon developing symptoms. Further, if the source of infection is believed to be a person or asset within the structure this should be recorded.

It is important to document items in the infected person's work area and items with which they are in contact.

Obtaining information on an infected person's typical movements around the building during their work shift is important. Given the recommended physical distance of 2 metres, knowledge of a person's movements can help delineate the highest risk areas for cleaning and disinfection.

Meetings, use of lunchrooms, bathrooms, kitchens, and interaction with others that may then have carried the virus to separate work areas are important to understand.

Recording the toilet facilities used is also recommended.

Given that the focus of the testing is around surfaces it is vital to understand which surfaces may be impacted to show that they have been successfully cleaned and disinfected.

Where no COVID-19 cases have been recorded in the building, it may not be possible to rule out the possibility of asymptomatic COVID-19 infected people. In this case high-touch-point areas used by multiple individuals should be listed. Such locations may include:

- common seating areas,
- meeting areas / meeting rooms, and the desks of those who shared the meeting, and their immediate work areas and objects they use,
- shared computers, printers, machinery, plant equipment,
- shared phones, light / fan switches, rails, and handles,
- items handled to complete tasks, such as EFTPOS machines, cash registers, tools, utensils, uniforms and PPE,
- common areas or items used,
- elevators, stairwells, and escalators,
- vehicles, and those who shared the vehicle or used it after the infected person, and
- high touch points in the building such as door handles, light switches, desks, computer keypads, EFTPOS machines, cash registers and utensils, etc.

5.4. Recording specific at-risk areas and items

Items or areas handled by an infected person who frequently handles shared items with visitors or customers pose increased risk of viral spread through cross-contamination e.g. from a shop

assistant or receptionist. The customer or visitor may have spread the virus onto numerous surfaces, e.g. the receptionist or cashier may shed the virus and it may get picked up by a large number of people and deposited on door handles etc. Such items or areas require documenting as high-risk high touch point items.

5.5. Documenting potential routes of contamination

In the event that there has been a reported case or multiple cases of infection, documenting the main and potential exposure routes is important in deciding where to clean and where to test. Selecting the items to treat as contaminated may include consideration of several factors:

- Pathways of transmission need to be noted or mapped, for example air pathways through the building, including a copy of mechanical services plans showing the path of air during mechanical handling from the locale of the person's desk. Air from their main work area, toilets, showers or changing areas should be considered as SARS-CoV-2 may be shed from clothing, PPE, or faeces.
- Special notice may be made of potential for the faecal/oral route of transmission as work by Y. Liu *et.al* and Ong *et.al*. respectively showed evidence of airborne and surface viral loading in toilets, and at high touch points associated with their use.
- Potentially impacted surfaces should be recorded, including personal equipment and effects around the person's work area.
- A list of people who came into contact with the infected person should be held. We anticipate that list preparation is not the role of the consulting Hygienist, however it is important to ensure that such a register is in place.
- The name of all staff or stakeholders entering the site should be stored along with the time of their arrival and departure. A simple sign-in sheet may be used by the consulting hygienist or site supervisor.
- A record should be taken of any hazardous material registers pertaining to the site.

5.6. Recording risk profiles of occupants

Special considerations may be required for the most sensitive groups of people. Testing in the vicinity of those sensitive individuals may require increased sampling density of their workspace, home, or items they handle. Higher levels of quality control may be needed to ensure their safe return or ongoing use of the space they occupy. High-risk and vulnerable individuals include those who:

- Are aged over 65 years.
- Suffer from one or more of the following:
    - Coronary heart disease.

- Hypertension.
- Diabetes.
- Take ACE 2 inhibitor medication.
- Compromised immunity.
- Other pre-existing health conditions, particularly when more than one of the above listed or other conditions is present.

5.7. Cleaning history

The person assessing the site (Section 6) must ensure that they have access to full documentation provided by the cleaning and disinfection contractor. It will be the role of the Assessor to define the scope of works and set the criteria for site validation after works.

Necessary documents include not exhaustively, the following:

- Safety data sheets (SDSs) for products used.
- Documents showing that the cleaning and disinfection process is reasonably expected to leave insignificant risk of exposure to surface microbial particulate matter.
- Safe Work Method Statements (SWMS) for procedures followed.
- A written Remedial Action (and Safety) Plan (RA(S)P) that includes reference to waste management, a list of affected areas to be treated, and reference to the clean-up targets recommended in this document.
- Soft furnishing and hard surface cleaning protocol and documentation.
- Dates that cleaning and disinfection took place.
- Frequency of both targeted and maintenance cleaning from when the person was believed to have become infective.

Cleaning and disinfection should have been completed to a level where subsequent clearance testing can reasonably assure that the site is free of microbial particulate matter at the end point of cleaning. To have achieved an even higher level of safety, the site will need to have been effectively disinfected to ensure maximum impact on viral debris. Detailed below are the key items that can be reviewed to confirm that this has been done, prior to entering the site for testing.

Given that the virus is largely inactive on most surfaces after 72 hours (Public Health England, 2020, van Doremalen *et.al.*, 2020), it is critical to establish at the outset of the project the date when the infected person/s vacated the site. However longer periods of activity on some surfaces of up to 9 days have been noted (van Dorelamen *et.al.,* 2020). The duration since their

departure may have a significant impact on the level and nature of worker protection and the cleaning/ disinfection process that is required.

Cleaning methods should be validated to ensure that the methods themselves do not act as a mechanism of viral spread. Use of single use cloths and employing aseptic technique is strongly encouraged. The preferred method as outlined in peer review literature is to use each cloth once, on only one surface, whilst wiping only in one direction (Ramm *et.al.*, 2015). It should be noted that reusable microfibre and other cloths have been shown to both collect and then disseminate virus particles when used poorly (Gibson *et.al.*, 2012). Other cloths may be a better choice. The importance of the correct cleaning method is emphasised by Leas *et.al.,* 2017 in their article on environmental cleaning in Healthcare settings.

The Singapore Government provides links to Cleaning and Decontamination procedures for a range of situations, such as transient people, non-healthcare settings and residential settings (National Environment Agency, 2020a, 2020b, 2020c).

5.8. Standard operating procedure/s documentation

Standard Operating Procedure documents should be available for review and should be of an acceptable level to the assessor and consistent with recommendations of State and Local Government recommendations and requirements, the World Health Organisation (WHO) and the CDC.

Trade organisations such as the IICRC (Institute of Inspection, Cleaning and Restoration Certification) and RIA (Restoration Industry Association) have also provided standard operating procedures consistent with recommendations of cognisant authorities for their stakeholders.

At the time of publication, no new anti-SARS-CoV-2 surface disinfectants were to be processed by the US EPA, and for which new efficacy tests were required. Applications were to be limited to updates on claims around substances already listed under the *Emerging Viral Pathogen Claims for SARS-CoV-2: Submission Information for Registrants* [5].

A list of approved products in the US for disinfecting surfaces are set out under the US EPA *List N*: *Disinfectants for Use Against SARS-CoV-2*[6]. This list may be referred to when examining a product proposed for disinfection, however the US EPA is not the Regulator for Australia.

The suitability of the products used for decontamination may not be acceptable for use in Australia and preferentially included in the US EPA N-list.

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[5] Accessed at: https://www.epa.gov/pesticide-registration/emerging-viral-pathogen-claims-sars-cov-2-submission-information-registrants on 28 April 2020.

[6] Accessed at: https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2 on 28 April 2020.

Products should be approved by the TGA for inactivation of SARS-CoV-2.

Recent research however has indicated that care must be taken in deciding the correct choice of product. Work by Becker *et.al.*, 2019 showed that the use of wipes containing quaternary ammonium compounds and isopropanol were less effective than those containing per acetic acid for norovirus, adenovirus, and polyomavirus surrogates.

The choice of cleaning cloths may also be important, as not all are equal in their ability to remove viruses without spreading them across the surface (Gibson *et.al.,* 2012).

Notification that the TGA is fast-tracking approval of disinfectants by approving use of surrogates for SARS-CoV-2 (namely Coronavirus 229E and Murine Coronavirus) was released on 20 March 2020 to speed up the process of approving suitable products (TGA, 2020 a). These products and more details may be found on the TGA website (TGA, 2020b).

Safety documentation must comprise as a minimum:

- Safe Work Method Statement or SWMS, and Job Safety Analysis for specific site issues.
- Process and steps of cleaning and waste management (in accordance with WMRR, 2020) including details of:
    - The Personal Protective Equipment (PPE)/Personal Protective Clothing (PPC) to be used during works.
    - Gowning/gloving/mask/eye protection/chemical protection procedures.
    - Safe entry and exit procedures.
    - Sequential order of donning and doffing of PPE/PPC.
    - Cleaning/disinfection steps and coverage plan of the site to be treated.
    - Disinfection cleaning plan and procedures including critical touch points, surfaces, benches (follow DHHS or similar guidelines).
    - Disinfection (surface application, fogging or other – following manufacturer's recommendations, concentrations, applications, and exposure times).
    - Testing for efficacy after elapsed exposure time.
    - Exit process, doffing of PPC/PPE and safe disposal methods (Clinical/Biohazardous waste as per WMAA BMI Clinical Waste Guidelines, and following State and Territory requirements / guidelines for Clinical waste).

5.9. Safe Work Procedures

Safe work procedure should include the following as a minimum:

- SWMS that have been reviewed and signed prior to commencement, with special attention paid to the novel risks of viral contamination, higher level PPE usage and the use of specialty chemicals or equipment,
- appropriate decontamination procedures for remediation contractors,
- safety precautions including PPE/PPC and other controls. The cleaning and disinfection personnel will have to assume the site has active biological contamination on surfaces, and
- We recommend documentation of toolbox meetings with personnel.

Within health care, according to the Australian Government, "…*disinfection cleaning is a complete and enhanced cleaning procedure that decontaminates an area following discharge or transfer of a patient with an infectious/communicable disease, sometimes also referred to as an 'infectious clean*'".

The Federal Government sets out its recommended procedures for disinfection (Australian Government, 2020). Reference should also be made to the IICRC/RIA cleaning procedures and other trade organisation recommendations.

Federal and State guidelines for safe work should be complied with in all procedures and practices.

Provisions should be made to ensure that personnel are aware of the risks of the potential contamination and chemicals detailed in the SWMS and work procedures.

5.10. Personal protection

Given the nature of a surface and possible air contamination by COVID-19 and other pathogens, the following minimum PPE is critical to be fitted BEFORE a worker enters the site for cleaning/disinfection duties. Similarly, responsible disposal of the contaminated PPE must be conducted on exiting the contamination area.

- Respiratory protection to P2, Particulate 2 rated, (or N-95 equivalent) levels or above, single-use or reusable respiratory protection device (RPD). Where reusable devices are to be used, they should not be shared and filters should be changed regularly[7].

[7] Where it is not possible to obtain RPD due to critical shortages, reference should be made to the CDC recommendations on elastometric respirators (CDC, 2020d). Note should be made however that sharing of masks should only be considered as a last resort when no other N95 protection is available, and that qualitative fit testing should be a minimum requirement.

- Users of RPD should be fit tested as per Australian Standard AS/NZS 1715:2009 to ensure the wearer achieves adequate facial seal[8]. Ideally fit testing should be quantitative. Qualitative fit testing is acceptable under AS/NZS 1715:2009 although it does not achieve the same level of confidence in facial seal as the quantitative method.
- Wearers of RPD should only wear RPD they are fit tested for, i.e. the specific manufacturer, model number, and size as one size / model often does not fit everybody.
- Wearers of RPD should be trained in the use, care and handling of RPD and in particular the limitations of RPD in relation to facial fit and issues such as facial hair and personal adornment.
- Eye protection to Australian standards compliance.
- Where airborne contamination is expected to be present, we recommend moving to N-100 filtration, and if possible, using full-face RPD to minimise exposure pathway via eye contact. This would apply for example where a person is entering a building for the first time to ventilate it, or going onto a confined space or space with limited ventilation (semi-confined) where resuspension risk is high e.g. a toilet or Changing Room, or in a Clinical setting or Mortuary.
- Full coverage Type 5 or 6 coverall suits with hoods and shoe covers, ideally single use breathable disposable suits, with splash protection where appropriate based on work activities. Fully encapsulating non-breathable suits are not recommended due to heat stress concerns.
- In the event that disposable coveralls become unavailable due to supply restrictions, it will be necessary for IAQAA to make recommendations around laundering.
- The use of a contained decontamination area with negative air pressure and a HEPA filter for doffing of PPE could be considered as part of the risk management process. Removal of PPE poses a significant risk, as it has been shown to generate potential airborne SARS-CoV-2. Given that some particulate will still pass through or around coveralls, clothing under the coverall may be removed and laundered at the highest recommended temperature setting as detergent is known to deactivate the virus.
- A sufficient amount of an alcohol-based hand rub (>65% ethanol or isopropanol, per acetic acid or similar) should be available prior to donning PPE and for use immediately following doffing of PPE to avoid contamination by the hands on the face, nose or eyes.

[8] We note that the IICRC/RIA have also employed this methodology for people decontaminating the buildings.

- Special care must be taken when using toilet facilities as these have been shown to become contaminated possibly from faecal matter (Ong *et.al.*, 2020; Y. Liu *et.al.*, 2020). Hands could be sanitised prior to handling clothing, and the toilet flushed with the lid down to reduce transmission on clothing and in air.

If single use PPE is not utilised, the decontamination process for the item must be documented and appropriate steps must be taken to decontaminate the PPE (ideally on site), including safe transportation and containment off site between uses or at the end of the project.

For a cleaning and restoration industry perspective on these issues, reference may be made to the most recent advisories from IICRC/RIA *Preliminary report for restoration contractors assisting clients with COVID-19 concerns* and other suitable restoration or cleaning industry documents.

5.11. Exposure risk management

The risk of exposure to SARS-CoV-2 is linked to exposure through:

- Inhalation, and/or
- surface contact with subsequent transfer to mouth, nose, or eyes.

To manage inhalation risk prior to the start of cleaning works, it is imperative that the building is well-ventilated for a sufficient period of time to ensure appropriate air exchange that will dilute any airborne particulate. If a person is required to enter the building to set it up for ventilation, that person will require the correct level of PPE depending on the risk of airborne virus being present and viable. This should be considered as part of the risk assessment process based on the density of cases, the time since no infected people were present and other factors.

Resuspension of surface viral particles (bioaerosols) is a known risk for inhalation exposure. 90% of the microorganisms in indoor air are released by moving around a building. Therefore, even in the absence of specific cleaning activities, the potential for inhalation exposure exists.

Bahl *et.al.,* (2020 in press) provided a recent literature review on airborne transmission of COVID-19 in relation to the use of PPE. The paper notes that many studies on horizontal transport of droplets indicate that 2 metres separation is likely inadequate to prevent exposure by inhalation from an infected person. The 1 metre rule has stemmed from a very basic study in 1942 by Jennison whose methods were not adequate to show how far aerosols may travel from an infected person. It is prudent to use at least N95 RPD when cleaning areas that may be contaminated with SARS-CoV-2, such as areas where known infections have been present or in toilets and bathrooms, and masks when cleaning areas where contamination is less likely.

