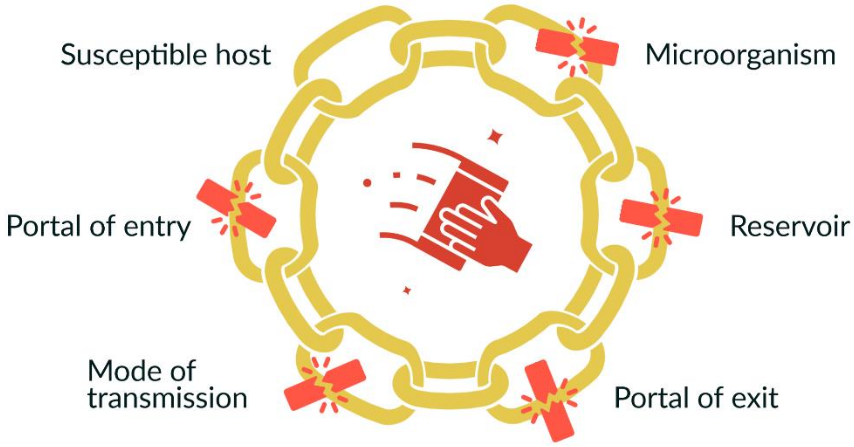
CLEANING DURING A PANDEMIC

RESEARCH FINDINGS AND INSTRUCTIONS UPDATE



Safe and Effective Cleaning
in Pandemic Situation

PandemicClean – Safe and Effective Cleaning in Pandemic Situations

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INTRODUCTION

The corona pandemic revealed that the cleaning industry was not prepared for that type of new situation. At the beginning of the pandemic, unnecessary cleaning was done, e.g., disinfectants were used for a feeling of security, not needs-based.

In the project PandemicClean – Safe and Effective Cleaning in Pandemic Situations, cleaning instructions for the coronavirus pandemic were gathered from 15 countries. At the beginning of the project, several scientific findings were summarised and later updated. On that basis, the following proposal was compiled for planning the cleaning work in the next pandemic situation. Cleaning should be considered from the point of view of both cleaners and users of the space cleaned.

The role of cleaning in a pandemic situation

Questions to answer about the pandemic

- What is causing it – a bacterium, a virus, or some other microorganism?
- How does it spread – via direct contact, surfaces, droplets, or the air?
- How long does the microorganism stay alive on surfaces?
- How virulent is the pathogen?
- What are the risk groups for catching the disease?

Protecting and guiding the cleaning staff

- Carry out a risk assessment
- Plan the necessary communication and the channels for it
- Provide training
- Ensure correct hand hygiene and use of protective gloves
- Inform the cleaners on the procedure to follow when they feel sick

Protecting the users of the spaces

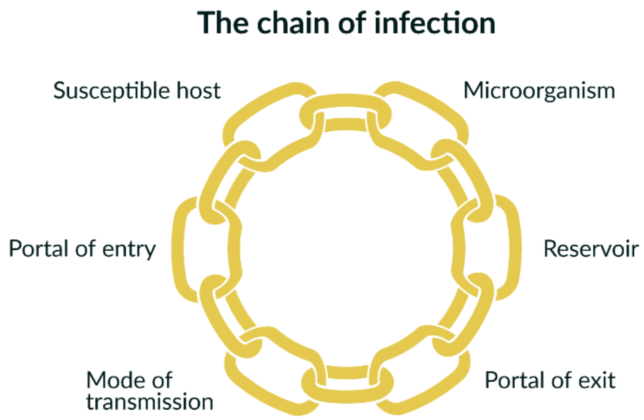
- Carry out a risk assessment
- Prepare contingency plans
- Identify the most important premises, spaces, and contact surfaces to be cleaned
- Take into account the surface materials
- Define the most effective detergents and disinfectants
- Define the most effective cleaning methods and equipment
- Control the thoroughness of cleaning
- Define the cleaning frequencies required
- Define the order and timing of the cleaning
- Review the current waste management procedures
- Give feedback
- Keep up to date with other means

WHAT IS CAUSING THE PANDEMIC

Bacteria and viruses have caused pandemics throughout history. The plague and cholera, for example, are caused by bacteria, and influenza and COVID-19 by viruses.

