Draft Guidelines for Post Cleaning Validation of Buildings Contaminated with SARS-CoV-2 v2

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. COVID-19 has a sufficiently low mortality rate, and a silent start to infection symptoms, promoting its spread by even non-symptomatic 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, those they come in contact with, and those returning to a building where an infected person was present. 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 .

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Disclaimer

The Indoor Air Quality Association Australia (IAQAA) has developed this draft set of guidelines based on commonly employed infection control practices and methodologies. This Guideline is a living document based on the scientific evidence available to the authors at the time of publication. It has been written for the purpose of disseminating information free of charge for the 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 this report is awaiting printing and sometimes pending peer review. IAQAA does not take liability for recommendations made based on that early evidence and acknowledges that this may change at short notice as different information becomes available. IAQAA is not guaranteeing that these guidelines will be updated as frequently as new findings are released, and it is the user's responsibility to ensure the currency of information used in their decision-making process.

IAQAA does not guarantee its content, and does not accept any liability whatsoever arising from, or connected with factors including its reliability, accuracy, comprehensiveness, completeness or currency 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 and resources. Users should also exercise their own judgement and skills to evaluate these same factors for their own purposes and uses.

These guidelines are not a substitute for professional advice, and IAQAA encourages its members and other users to seek advice for their own purposes.

These Guidelines are not designed to be used for assessing health risks.

These Guidelines focus on providing the tools for assessment of remediated buildings 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).

There will be a need for property owners, facility managers and others to consider undertaking a risk assessment to minimise their risk of exposure to and spread of COVID-19 in their buildings. 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 buildings. It does not purport to show that there is no viral particulate matter remaining in a building, nor that remaining health risks associated with SARS-CoV-2 or other microbial contaminants or pathogens have been ameliorated.

This publication is designed to help 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.

1 Introduction to the SARS-CoV-2 contamination

SARS-CoV-2 is a type of coronavirus -similar to that which caused Sudden Acute Respiratory Syndrome (SARS-CoV / SARS-CoV-1) in November 2002 in China. Infecting 8,500 persons in several countries, SARS-CoV-1had close to a 10% mortality rate, killing 774 people. Middle East Respiratory Syndrome is also a novel coronavirus (MERS-CoV) first identified in Saudi Arabia in 2012 associated with camels, with a 35% mortality rate, killing over 800 people to date.

The first report of the new virus was documented on the 8 December 2019 (Cheng *et.al.*, 2020). SARS-CoV-2 has infected well over 1.2 million persons at the time of writing, with millions more to come. SARS-CoV-2 kills a smaller percentage of infected persons than these other human coronaviruses, but is still responsible for over 50,000 deaths, given its enormous spread throughout the world. 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.

The U.S Center for Disease Control (CDC) provided comprehensive practical measures for managing COVID-19 (U.S. CDC, 2020).

The difference in infectivity of SARS-CoV-2 compared with these other human coronaviruses is still being elucidated, and may include its ability to spread prior to symptoms arising, the possibility that infected persons capable of shedding the virus have no symptoms (are asymptomatic – Bai *et.al.,* 2020), along with the anticipated strong ability for the virus to bind to a host cell (Wand *et.al.*, 2019). Pre-symptomatic transmission has been documented as being associated with outbreak clusters (Wei *et. al.*, 2020).

At the time of writing this document, four other known types of coronavirus were circulating in the human population. All four cause the common cold and are relatively harmless by comparison.

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 its ability to spread prior to symptoms arising along with the anticipated strong ability for the virus to bind to a host cell (Wand *et.al.*, 2019).

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. At present the full role of transmission through faecal matter is under investigation. 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 other 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[1]. Viruses can also spread through contact with bodily fluids contain 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. "The virus" for the purpose of this publication is deemed to be the virus known as SARS-CoV-2 at the time of writing.

It is noted that the U.S. CDC (Centers for Disease Control) describes the infection as highly contagious[1], yet the UK Government has removed its status as a High Consequence Infectious Disease following agreement by the Four Nations HCID group, stating[2]:

"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".

COVID-19 is recognised as having less mortality than infections such as the avian influenzas, MERS and SARS-CoV-1. 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 much higher.

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[1] https://www.cdc.gov/coronavirus/2019-ncov/prepare/transmission.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fabout%2Ftransmission.html

[2] https://www.gov.uk/guidance/high-consequence-infectious-diseases-hcid#definition-of-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.

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

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.

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 or sufficiently validated for this application.

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[3].

Testing should instead be considered a key part of a quality assurance procedure to demonstrate that the building 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 will also disrupt the viral

[3] https://www.nature.com/articles/d41586-020-00974-w

envelope and by extension, begin to deactivate (kill) the virus. Disinfection is required to provide validated method for viral deactivation.

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

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 become an appropriate testing modality for targeted testing of areas of known contamination, as discussed in Section 9. Airborne sampling for SARS-CoV-2 RNA is possible but is unsuitable for assessing airborne infective viral loading.