The use of vacuum cleaners including HEPA vacuums may require reconsideration as they have been shown to aerosolise bacteria and therefore viruses which are much smaller could be

released during vacuuming (Veillette *et. al.*, 2013). Vacuuming, unlike hot water extraction, does not offer the option of using detergent to inactivate the virus in the material being cleaned.

The IICRC S300 *Standard and Reference Guide for Professional Upholstery Cleaning*[9] (2000) refers to the use of hot water extraction as a suitable method for cleaning upholstery.

The use of hot water extraction with a suitable detergent will likely deactivate SARS-CoV-2. Although the detergent will have minimal contact time with the virus as it is being aerosolised, the increased temperature will enhance its ability to emulsify the viral envelope lipids.

Portable hot water extraction cleaners will still generate an aerosol within the space; however, the heat would be expected to inactivate the virus.

Truck mount hot water extraction systems provide high levels of heat that would be expected to inactivate SARS-CoV-2 whilst potentially venting particulate matter to the outdoor air. Where possible, truck mount hot water extraction cleaners could be considered as the lowest risk option for remediation of contaminated upholstery. In addition, the temperature of the detergent solution at the wand should be optimised for using the maximum temperature for the type of material being cleaned so as to affect greatest cleaning and disinfection capability.

5.11.1. Chemical safety assessment

Safety Data Sheets (SDS's) should be compiled for each decontamination project. SDS's should be reviewed by a suitably qualified person (such as a consulting hygienist, chemist, or toxicologist) for the effectiveness and appropriateness of the chemicals used in the site decontamination. Chemicals utilised may be broadly classified into cleaning agents and disinfection chemicals. Health risks should be assessed around their use, and recommendations recorded for correct PPE. Where the chemical in use is part of an overall cleaning or decontamination process, the overall process should be assessed to show that any risks associated with the chemical of concern are ameliorated.

Under each category the following documents should be readily accessible within an identifiable, and local or remote storage location:

- **Cleaning agents**: Evidence of appropriate commercial cleaning agents such as detergents / antibacterial agents. SDS's of these materials and proof / records showing they were used at recommended dilutions/concentrations should be available for review.
- **Disinfecting/Sterilising agents**: Where possible, only TGA Approved Hospital Grade Disinfectants with viricidal claims including "Kills SARS-CoV-2 (COVID-19)" should be used for decontamination. High Level Disinfectants (HLD) and Sterilants are able to

[9] IICRC S300 *Standard and Reference Guide for Professional Upholstery Cleaning.*

inactivate viruses, however, these products are generally very hazardous and are not intended for use as surface disinfectants or fogging disinfectants.

- All disinfectants must be supported by technical documentation to uphold claims made for their efficacy. Any Regulatory approvals validating the claims (TGA ARTG, APVMA, HACCP etc.) must be included. All disinfectants must be applied as per manufacturers' recommendations/ instructions, particularly with regards to dilution and contact time, using correct PPE, and not used in an inappropriate manner.

Disposable cleaning wipes/mops are to be encouraged in these situations. Evidence of responsible disposal, and disinfection prior to disposal should be available. If reusable items are required, then decontamination / disinfection before they are removed from the site is required, and significant evidence of the process required for effective disinfection should be available for review.

5.11.2. Toxicological appraisal and cross-reactions

A check for known incompatibility and harmful cross-reactions must be carried out prior to deploying cleaning or disinfectants.

For example, bleach reacts with acids such as vinegar, or ammonia-based products, and the use of oxidising compounds with terpenes in pine / citrus based or scented cleaners also creates hazardous reaction products.

Further it is important to show that the product being employed does not cause damage to the treated surfaces. For example, bleach has potential to damage stainless steel and aluminium. In this case a product that does not show reactivity but is recommended for SARS-CoV-2 is should be used.

IAQAA notes that the Australian Government is recommending use of 1000 ppm bleach with a 10-minute residence time on the surfaces. This period may be insufficient to allow the bleach to become inactive in relation to preventing the ATP reaction. Where bleach is used and the surface is to be validated using ATP measurement, a rinse step may be required prior to testing, or the area left to off-gas or allow the remaining bleach residue to dissipate for a considerable period so as not to interfere with the testing.

ATP manufacturers recommend testing prior to the application of disinfectant. Given that detergent has been shown to provide a greater SARS-CoV-2 deactivation efficiency than bleach or a sterilant (Gibbens, 2020), it is preferable that testing is conducted prior to treatment with disinfectants.

Further, the presence of organic material on the surface will result in loss of efficiency of many disinfectants, so knowing that the surface is free of debris is an equally critical step in evaluating suitability for disinfection.

5.11.3. Safety around sewage related plumbing

According to Gormley *et.al.,* 2020 a range of actions are required around plumbing, being:

(1) Do not ignore unexplained foul smells in bathrooms, kitchens, or wash areas.
(2) Make sure that all water appliances in bathrooms and kitchens are fitted with a functioning U-bend.
(3) To prevent the loss of the water trap seal within a U-bend, open a tap on all water appliances for at least 5 seconds twice a day (morning and evening) paying special attention to floor drains in bathrooms and wet rooms.
(4) If the wastewater pipework from an appliance appears to be disconnected or open, seal it immediately (i.e. use an elastic rubber glove to cover the end; a plastic bag and some tape will suffice, ensuring the bag has no holes),
(5) If there appears to be any crack or leak in pipework, seal with tape or glue.
(6) Continuously monitor whole system performance (for large or tall buildings).

We therefore recommend checking with the owner or facilities / property manager that there have been no odour complaints, leaks or sewage backflows since the start of 2020 or in the last 3 months whichever is sooner.

Ensure that all floor drains and U-bends are full of water prior to cleaning or inspecting areas with plumbing around wet areas or floor drains that may lead to the sewerage system.

Periodic inspection of the plumbing system would be prudent in avoiding spread of the infection prior to an outbreak or case in the building or structure.

6 Required qualification for persons engaged in COVID-19 cleaning projects

6.1. Requirements for persons conducting cleaning and disinfection works

The individuals or organisation providing decontamination of the site should be classed as a Suitably Qualified Person (SQP) based on holding the following qualifications or certifications:

- Disinfection or outbreak management cleaning training to Department of Health and Human Services guidelines or similar, Cleaning Management Institute certification or other appropriate qualifications.
- TAFE qualifications specifically designed to teach methods of cleaning for health-care facilities and around infection control.
- Courses in hazardous biological materials, building microbial control (such as those provided by the Institute of Inspection Cleaning and Restoration Certification / Restoration Industry Association).

- Specific coronavirus cleaning training as delivered by qualified individuals and/or organisations with expertise in occupational hygiene including biological hazards, biological decontamination, and/or infection control.

6.2. Requirements for persons conducting assessment and cleaning validation

The person conducting the assessment and validation of the site should be independent of the cleaning contractor.

This person requires training in the same categories as those listed in Section 6.1. However, they should be engaged independently of the contractor. The Assessor will be responsible for providing Post Cleaning Validation (Verification) documentation including rationale and uncertainty around collection of samples and management of laboratory Chain of Custody and analytical data where appropriate.

6.3. Licencing for the use of aerosolised disinfectants

Fogging is considered a form of fumigation in all States/Territories in Australia. Fumigation using certain products and following certain processes may require a licence for internal and external use. It is important that operators hold the correct licence for their processes. The State (or Territory) based health Departments normally manage licences for treating internal spaces. The Federal Department of Agriculture usually provides the licences where required for external fumigation. We recommend that operators ensure their licences are appropriate and up to date.

Fumigation is not suitable without cleaning, therefore certifications showing a suitable level of training around cleaning is also important.

It should be noted that in Australia, disinfectants with viricidal claims, including for SARS-CoV-2 and other Coronaviruses, must be registered with the TGA. Use of unapproved products will bring with it an increased risk of statutory non-compliance. Products are now being registered by the TGA with label claims including Kills SARS-CV-2 (COVID-19) and are available in Australia and New Zealand (TGA, 2020b).

7 Visual inspection

7.1. Pre-cleaning inspection

When applicable, items should be inventoried using photographic and other procedures currently employed by remediators during decontamination for other types of contaminants such as fire residues, methamphetamine residues and / or mould.

Pre-existing tools utilised for other purposes, such as adapting NIOSH site inspection tools for mould to record the extent of surface staining or dust likely to be due to poor cleaning might

be considered (*Dampness and Mold Assessment Tool General Buildings* and for *School Buildings*). The visual assessment should assess the cleanliness of building surfaces and contents / fit-outs. Findings may be recorded based on the size of areas impacted.

Documenting of odours, water damaged area, or mould-like staining, and any exposed hazardous materials such as lead-based paints or asbestos should be noted in the report. Note that such record-keeping may not involve a full hazardous materials inspection but demands that as the Person Conducting a Business or Undertaking that the Assessor notes risks that they observed within their own area of expertise. Where applicable, these risks should be reported to Supervisors under regular health and safety protocols so that the correct process may be followed to keep workers and occupants safe.

Mould risks are significant in buildings when they have been unoccupied with no climate control operating. Care must also be taken as there may be an increased risk of *Legionella pneumophilia* in cooling towers, air handling units and water faucets. It is important to document observations showing potential or actual risk from exposure to hazardous materials or notable other health and safety hazards.

Given that buildings may be shut up for some time, it is important to ensure that there are no obvious signs of other health-related issues arising from contaminant build-up such as carbon monoxide in or close to plant rooms due to poor ventilation.

7.1.1. Assessing condition of high touch areas

Extra care is required when noting soiling of high-touch-areas as these are likely to have the highest viral loading. Any moveable surfaces or items that are porous or semi-porous, deteriorated or worn may prove difficult to assess and clean effectively and may remain a reservoir for viral contaminants even after cleaning and disinfecting activities. Extra care should be taken when handling these items.

These items/surfaces should be clearly identified and documented and either disposed or contained and set aside for later evaluation/decontamination.

Examples include deteriorated vinyl on leather arms of chairs with exposed porous materials and/or foam, and painted doorways (especially toilets and bathrooms) with worn or deteriorated painted surfaces.

7.1.2. Assessing objects prone to contamination by fomites

Where items are readily disposable and/or not suitable for wet cleaning, they should be disposed of as biologically hazardous waste.

Where items are reusable, they should be laundered in the hottest water setting for that item as recommended by the CDC (CDC, 2020b), and the U.K. Government (Public Health England, 2020), and where possible at 70° C (NEA, 2020). Note that infection spread at present has not

been shown to occur as a result of transfer on fomites (CDC, 2020a), however airborne virus was detected in rooms where healthcare workers were doffing uniforms and PPC, and areas in the vicinity of patients in hospitals have been shown to contain elevated levels of viral markers (RNA). However, the action of hot water and detergent seems adequate to inactivate SARS-CoV-2; the U.K. document states that there is no need to separate laundry from unaffected person/s (Public Health England, 2020). Whilst the U.K. further does not recommend disposal of waste as hazardous, where a known infection has occurred and based on air and surface testing in Wuhan by Y. Li *et.al.,* IAQAA recommends hazardous waste disposal for non-laundered items.

Hazards would be encountered during handling of waste, however once sealed, disposal at landfill does not pose an environmental or health risk. Therefore, it is important that non-clinical waste is securely wrapped in two layers of 200 µm thick plastic prior to disposal.

7.1.3. Inspecting work areas

If relevant, it is important to understand the daily tasks undertaken by the infected person. This can be achieved through a questionnaire completed by, or discussion with the Direct manager. The precise list of items to check will be highly variable depending on the person's job.

Work areas most impacted by the infected person will likely include the immediate work area to at least 2 metres from that location, kitchen and food preparation areas, printing and stationery storage areas, toilets, lifts and lift keypads, staircase and bannister handrails, vehicles and the desks and environments of team members who interact with the patient.

Checking of office monitors, desks, seats, work uniform, or home clothing stored at work in lockers for example or at the desk, photographs, keyboards, mouse/mouse mats will be commonly needed in office environments.

Infection in a non-office-based person requires consideration of their daily activities.

Consideration may be needed for small items and packaging handled by the virus patient, the person's breathing zone or hand to surface interaction potential with manufacturing and plant equipment, tools, registers, hand-held devices and phones, vehicles, food preparation areas, overalls, personal safety equipment and PPE.

Low cost items such as desktop stationery may be more fiscally appropriate to be replaced.

Single dwellings will require full decontamination, and multi-storey residential buildings require consideration of air flow through HVAC systems and in plumbing systems such as floor drains or any other drains (Gormley *et.al.*, 2017).

7.2. Supervision of cleaning operations

Due to the sensitive nature of the viral outbreak and concern felt across the community, having an independent and suitably qualified person supervise the cleaning activities is advisable.

A suitably qualified person may be engaged to directly supervise all cleaning activities as well as any application of disinfectants to ensure the appropriateness and correctness of the methods implemented.

Any such person should be engaged independently of the cleaning contractor and have specific training and qualifications in conducting evaluations of cleaning activities. Such individuals include Occupational Hygienists trained or experienced in chemical or microbial decontamination, infection control consultants or other such trained professionals.

Persons trained to a high level in microbial remediation may also be suitable for supervising cleaning projects. Examples include independent parties qualified by the IICRC as Applied Microbial Remediation Technicians (AMRT) who have completed training and have experience in forensic cleaning applications such as post-hoarding or Crime and Trauma Scene clean-up.

7.3. Post-cleaning inspection

Post-cleaning inspection should follow the premise, items, areas, and procedures as used for pre-cleaning inspection. Further effort is required to show cleaning operations have been completed.

7.3.1. Inspection of the occupied space

Following the cleaning process, the reportedly cleaned surfaces should be evaluated for cleanliness.

The following considerations may be used to help validate cleaning and / or disinfection works.

Visual observations should be recorded. The NIOSH site inspection tool for mould and water damage may be modified to record the extent of surface staining or dust likely to be due to poor cleaning (*Dampness and Mold Assessment Tool General Buildings* and for *School Buildings*). The visual assessment should assess the cleanliness of building surfaces and contents / fit-outs. Findings may be recorded based on the size of areas impacted.

The objective of the inspection is to show that surfaces have been cleaned. Visible dust, items of undisposed waste, used items such as utensils, stains from spills on floors or desks and other indicators of unclean surfaces should be noted. These areas should not be tested until they are visibly clean, and if required, re-cleaned prior to surface testing.

Where the area inspected is rarely occupied (Data Centres, plant rooms or unoccupied tenancies or storage areas etc.), visual inspection may be all that is required to confirm cleaning. This may be accompanied by an additional step using a "white-glove" technique or tracer method which are discussed below.

In areas or on items to be tested, the "white-glove" technique (Section 3.4.1) should be used as a preliminary tool in identifying areas where cleaning is inadequate to remove visible soil. A torch is often useful to see settled debris that is otherwise invisible to the naked eye. Reassessment of cleaning methods and/or re-cleaning may be required if soiling is observed on the cloth. At this stage, no further surface testing may be indicated prior to removal of soil. Additional quality assurance measures may be taken to ensure cleaning methods are effective (Section 8).

Note should be taken of other hazards as described for pre-cleaning inspection.