To analyse the role of cleaning in a pandemic situation, we need to find out the pathogenic properties of the microorganism causing the pandemic. In analysing the role of cleaning, we can also use the chain of infection presented below.

Figure 1. The six links in the chain of infection are a microorganism, a reservoir, a portal of exit, a mode of transmission, a portal of entry, and a susceptible host.



Microorganism

The microorganism, the infectious agent, can be a bacterium, a virus, or a fungus, for example. It is crucial to know which pathogen is causing the disease because different microbes have different abilities to spread, to survive on surfaces and in the air, and to infect people. Generally, most microbes live and thrive best in moist, warm, and protein-rich (dirty) environments. This is worth remembering in all cleaning work.

Bacteria and fungi can stay alive and multiply on surfaces in favourable conditions. Some bacteria form spores that are highly resistant to extreme conditions such as drought, cold, heat, and disinfectants. Wang et al. (2015) did a laboratory study on how *Escherichia coli* bacteria grew on polyethylene terephthalate surfaces. They found that both single cells and colonies of bacteria could be found on surfaces. In 10 hours, the entire surface was covered by multi-layered colonies of bacteria, which were more strongly attached to the surface than single cells and therefore more difficult to remove. By that time, there were also dead bacteria found on the surfaces.

To multiply, viruses need to infect a human cell, but they can stay alive on surfaces for various periods of time, depending on the virus and the surface. Surface biofilms help microbes to survive.

Vasickova et al. (2010) point out in their review article that the persistence of a virus in the environment is affected by the structure of the virus. Non-enveloped viruses (e.g., the rotavirus and the norovirus) have higher resistance to drying and therefore spread more easily than enveloped viruses (e.g., SARS and the influenza virus). The survival time on surfaces varies. The rotavirus, for example, can be infective on surfaces for at least two months, but respiratory viruses usually remain infectious for a few hours to a few days only. It is worth remembering, however, that there is variation in the survival time even within the same viral family or even the same genus. Also, many viruses remain viable for a longer period on non-porous materials, though there are exceptions.

The virulence of a microbe is an important factor. It describes how easily a microbe can cause an infection. Microbes of high virulence should be given special consideration in cleaning practices.

Example

The SARS-CoV-2 is an enveloped virus with a lipid membrane. Viruses of that kind are relatively easy to kill with, e.g., soap, detergents, and disinfectants. The virus has a high mutation rate, so that the infection-causing properties keep changing. Thus, the virulence of the coronavirus has been changing during the pandemic.

Reservoir

A reservoir is a place where microbes can stay alive and possibly grow or multiply. A reservoir can be a person, a surface, a tool, an animal, faeces, food, or water.

Example

The main reservoir of the SARS-CoV-2 is a person, but the virus can also stay alive on different surfaces, in the air, faeces, and urine.

In the beginning of the coronavirus pandemic, several studies were published about the stability of the virus on different surfaces. Virus RNA was found on surfaces, especially in places where people infected with Covid-19 were treated. However, the virus RNA findings on surfaces are no indications that the viruses are viable. In fact, viable coronaviruses were found on surfaces quite rarely.

Portal of exit

The portal of exit is the way the microorganism leaves the reservoir. For a human reservoir, the portal of exit can be coughing, sneezing, or breathing, for example, and via blood, faeces, or urine.

Example

The SARS-CoV-2 is found on droplets and aerosols produced in coughing, sneezing, and breathing, and in faeces and urine. The virus is more stable in moist conditions, so that instant cleaning of these body secretions is important.

Mode of transmission

The mode of transmission describes how microorganisms are transmitted from one person or surface to another person. This may happen via direct person-to-person contact, via indirect contact, e.g., from surface to person or via the air.