Reagents and laboratory resources for detecting SARS-CoV-2 by amplifying the genetic code from SARS-CoV-2 using qPCR (quantitative polymerase chain reaction), the current Gold standard for human infection detection, will likely be prioritised for testing suspected patients.

Testing kits for SARS-CoV-2 may also be available based on immunoassay technology; however, they have not been calibrated or validated for environmental conditions at present.

Given the likely scale of testing required, a wider range of methods needs to be considered that focus on providing confidence that the level of cleanliness and hygiene achieved post-remediation is sufficient to allow the building to return to its original use with negligible risk to occupant health.

This guideline therefore is designed around ensuring the building or affected area/s within a building 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.

At the time of writing this document, the World Health Organisation (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 probably transmission is the disruption of fomites (deposited virus on surfaces) which can result in resuspension of airborne particles containing the virus. This has been shown to occur when changing clothes or in toilets / bathrooms (Y. Liu *et.al.,* 2020) and Hospodsky *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.

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.

or natural ventilation in buildings is vital in managing risks from airborne exposure, based on the potential for this route to be present (precautionary principle).

We are advised globally that the greatest risk of infection is encountered through face-to-face interaction and disturbance of viral particles from surfaces during agitation of heavily viral laden items such as personal protective equipment (PPE) and Personal Protective Clothing (PPC) from health care workers.

The remediation validation approach described in this document will be to verify that the work practices required to successfully clean are being consistently practiced, and that surface cleaning has been successfully achieved through a combination of visual inspection and surface testing.

Outside the human host a coronavirus is comparatively easy to disrupt and inactivate, as a large number of disinfectants on a clean surface are effective when used at the appropriate concentration and allowed to dwell for the correct contact time: examples of proven disinfectants include certain detergents and a range of oxidising agents. Technologies such as germicidal ultra-violet (uV) light displays effectiveness at destroying 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, supported by peer-reviewed scientific publications.

3 The decontamination process

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

In the case of very recent contamination, however, disinfection may be required prior to cleaning for the safety of workers. However, care must be taken as the risk from particle resuspension will be increased with people disinfecting the site, so ventilation and P100 respiratory protection would be advised during this latter 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, as otherwise organic material will prevent successful treatment (Cremieux *et.al.,* 1991). Therefore, testing prior to disinfection to show residues have been removed is recommended.

The Center for Disease Control (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, 2020a 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.*

3.1. Overview of testing methods

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 expected to be carried in oral or nasal secretions that are expressed by an infected carrier. 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.

The use of Adenosine Triphosphate (ATP) for hygiene status assessment is commonplace and is utilised under this Guideline document 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. Using ATP as a marker for biological materials seems logical and reasonable.

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 be recognised. 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 been set in this document based on those recommended by manufacturers for health care settings.

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 can 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 will not be able to 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 reproducibility of test results. It is known to be unreliable unless sufficient replicate samples are collected (Whiteley, 2016). This document therefore guides the user toward methods to prevent underestimating the actual COVID-19 risk in a building.

Chlorinated disinfectants in particular are rapidly used up by any organic debris on a surface. To show that ATP has correctly indicated clean conditions, and to validate ATP swabs, surface debris samples are recommended to show that general environmental particulate matter has been removed at microscopic level as well as being absent visually during inspection. This will allow close scrutiny of surface conditions at 400x magnification using standard methods designed to assess such debris.

While ATP testing relies on a chemical reaction, surface debris samples examined by visual microscopy has no such interference. Sampled correctly, the visual image should accurately represent that material collected from the surface. Surface debris can provide useful information on the broadscale deposition of environmental particulate matter as well as human-related dander such as skin and hair. As it is continually settling out of the air, debris loading indicates the general cleanliness of the surface, and allows confirmation that disinfection will likely be successful.

If cleaning has progressed satisfactorily, minimal debris should be visible during visual inspection as well as microscopically via sticky tape lift technology at the resolution afforded by light microscopy.

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.

4 Treating air in contaminated buildings and the application of air testing for SARS-CoV-2

4.1. Behaviour of airborne viruses

The virus is 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.

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 m 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 m 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 containing virus particles 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[4]. 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.

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

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

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

and its RNA in the sampling device, and due to rapid desiccation because the particles are so small that their large surface areas encourage drying of the 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 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 Prof. Lidia 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 U.S. CDC (2019) recommends taking precautions that would apply to more well-established airborne viruses such as influenza or SARS[5]. IAQAA supports this recommendation.

At the time of publication, the surface or airborne exposure dose required to elicit infection has not been established. It is reasonable to assume however that minimising airborne viral load will provide optimal risk reduction against exposure to viral aerosol 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, but an absence of proven infectivity) must be taken to indicate possible airborne transmission risk for SARS-CoV-2.

Risk mitigation measures such as the use of PPE, ventilation and ensuring not air is exiting from the plumbing system in the buildings may be considered as part of the project risk assessment.