Where other remediation-related hazards such as damaged of friable asbestos or lead based paints, or mould-like staining are suspected these may be considered as part of the cleaning and disinfection validation procedure.

A further hazard is the presence of *Legionella pneumophilia* in cooling towers, but also in the plumbing system where water has been stagnant in pipes and faucets. It may be necessary to test these items for *L. pneumophilia* and treat contamination if present prior to reoccupation.

7.3.2. Inspecting wet areas

Wet areas should be examined carefully as the increased humidity in these locations may promote the viability of the virus (Chan *et. al.*, 2011). Care must be taken to ensure a high level of PPE / RPD and control measures are applied, as Toilets are likely high-risk areas for cleaners and Assessors.

Testing of horizontal and vertical surfaces including splash-backs, over-sink mirrors and wall cabinets should be considered. High touch points such as toilet flush points, taps and door handles / locks require careful assessment.

7.3.3. HVAC system / condensers / air filters / cooling coils / registers and ducts

Where air is extracted from the work location of an infected person, for example in a mechanically ventilated building with mixed mode or recycled air, or in a kitchen or work area with active air extraction, sections of the receiving system may require decontamination.

Given that cooler, higher humidity environments have been shown to increase coronavirus longevity (Pyankov *et.al.,* 2017, Chan *et.al.,* 2011), it is important that all filters are fitted correctly and working efficiently within the HVAC system. Return air and supply air registers

may require cleaning, and ducts may be cleaned depending on the time since the infection, given that the virus lasts for at least 9 days on stainless steel (van Doremalen *et.al.,* 2020).

We recommend replacing return air path filtration as an additional precaution after leaving for a suitable period of time to allow active viral loading to drop where this is possible. Service personnel should be properly trained to manage potential biohazard risks when handling HVAC components and filters. We recommend reference to AIRAH HVAC Hygiene Best Practice Guides available on the AIRAH website[10] when preparing work scopes for decontamination of the systems.

Note should be taken that controlling the indoor environment to mitigate risks of infection is not recommended at the time of publication by the Federation of European Heating, Ventilation and Air Conditioning in their recommendations around COVID-19 REHVA (2020).

8 Cleaning quality control

It is important that the cleaning contractor shows that the cleaning process they are employing is effectively removing stubborn material from the surface.

Methods used should be the best available technique for removing soil and microbial debris from the surface. There is considerable variability between methods in their ability to remove debris. The image below presented by Dr John Richter, Miami University, on 31 March 2020 to the Cleaning Industry Research Institute demonstrates a clear difference in effectiveness of two different cleaning methods on the same surface. A cloth and spray (orange line, square data points) becomes less effective than the squeegee bulk flow method (black line, diamond data points).

[10] Accessed at: https://www.airah.org.au/AIRAH/Navigation/Resources/BestPracticeGuides/Best_Practice_Guidel.aspx on 15 April 2020

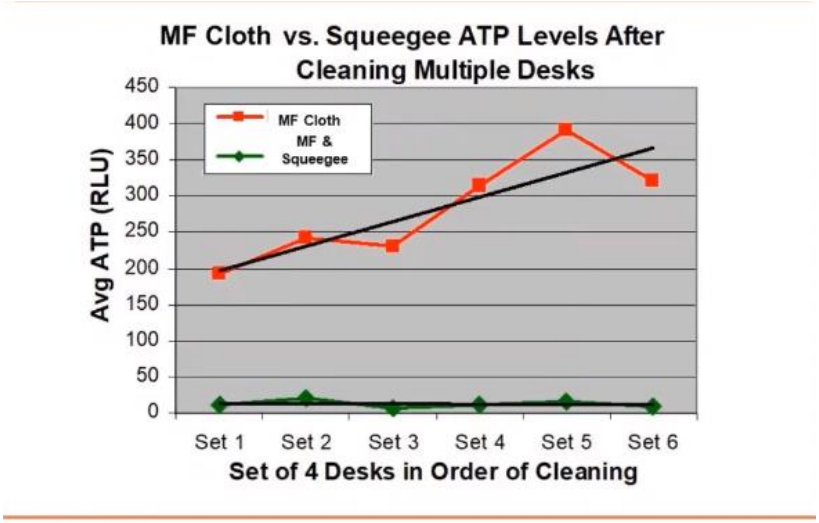


Figure 2: 4-month study of desk cleaning - from Richter presentation, CIRC Symposium, 31 March 2020

A visual inspection using a white-glove and / or torch (including for the purpose of shining an oblique light across the surface) may provide initial quality assurance for a given process or product. These items may be used to allow dust to be seen if the surface is visibly soiled. In this case, a white cloth (or dark cloth, as deemed appropriate for the surface involved) may be used to wipe a surface and if any visible dust or discoloration is readily observable on the cloth, the surface should be deemed not properly treated.

Alternative methods include spiking the surface with a known but invisible marker, or "tracer" such as an introduced UV or biological indicator that sticks to the surface and can be visualised or tested before and after cleaning to show process effectiveness.

8.1. Application of a fluorescent or biological marker

Note that these methods are not specific to pathogens (including viruses) and are NOT a substitute for validation testing unless in unoccupied or rarely occupied areas.

8.1.1. Fluorescent tracers

Fluorescent tracers may be used to test the effectiveness of cleaning activities in relation to critical environments and may be applied to COVID-19 cleaning. A fluorescent water-soluble product is painted onto the surface, which upon drying becomes visible only when using UV light. This method is recommended by the US Centers for Disease Control and Prevention's (CDC) *Healthcare Associated Infection (HAI), Preventing HIA, Prevention Toolkits Appendix B - Options for Evaluating Environmental Cleaning*.

Note that these methods are not specific to pathogens (including viruses) and are NOT a substitute for validation testing unless in unoccupied or rarely occupied areas.

Fluorescent marking should preferably be conducted by a third-party independent Assessor as defined under Section 6.2, or by a Site Supervisor documents and signs to say they have not advised the cleaning staff of the location of the tracer.

Care should be taken to avoid the situation of cleaning contractors pre-marking surfaces and then focusing cleaning efforts on those areas and potentially under-cleaning an impacted area or item.

Upon drying, the fluorescent gel becomes transparent on surfaces and is resistant to abrasion. It therefore requires thorough cleaning to remove from the surface it is applied on.

A "black" light (i.e. UV) is then used after cleaning has been completed to assess whether all residue of the tracer has been removed, and hence the surface adequately cleaned. The use of UV marking, and black light detection may be employed as part of the quality control process by the cleaning operative.

8.1.2. Method for use of fluorescent tracer

The following equipment is required if using a fluorescent tracer as an initial appraisal of cleaning method effectiveness:

- Water-soluble fluorescent tracer.
- Ultraviolet (UV) Light (torch).
- Rubber disposable gloves.
- PPE during application as surfaces may be contaminated.
- Example Product: Clinell EvaluClean.

Fluorescent Tracer Sampling Preparation

It is necessary to prepare the sampling medium and test kit prior to testing.

Number of Surfaces to Mark

Between 10 and 100 marks should be made per 100 m^2 of floor space (minimum of 10 locations).

Marking Surfaces

The fluorescent tracer should be used to mark multiple high touch or other surfaces designated for cleaning.

It is important that the fluorescent gel from the tracer fully dries prior to cleaning.

Evaluation with Black (UV) Light

At completion of the cleaning activities, a UV light is used to identify any surfaces with remaining tracers.

Fluorescent Marker PASS/FAIL Criteria

For an area to be determined as properly cleaned, the cleaning process must have removed 100% of visible fluorescent tracer from all tested areas or items.

Any surfaces/items with residual tracer must be re-cleaned and re-assessed.

It should be remembered that the black light test is not sufficiently sensitive alone to show surfaces are adequately cleaned and used incorrectly can lead to wrong conclusions. In some cases, surfaces were shown to be dirtier after removal of the UV tracer because the cloth used for cleaning was already contaminated.

Measuring surface ATP and showing removal of surface debris, virus and/or viral particulate matter indicators may better indicate effective cleaning.

8.1.3. Biological indicators

Biological indicators are recognised microorganisms that have been approved as a proxy for treatment of COVID-19. By measuring the concentration of the organisms on the surface before and after cleaning, it is possible to estimate the logarithmic (log) reduction in concentration of the organism and therefore make claims on behalf of the product for treating SARS-CoV-2.

To date, the TGA has approved viral surrogates for this purpose, and some suppliers are providing TGA approved products on this basis (TGA, 2020a). At the time of publication, agreed surrogates are Human Coronavirus 229E (causes the common cold and has a bat host) and Murine coronavirus known to be associated with SARS. Live virus should not be used for testing in facilities that are not designed for handling pathogenic organisms.

For general viral model testing the harmless bacteriophage virus MS2 is routinely used, however this virus is not listed as applicable for assessing effectiveness of process efficiency for cleaning.

9 Testing of surface cleaning effectiveness

At the time of publication, TESTING DOES NOT PROVIDE CLEARANCE FOR COVID-19 as there are no specific tests or thresholds readily available that can be applied to the building.

In accordance with the ASTM D7338:2014 – *Standard Method for the Fungal Assessment of Buildings*, no testing should be conducted without a hypothesis. The same rule applies to

assessment of buildings contaminated with methamphetamine and to contaminated environmental sites under standard methods employed in Australia.

These guidelines are devised around the hypothesis that a building is sufficiently hygienic and free of debris to be considered unlikely to house residual COVID-19 virus.

Sampling forms part of an overall qualitative risk assessment around the contagion event, cleaning protocols, extent of testing and analytical methods that result in a rating, and therefore a given recommended outcome. It is therefore critical that the quality of the data to be recorded is assessed prior to the onset of work.

9.1. Choosing when to test

Decontamination is a two-stage process comprising cleaning with detergent and water and disinfecting. Depending on the chemicals and/or validation techniques used, rinsing may be necessary.

Given that the tests to be conducted rely on cleaning the surface thoroughly to allow the disinfectant to act, we recommend that surface samples are collected BEFORE disinfecting surfaces as surface debris or organic matter may prevent the disinfectant from working effectively.

9.1.1. Unoccupied or rarely occupied areas

In rarely occupied or unoccupied spaces such as server rooms, plant rooms and unoccupied tenancies that are not regularly subject to air ingress from an occupied part of the building, the level of risk of contamination should be considered carefully when justifying costs and mitigating risk. In this case the use of a white or black glove to show successful removal of visible debris would be a useful additional tool in ensuring cleaning was adequate.

9.1.2. Asymptomatic individuals

It must be remembered that COVID-19 has been shown to be shed by asymptomatic individuals, but numbers of asymptomatic patients are unknown. Therefore, there remains an unquantified residual risk in the general population which should be considered.

9.2. Selecting sample locations

Sample locations must always be chosen so as to minimise risk of inadequate cleaning.

Testing can have several purposes, and locations should be included so as to show the following conditions have been met:

1. Broadscale cleaning of a structure has been adequate to return it to the required condition for general use areas based on hygiene testing and surface debris.

2. High-risk areas such as high-touch-point areas where a person known to be infected likely contaminated the surface should have minimal organic material remaining based on hygiene testing and surface debris.
3. High-risk areas where general users of the structure may be infected but are not reported or are asymptomatic, but where the item is commonly used by another person or persons should have minimal organic material remaining based on hygiene testing and surface debris.
4. High risk items known to be contaminated with COVID-19 that require special treatment should be shown to be free of viral residue or its indicator compounds.

This Guideline does not attempt to resolve Item 4. A method such as nucleic acid or antibody-based technology, or culturing is required to confirm that COVID-19 has been removed from a surface. However, this type of testing is not normally required to show that cleaning has adequately mitigated risks in occupied structures. Special consideration may be given to testing in locations with high-risk or vulnerable populations where the virus has to be shown to have been eliminated.

9.3. Ensuring high quality of data

Sampling requires establishing at least qualitatively the level of certainty in the final outputs of any real-time, on the spot or laboratory analytical procedures.

Certainty is governed by several factors:

- Representativeness of sample locations to the tested area.
- Representativeness of samples collected from one type of medium for another, for example using surface testing as a proxy or air quality based on assumptions around settling of particles onto surfaces.
- The effectiveness of the sampling matrix to pick up the analyte being measured.
- Repeatability of the on-site testing or sample collection procedure.
- Effectiveness of the sample collection process.
- Accuracy and precision of indirect reading instruments for airborne particulate, wet bulb temperature / humidity (relative / absolute) or for ATP from surfaces.
- Quality of the laboratory procedures.
- Potential for interference of analysis by cross-contamination, surface residual material or environmental interference from the cleaning process e.g. bleach residues after disinfection.

Where the disinfectant product is used prior to testing, and may inhibit the testing processes, it may be necessary to improve quality outcomes by selecting a different testing system. For example, Hygiena has shown that their SuperSnap ATP swabs have much lower inhibition with a range of sanitisers than their UltraSnap swabs (Hygiena, 2014).

Reference to the relevant impact of the chosen sampling strategy on each of the above should be made as part of reports provided when validating cleaning works.

9.4. Hygiene level assessment

Hygiene assessment may be conducted using adenosine triphosphate (ATP) testing in keeping with Shaughnessy *et.al.*, 2013. The use of ATP as a cleaning proxy is in keeping with the recent endorsement by the Cleaning Industry Research Institute (CIRI Symposium 31 March 2020) Institute of Inspection, Cleaning and Restoration Certification (IICRC) / Restoration Industry Association recommendations set out in their *Preliminary Report for Restoration Contractors Assisting Clients With COVID-19 Concerns* released on 19 March 2020.

Research shows reasonable agreement between cleaning / disinfection failure rates of a surface cleaning process based on surface bacterial concentration (nominally 2.5 CFU/cm^2 in hospital environments) and failure based on ATP concentrations. The ATP test is designed to provide an accurate estimate of cleaning efficiency when the surface contamination is of biological origin (containing measurable ATP) (Shaughnessy *et. al.*, 2013). Skin cells with attached bacteria are ubiquitous on surfaces occupied by humans (bacteria make up around 50% of the cells in a human body). If cleaning is adequate to remove ATP it is therefore considered a reasonable proxy for removal of human-borne microbial matter, although an acceptable ATP value does not provide definitive evidence that COVID-19 residue has been partially or fully removed.

9.5. ATP sampling

ATP swabs are routinely collected from a predetermined area, usually 2 cm x 5 cm, 5 cm x 5 cm, or 10 cm x 10 cm (Whiteley *et.al.,* 2018). Given that surfaces are being tested for cleanliness for a highly sensitive purpose, the limit of detection should be kept as low as possible within the operational reliability of the testing system. Collection of a larger sample surface area where available will provide this, as well as serve to reduce the number of swabs needed to test the same area, when they are likely to be in high demand. This Guideline therefore recommends where possible testing a 100 cm^2 surface area wherever possible.

When an area of 100 cm^2 is swabbed on a cleaned surface, it is important to ensure that the recommended number of passes with the swab is employed to avoid overloading the swab but to trap a representative quantity of the surface.

To reduce variability between test areas of different sizes, swabbing at a rate of 1 pass per cm in each of a horizontal and vertical direction is recommended to match the strategy recommended by many suppliers.

For example, a 10 cm x 10 cm area would require 10 swab passes in each direction being a total of 20 swab passes.