Vasickova et al. (2010) state that infective viral particles have been demonstrated to survive on human hands and be transferred to animate and non-porous surfaces. According to research, once the surface, such as a door handle, is contaminated, at least 14 persons can be contaminated or infected by touching it. Successive transmission of the virus from one person to another could be followed up to the sixth contact person. Also, contaminated fingers could subsequently transfer a virus from up to seven clean surfaces.

Singh et al. (2021) suggest that the viral load of surfaces is the key determinant of viral transmission from fomites.

Example

In the beginning of the Covid-19 pandemic it was assumed that the virus spread mostly via droplets, hands, and surfaces. However, researchers quite soon brought up the possibility that the virus can also spread via the air, and the importance of surfaces was discussed.

Portal of entry

The portal of entry is the way the infectious agent enters a new host. This may happen, for example, through broken skin, eyes, mouth, the respiratory tract, and mucous membranes.

Pathogens often enter the body through the same route they exited the reservoir, e.g., airborne pathogens from a person's sneeze can enter through the nose of another person.

Susceptible host

A susceptible host is a person who is vulnerable to infection. It can be any person. It is good to keep in mind, however, that infection does not occur automatically when a pathogen enters the body. Contracting the disease depends on several factors related to the person's immune system and the pathogen. The dose of microbes that can initiate infection varies from person to person and is referred to as the PID (Personal Infection Dose).

Example

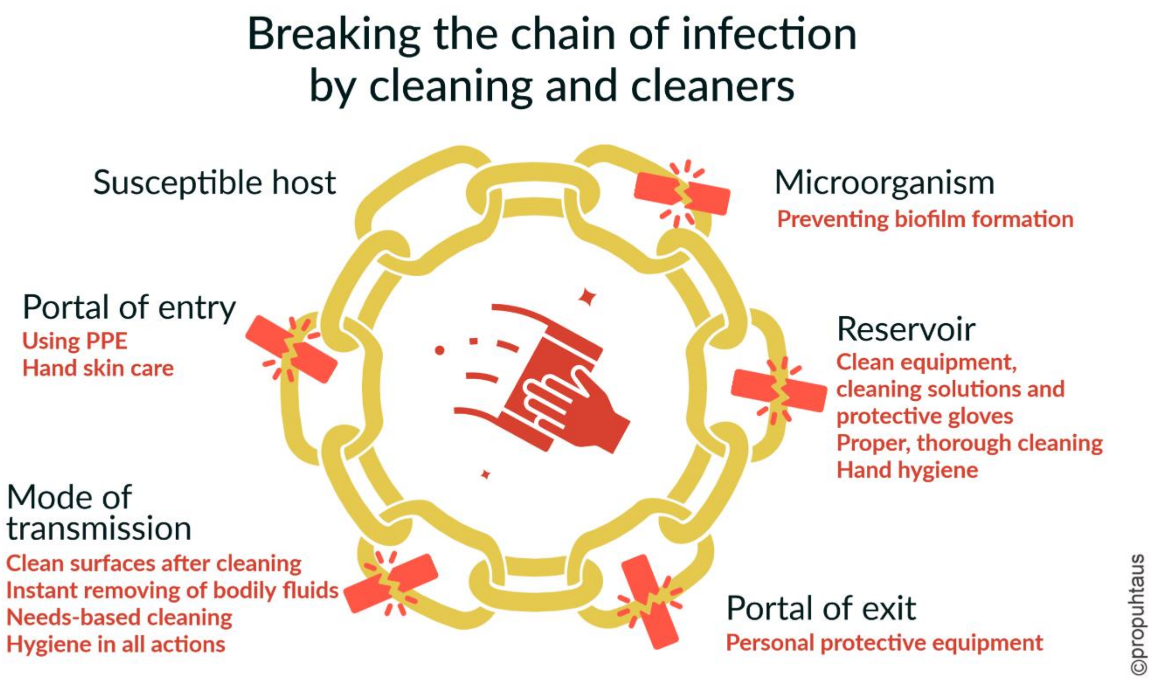
According to the European Centre for Disease Prevention and Control (ECDC), the high-risk groups for COVID-19 are people aged 60 years and older, those living in long-term care facilities, and people with underlying health conditions, such as hypertension, diabetes, cardiovascular diseases, chronic respiratory diseases and weakened immune systems.