[5] https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html

Therefore, the focus of post-remediation validation of SARS-CoV-2 needs to be on surface cleaning as the first line of defence (Australian Government, 2020, CDC, 2020a).

4.2. Interaction with surfaces

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.

Droplet nuclei will settle out of air onto surfaces at sufficiently high concentrations to generate a high surface load. Touching those surfaces and then touching the face, nose, or mouth will result in exposure. The survival of the virus on surfaces varies depending 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), but the virus has been shown to remain active for several days, notably on steel, hard plastic, and paper-based products (Dorelmalen, 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.* showed that there is potential for SARS-CoV-2 to remain viable on plastic for up to three days (72 hours).

Also, at present we do not know what the lowest harmful concentration is on a surface, so turning this into a meaningful method for testing surfaces is not possible.

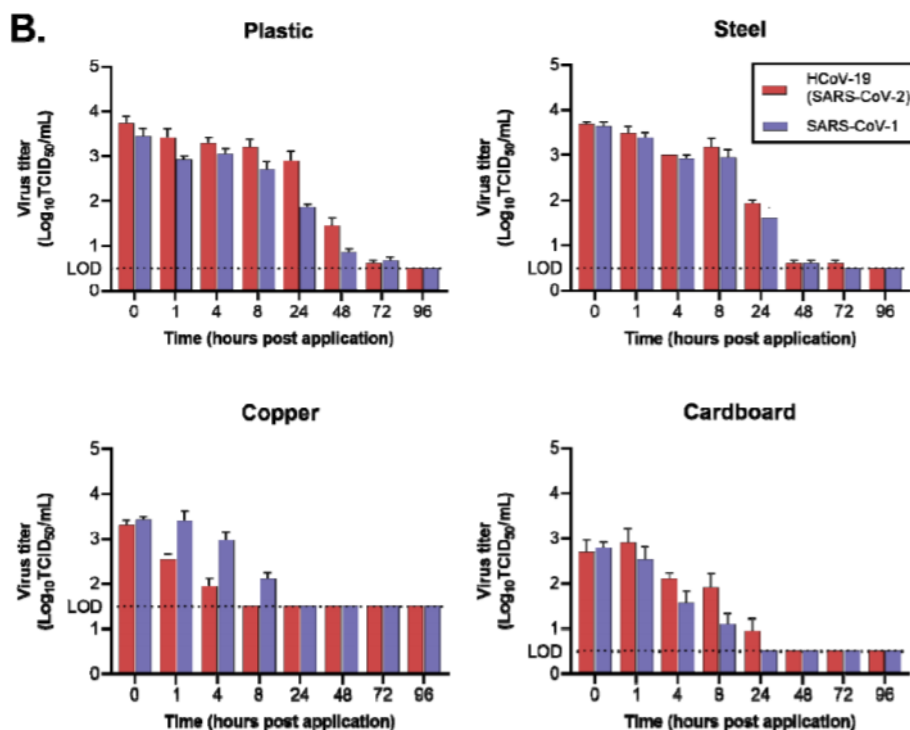

Figure 1: Variability of SARS-CoV-1 and SARS-CoV-2 (HCoV-19) on different surfaces - from van Doremalen *et. al.*, 2020.

The experiment by van Doremalen *et.al.* was conducted only under a single set of climatic conditions (21-23 °C and 65% 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.

Caution is required if entering the building in the first 72 hours post-vacation of the infected person/s. Delaying entry for a period of at least four days, and preferably longer is therefore an important risk management and project cost reduction tool. Ventilation is recommended prior to entry without personal protection even after this time.

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 UK 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.**

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

COVID-19 infection spread remains predominantly from viral movement directly from person-to-person, but it is vital that we are confident on return to our homes, schools, shops, Offices

or other indoor space that all reasonably achievable steps have been completed to ensure our safety from infection.

It is important to note that there are no known health effects from exposure to a viral particle that is no longer "viable", that is 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, disinfecting 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 Event history documentation:

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

- the source of infection,
- route of transmission, and
- susceptibility of the infected person.

It is vital to document information around each of these three key factors following an outbreak of COVID-19 in an occupied space.

5.1. Infected person / persons movements and activities

It is critical that full documentation is made of the infected person's time leading up to and upon developing symptoms, and the source of infection if this is known.

It is important to document items in their 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.

Frequent contact with members of the public may indicate increased risk for visitors from contact with the infected worker e.g. a shop assistant or receptionist. Those persons could have spread the virus onto numerous surfaces after purchasing goods or going to Reception, 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.

5.2. Possible affected areas and surfaces

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.

Surfaces to consider include:

- seating areas,
- meetings / meeting rooms, and the desks of those who shared the meeting, and their immediate work areas and objects they use,
- 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, PPE,
- common areas or items used,
- lifts, 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, desks, computer keypads, EFTPOS machines, cash registers, utensils etc.