A 5 cm x 2 cm area would require 5 passes along the 5 cm direction and 2 passes along the short direction totaling 7 swab passes. It is recommended that the Assessor adheres to the correct number of passes of the swab.

It is acceptable to follow the manufacturer's recommendations for the size of each sample; however, the same size area will require swabbing to achieve a chosen DQO set out when selecting the number of samples. Four 5 cm x 5 cm swabs areas equate to one 10 cm x 10 cm area.

Results should be reported in Relative Luminescence (Light) Units (RLU) per 100 square centimetres (100 cm^2), with pass or failure based on the surface ATP thresholds applicable to the number of fmoles per 100 cm^2 set out in Table 1. Table 1 provides the equivalent reading based for a 100 cm^2 area for some commonly used ATP testing systems.

Where ATP is measured, reports must show the manufacturer documentation with the conversion of fmoles to RLU of ATP along with an up to date Calibration certificate for the ATP meter being used.

Where an item to be tested is too small or intricate to swab 100 cm^2, or where heavy dust would make the sample suspension opaque when placing the swab in the reagent mixture, a smaller swabbing area may be required. Where a reduced sized swab is collected the ATP reading must be normalised by extrapolating to the equivalent instrument reading expected across an area of 100 cm^2 assuming a linear response to surface concentrations.

9.6. ATP threshold for cleaning after COVID-19 contamination

The acceptable thresholds for cleaning have been updated in Version 3 to reflect feedback on the need to treat areas of a building where a person was infected differently to routine cleaning where cleaning effectiveness is to be monitored but no COVID-19 cases have been reported.

ATP thresholds have been updated based on discussions with stakeholders including ATP meter manufacturers and supported by further literature review.

The bacterial surface concentration threshold commonly set for high touch areas to be considered effectively disinfected is 2.5 CFU/cm^2 based on an Aerobic (bacteria) Colony Count (ACC). Studies determining ATP thresholds are commonly designed to show that a particular concentration of ATP on a surface correlates with a value of 2.5 CFU/cm^2.

ATP thresholds vary in this Guideline based on whether there have been reported cases of COVID-19 in the structure to be cleaned.

9.6.1. Routine cleaning / cleaning prior to re-occupation with no reported cases

Areas that are occupied but where no positive cases have been confirmed will be deemed as a lower risk than an area with infected person/s.

Given the evidence of pre-symptomatic faecal shedding from infected individuals, a threshold of 25 fmoles ATP / 100 cm^2 is considered essential in bathrooms / toilets and on high-touch-point locations. This value is borne out in work by Griffith *et al.* (2000), who showed that ATP could be used for surface testing for aerobic bacteria and Enterobacteria successfully correlating with failures when surface contamination levels rose above 2.5 CFU/cm^2 ACC.

Boyce *et. al*. (2015) demonstrated a threshold of 100 RLU/25 cm^2 using a Biotrace monitor and Cleantrace swabs provided confirmation of achieving 2.5 CFU/cm^2 ACC over a 25 cm^2 (4 square inch) area. This reading equated to 40 fmoles/100 cm^2.

These Guidelines assume any high touch areas are classed herein as at least Hygiene Level 5 as defined by the Danish Standards EN/DS2451-14:10E where "cleaning shall primarily eliminate/minimise the risk of transmission of infectious matter by direct or indirect contact."

Non-impacted areas in the absence of reported cases are classed herein as Hygiene Level 4-3 allocated to "surfaces requiring risk reduction in relation to infection".

No exceedance of a threshold of 25 fmoles/100 cm^2 ATP is recommended in the Danish Standard EN/DS2451-14:10E[11] for Hygiene Level 5. Hygiene Level 3/4 requires ATP concentrations of less than 50 fmoles/100 cm^2.

This Guideline has employed the threshold of 50 fmoles/100 cm^2 for general areas in buildings with no recorded infections but a chance of contamination by non-infected persons.

9.6.2. Decontaminating areas occupied with confirmed case/s of COVID-19

Where infected persons were present and the item to be tested is a high-risk item, a lower tolerance is considered desirable. Therefore, thresholds have been evaluated on the basis of normally achieving an equivalent concentration of 2.5 CFU/cm^2 except on high touch points where a lower tolerance has been set.

High touch items known believed to be impacted by an infected person are potentially microbially contaminated through a number of possible mechanisms. Contamination by faecal-hand route is possible, by fomites formed during sneezing, coughing or possibly exhalation and by resuspension of surface viral particulate matter and re-settling onto surfaces not immediately adjacent to the source.

[11]Danish Standards EN/DS2451-14:10E *Infection Control in the Health Care Sector - Part 10 - Requirements for Cleaning* - 2014.

Thresholds considered acceptable for high touch points previously used by an infected person were therefore revised to bring them into line with the ATP threshold for Healthcare, Hospitals and Patient Care Settings which have become grossly contaminated (Bioreveal (a)).

For high touch points and Toilets/Bathrooms, an upper acceptable ATP threshold of 10 fmoles/100 cm^2 has therefore been adopted in these Guidelines.

General areas where the infected person was working, and downstream of any return air from their work locations should be returned to Hygiene Level 5, being less than 25 fmoles/100 cm^2.

Other areas of the building not used by, and that are not down-air-stream of the person, and where the areas do not share a potential airborne route through the plumbing to sewage to the locations frequented by that person should not exceed 50 fmoles/100 cm^2 in accordance with buildings with no reported infections.

9.6.3. Converting concentrations to ATP meter readings

The same concentration of surface ATP equates to different output values across different ATP meter models. Table 1 below shows the failure threshold readings expected when testing with the most commonly used swabs and ATP meters, based on achieving the acceptable Hygiene Levels described above.

Please refer to manufacturers' recommendations to identify the ATP concentration conversion for the make and model of ATP meter used.

Table 1: Guide to ATP thresholds for commonly used meters

Known infection – high touch points and Bathrooms / Toilets[12]
Known infection – general impacted area/No known infection – high touch points and Bathrooms / Toilets
No known infection – general area[13]

Instrument	ATP surface threshold – (fmoles / 100 cm²)	Failure reading – threshold for an area of 100 cm²	Failure reading – threshold for an area of 10 cm² (recommended for smaller high touch point surfaces [14])
Hygiena Systemsure – UltraSnap swab	10 (25) (50)	10 (25) (50)	1 (3) (50)
Hygiena Ensure – UltraSnap swab		20 (50) (100)	2 (5) (10)
Hygiena Ensure – SuperSnap swab		80 (200) (400)	8 (20) (40)
3M Biotrace		100 (250) (500)	10 (25) (50)
Kikkoman Lumitester*	10 (25) (50) for ATP only	60 (150) (300)	6 (15) (30)

** the Lumitester measures total adenylates (ATP, ADP, and AMP). The thresholds for this guideline have been rounded down to the nearest 10 RLU / 100 cm² based on manufacturer advice that 80 fmoles ATP = 500 RLU.*

9.7. Establishing sampling density

We recommend following the principles of the following documents when devising a sampling plan:

Clandestine Drug Laboratory Remediation Guidelines, Commonwealth of Australia, which is based on the *National Environmental (Assessment of Site Contamination Assessment) Protection Measure (2011) Schedule B—General guidelines for the assessment of site contamination* "the NEPM".

[12] Bioreveal (a).

[13] Bioreveal (b).

[14] Whiteley *et.al.*, 2016.

Sampling density should ensure that the desired Data Quality Objective (DQO) is reached. This should be set at a minimum 95% confidence limit in accordance with the NEPM.

A selection of an appropriate margin of error is required prior to creating a sampling procedure.

Assessing error margins may be achieved by carrying out the calculation below, or more readily by using one of a range of sample size calculators available online. Care must be taken to ensure that the online tool provides consistent results with the basic formula shown below.

Equation 1: Calculation of sample size based on surface area of tested item or structure[15]

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

As ATP swabbing is recommended in these Guidelines over an area of 100 cm^2, to determine how many swabs are needed it is necessary to work out the size of the area that needs testing based on the size of the tested item in square centimetres.

It is important to understand the hypothesis being tested.

<u>Example 1:</u>

If a wall is 2.5 m high by 4 m long, it is a total of 10 m^2. Converting this to square centimetres means the wall is 250 cm x 400 cm = 100,000 cm^2 in area.

We can tell the calculator that we want to have no more than a 5% margin of error in the estimates and be 95% confident of making that statement.

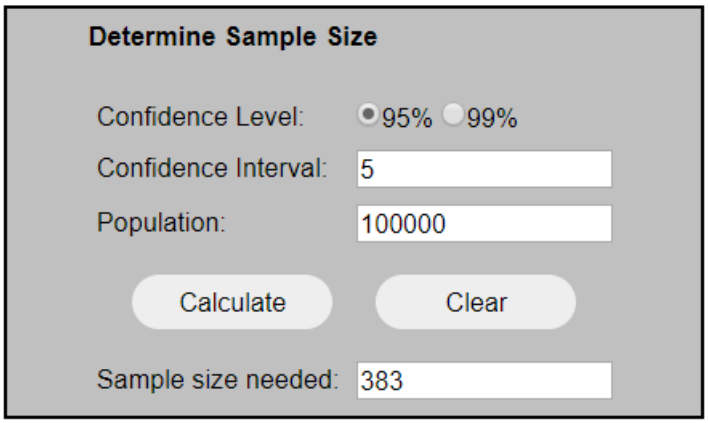
We select that we want 95% confidence (usual selection) and a 5% margin of error and put in our wall size in cm^2.

The tool will then automatically generate an output value of 373, which in this case is the size of the area we need to test in cm^2.

Below is an output from an online sample size calculator showing how the online tool can be used. The example is based on testing a 10 m^2 wall using the Survey System online tool[16].

[15] Sample size=total area to be tested (cm^2), z=z-score, p=standard deviation, e=margin of error, N=total area being assessed (cm^2).

[16] https://www.surveysystem.com/sscalc.htm



As each ATP swab area is 100 cm^2 if we test at three locations, we have tested 300 cm^2, being less than the required 383 cm^2, so we now have a greater than 5% uncertainty in our findings.

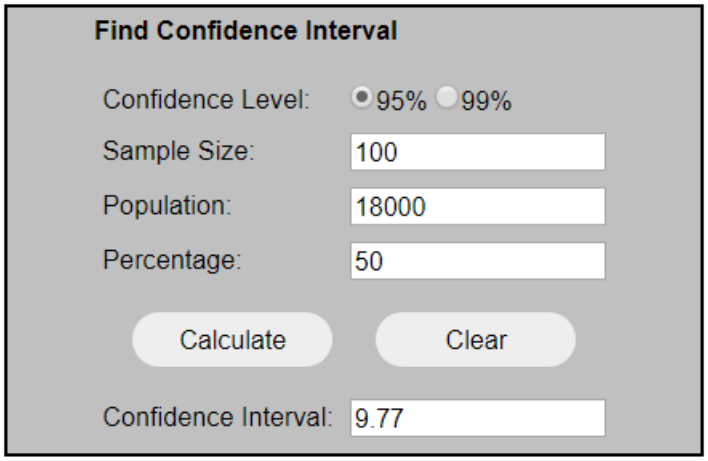
If we instead test at 4 locations on the wall, so we test 400 cm^2 we can be more certain in our findings, and our uncertainty falls to less than 5%. We can now state that we are at least 95% certain that our testing is representative of conditions on the wall, assuming that the contamination is evenly spread across the surface.

Example 2:

Where budgetary restraints require collection of a predefined number of samples rather than being based on the size of the area to be tested, we are able to instead input the area to be tested and area of the overall item (such as the wall in this case) into the tool, and the tool will tell us what our uncertainty will be based on that testing regime.

Using the tool in this way allows Assessors to predict the margin of error from testing and report it to the person making the final decision on the sampling strategy.

As an example, if an Assessor is assessing a dining table that is 180 x 100 cm (1.8 m x 1 m), the total area is 18,000 cm^2. If we are only able to test 1 area that is 100 cm^2 we can put these figures into the table to find out the resultant uncertainty and advise the decision maker. The output below was generated by the Survey Systems website and shows that we would have a 9.77% uncertainty in our testing regime if we collected 1 sample from the table.



The level of certainty in the sampling strategy must be documented in post-cleaning validation reports.

9.8. Testing heating, ventilation, air conditioning

Where HVAC systems extract air from the vicinity of a known infected individual, the extractor or return air register may be expected to concentrate viral airborne particulate matter. Viral particulate matter may become entrained on surfaces by impaction or become lodged in filter matrices. At present, the role of airborne transmission in the spread of COVID-19 is hotly debated, however we recommend that this is an important consideration when working in or around the HVAC system for maintenance of cleaning purposes.

Bioreveal® provides an ATP Guideline that may be considered for testing to show that the HVAC system is hygienically clean where a contamination source was present; in this case where an infected person or persons was present [17].

9.9. Minimum number of samples per location

Samples should be collected in accordance with manufacturer's recommendations.

- All ATP samples should be collected in duplicate.
- If a single sample fails, a third sample should be taken.
- If the median value of the three samples remains above the threshold a fourth sample will be required.
- The final result will be the median of the four samples in this instance (Whiteley *et.al.*, 2016).

Readings from each sample should fall below the sum of the mean plus 3 Standard Deviations (Hygiena, 2005).

[17] Bioreveal (c)

If this is not shown to be the case, further sampling will be required until enough samples are collected to meet this criterion (in accordance with Hygiena thresholds for cleaning failure).

The median ATP reading should be taken to provide the value for that item (Whiteley *et.al.*, 2016) and should fall below the necessary threshold.

9.10. Factors for consideration when using ATP

9.10.1. Interference or amplification of ATP signal

There is some evidence that cleaning products can lead to false positive or negative readings when using an ATP meter. Sensitivity varies widely between meters and for different cleaning reagents. Advice should be sought from the manufacturer for a particular cleaning procedure and where possible those products avoided until after testing. An example of interfering cleaning agents include bleach and sporicides, some of which has been shown to prevent the luciferase reaction with ATP after cleaning (Hygiena, 2014).

Following the required residence time for the cleaning or disinfection product, cleaning products and disinfectants may be rinsed prior to testing for ATP to avoid costly recleaning or extensive testing where interference with the ATP reaction may be likely.

If a rinsing step is undesirable, or disinfection is required prior to testing, a different method for surface validation may be employed e.g. surface debris adhesive tape lift testing.

9.10.2. Where ATP values consistently exceed thresholds

Where ATP values are above the acceptable threshold, re-cleaning may be required.

To establish if the cleaning method is the cause of the failure on a particular surface, a cleaning intervention step may be undertaken prior to recleaning the entire item or area. Where it is reasonably believed the failure is due to inadequate cleaning effort, a re-clean may be preferred. In either event, it is necessary to decide whether the failure is due to the cleaning procedure or the material being tested. Identifying the cause for the failure is a critical step to decide if:

1. re-scoping of the cleaning procedure may be required, or
2. an item- or area-specific ATP threshold is acceptable.