Breaking the chain of infection

Cleaning, if done correctly, can play a role in breaking the chain of infection. The key issues are use of clean equipment, careful work to remove dirt, and knowledge of appropriate cleaning agents, equipment, and methods.

Cleaning, if done incorrectly, may also strengthen some parts of the chain of infection. This may happen if dirt and microbes are not removed sufficiently, making biofilm formation possible, or if there are detergent residues left on surfaces. These residues may enable the spread of microbes from surfaces via hands or via protective gloves. Also, incorrect wiping techniques can spread dirt and microbes to other surfaces.

Figure 2. Cleaning is one of the ways of breaking the chain of infection.



PROTECTING THE USERS OF THE SPACE

During a pandemic, the main purpose of cleaning is to reduce the concentrations of harmful microorganisms on surfaces to safe levels. To achieve this objective, different premises and spaces require different means. In the beginning of a pandemic situation, cleaning organisations need to be alert to all information about the pathogenic microorganism and its properties to be able to choose efficient cleaning methods.

Carry out a risk assessment

To analyse the need to change cleaning routines during a pandemic, it is important to carry out risk assessments to define the role and importance of cleaning in a pandemic situation.
To draw conclusions, it is important to know
- how vulnerable the users of the space are,
- how virulent the microorganism is, and
- whether the microorganism causing the pandemic can spread via fomites.

Example

The most vulnerable people for the Covid-19 disease are people aged 60 years and older, those living in long-term care facilities, and those with underlying health conditions. Consequently, pandemic-time cleaning actions should be given special attention in hospitals and long-term care facilities. Those are also the places where patients or residents may not be able to take care of hand hygiene and the use of personal protective equipment.

Research findings do not agree on the role of surfaces in spreading the virus. Some suggest that the role is minor, others that it is a relevant risk. However, cleaning high-touch surfaces is important, and so is cleaning body fluid stains, for they may have high concentrations of viable viruses.

Prepare contingency plans

In a pandemic situation, cleaning services must be available as agreed with the customer. The services cannot be left undelivered. Therefore, contingency plans are needed, e.g., for situations where a cleaner gets sick or necessary protective equipment or detergents are not available on the market.

For acute cases of sickness, a cleaning organisation can prepare by training substitutes for employees. These cleaners need to know not only the pandemic-time cleaning principles but also the cleaning plan for the site where they are replacing the cleaner. It may also be useful to define the most important premises, rooms, and surfaces to be cleaned if there is a shortage of labour. This can also be helpful if there is a shortage of protective equipment or detergents.

Identify the most important premises, spaces, and contact surfaces to be cleaned

During a pandemic, cleaning should be concentrated on high-touch surfaces. Many studies have examined from which surfaces and how much microorganisms can be found. Most of the studies are conducted in hospitals, because in those premises it is very important to break the chain of infections by using all means available. Most of the coronavirus studies have also been conducted in hospitals.

In a study of 51 patient rooms in three non-intensive care units, Zhang et al. (2022) examined if there were any SARS-CoV-2 RNA left on the surfaces after terminal cleaning. Virus RNA was detected on 32.1% of the surfaces. The most contaminated surfaces were the floors (78.7%), elevated high-touch surfaces (23.0%), and elevated low-touch surfaces (8.5%). The researchers state that the significance of floors for virus transmission is uncertain. There is recent data, however, suggesting that hospital floors may serve as an underappreciated source of pathogen dissemination via footwear, portable equipment, or contact with high-touch objects.