5.3. Sensitivity of occupants - age, immune system health

The most sensitive groups of people have been identified as those individuals who:

- are aged over 65 years,
- suffer from one or more of the following:
  - Coronary heart disease.
  - High blood pressure.
  - Diabetes.
  - Compromised immunity.
  - Other pre-existing health conditions, particularly when more than one of the above listed or other conditions is present.

5.4. Documenting potential routes of exposure

Documenting the main and potential exposure routes is important when cleaning the building and therefore when testing. These may include consideration of several factors:

- Pathways of transmission should 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 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.

5.5. Cleaning history

The person assessing the site (Section 5.6) 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.

These include the following:

- Safety data sheets (SDSs) for products used.
- Documents showing that the cleaning and disinfection process would be 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 Dorelamen *et.al.*, 2020), it is critical to establish at the outset of the project the date when the infected person/s vacated the site. 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, 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, and only wiping 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).

Singapore provides a range of 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).

5.6. Required qualification for person 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.

5.7. Required qualification for person conducting assessment and validation works

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 of those listed in Section 5.6., however should be engaged independently of the contractor. The Assessor will be responsible for providing Post-Remediation Validation documentation including collection of samples and management of laboratory Chain of Custody and analytical data where appropriate.

5.8. The use of aerosolised disinfection

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 virucidal claims, including for SARS-CoV-2 and other Coronaviruses, must be registered with the Therapeutic Goods Administration. 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[6].

5.9. Standard operating procedures documentation

Standard Operating Procedure documents should be available for review, of an acceptable level to the assessor and consistent with recommendations of State and Local Government

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[6] https://www.tga.gov.au/disinfectants-sterilants-and-sanitary-products

recommendations and requirements, the World Health Organisation and the U.S. Center for Disease Control and Prevention.

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[7].

A list of approved products in the US for disinfecting surfaces are set out under the US EPA List N: *Products with Emerging Viral Pathogens AND Human Coronavirus claims for use against SARS-CoV-2*[8]. 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. Recent research however has indicated that care must be taken as there may be more recent findings that may be referenced in deciding the correct choice of product such as Becker *et.al.*, 2019 who showed that the use of wipes containing quaternary ammonium compounds and isopropanol less effective that per acetic acid for norovirus, adenovirus and polyomavirus surrogates.

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

Notification that The Australian Therapeutic Goods Association (TGA) is fast-tracking approval of disinfectants by approving use of surrogates for SARS-CoV-2 was released on 20 March 2020 to speed up the process of approving suitable products[9]. These products and more details may be found on the TGA website[10].

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:

[7] https://www.epa.gov/pesticide-registration/emerging-viral-pathogen-claims-sars-cov-2-submission-information-registrants
[8] https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2
[9] https://www.tga.gov.au/surrogate-viruses-use-disinfectant-efficacy-tests-justify-claims-against-covid-19
[10] https://www.tga.gov.au/disinfectants-sterilants-and-sanitary-products

- 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 - follow manufacturer's recommendations, concentrations, applications and exposure times),
- testing for efficacy after elapsed exposure time, and
- 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).

5.10. 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 ventilate, that person will require the correct level of PPE depending on the risk of airborne virus. This should be considered as part of the risk assessment process.

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.

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[11] (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, whereas 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 outside of the building. 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 effect greatest cleaning and disinfection capability.

5.11. Chemical safety assessment

A group of 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 virucidal claims including "Kills SARS-CoV-2 (COVID-19)" should be used for decontamination. High Level Disinfectants (HLD) and Sterilants are able to inactivate viruses, however, these products are generally very hazardous and are not intended for use as surface disinfectants or fogging disinfectants.

[11] https://webstore.iicrc.org/index.php/catalogsearch/result/?q=s300 accessed on 1 April 2020.

- 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 as regards 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.

5.12. Toxicological appraisal

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

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

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[12], 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.

5.13. Safe Work Procedures

Safe work procedure should include the following as a minimum:

[12] https://www.nationalgeographic.com/science/2020/03/why-soap-preferable-bleach-fight-against-coronavirus/

- SWMS should be 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 staff will have to assume the site has active biological contamination on surfaces.
- We recommend documentation of toolbox meetings with staff.

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 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 assure that staff are aware of the risks of the potential contamination and chemicals detailed in the SWMS and work procedures.

5.14. 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, ideally with quantitative fit testing for the specific manufacturer, model number, and size utilised.
- Where airborne contamination is expected to be present, we recommend moving to N-100 filtration, ideally with quantitative fit testing for the specific manufacturer, model number, and size utilised[13]. 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

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

limited ventilation (semi-confined) where resuspension risk is high e.g. a toilet or Changing Room, or in a Clinical setting or Mortuary.

- Eye protection to Australian standards compliance.
- Full coverage Type 5 or 6 coverall suits with hoods and booties, 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 (according to Y. Liu *et.al.,* 2020). 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.
- 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, 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.