This decision will be based upon confirming that cleaning has indeed removed soil (debris) which is large enough to be viewed under a standard light microscope with sufficient resolution to be suitable for microbial analysis such as that required for reliable identification of fungal particulate matter. If debris is absent it is important to show the readings are not due to ongoing persistence of bacteria, so culturing is required in line with that commonly applied for verification of successful disinfection in Hospital settings.

If high ATP values persist following a cleaning intervention or second round of cleaning, samples should be submitted to an analytical facility for microscopy for visible debris (so called "debris loading" analysis.

If the area consistently failing ATP testing shows less than 1% visible debris ("debris loading") at 400 x magnification, an area of 25 cm^2 of the tested item or surface immediately adjacent to that which failed ATP testing should be swabbed. Alternative methods for surface testing include contact plates and dipslides which require less laboratory handling but also test a smaller surface. Larger areas may be swabbed using sponges or similar devices. Environmental surface testing options are provided by the New South Wales Government (NSW Govt., 2013).

Samples should be cultured for total Aerobic Colony Counts (ACC) in all cases, and should include culturing of thermotolerant bacteria in the high-touch and high-risk areas anticipated to be impacted by the infected person/s. Both ACC and thermotolerant bacterial counts should fall below 1 CFU/cm^2 in these cases, in line with Operating Theatres (Najotra *et.al.*, 2017). ACC counts should fall below 2.5 CFU/cm^2 on all other failing areas or items.

Where debris and bacterial testing has shown adequate cleaning, but ATP readings remain higher than indicated in Table 1 an adjusted ATP threshold may be applied.

The process to reach this decision along with laboratory certificates require documenting. The new threshold may be applied to similar items or material only when the reason for the change is understood and documented and only where this is feasible to measure in general areas[18].

Methods for rapid broad bacterial enumeration based Molecular techniques or biochemistry may be considered to expedite the cleaning procedure (such as antibody-antigen testing, or other enzyme-based / fluorescence measurement techniques). However, the uncertainties around these methods are likely less well understood from environmental samples and therefore testing uncertainties require documenting if elected to support ATP findings.

Other testing approaches may be utilised where they have been shown through peer reviewed publication to provide a strong indication of bioburden in relation to cleaning, and where interference of the enzymatic reaction is not reasonably anticipated as a result of interaction with the cleaning or disinfectant product, the nature of the impacted material or other identified factors.

9.10.3. Items unsuitable for ATP swabbing

Fabric samples or damaged surfaces are often unsuitable for swab collection of ATP samples as it is not possible to reach all areas of the fabric. In these cases, samples should be collected

[18] It is acknowledged that the limit of detection may be higher when samples are collected on smaller surfaces, however the lowest achievable detection limit should be targeted if necessary, by extracting swabs into a smaller volume of eluent.

using a debris sampling method suitable for that material such as tapelift or micro-vacuum sampling.

10 Debris testing and Microscopy

Mulvey *et.al.* (2012) showed that ATP values do not correlate strongly to surface bacterial concentrations when present at low levels. For this reason, it is important to have a strategy to establish where both false negative and false positive readings may arise.

Debris testing is required to support ATP as a validation technology. A surface debris sample should accompany 1 in every 20 ATP samples, or 1 in every 10 test locations whichever is greater. The sample should be collected immediately adjacent to the ATP test area. At least one (1) debris sample should be collected from each surface or item type.

Debris samples should be sent to a laboratory for indirect microscopic analysis of the surface. Surface conditions will be defined based on Debris rating as described under ASTM D7658-17 and detailed in Section 11.1.

It is further acknowledged that there may be restrictions on the supply of ATP meters and swabs upon release of IICRC/RIA 2020, and other documents recommending worldwide application in validating successful sanitisation of surfaces.

An alternative surface testing method comprises indirect examination of surface debris. Where debris is shown to be absent from the surface, it is deemed adequately cleaned. The premise in this case for confirming successful remediation of the surface is that the chemical used as part of the cleaning procedure has suitable anti-SARS-CoV-2 properties for emerging diseases. Guidelines around this premise are set out under a number of documents, by the TGA and are included in IICRC/RIA recommended procedures. It also assumes that cleaning has been used in accordance with the manufacturer's recommended conditions. Further it assumes that a full procedure to prevent cross-contamination of surfaces has been employed.

10.1. Collection of debris samples

10.1.1. Tape-lift

Samples from non-porous, intact surfaces should be collected in accordance with ASTM D7910:14- *Standard Practice for Collection of Fungal Material from Surfaces by Tape Lift* or a similar surface debris removal method.

Given that a low threshold for debris is required to validate cleaning, opportunity for cross contamination during sample handling is significant. For this reason, it is important that field blanks are collected and that the proportion of debris if any in the field blank is deducted from

that in the sample. Procedural blanks will be required by the laboratory to show that contamination has not occurred during laboratory preparation.

To minimise cross-contamination, it is recommended that tape-lift samples are mounted directly onto the inspection surface such as a microscope slide, at the time of collection on site.

Alternatively, tape may be stuck to small sandwich-style bags where the sample can then be transferred to a mounting surface upon delivery to the laboratory.

10.1.2. Microvacuum sampling

Samples may be collected from non-porous or semi-porous surfaces, or a damaged surface using microvacuum testing [19, 20]. Following sampling using a microvacuum onto a filter, the filter may be analysed using microscopy or other suitable methods. The size of the area vacuumed must be recorded in cm^2 and the surface concentration assessed based on the size of the tested area. For example, a large area may be vacuumed if a lower limit of detection is required, or a smaller area may be tested if the item is fabric which likely has loose inorganic fibres that could overload the filter, such as vacuuming from carpet. A health-critical item, which would be expected to have little inherent debris may be the subject of testing from a larger area.

10.1.3. Sample location density

Where such indirect measurement of debris through tape lift is employed as the primary method of analysis, samples should be collected at the same rate as ATP samples. The minimum number of samples should equate to the same number of samples calculated for ATP under Section 9.3 based on the equation shown in Equation 1: *Calculation of sample size based on surface area of tested item or structure* based on a sample area of 100 cm^2.

1 in every 10 debris samples must be collected in duplicate by collecting samples from adjacent locations.

10.2. Field sampling quality control

10.2.1. Field blanks

Field blanks must be collected at the beginning and end of each day for swabs, tape lift and microvacuum samples. Sample debris loadings require adjustment for debris on field blanks.

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[19] ASTM-D5755:09(2014)e1 - *Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading.*

[20] ASTM -D5756 (02)2008 - *Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Mass Concentration.*

10.2.2. Replicate samples

Duplicate samples must be collected at the rate of 1 in 20 samples for ATP swabs, tape lift and microvacuum samples collected in accordance with relevant standards[21, 22].

1 in 20 ATP swabs, or 1 in 10 ATP sampling locations, or 1 ATP test per item whichever is greatest must be accompanied by a debris sample.

1 in every 10 debris sample locations must be collected in duplicate by collecting samples from adjacent locations.

10.3. Sample documentation

The following should be documented as a minimum during testing:

- Date and time.
- Name of person sampling.
- Job specific reference.
- Unique Sample ID.
- Sample locations: Occupied Room or space name e.g. Lounge.
- Location in room e.g. height above floor level, wall elevation orientation etc.
- Item composition – material type, qualitative porosity (porous/non-porous), item use, item proximity to infected person.
- Calibration records of equipment.
- Specifications of the microscopes used. As a minimum they must be compliant with the requirements of ASTM D7658- 17 *Standard Test Method for Direct Microscopy of Fungal Structures from Tape.*

10.4. Chain of Custody

A Chain of Custody is a requirement when handling samples. A Chain of Custody should always accompany samples collected for analysis.

Information on a Chain of Custody must allow the receiving laboratory to identify:

- The number of samples submitted.
- Unique sample identification, e.g. Sample 1
- Sample location: Occupied Room or space name e.g. Lounge.

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[21] ASTM-D5755:09(2014)e1 - *Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading.*

[22] ASTM -D5756 (02)2008 - *Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Mass Concentration.*

- Location in room e.g. table, west wall etc.
- The sample type, for example surface debris sample.
- The nature of the sample i.e. surface sample for SARS-CoV-2 PRV.
- The name and contact details of the sender.
- Any relevant purchase order and job number associated with the project.
- A signature of the sender.
- The date of handover or posting of the sample.

11 Laboratory procedures

Upon receipt of the Chain of Custody the receiving person or laboratory should complete those details recommended or required for their facility under their in-house or NATA[23] requirements, but as a minimum:

- Number of samples received.
- Date and time of receipt of samples.
- Name and signature of person receiving the samples.

A sample submission form will also be required which may or may not be part of the same form as the COC. This must contain the above information if not provided separately on the COC:

- Unique job identifier that matches that in the COC.
- Unique Sample identification – anything written on the sample itself should match identically that supplied in the sample submission form for each sample.
- Date (and optionally time) of sampling.
- Size of area tested if not using tape lift.
- The area and time spent vacuuming if providing a microvacuum sample.

11.1. Laboratory analysis procedures

The target debris Category rating as defined under ASTM- D7658-17, *Test Method for Examination of Fungal Structures on Tape Lift Samples by Optical Microscopy* which classifies debris loading at 400x magnification based on:

- less than 1% debris = Category 0
- 1 to less than 5% debris = Category 1
- 5 to less than 25% debris = Category 2
- 25% to less than 75% debris = Category 3
- 75% to 90% debris = Category 4
- Over 90% debris = Category 5

[23] National Association of Testing Authorities

This Guideline requires that debris does not exceed ASTM D7658 Category 0 on the surface, therefore less than 1% debris must be present as an average when examined under 20 fields of view at 400 times (400x) magnification with a variation of less than 3 Standard Deviations across the sample. Where a single value exceeds 3 SD greater than the mean, the sample should be rejected or reported as "non-uniform" or "hand-picked".

Given that COVID-19 is a human-associated virus, the presence of any hair, skin cells or other indicator of human shedding at 400x magnification following examination of at least 20 Fields of View would result in a failure.

Where the debris is classed as ASTM D7658 Category 1, that is showing debris between 1% and 5%, a statistical approach may be taken based on other samples collected from the same surface.

Where sufficient samples have been collected from a test area or item, the mean debris percentage loading of all samples should fall below 1% loading and no single loading value should be greater than 3 Standard Deviations above the mean.

Where the surface still shows ASTM D7658 Category 1, after taking the statistical approach, or has a loading value greater than ASTM D7658 Category 1, the item will fail testing. Under these circumstances, we recommend one of two possible independent approaches to return the surface to ASTM D7658 Category 0:

1 A cleaning intervention step may be employed (Whiteley *et.al.,* 2018), and the cleaned surface re-tested to ensure that it is possible to return the surface to ASTM D7658 Category 0. If cleaning intervention is successful, cleaning with the appropriate technique and re-testing will be required.
2 A case should be presented to accept a higher percentage loading threshold based on methods and thresholds for bacterial surface testing as described in Section 9.10.2.

11.2. Assessing the size of the tested area based on tape lift analysis

Where tape lift is used to collect a sample, the size of the area observed under the microscope matches the size of the tested area.

The area of the surface viewed under the microscope should be calculated based on the specifics of the microscope and using a micrometer to calibrate that size is correct as part of normal laboratory protocols.

11.3. Calculation of surface debris from microvacuum samples

Where a microvacuum is used to collect debris, the area vacuumed is typically larger than the area of the filter. Consequently, the debris is concentrated onto a filter, so the debris deposited will be concentrated by a sample-specific concentration factor. To calculate the original

concentration on the tested surface it is necessary for the laboratory to include this concentration factor in their processes and calculations.

The Assessor should provide the size of the area sampled to the analytical facility, and the analytical facility will be required to calculate the percentage loading on the tested surface based on this concentration factor.

Preparation of mixed cellulose ester (MCE) filters collected using 25 mm asbestos cowls or in other debris sampling devices using MCE filters may follow the area NOHSC Membrane Filter Method designed for counting airborne asbestos fibres (NOHSC, 2005).

Example 1:

If a microvacuum sample is collected on a 25 mm diameter filter in an asbestos sampling cowl, the effective diameter of the filter is approximately 22.4 mm.

If the effective surface area of the filter = A_F (mm^2),

$A_F = \pi r^2 = \pi \times (22.4/2)^2\ mm^2 \simeq 394\ mm^2 = 3.94\ cm^2$.

Where r = filter radius = (diameter÷2)

If area tested = A_T (mm^2)

The concentration factor of debris onto the filter = $C = A_T/A_F$

If the acceptable threshold concentration on the surface is P%, the acceptable concentration on the Microvacuum filter = MV% where:

$MV(\%) = P(\%) \times C = P(\%) \times (A_T/A_F)$ – Equation 2

Simplification by testing under standard conditions:

When using a 25 mm filter cartridge, $C = A_T/3.94$

When collecting a sample from the standard test area[17, 18] of 100 cm^2, $A_T = 100\ cm^2$
The concentration factor of debris during sampling = $100\ cm^2/3.94\ cm^2 \simeq 25.4$
With an acceptable threshold on the surface of 1%, and the acceptable amount of debris on the filter,
$MV = P \times C = 1\% \times 25.4 \simeq 25\%$ loading.

Therefore, under standard sampling conditions using a 25 mm diameter filter should show no more than 25% loading under the microscope.

Care must be taken to ensure that the microvacuum filter does not become overloaded with inorganic fibres from fabric. Where this may be important, the sample may be collected from a smaller area, for example an area 5 cm x 5 cm from a carpet may be reasonable depending on

the type of carpet and tendency to release fibres. Additional smaller samples may be collected if the Assessor wishes to test the standard area of 100 cm^2.

Where a different filter size is employed, or the area sampled is less or greater than 100 cm^2, the actual acceptable % loading (MV%) requires calculation based on Equation 2.

A caution value based on reaching 5% loading (ASTM D7658 Category 1) cannot be set when sampling using microvacuum over 100 cm^2 with a 25 mm diameter filter, as 5% on the tested surface would result in overloading the filter. If the surface may result in sampling high levels of inorganic debris, multiple numbers of smaller areas are recommended.

11.4. Laboratory quality control

11.4.1. Replicate counting

Duplicate counting by the same analyst and by a second analyst should be employed in the laboratory in accordance with laboratory procedures, and uncertainty values recorded.

11.4.2. Analytical blanks

The laboratory must follow strict protocols around quality control. A single analytical blank must be included in each batch of samples. Analytical blank values must be evaluated and reported as part of the Certificate of Analysis (COA).

11.4.3. Laboratory reports

Certificates of Analysis (COA's) must include as a minimum that normally expected under best practice including not exclusively unique sample ID, client details and sample ID, name of analyst, date of analysis, name and address or issuing laboratory.

11.4.4. Item-specific threshold setting for debris

Where an item may not reasonably be expected to return to ASTM D7658 Category 0 due to for instance surface roughness, it is possible to set an item-specific debris threshold. The reason and justification for the item-specific threshold must be documented, and a risk assessment conducted to show that the risk of exposure to SARS-CoV-2 is not increased by adopting an adjusted threshold.

Where ATP and bacterial (ACC) as described in Section 9.6 has shown adequate cleaning, that Debris threshold may be applied to that item or material. Referencing the same threshold to other items may only be undertaken when the reason for the change is understood and documented.