Tannhäuser et al. (2022) examined bacterial colonization on the screens of smartphones used by healthcare workers before (2012) and during the Covid pandemic (2021). Bacterial contamination was present on 99.3% of the phone screens. During the pandemic, the phones were cleaned more often than in the year 2012. In 2021, 45.9% of the phones were cleaned daily (in 2012, 23.2%), 50.5% when obviously contaminated (in 2012, 68.7%), and 3.6 % were not cleaned at all (in 2012, 8.1%).

The bacteria most commonly found on the screens were the staphylococci bacteria that commonly live on people's skins. These bacteria were found on 80.8% of the samples in 2012 and 75% in 2021. Despite the increased cleaning in 2021, more spore-forming aerobic bacteria and polymicrobial contamination were detected in 2021 than in 2012: 79.1% / 54.5% (2021) as opposed to 66.3%/37.4% (2012). The results suggest that the cleaning frequency does not matter if the cleaning methods are not efficient enough.

Mody et al. (2021) investigated the frequency and persistence of SARS-CoV-2 on nursing home surfaces. Samples were taken in resident rooms from bed controls, the call button, bedside tabletop, TV remote, privacy curtain, windowsill, toilet seat, doorknob, and air vent. From nearby common areas, samples were taken from a sitting area tabletop, sitting area chair or arm rest, dining room tabletop, nurses' station tabletop, nurses' station computer keyboard, and elevator buttons.

In resident rooms, the most contaminated surfaces were the TV remotes (43.6%), windowsills (38.8%), call buttons (38.5%), air vents (27.1%), tabletops (24.0%), and bed controls (23.1%). In common areas, viruses were found especially on sitting area chairs (12.1%) and dining room tables (6.3%).

If the patient had a Covid-19 infection, viruses were very likely to be found on the room surfaces. Patients with greater independence were more likely to contaminate their immediate environment than the fully dependent patients were.

Ding et al. (2020) found in a study conducted in a hospital that the SARS-CoV-2 virus was most frequently found on toilet surfaces.

Abney et al. (2021) came to the same conclusion when compiling results from several studies to highlight the role of toilets. They summarise that toilets are areas where pathogens are easily spread via aerosols and surfaces.

A toilet bowl may contain up to 10^{14} virus particles. Pathogenic enteric bacteria appear in greater numbers in the biofilm found in toilets than in the bowl water. During flushing, pathogens can be ejected from the toilet bowl, urinal and sink and be transmitted through inhalation and contaminated surfaces. The build-up of biofilm within a toilet bowl, urinal, and sink can result in persisting pathogens and odours. There are also results to the effect that salmonella bacteria can colonize the underside of the toilet bowl rim and persist up to 50 days.

Source tracking of bacteria in homes demonstrated that during cleaning, enteric bacteria may transfer from the toilet to the bathroom sinks and that these same bacteria can colonize cleaning tools used in the restroom.

Cleaning with soaps and detergents without using disinfectants in public restrooms may spread bacteria and viruses throughout the restroom.

Significant aerosolization can occur when a toilet bowl is flushed, resulting in potential transmission of pathogens via inhalation and surface contamination. Large droplets settle within minutes, but smaller ones may persist and continue to settle on surfaces for even 90 minutes. Residual levels of microorganisms may remain in the bowl after the initial flush, resulting in aerosolization of bacteria in consecutive flushes. In a seeded toilet experiment, Salmonella could be isolated from the air, the toilet seat and the lid after flushes of the toilet bowl. In the bowl water, Salmonella was found for 5 days and was isolated from the biofilm below the water line for up to 50 days.

Take into account the surface materials

The properties and condition of the surface materials affect their cleanability.

Hardison et al. (2022) studied the effectiveness of surfactant-based chemicals and wiping to remove viruses from non-porous stainless steel, plastic, and laminate and from fibrous porous material used in bus seat fabric. Three different cleaning methods were tested immediately after the soiling of the surfaces and after two hours of drying.

When fresh, viruses were easily removed from hard, non-porous stainless steel, plastic and laminate surfaces by the physical action of wiping. The addition of detergent solution or hard water did not significantly increase virus removal. The removal of dried virus (two hours, cell culture media, 5% soil load) from hard, nonporous surfaces was more effective when the surface was wetted with a wetting agent (hard water or detergent) prior to physical wiping.