6 Visual inspection

6.1. Pre-cleaning inspection

Areas and specific items/surfaces to be cleaned should be clearly identified and agreed to by relevant stakeholders. Relevant stakeholders should be identified and documented prior to project initiation.

When appropriate, 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. Mould risks are significant in buildings when they have been closed up with no climate control operating.

Where mould is identified during Post-Remediation-Validation sample analysis, this may be reported as indicated.

6.2. Assessing condition of high touch areas

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.

6.3. Objects prone to contamination by fomites

Where items are readily disposable, 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, 2020a), and the UK 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, the UK document states that there is no need to separate laundry from unaffected person/s, indicating that the virus does not remain active after laundering (Public Health England, 2020).

The UK further does not recommend disposal of waste as hazardous. Hazards would be encountered during handling of waste, however once sealed, disposal at landfill does not pose an environmental or health risk.

6.4. Cleaning supervision - works supervisor, consulting hygienist

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.

6.5. Post-cleaning inspection

6.5.1. Occupied space

Following the cleaning process, the cleaned surfaces should be evaluated for cleanliness. The following considerations may be used to help validate remediation works.

Recording Visual Observations

A visual inspection should be conducted. 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.

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.

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. 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.
Where other 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.

6.5.2. 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, 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).

6.5.3. 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).
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.

6.5.4. 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 up to 9 days on stainless steel, and maybe longer (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 Guidelines[14].

7 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) becomes less effective than the squeegee bulk flow method).

[14] https://www.airah.org.au/AIRAH/Navigation/Resources/BestPracticeGuides/Best_Practice_Guidel.aspx

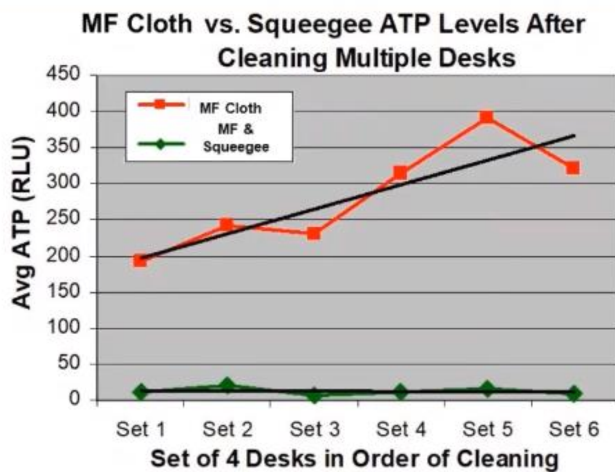

Figure 2: 4-month study of desk cleaning - from Richter presentation, CIRC Symposium, 31 March 2020

The use of the "white-glove technique" may be used to assess the presence of soiling remaining on cleaned surfaces.

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. Re-assessment of methods and re-cleaning is required. At this stage, no further testing may be indicated.

7.1. Application of a fluorescent marker

Another method for determining the effectiveness of cleaning activities in relation to critical environments which could be applied to COVID-19 cleaning is the use of fluorescent markers and ultraviolet (UV) light as per the US Center 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 testing.

In this process, high touch surfaces (or trial surfaces to be cleaned) are marked with an invisible water-soluble fluorescent marker and allowed to dry before cleaning occurs. This marking should preferably be conducted by a third party, or otherwise by a site Supervisor who does not advise the cleaning staff of the location of the marker.

The fluorescent gel dries transparent on surfaces, is resistant to abrasion and requires thorough cleaning to remove from the surface it is applied on.

A "black" light (i.e. ultraviolet (UV)) is then used after cleaning has been completed to assess whether the marker has been removed and hence the surface adequately cleaned.

The use of UV marking, and black light detection is recommended as part of the quality control process to be employed by the cleaning operative.

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.

A possible way to address this could be by direct supervision of cleaning by an independent person or marking of areas by an independent person. See Section 5.4.

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 marker 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.

7.2. Method for use of fluorescent marker

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

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

Fluorescent Marker 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 $100m^2$ of floor space (minimum of 10).

Marking Surfaces

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

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

Evaluation with Black (ultraviolet) Light

At completion of the cleaning activities, an ultraviolet light is used to identify any surfaces with remaining markers.

Fluorescent Marker PASS/FAIL Criteria

For an area to be determined as properly cleaned, the cleaning process must have removed 100% of all the fluorescent markers applied to surfaces.

Any surfaces/items with remaining markers must be re-cleaned and re-assessed.

8 Testing of surfaces

In accordance with the ASTM 7338:2014 - *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. As of 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.

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.

8.1. Choosing when to test

Decontamination Is a two-stage process; cleaning with soap (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, we recommend that surface debris samples are collected BEFORE disinfecting surfaces as surface debris may prevent the disinfectant from working effectively.

8.2. 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.
- Interference of findings by cross-contamination, surface residual material, environmental interference e.g. bleach residues after disinfection.
- Where the disinfectant product is used prior to testing, and may inhibit the ATP reaction, it may be necessary to select 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 Technical Document – Sanitizer Effects on Hygiena ATP Surface Test Devices, downloadable from www.hygiena.com).