11.5. Health and safety of laboratory staff

It is important for laboratories to show that they have prepared documentation detailing how they are protecting their staff during sample receipt, handling, preparation, analysis, and disposal.

As a minimum the following should be considered:

- Possible contamination of the sample during handling by the assessor collecting the sample meaning that received samples have surface contamination.
- Potential for release of the virus when opening containers with surface-facing adhesive such as pre-prepared slides.
- Potential for release of the virus during microvacuum sample preparation.
- Potential for cross-contamination between samples by the analyst preparing the samples.
- Potential for release of the virus after disposal by coverslips becoming loose, drying out of adhesive or resuspension in the waste container.
- Disposal of the samples as Biohazard waste.

12 Interpreting laboratory outputs in relation to validation

12.1. Laboratory "Pass" result for a sample

Where a sample has a "Pass" output from a sample this indicates that the debris or bacterial concentration for that sample was below the recommended thresholds. Where all samples have passed there is no requirement for further data analysis.

Where multiple samples have been collected from a tested item or surface, in the event that one or more samples collected from an item or area exceeds the threshold it is necessary to refer to Section 12.2.

12.2. Laboratory "Fail" result for a sample

Exceedance of the bacterial concentration thresholds or where debris exceeds ASTM 7658 Category 1, the surface or item requires recleaning or a cleaning intervention.

12.3. Laboratory "Caution" result for a sample

Where the debris is classed as ASTM D7658 Category 1, a Caution will be required.

In this case it is possible to take a statistical approach may be taken based on other samples collected from the same surface.

Where sufficient samples have been collected from a test area or item, the mean debris loading percentage of all samples should fall below 1% loading (i.e. be classed as ASTM D7658 Category 0), and no single percentage debris loading value should be greater than 3 Standard Deviations from the mean.

Where the resultant mean debris loading value is equal to or greater than 1%, or a single reading exceeds 3SD above the mean, the item will fail testing. Under these circumstances, we recommend one of two possible independent approaches to return the surface to ASTM D7658 Category 0:

1 A cleaning intervention step may be employed (Whiteley *et.al.*, 2018), and the cleaned surface re-tested to ensure that it is possible to return the surface to ASTM D7658 Category 0. If cleaning intervention is successful, cleaning with the appropriate technique and re-testing will be required, or otherwise a case should be presented to accept a higher ASTM D7658 Category showing that no perceived increased risk of SARS-CoV-2 is thus created.

2 The area is recleaned in its entirety, and testing repeated with final surface debris being classed as ASTM D Category 0.

13 Risk assessment

The preparation of a risk assessment which addresses the likely level of risk following post-remediation validation of SARS-CoV-2 impacted sites requires consideration of a range of factors.

Currently, we do not have the full information on the infective dose of the virus, the precise routes of transmission, so at best any risk assessment is likely to be qualitative.

The following factors have been identified by IAQAA as being useful as part of a Risk Assessment:

- Sampling density.
- Likely duration of infection prior to vacating the building.
- Sensitivity of building use or occupants who may use the building post-remediation.
- The frequency of passage or residence in the building by its users - e.g. public building, educational facility, school, office, warehouse, factory, transport vessel, GP / dentist / personal care facility, food outlet where people will sit together often face to face, hospital etc.

Risk assessment should follow the principles of ISO 31000 and risk mitigation controls should follow the principles of the risk hierarchy wherever possible.

Occupational exposure risk by workers are in part determined by the impacted building elements and surfaces that are potentially impacted by the SARS CoV-2 virus. The location of high touch points indicates a significant increase in exposure risks.

13.1. Risk assessment of occupation

The type of workplace and/or living space is relevant, as well as likelihood of people being able to maintain an inter-personal distance of 1.5 m from another individual. Another thing to consider is the requirement for repeated or extended contact with persons known to be or suspected of being infected.

13.1.1. High risk occupations

High-risk occupations relate to specific medical, postmortem, or laboratory facilities. Workers may be performing aerosol-generating procedures such as intubation, cough induction, bronchoscopies, some dental procedures and exams, or invasive specimen collection. These activities can heavily contaminate surfaces with viral particulate matter and so pose a high risk of exposure.

People working in these environments who are not directly engaged in medical, postmortem, or laboratory procedures and are not performing aerosol-generating procedures can still be put into a high-risk category based on risk of primary aerosol exposure as well as from resuspension of viral particulate matter from impacted materials. Workers at risk in this category include healthcare staff such as doctors, nurses, dentists, paramedics, emergency medical technicians and porters.

13.1.2. Medium risk occupations

Medium exposure risk occupations are defined as those requiring frequent and/or close contact (*i.e.* with that 1.5 m perimeter) with a high proportion of potentially COVID-19 infected persons. Airports, transport vessels including buses, trains, aircraft, cruise ships and other marine vessels all have greater potential for transmission as people are travelling internationally and are in a situation where physical distancing is impossible.

Recent community transmission has occurred in Australia where baggage handlers were infected with SARS-CoV-2 at Adelaide Airport. Further similar transmission could happen via frequent contact with travellers returning from international locations with widespread COVID-19 transmission.

Other medium exposure risk environments include schools, high-population-density work environments, and some high-volume retail settings. For this reason, many of these types of businesses are either operating from home or not operating at all at the time of writing.

13.1.3. Low risk occupations

Low risk occupations are defined as those who do not require contact with people known to be, or suspected of being, infected with SARS-CoV-2 nor to have frequent close contact with them. Workers in this category have minimal occupational contact with the public and other coworkers.

13.1.4. Unidentified risks

It was initially estimated that around 9 times the number of confirmed cases of COVID-19 were present than the numbers reported at any one time (Nishiura *et.al.*, 2020). In recent weeks, research has shown that between 50-85 times the number of people expected to have antibodies to the virus were shown to have potentially been infected (Bendavid *et.al.,* 2020). Therefore, there are likely unidentified risks which are hard to assess but may be considered.

Consideration in risk assessments can include questioning how to accommodate undetectable risks, and therefore it is possible to improve risk outcomes by including unidentifiable risks into the assessment.

14 Supplementary information

14.1. COVID-19 – a Short story with huge outcomes

An overview of the early outbreak was provided by Zheng, 2020 wherein a 'pneumonia-like' condition of unknown origin was detected in Wuhan, China and was first reported to the WHO Country Office in China on 31 December 2019 (WHO, 2020a).

Coronaviruses are a large family of viruses that are common in humans as well as other animals such as camels, cattle, cats, and bats. The spread of these 'animal' viruses whereby they unpredictably jump from animal to human are known to be very rare. The current evidence indicates origin in bats but transmission to humans only occurring after passing through an intermediate host such as camels, cats, and most recently implicated pangolins (NCIRD, 2019).

The first report of the new virus was documented on the 8 December 2019 (Cheng *et.al.*, 2020). SARS-CoV-2 had infected over a known two million individuals at the time of writing, with projections into the future remaining uncertain.

SARS-CoV-2 has been reportedly linked to a large "wet" seafood and live animal market, suggesting animal-to-person spread in Wuhan, a Hubei Province in China. Workers at the market made up a significant number of initial cases, suggesting initially that the virus was the result of an animal to person exposure pathway. Around a third of early cases however were not associated with the market, so the source of the virus has not been fully ascertained at the time of this publication version. The second wave of Hubei Province infection was not derived from the markets, data instead indicating person-to-person spreading was driving infection. Person-to-person spread was subsequently reported outside Hubei Province and later in many countries outside China (NCIRD, 2019).

Very recent evidence suggests the number of infected individuals could be a much as 50 to 85 times higher with many individuals having contracted and recovered from the disease with minimal or even no symptoms (Bendavid *et.al.,* 2020). This may be due to false positive outputs from the antibody test; however, this has not yet been documented.

There is evidence that 25% of occupants tested outdoors in New York City were positive for antibodies to the virus[24].

This may indicate an earlier start to the virus or provide evidence of significant community transmission through airborne transmission or the faecal-oral route. The airborne mode of

[24] CBSN New York News (2020*) Coronavirus Antibodies Present in Nearly 25% Of All NYC Residents, Cuomo Says; Un-PAUSE in Certain Regions Of NY Might Begin In May*.

https://newyork.cbslocal.com/2020/04/27/coronavirus-antibodies-present-in-nearly-25-of-all-nyc-residents/ Reported by CBSN New York News, April 27, 2020 at 11:30 pm. Accessed 29/04/2020.

transmission by viral aerosol believed by leading scientific authorities to be of concern (Morawska and Cao, 2020). This data further suggests that airborne transmission may be a dominant route of transmission.

Pre-symptomatic transmission has been documented as being associated with outbreak clusters (Wei *et.al.*, 2020). Some individuals may spread the virus but remain asymptomatic (Bai *et.al.*, 2020).

SARS-CoV-2 has resulted in a reportedly lower mortality rate than avian influenza, SARS, or MERS, but is leading to significant loss of life throughout the world. Ebola and some haemorrhagic viruses which spread through contact with on-person and on-surface bodily fluids resulted in lower transmission rates. These diseases partly avoided becoming a pandemic because their mortality rate was ironically much higher.

Having a lower mortality rate has allowed the virus to be transmitted via people who remain sufficiently healthy to infect those who are more vulnerable. Unlike SARS and MERS, a COVID-19 infected individual's immune response is not suppressed as they were in cases of MERS and SARS, reducing the COVID-19 mortality rate. It however remains highly contagious and the possibility of newly identified modes of transmission from faeces and through airborne aerosol transmission are evolving.

In contrast, once in the body SARS-CoV-2 is much more readily able to bind to cells (Wand *et.al.,* 2019), and notable retention in the gut means it can persist as a potential threat post-respiratory recovery. Tracing of COVID-19 cases by following its presence in sewage plumes is being investigated. The article to be released by Bertsch *et.al*. from CSIRO along with the University of Queensland is in publication with the Science of the Total Environment (CSIRO, 2020).

The U.S Centers for Disease Control and Prevention (CDC) provided comprehensive practical measures for managing COVID-19 (CDC, 2019c).

The difference in infectivity of SARS-CoV-2 compared with these other human coronaviruses is still being elucidated, and may include further explanation around its ability to spread prior to symptoms arising (Bai *et.al.,* 2020), along with the anticipated strong ability for the virus to bind to a host cell (Wand *et.al.,* 2019).

COVID-19 is much more infective to humans than MERS-CoV or SARS-CoV-1 but is expected to have a significantly lower mortality rate.

Key differences include:

- SARS-CoV-2 has the ability to result in infection prior to symptoms.

- SARS-CoV-2 is anticipated to bind more strongly to the host cell ACE2 receptor making it more effective at infecting the body (Wand *et.al.,* 2019)., and allowing strong binding in the lungs as well as presenting in the intestines (Han *et.al.,* 2020).
- SARS-CoV-2 displays a likely lower mortality rate than MERS or SARS-CoV-1 likely due to different ways that the body fights the infection.

Coronavirus 2019, abbreviated to COVID-19, the disease caused by SARS-CoV-2, can lead to severe respiratory distress, and loss of oxygen across the alveoli in the lungs, with consequent hospitalisation of around one-fifth of those contracting it, with an average of around 1 in 20 people becoming critically ill. Many patients require supplementary breathing support, including the use of ventilators. It can also lead to digestive problems which can impact recovery rates and potentially cause damage to the liver.

However, given its closer evolutionary relationship to Ebola and HIV than to SARS-CoV-1 it is feasible that other types of transmission than face-to-face contact are possible.

The potential for long-term organ damage is still being investigated.

The virus is spread by respiratory droplets, mucous particles of varying sizes, generated when a victim breathes, coughs or sneezes (CDC, 2020a). Viruses can also spread through contact with bodily fluids containing virions (individual viruses).

A sufficient exposure to these particles and the virus when contained within our nose, mouth, face, eyes, or intestines creates the potential to cause infection.

It is noted that the CDC describes the infection as highly contagious (CDC, 2020c)[1], yet the U.K. Government has removed its status as a High Consequence Infectious Disease following agreement by the Four Nations HCID group, stating (U.K. Govt, 2020):

"As of 19 March 2020, COVID-19 is no longer considered to be a high consequence infectious disease (HCID) in the UK.

The 4 nations public health HCID group made an interim recommendation in January 2020 to classify COVID-19 as an HCID. This was based on consideration of the UK HCID criteria about the virus and the disease with information available during the early stages of the outbreak. Now that more is known about COVID-19, the public health bodies in the UK have reviewed the most up to date information about COVID-19 against the UK HCID criteria. They have determined that several features have now changed; in particular, more information is available about mortality rates (low overall), and there is now greater clinical awareness and a specific and sensitive laboratory test, the availability of which continues to increase. The Advisory Committee on Dangerous Pathogens (ACDP) is also of the opinion that COVID-19 should no longer be classified as an HCID".

A critical reason for the spread of COVID-19 is reportedly that a percentage of carriers are asymptomatic or do not recognise symptoms such as diarrhoea present in approximately half of cases and being the first symptom for approximately one-fifth of infected people. Other warning signs such as loss of smell or taste are symptoms which appear before the more severe and well-publicised symptoms.

The World Health Organisation (WHO) is a global body operating to promote health, keep the world safe, and serve the vulnerable. They provide information that is used by Governments in forming decisions around risks (WHO, 2020 b).

Whilst reluctant to declare a pandemic, the outbreak was declared a Public Health Emergency of International Concern by the WHO on 30 January 2020 (WHO, 2020 b). On 11 February 2020, the WHO announced a name for the new coronavirus disease: COVID-19. Thereafter, clear source and receptor pathways of subsequent waves of infections were starting to blur, as it spread throughout the community, meaning that many people were unaware of how they had become exposed and contact tracing becomes untenable.

The United States Center for Disease Control & Prevention[25] has provided further insight into COVID-19 which is caused by a coronavirus (NCID, 2020).

14.2. Modes of transmission

At the time of writing this document, the WHO advises that the main modes of transmission of SARS-CoV-2 are through droplet nuclei close to the infected person and surface contact (WHO, 2020a). In both instances, self-inoculation from the hands is the likely mechanism for virus entering the body and contacting mucosal receptors required by the virus for cellular adsorption.

However, many cognisant public health authorities and experts who understand aerosol science believe that sufficient evidence exists to suggest potential for more distant transport via aerosols (smaller droplets) containing the virus, a third mode of transmission. Whilst this topic remains under active scientific debate, evidence shows that viral aerosol is diluted readily by good ventilation unless in a room with a lot of movement of people such as in a changing room or toilet. Close transmission of droplet nuclei will therefore result in significantly greater viral load and greater likelihood of infection than more distant transmission via aerosol with accompanying lower viral load. Nonetheless, the possibility of transmission via aerosol shed by infected persons remains a concern and may be an important component to consider during risk assessment conducted prior to starting works.

A fourth mode of probable transmission is the disruption of fomites (deposited virus on surfaces) which can result in resuspension of airborne particles containing the virus. This has

[25] https://www.cdc.gov/coronavirus/2019-nCoV/index.html

been shown to occur when changing clothes or in toilets / bathrooms (Y. Liu *et.al.,* 2020) and Hopsodsky *et.al. (*2012) showed that the around 90% of indoor microbial aerosol is comprised of resuspended surface particulate matter. The treatment of large surface areas where fomites may be present using methods that suppress dust generation upon staring work is a key first step in remediation.