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.

8.3. Selecting sample location

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".

8.4. Establishing sampling density

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

A selection of an appropriate margin of error is required prior to creating a sampling procedure based on a preliminary qualitative risk assessment around the outbreak and the building use

and occupants. Assessing error margins may be achieved using a calculation or 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

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

Where: 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).

Below is an output from an online sample size calculator showing how the tool can be used[15]:

Confidence Level:

95% ▾

Population Size:

100000

Margin of Error:

5% ▾

Ideal Sample Size:

370

To learn more about the variables you can read this post on how to find your sample size or scroll down to learn more about confidence interval or level.

The example above would be for a 10 m^2 wall which shows that an area of 370 cm^2 would provide a 5% margin of error at 95% confidence level.

Where budgetary restraints prevent achieving a desired margin of error due to collecting samples at a reduced frequency / density, the expected margin of error must be clearly articulated to the project owner prior to sampling and must be recorded in reports.

[15] https://www.qualtrics.com/blog/calculating-sample-size/

8.5. Hygiene status assessment

Hygiene assessment may be conducted using adenosine triphosphate (ATP) testing in keeping with Shaughnessy *et. al.*, 2013. The use of this method 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.

ATP has been shown to provide a reasonable correlation to bacterial loading and a reasonable 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 it does not provide definitive evidence that COVID-19 residue has been partially or fully removed.

8.6. ATP sampling and thresholds

ATP swabs are routinely collected from a predetermined area, usually 2cm x 5 cm, or 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, a lower limit of detection is recommended. Collection of a larger sample surface area where available will provide this, as well as reduce the number of swabs needed when they are likely to be in high demand.

Therefore, when an area of 100 cm^2 is swabbed on a cleaned surface, it is important to ensure that only the recommended number of passes with the swab is employed to avoid overloading 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 however should be reported in Relative Luminescence Units (RLU) per square centimetre (cm^2). It is vital not to overload the swab so the person conducting the test should strictly adhere to the correct number of passes of the swab.

Where an item to be tested is too small 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 value expected across an area of 100 cm^2.

8.7. ATP threshold for cleaning after COVID-19 contamination

The acceptable threshold for ATP is 80 fmoles / 100 cm^2. This equates to different output values across different ATP meter models.

Table 1 shows the reading expected on the most commonly used swabs and readers based on the acceptable threshold of 80 moles ATP / 100cm^2.

Table 1: Guide to ATP thresholds for commonly used meters

Instrument	Threshold for an area of 100 cm^2	Threshold for an area of 25 cm^2 (not recommended for this purpose)
Hygiena Systemsure – UltraSnap swab	40	10
Hygiena Ensure – UltraSnap swab	80	20
Hygiena Ensure – SuperSnap swab	320	80
3M Biotrace	400	100

Please refer to manufacturers' recommendations to identify the threshold for an instrument.

8.8. Minimum number of samples

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 a single tested surface should fall within 3 Standard Deviations of the mean or 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).

Where the number of samples collected is lower than that required for the necessary margin of error to be achieved, the higher number of samples should be collected.

8.9. Factors for consideration when using ATP

8.9.1. 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.

An example of this include bleach which has been shown to prevent the luciferase reaction with ATP after cleaning[16].

Following the required residence time for the cleaning or disinfection product, cleaning products and disinfectants must be rinsed prior to testing for ATP. If a rinsing step is undesirable, a different method for surface validation may be employed e.g. surface debris adhesive tape lift testing.

1 in every 20 ATP samples, or one sample from each surface type in each area, whichever is greater, must be accompanied by a debris sample which is sent to a laboratory for indirect microscopic analysis of the surface. Surface conditions will be defined based on Debris rating as described under ASTM D7910:14- *Standard Practice for Collection of Fungal Material from Surfaces by Tape Lift.*

8.9.2. Where ATP values are not falling below the threshold

Where ATP values are above the allowable threshold, we recommend re-cleaning the area. If high ATP values persist following a second round of cleaning, samples should be submitted to an analytical facility for microscopy for debris. If less than approximately 1% (trace) debris is visible at 400 x magnification, the area that failed ATP testing should be swabbed over 25 cm^2 and the sample cultured for total and thermotolerant bacteria, with counts falling below the limit of detection as was observed in Operating Theatres (Najotra *et.al.*, 2017).

8.10. Debris testing and Microscopy

It is 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 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 as set out

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16 file:///C:/Users/Claire%20Bird/Downloads/Tech%20Doc_Sanitizer%20Effect%20on%20UltraSnap%20and%20SuperSnap%20072014.pdf

under IICRC/RIA recommended procedures, and 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.

Additionally, collection of debris samples is required under this Guideline to accompany every tenth ATP swab to confirm that removal of ATP is consistent with cleaning practice.

8.11. Collection of debris samples:

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.

Where indirect measurement of debris through tape lift is employed as the primary method of analysis, samples should be collected at the same rate as an ATP sample. The minimum number of samples should equate to the same number of samples calculated for ATP under Section 8.4 based on the equation shown in Equation 1: *Calculation of sample size based on surface area of tested item or structure*.

The number of samples collected should be based on collecting a single debris sample immediately adjacent to every tenth ATP sample.

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

Debris is described for the purpose of this procedure as opaque or semi-transparent material observed at 400 x magnification utilising light and / or phase contrast microscopy.

The term used for the area of a slide or sample matrix occluded is “debris loading” as defined under D7658:17.

The sample should be analysed in accordance with the debris component of the Standard with a minimum of 20 Fields of view.

It is important that localised deposition of debris is not missed by averaging the loading.

Therefore, in accordance with AS 4964—2004 *Method for the qualitative identification of asbestos in bulk samples,* as a minimum a visual assessment is required of the entire sample at 100x magnification to ensure uniformity that could, if absent, lead to a false negative result.

8.12. Validation threshold

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.*

This method classifies debris loading from the surface based on the percentage of area under a microscope at 400x magnification where light is occluded by particulate matter as shown below:

- 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

The method of analysis requires an assessment of the amount of debris from a known area.

This guideline document requires that the debris does not exceed Category 0, therefore less than 1% debris must be present as an average when examined under 20 fields of view at 400 x magnification with a variation of less than 3 Standard Deviations across the sample.

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 Category 1, 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 of item, the mean debris loading percentage of all samples should fall below 1% loading and no one loading should be greater than 3 Standard Deviations from the mean.

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

Where an item may not reasonably be expected to return to Category 0 due to for instance surface roughness, 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.

If ATP fails after the second round of testing, a sample may be collected and sent for debris loading measurement before and after conducting a cleaning intervention step.

Fabric samples or damaged surfaces are often unsuitable for ATP testing as it is not possible to reach all areas of the fabric. In this case, samples should be collected using a debris sampling method suitable for that material such as tape lift or micro-vacuum sampling.

8.13. Microvacuum sample analysis

Samples may be collected from non-porous or semi-porous surfaces, or a damaged surface using microvacuum testing [17, 18]. When sampling using a microvacuum onto a filter, the filter may be analysed using microscopy or other suitable methods.

When microscopy is to be engaged, the sample should be prepared and examined based on the Membrane Filter Method.

When employing microscopy, evidence of human debris must be absent including skin or hair, or other evidence of human shedding, when at last 20 fields of view are examined at 400x magnification as per tape lift samples.

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. Where a microvacuum is used the debris is concentrated onto a filter, so the debris deposited will be concentrated by a sample-specific concentration factor. The Assessor will 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 that concentration factor.

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

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[17] 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*

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

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 concentration on the surface is S%, the acceptable concentration on the Microvacuum filter = MV% where

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

<u>Simplification when testing under standard conditions:</u>

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 ≃ 25.4

With an acceptable threshold on the surface of 1%, and the acceptable amount of debris on the filter,

MV = S x C = 1% x 25.4 ≃ 25% loading = upper threshold for ASTM Category 2.

Therefore under standard sampling conditions using a 25 mm diameter filter, samples showing a Category value greater than 1 are deemed to be equivalent to a surface Category value of 0. Thereafter data should be treated as per tape lift analysis, but replacing a Category 0 threshold with a threshold of Category 1.

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 Category 1 cannot be set when sampling using microvacuum over 100 cm^2 as 5% on the surface would overload the filter. If a caution is required in laboratory outputs, an area of no more than 2.5 cm x 2.5 cm is recommended.

8.14. Quality control

8.14.1. Field blanks

Field blanks must be collected at a rate of 1 in 20 ATP swabs, tape lift and microvacuum samples.

8.14.2. 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[19].

1 in 10 ATP samples must be accompanied by a debris sample.

8.14.3. Analytical blanks

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

8.14.4. Laboratory reports

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.

8.15. 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 name or Area tested.
- 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.

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*

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

8.16. 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.
- 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.

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[20]'s 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.

9 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.

[20] National Association of Testing Authorities

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 affected with the SARS CoV-2 virus. Their location in high touch point areas indicate a significant increase in exposure risks.

9.1. Risk assessment of occupation

The type of workplace and/or living space is relevant, as well as likelihood of people being able to prevent breaching the current recommended 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.

9.1.1. 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 contamination.

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 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.

9.1.2. Medium risk occupations

Medium exposure risk areas require frequent and/or close contact (i.e. with that 150cm perimeter) with a high proportion of potentially COVID-19 infected persons based on that person's activity. Airports, transport vessels including buses, trains, planes and cruise ships and other marine vessels, all have greater potential for transmission as people are travelling from overseas 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.