A final potential fifth mode of transmission is via aerosolisation of virus-containing particulate capable of causing infection from faecal viral loads and toilet waste plumbing systems. The transport route was demonstrated using a test organism as a possible route of viral transport through the building to assist in explaining the spread of SARS-CoV-1 at Amoy Gardens (Gormley *et.al.*, in 2017). No measurements were made at the time of the spread, however. Movement through plumbing was reported in the media on one occasion in Wuhan, but such movement has not yet been investigated or documented for SARS-CoV-2. Given that recent research has shown heavy viral loads in faeces from infected people, a treatment process for plumbing systems may be considered, along with strategies to prevent infection of remediation staff when working in wet areas where water traps may have dried out in an empty building. Given the observation of high rates of antibodies in New York City could feasibly be the result of airborne transmission from their combined sewage and rainwater run off system that vents into the streets of the City given that CSIRO is tracking the virus through sewerage networks.

Rates of person-to-person transmission remain lower than a highly airborne transmitted disease such as measles. This suggests that whilst airborne, testing of air is not the priority. The role of ventilation as a key factor in mitigating risk has been stressed by Jordan Peccia at the 2020 CIRI Science Symposium: COVID-19 and Pandemic Preparedness.

In the absence of definitive evidence and specific recommendations by public health authorities, IAQAA has reached the opinion that ventilation through air conditioning (flushed with maximum available outside air prior to starting work). Also, consideration could be given to filtration and humidity control of the outside air to prevent encouraging mould growth or other indoor air quality challenges. We know from research on MERS-CoV and SARS-CoV-1, that changes in indoor climatic conditions alter the infectivity of coronaviruses (Pyankov *et.al.*, 2018). At the time of publication, we do not have sufficient information on how to control internal building conditions to reduce risk for SARS-CoV-2.

14.3. Severity of COVID-19

The mortality rate of COVID-19 is not fully understood. The clinical picture so far has been reported as ranging from very mild (including some with no reported symptoms) to severe, including respiratory distress to multiple organ failure and sepsis, resulting in death.

A current study by Guan *et. al*, (2020) from the China Medical Treatment Expert Group for COVID-19 suggested that the vast majority of cases are ‘mild’ whilst 16% of the cases were

deemed as suffering from a serious illness. This number varies depending on the demographic, capability of the health system, imposed personal movement control measures and possibly climatic conditions in the respective country.

Older people and people of all ages with severe chronic medical conditions such as heart disease, blood pressure, lung disease and diabetes display were, at the time of writing, at significantly higher risk of developing serious COVID-19 illness.

The CDC showed that 80% of deaths from COVID-19 in the United States were among adults 65 years and older with the highest percentage of severe outcomes occurring in people 85 years and older (Morbidity & Mortality Weekly Report) when examining severity based on age demographic.

14.4. Coronavirus mode of attack

Humans are more rapidly transmitting COVID-19 than SARS or MERS due an S-protein on the virus surface which has a strong affinity to a specific enzyme receptor within the human body called Angiotensin-Converting Enzyme 2 (i.e. ACE2). Once attached to the host cell, the viral RNA enters the cell. This RNA can incorporate into the host cell function, dividing rapidly, breaking (lysing) the host cell, and invading the neighbouring cell, and so causing the occurrence of infection (Wand *et.al.*, 2019).

This mode of attack operates within the respiratory tract but is even more efficient in the digestive system where the virus expresses over 100 times more effectively (Spiegel *et.al.*, 2020). This response means that it takes much longer to recover from the virus if digestive symptoms are present, and further has likely led to shedding in human faeces. Digestive symptoms indicate a route of exposure through ingestion, as the virus is swallowed into the stomach. Mouth breathers are therefore more prone to exposure through ingestion.

Very recent research on the genome of SARS-CoV-2 has shown that the genes responsible for binding to cells makes is potentially up to 1,000 times more efficient than the respective SARS-CoV-1 and MERS-CoV (Wrapp *et.al.,* 2020). Further analysis revealed that the genetic code in SARS-CoV-2 (cleaving furin) was in fact 98% similar to Ebola and HIV, and only 79% similar to these other coronaviruses.

Given that COVID-19 causes diarrhoea in around half of its patients (Spiegel *et.al.*, 2020), this may in part explain the findings of Y. Liu *et.al.,* 2020, who detected high levels of SARS-CoV-2 RNA in toilets. At least 50% of patients confirmed with the disease will shed virus in their faeces (Xiao *et.al.*, 2020). Those developing only digestive symptoms (estimated at 6% of cases) is believed to comprise a subset of patients who often have milder symptoms (Spiegel *et.al.,* 2020).

14.5. Airborne transmission of COVID-19

Most of the airborne SARS-CoV-2 pre-publication research has not passed the usual level of peer review, and the scientific community is not in agreement at this time about the importance of airborne transmission (Lewis, 2020). Below is an overview of the current opinions and evidence base behind the differing beliefs around the significance of airborne transmission of COVID-19.

Indoor environmental conditions at the time of testing may affect SARS-CoV-2 viability. Research by Pyankov (2016) on MERS-CoV, and research by Chan on SARS-CoV-1 showed that coronaviruses are sensitive to environmental stressors.

Loss of infection capability has been shown to be linked to the inability of the MERS-CoV virus to remain stable in the indoor environment at low relative humidity and high temperatures (Pyankov *et.al.,* 2017cox). Temperature and relative humidity are key factors in the longevity of coronaviruses. Both MERS-CoV and SARS-CoV-1 were inactivated by increased temperature, and variously impacted by extremes of relative humidity (Pyankov *et.al.,* 2017, Chan *et.al.*, 2011). It therefore remains possible that aerosolised SARS-CoV-2 may cause infection under those conditions where it remains stable, so application of ventilation is a very important risk mitigation step when conducting works in contaminated or remediated buildings.

There will be an ongoing reduction in airborne concentration as particles settle onto surfaces, but there is significant risk from resuspension with even small amounts of indoor air movement, especially from clothing or carpeted areas. Prof. Jordan Peccia advised during the CIRI symposium on COVID-19 (31 March 2020) that up to 90% of airborne microorganisms in the indoor environment have been resuspended from carpets (Hospodsky *et.al.,* 2012).

Further evidence of floor-borne resuspended viral particulate matter has been indicated by the presence of viral RNA on the surface of protective shoes of healthcare workers but not on the remainder of their PPE (Ong *et.al.*, 2020).

It is important that re-aerosolisation from surfaces is prevented during cleaning or other works, or airborne conditions may change unexpectedly. SARS-CoV-2 particles (virions) may remain viable for several days on surfaces (CDC, 2020b) and have potential to be re-aerosolised from surfaces if they dry out, and therefore become airborne (Y. Liu *et.al.*, 2020).

14.5.1. Evidence in favour of airborne transmission

It will likely be a considerable time before all of the metadata is accumulated and processed from the current COVID-19 epidemic spread.

Whilst having differences in its mode of transport to SARS, its external structure and location of attack in the body appears similar. It causes sudden infection of the alveoli of the lungs, leads

to pneumonia and harbours in the intestine. Therefore, its transmission mode may reasonably be expected to have some commonality with the spread of SARS.

The main locale of the SARS outbreak was at Amoy Gardens in Hong Kong. Epidemiological analysis was conducted based on atmospheric transport and air flow modelling, rather than relying on air sampling results which are influenced by local factors in a small indoor area and so was dominated by droplet nuclei. The data strongly suggested that a significant mode of transmission was airborne transport of the virus over a distance of greater than 200 metres. Probable sources were identified as open windows and doors however and a potentially significant viral source was identified as plumbing in multi-storey buildings where wastewater and faeces containing the virus would have been present at very high levels. Computational fluid dynamics (Ignatius *et.al.,* 2014, Li, *et.al.*, 2014) as well as physical modelling of a rigged plumbing system spiked with *Pseudomonas putida* as a surrogate for an infection showed this to be a potential major factor in disease spread (Gormley *et.al.*, 2017). Further, Ignatius *et.al.* pointed to wind direction and bathroom extractors facing the dominant direction of transmission between buildings.

Recent testing in clinical settings has shown that enclosed areas such as toilets and changing rooms in a Wuhan Hospital contained a higher concentration of the viral RNA than a ventilated ward with COVID-19 patients (Y. Liu *et.al.*, 2020).

The work by Y. Liu is unique in demonstrating the particle size distribution of viral particulate matter (not necessarily viable virus at this stage) in areas where virus was detected. These were limited to levels of high physical activity where air was possibly impacted by removal of contaminated PPE, and possible lower ventilation rates. Figure 1 demonstrates potential for long-term suspension of viral aerosols and transport through mechanical and building-design related air pathways suggesting that this may be a removal route from Wards.

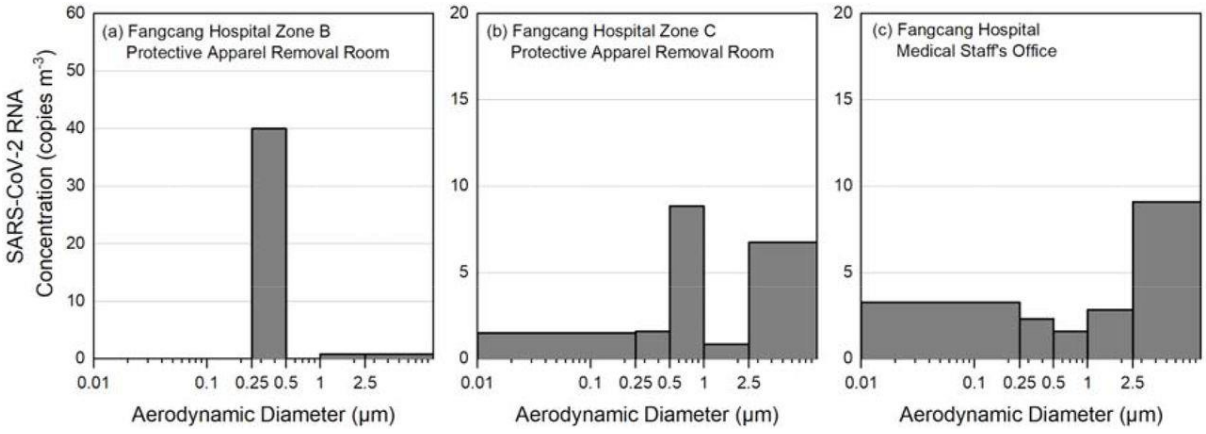

Figure 1: Particle size distribution of SARS-CoV-2 RNA airborne particulate in Fangcang Hospital, Wuhan, during treatment of COVID-19 patients.

Similar findings were preliminary reported by Chia *et.al.,* 2020, who showed a bimodal distribution of SARS-CoV-2 aerosol in the 1-4 μm as well as the >4 μm particle diameter size ranges. Airborne particles of these sizes could remain airborne for many hours.

A key consideration in viral aerosol particle size is the impact of relative humidity on very small particulate matter. Here, particles will grow relatively quickly in humid environments such as Wuhan.

Recent laboratory-based studies suggested that the half-life of SARS-CoV-2 in airborne aerosols under ideal conditions was approximately 1.1 hours, surviving for up to 3 hours (van Dorelamen *et.al.*, 2020) and for a similar time to SARS-CoV.

Laboratory cultured SARS-CoV-2 was deliberately released using a nebuliser, as an aerosol into a vessel where it was sampled and analysed to see if it would infect animal tissue culture. This work has been seen to indicate that airborne COVID-19 infection transmission is possible and that risks may exist for at least 3 hours after release from the human body.

The test conditions employed in the van Dorelamen study provided a worst-case scenario and was not a study in a Hospital ward with infected people for example. Further, the experiment measured the impact of the virus based on its ability to still grow on tissue culture as a proxy for infection. It is possible that the aerosol composition, physical and aerodynamic properties of the virus during the test were different to that which may be present where people were becoming infected. The survival time may hence not represent the longevity of the virus in the indoor environment; however, the findings must be considered in appraising airborne transmission.

An early research letter accepted for July 2020 publication by Lu *et.al.* demonstrated evidence of airborne transmission of COVID-19 in a restaurant potentially through the air conditioning system. The virus was not detected however in the air conditioner, so it may be possible that the cause was due to a different factor. Publication by Gormley *et.al.* (2020) indicates potential for spread through toilet use and Y. Lui *et.al.* (2020) demonstrated detection of the virus in toilets. Lu's conclusions may change; however, his article is currently extensively cited so is included in this Reference guide for the purpose of providing current information. Until the mode of airborne transmission and role of faecal aerosol or surface transmission is clear, it cannot be excluded from risk assessments.

Transmission of the virus via an airborne route is also indicated based on studies on SARS-CoV-1 (SARS).

Testing in Singapore in rooms with isolated patients showed significant pre-cleaning contamination but no detection of airborne SARS-CoV-2 RNA (Ong *et.al.*, 2020), again suggesting low airborne loading. The extractor fan in the room showed evidence of RNA but the fan was reportedly directly above the patient and likely impacted by droplet nuclei during

sneezing or coughing. Ong showed viral RNA was present on surfaces other than handled surfaces, suggesting airborne transport of viral particulate matter was contaminating surfaces. Aerosol sized particles would be less likely than droplet nuclei to become entrained on the surface due to lack of inertia, but the data does suggest that we cannot at this time exclude the possibility that HVAC systems may become contaminated with SARS-CoV-2 from infected patients. Where HVAC systems extract air from the vicinity of a known infected individual, the extractor or return air register may be expected to concentrate the virus.

Testing in isolation rooms of COVID-19 patients successfully detected airborne viral particles in the isolation room, the door threshold, and the adjacent Corridor. Further, viruses on surfaces that were most likely impacted by air (Santarpia *et.al.*, 2020).

14.5.2. Evidence of limited airborne transmission

Unreviewed data released by Y. Liu *et.al.,* 2020 indicated that the virus when measured based on its RNA signal, was undetectable in air at a treatment Centre in Wuhan that was treating COVID-19 patients, where air was tested in intensive care, coronary care and in a general ward. Their work demonstrated the importance of ventilation, and prevention of resuspension of viral particulate matter. The role of resuspension and ventilation was emphasised when the authors detected viral RNA in a toilet block and in Healthcare worker changing rooms PPC and PPE, particularly respiratory protective equipment was removed or handled.

In part the lack of success in capturing an infective pocket of air during sampling may be due to the challenges posed by bioaerosol monitoring for viruses (Morawska, 2020).

Influenza has been shown to be released on breathing, but research also shows that upper and lower airway infections potentially have different modes of transmission. As COVID-19 primarily attacks the lower respiratory tract, based on work by Yan *et.al.,* (2018) on influenza spread, it is possible that release of viral aerosol is less than would be expected with upper airway symptoms.

Not all organisations are in agreement that airborne transmission is highly relevant. At the time of publication, the WHO stated (WHO, 2020a, 2020 c):

"COVID-19 is transmitted via droplets and fomites during close unprotected contact between an infector and infectee. Airborne spread has not been reported for COVID-19 and it is not believed to be a major driver of transmission based on available evidence; however, it can be envisaged if certain aerosol-generating procedures are conducted in health care facilities. Fecal shedding has been demonstrated in some patients, and a viable virus has been identified in a limited number of case reports. However, the fecal-oral route does not appear to be a driver of COVID-19 transmission; its role and significance for COVID-19 remains to be determined."