9.1.3. Low risk occupations

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

9.1.4. Unidentified risks

It has been estimated that around 9 times the number of confirmed cases of COVID-19 are present than the numbers reported at any one time (Nishiura *et.al.*, 2020). Consideration in risk assessments can include questioning how to assess undetectable risks, and therefore it is possible to improve risk outcomes by including unidentifiable risks into the assessment.

10 Supplementary information

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

The following is a brief summary of the emergence of COVID-19. The World Health Organisation (WHO) works worldwide to promote health, keep the world safe, and serve the vulnerable. They provide information that is used by Governments in forming decisions around risks[21]. An appraisal of the early outbreak was provided by Zheng, 2020.

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, 2020). The WHO

[21] https://www.who.int/emergencies/diseases/novel-coronavirus-2019

have been working around the clock to analyse data, provide advice, coordinate with partners, help countries prepare, increase supplies and manage expert networks.

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

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.

Recent examples of new human infection of Coronaviruses are the MERS-CoV (Middle Eastern origins) in 2012, SARS-CoV-1 (China origins) in 2002, and most recently SARS-CoV-2. The SARS-CoV-2 virus is a beta-coronavirus, like MERS-CoV and SARS-CoV. These 'CoV' viruses are likely to all be from a single, recent emergence from an animal reservoir including bats (NCIRD, 2019).

SARS-CoV-2 has likely been 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 were a significant number of initial cases, suggesting that the virus was the result of an animal to person exposure pathway.

The second wave of 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 countries outside China (NCIRD, 2019).

It is now present in every continent and most countries globally with person-to-person transmission and believed to be the dominant means of spreading.

The outbreak was declared a Public Health Emergency of International Concern by the WHO on 30 January 2020 [1]. 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.

At the time of writing this document, COVID-19 had been reportedly mitigated in China following an extensive lockdown process and was a global pandemic with ongoing rates of growth unless person to person physical distancing measures were introduced.

10.2. 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 at the time of writing a 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.

10.3. Coronavirus mode of attack

Humans are more rapidly transmitting this virus due an S-protein within the virus which has a strong affinity to a specific enzyme receptor within the 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 at 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. This indicates 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).

10.4. 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[22]. 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 coronavirus' 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 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, 2020a) and have potential to be re-aerosolised from surfaces if they dry out, and therefore become airborne (Y. Liu *et.al.*, 2020).

10.4.1. Evidence in favour

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

[22] https://www.nature.com/articles/d41586-020-00974-w

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.

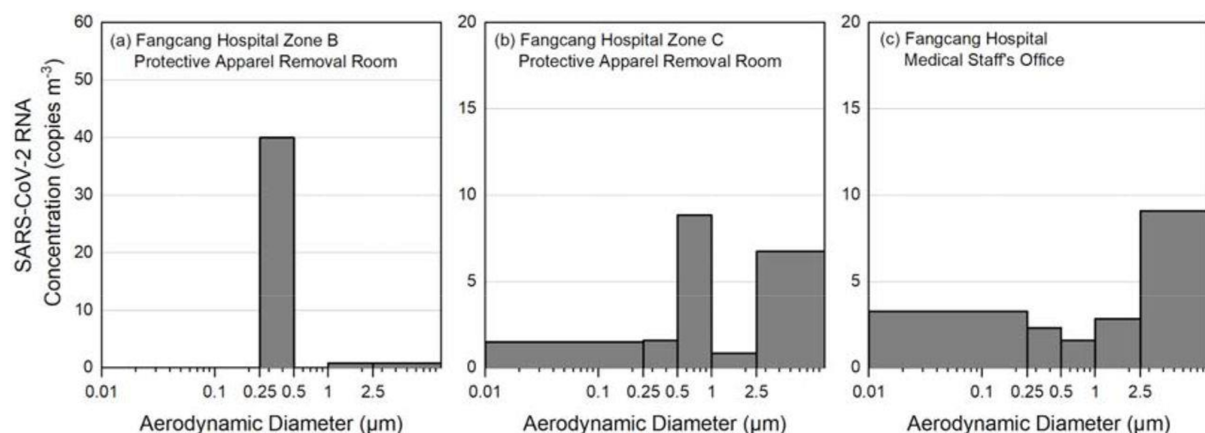

Figure 1: Particle size distribution of SARS-CoV-2 RNA airborne particulate in Fangcang Hospital, Wuhan, during treatment of COVID-19 patients.

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 e*t.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 Dorelmalen 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.

Transmission of the virus via an airborne route is possible 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.

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).

10.4.2. 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 World Health Organisation stated[23]:

"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."

[23] https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf

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). 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.

10.5. 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.

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 time 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 until testing shows that infective SARS-CoV-2 is absent from air, which to date has not been shown likely due to technical challenges in maintaining RNA integrity and virion (single virus) viability during 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.

Given that 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, 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.

10.6. 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 are termed bioaerosols, are generated during sneezing and breathing, remain airborne, and are therefore small enough to be inhaled into the lungs.

These 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 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.

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

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 spot.

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, we need to focus on 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 will 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 positives or false negatives 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).

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