According to leading University of Drexel Epidemiologist Prof. Michael LeVasseur:

"Air-to-air transmission is not a significant driver behind the virus' spread. If it [SARS-CoV-2] could easily exist as an aerosol, we would be seeing much greater levels of transmission, and we would be seeing a different pattern in who's getting infected. With droplet spread, it's mostly [spread] to close contacts. But if a virus easily exists as an aerosol, you could get it from people you share an elevator with."

Evidence (is) that the virus is predominantly spread through droplets and not as an aerosol."

In part this stance is the due to the observation of a relatively low transmission rate (1 person infects 2-3 people with COVID-19 compared to measles where spread is dominated by airborne transmission and so affects 12-18 people). If these values are correct following further testing, this value suggests that transport in air is less of a driver in infection spread than with measles.

Further, recent unreviewed publication by Senche *et.al.*, 2020, indicates that the R_0 value for COVID-19 may be between 4.7-6.6, in part likely due to its much stronger ability to enter human cells than SARS-CoV-1 or MERS-CoV (Wang *et.al.,* 2020), but this may also point to greater airborne transmission than previously estimated. In fact, the mode of cellular attack shows greater similarity to HIV and Ebola than it does to other coronaviruses.

The SARS-CoV-2 genome however shares around 79.6% of its base sequence with SARS-CoV-1 (Zhou *et.al.*, 2020) and has almost identical proteins (Xu *et.al.,* 2020). Given the physical similarities and therefore likely particle transport characteristics between the two viruses, we may wish to include findings around potential airborne transmission of SARS when considering the need for safe air testing methods for SARS-CoV-2. However, airborne SARS-CoV-2 may pose different health risks to SARS-CoV-1 and until an infective dose has been established, findings would be highly qualitative.

Another study has shown that there was only a 10.5% transmission rate of COVID-19 occurring within households (Burke *et.al.*, 2020). This number may be expected to be higher if airborne transmission was the key driver of disease spread.

Lower infectivity in air may not be due to transport of the aerosol but be due to the need to be exposed to a high infective dose, poor viral stability and desiccation of the viral aerosol or other as yet unidentified factors. Influenza has been shown to be released upon exhaling, but research also shows that upper and lower airway infections potentially have different modes of transmission. Yan (2018) showed minimal aerosol generation in relation to infection of the lower respiratory tract compared to the Upper Respiratory Tract. As COVID-19 primarily attacks the lower respiratory tract, it is possible that release of viral aerosol is less than would be expected with upper airway symptoms, and until we know the infective dose of SARS-CoV-2 we cannot say whether that may account for lower rates of transmission than say measles.

14.5.3. Current level of overall understanding

Most data used to consider safety measures is preliminary and lacks the usual robust peer review processes around scientific publication.

A wide size range of droplets/aerosols are released, from large visible droplets (100 µm in diameter) to droplets too small to be seen. The larger droplets will rapidly fall to the floor or an interrupting surface and pose a risk of becoming airborne at a later date through resuspension when the droplet dries.

Droplets greater than 5 µm aerodynamic diameter (droplet nuclei) travel up to no more than approximately 2 metres from an infected person's breathing zone if they speak, sneeze and / or cough. These particles may be inhaled or swallowed respectively if they enter the nose of mouth of a person within 2 metres of the infected person. Vigorous sneezing or coughing may expel these droplets even further as viral particles are found on windows and doors of infected patients. Close contact is generally thought to be the main route of person-to-person transmission by SARS-CoV-2.

Smaller aerosol sized droplets, less than 5 µm aerodynamic diameter (so called aerosols) containing virus particles (viral aerosols) will remain suspended in the air for an extended period and will be diluted to a final concentration based on the volume of the receiving air with which it mixes. Where the building is mechanically or naturally ventilated, the airborne virus can be diluted by incoming outdoor air in combination with filtration, reducing indoor airborne concentration. Filtration systems vary considerably in their ability to remove particulate matter across the particle size range, as set out under ISO 16890:2016[26]. Specialist advice may be sought from Mechanical Engineers or Filtration specialists to identify the optimal filtration system or other air conditioning technology that is suitable for each building.

The reason for this is unlikely due to its absence. Viral aerosols are very difficult to recover from air as the sampling process leads to loss of viability due to impact damage on the virion and its RNA in the sampling device. Resultant injury is amplified by rapid desiccation of the virus on filters because the particles are so small that their large surface areas encourage drying of their protective viral envelope.

Cox *et.al.,* 2019, stated:

"As with bacterial aerosols, the methods used to collect and analyze airborne viruses can be broadly divided into culture-based and culture-independent methods, and many of the same considerations apply. Culture-based methods require preserving the viability of an airborne virus during and after bioaerosol collection, which is more difficult than preserving the viability

[26] ISO16890:2016 *Air filters for general ventilation — Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM).*

of bacteria or fungi. In addition, because viruses are parasites and require host cells in order to reproduce, viral assays are considerably more complex and difficult than bacterial or fungal assays, and many viruses currently cannot be cultured. PCR and other culture-independent methods are more widely used than culture-based methods, but they do not determine if the airborne virus is potentially infectious or not, which is often the question of greatest interest."

According to Morawska of Queensland University of Technology, in part the lack of success in capturing an infective pocket of air during sampling may be due to the challenges posed by bioaerosol monitoring and lack of data, rather than proof of their absence in the environment (Lewis, 2020).

Demonstrated contamination of air and surfaces by viral RNA in healthcare settings with COVID-19 patients may indicate that absence of infective virus detection from air is due to lack of available research tools and time for studies to be completed, not lack of a potential risk.

There is strong evidence of potential SARS-CoV-2 survival under ideal indoor conditions for up to three hours, however this has not been shown in a clinical setting. The CDC recommends taking transmission-based precautions with patients that would apply to more well-established airborne viruses such as measles, influenza (CDC, 2019b). IAQAA supports this recommendation for COVID-19.

Whilst data does not yet show that the virus would remain infective in an aerosol, there is little doubt that droplet nuclei pose a threat of infection, and that the virus becomes airborne either directly from the infected person or due to resuspension of settled, dried droplet nuclei.

Whilst not widely acknowledged as a dominant route of infection in a normal setting compared to a virus like measles which infected around 6 times the number of people from each individual, the possible risk of airborne transmission must be considered as part of the Risk Assessment and Scope of Works for remediation work. The default position may be that we assume COVID-19 is transmissible un air until testing shows that infective SARS-CoV-2 is absent from air. Its presence should not be dismissed because of technical challenges in maintaining virion (single virus) integrity and hence its viability during air (bioaerosol) monitoring (Cox *et.al.*, 2019).

Getting a true model of how SARS-CoV-2 aerosol impacts infection that is sufficiently accurate to form part of a risk assessment would seem an attainable outcome but not one that would be applicable to the timing of the release of this publication or remediation of our buildings.

Viral RNA has been detected in the aerosol size fraction where resuspension and or reduced ventilation is present and pending updated publication and scientific conclusions by the experts. Infection spread may be greater than previously believed. The virus appears to remain active for up to 18 hours in air. In summation, it is wise to act in a conservative manner and

include potential for airborne transmission of COVID-19 as part of a risk assessment when keeping workers and others entering the building safe.

14.6. Contamination of the indoor environment

The Occupational Safety and Health Agency (OSHA) in line with current international understanding believes that the virus is spread mainly from person-to-person in relatively close contact, and is particularly contagious during invasive medical procedures on patients that generate airborne viral particles that predominantly fall rapidly to the surface.

There is evidence of environmental contamination by viral RNA in a clinical setting in Singapore (Ong *et.al.*, 2020).

OSHA states that infectivity is particularly dominant within a zone of approximately 1.5 metres around the infected person, where it is spread through respiratory droplets generated by the infected person during and after coughing and/or sneezing into the air or onto surfaces, their hands, clothing or body parts. These droplets can then enter the mucous membranes and secretions in the mouth and/or nose of bystanders. Therefore, the area within 1.5 metres of an infected person slightly above, or below their breathing height is at a high risk of contamination with viruses entrained in material originating in the upper or lower respiratory tract such as mucous, sputum or other proteins.

Smaller microbial particles less than 5 µm in aerodynamic diameter termed bioaerosols, are generated during sneezing and breathing, remain airborne, and are therefore small enough to be inhaled into the lungs.

Bioaerosol particles remain airborne for extended periods of time and are able to enter the return air pathway of HVAC systems. They also have the ability to spread further in the open occupied space and settle more slowly onto surfaces. Bioaerosols are also generated in response to resuspension from dried surface deposits meaning that over time there is an increased opportunity for viruses to become diluted where they were first deposited whilst spreading to previously unaffected surfaces.

An uninfected person can touch an affected surface or object that has SARS-CoV-2 on it and then touch their own face where virus can enter the mouth or nose (the primary exposure pathway), and/or possibly their eyes (a secondary way the virus may enter the body) (OSHA, 2020) .

There is some evidence that Coronavirus causes digestive symptoms with or without respiratory symptoms.

People are thought however to be most contagious when they are most symptomatic (i.e., experiencing fever, cough, and/or shortness of breath). Some spread might be possible before

people show symptoms; there have been reports of this type of asymptomatic transmission with this new coronavirus, but this is also not thought to be the main way the virus spreads.

The impact of relative humidity and temperature in buildings on the survival of SARS-CoV-2 was not understood at the time of publication.

Work by van Doremalen *et.al.* on viral survival (2020) was conducted only under a single set of climatic conditions of 21-23 degrees Celcius (°C), and 65% Relative Humidity (RH) whereby an accurate prediction of how long to leave an item before it is deemed free of active virus remains unclear. It must be remembered also that the graphs in Figure 1 demonstrate the decay in concentration for active viruses, which depends on the half-life of the virus on each surface.

Where the starting concentration of the virus may be higher, the time taken to reach a point where it is no longer detectable will be greater, and the time taken to reach that point with a smaller starting viral load would be shorter. Samples were analysed on tissue culture, a cost-prohibitive and time expensive method not suited to environmental testing in normal circumstances. The infectivity based on tissue culture growth may also not be directly transferable to a clinical setting or building where an infected person was present.

Earlier testing of longevity on surfaces for SARS-CoV-1 indicated that climatic conditions will likely have a significant impact on the viability of viral particulate matter prior to cleaning surfaces. Therefore, prescribing a safe time period prior to returning to a building is not possible at present.

14.7. The use of molecular techniques for detecting SARS-CoV-2

Technology to analyse surface samples for SARS-CoV-2 using molecular nucleic acid based techniques as a means for assessing success or failure of remediation are currently not being widely utilised, but with proper validation, may quickly become an appropriate testing modality for targeted testing of areas of known contamination.

Airborne sampling for SARS-CoV-2 RNA has been successfully used in research and may be possible in the near future, but at present is unsuitable for assessing airborne infective viral loading due to difficulties in recovering live virus from air samples.

Testing kits for SARS-CoV-2 may become available based on immunoassay technology; however, they have not been calibrated or validated for environmental conditions at present. In contrast, kits that allow culture-independent bioburden measurement based on bacterial loading are becoming available at the time of publication.

The tests currently used for confirming COVID-19 cases comprise molecular methods that rely on chemistry to either amplify its RNA or detect particular chemical compounds in its structure.

Quantitative Polymerase Chain Reaction (qPCR) is the method most commonly employed to confirm cases. The method targets a gene sequence in the viral RNA that it amplifies by

continually doubling the number of gene copies until there is enough to measure, and there back-calculates the output to the equivalent concentration that was present at the start.

Amplifying RNA is a more complex process than amplifying DNA, as it exists as a single strand and so must be made double stranded before it can start doubling and so must be measured.

qPCR has been used to detect the virus in many patients in Wuhan and is now the method of choice for diagnosing COVID-19 through testing. It is therefore easy to think that the method is transferable to cleaning validation (R. Liu, 2020).

However, the chemical reaction required to amplify DNA is prone to inhibition by chemical compounds found in the environment. Considerable time and effort are required during RNA preparation from environmental samples to overcome this limitation when testing for effectiveness of cleaning (P. Liu et.al., 2014), making it a highly complex procedure.

Further the PCR process is designed to detect RNA present in viruses, not necessarily active virus but the aim would be to ensure removal of active-virus-containing particles, which makes PCR an attractive proposition. However, viral shedding by a sick person happens unevenly in the environment (think sneezing on a desk). Viral particulate matter will predominantly accumulate locally to the infected person. Therefore, testing one area may easily miss the impacted area.

A better metric of broadscale cleaning is to measure something that is more constant and uniform in its deposition, being general dust and debris. A better metric of human shedding on high touch points is a general biological indicator (ATP) and evidence of skin cells or other biological material within the debris on the surface.

At present, this publication focuses on the effectiveness of broad-scale and high touch point removal of soil (surface debris) and general biological material (ATP). If these substances are removed through the use of proper technique and chemistry, SARS-CoV-2 should also be removed. The presence of PCR inhibitors in the environment. or cleaning and disinfectant products that may give a false positive or negative signal from the target sequence, have the potential to create false alarms or unquantified risk when using PCR technology.

Until specific, documented and approved specific test methods exist, the cleaning and remediation industry currently recommends observation of surface debris and ATP testing as the methods of choice for validation of cleaning in SARS-CoV-2 contaminated sites (CIRI Symposium, 31 March 2020).

Recent research by Bakka *et.al*. (2019) has shown that total adenylate which includes measuring the breakdown products of ATP (being ADP – adenosine diphosphate and AMP – adenosine monophosphate) may provide a more reliable indicator of biological surface deposits, as ATP can break down readily in the environment and consequently lose instrument signal strength when the surface is tested.

It is important to note that a number of new technologies will likely arise in the future that are suitable for assessing bioburden and therefore flexibility to the approach may change as those technologies become established.

There are additional barriers to implementing such technology, such as how surface conditions including surface type, and the use of detergents or disinfectant/sterilant relate to infection risk. We do not fully understand the size of the infective dose required to make a person sick, such that interpretation of environmental measurements would be challenging (Lewis, 2020).

14.8. Upcoming technologies for surface testing

Even since the release of the second Draft of these Guidelines, two technologies for surface testing have been provided to IAQA Australia by personnel in the US IAQ industry.

It can be certain that these examples will be added to rapidly as the disease management progresses.

The first is the use of a desktop analytical kit for testing surface bacteria which has been adapted for post-COVID-19 cleaning validation by dropping the usual Failure threshold for aerobic bacterial count by 90%.

The second is the pre-cleaning marking of surfaces with a bacterium called *Saccharomyces cerevisiae*. Measuring the surface concentration before and after cleaning allows log reduction to be calculated for a surface, showing that it has been successfully disinfected.

No doubt increasing numbers of methods for testing and analysing surfaces will become available in due course. IAQAA will include a list of proposed method overviews when sent to us or arise in our searches, however such novel methods mentioned are not endorsed, may still be awaiting trials, and are referred to for information only.

15 References

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