The researchers note that, in general, using a detergent-based cleaning solution does not appear to produce a significant benefit compared to wetting the surface with water alone. However, in real-world situations, respiratory droplets from potentially infectious individuals may not be cleaned immediately after deposition on a surface. In these cases, wiping with a damp wipe might not be sufficient to remove dried viruses from surfaces.

Brigando et al. (2023) investigated in a clinic what kinds of microbes were present on porous and non-porous surfaces and which factors influenced their abundance. Bacterial and fungal contamination on clinic surfaces was most closely correlated with the type of surface and how that surface was contacted rather than the degree of contact or frequency of cleaning.

Porous surfaces had more bacterial DNA compared to non-porous surfaces. Total bacterial contamination was not correlated to patient contact. The findings suggest that the combination of the surface type (porous versus non-porous) and how the surface is contacted (hand versus foot contact) likely plays a role in determining the makeup of the microbiome. On non-porous surfaces such as metal and polished vinyl, there are fewer microbes compared to porous surfaces, such as foam mats and handles of exercise equipment including weights, bikes, and treadmills.

Waldhans et al. (2023) studied under laboratory conditions the cleanability of different plastic and metal surfaces used by the food industry. Cleanability was studied as bacterial reduction rates in relation to the surface topography of materials. They noticed that there were remarkable differences in the surface topography. Scanning electron microscopy was used to examine the microstructure of the surfaces.

When cleaning with water, the results showed that nanostructured aluminised surfaces achieved significantly higher cleanability rates compared to the eight thermoplastic surfaces, as well as the glass-bead blasted rough stainless steel. Thermoplastic surfaces showed low cleanability rates also when cleaned with alkaline detergent, while stainless steel and nanoporous aluminium showed high variations. The researchers also point out that cleanability is not only influenced by surface roughness, but also by the overall surface finish, scratches, and defects.

Define the most effective detergents and disinfectants

Soon after the corona pandemic began, the first results of disinfectants efficient for killing the virus were published. However, less research is available on efficient cleaning methods.

Detergents and disinfectants work differently. When a detergent is used, dirt and microbes are removed from surfaces with cleaning equipment, but the microbes are not killed. When a disinfectant is used, the aim is to kill microbes and remove them from surfaces.

Disinfectants are often tested with standard test methods in laboratories, which may not match real-life conditions.

Russel (2003) states that the efficiency of biocides is dependent on contact time, concentration, temperature, pH, presence of organic soiling matter, and the type of microorganism. In standard tests the contact time is often more than one minute. It is argued that in real-life conditions the contact time of a disinfectant solution is often less than that.

A lot of research has been done on the efficiency of different kinds of biocides, both in laboratories and in real-life situations. The efficiency depends on the microbe. According to Russell et al. (2003), the order from the most susceptible microorganisms to the most biocide-resistant ones is lipid-enveloped viruses, cocci, gram-negative bacteria, fungi, mycobacteria/non-enveloped viruses, and bacterial spores.

Tuladhar et al. (2012) investigated the efficacy of cleaning and disinfection procedures in reducing viral and bacterial contamination on artificially contaminated stainless-steel surfaces. The results show that the enveloped respiratory influenza A virus is more susceptible to disinfection than the non-enveloped enteric viruses. The researchers concluded that the two-step procedure consisting of a single wipe with liquid soap followed by a disinfection step with 250-ppm chlorine solution is a good method against viral respiratory disease outbreaks.

El-Azizi et al. (2016) tested the efficiency of glutaraldehyde, hydrogen peroxide, peracetic acid, and sodium hypochlorite in removing bacteria in planktonic and biofilm forms. They found that all biocides killed all nine types of bacteria tested in the planktonic phases with all concentrations and all contact times, but that there was wide variation in the biocide concentration needed. Biofilms were significantly less susceptible to the biocides than planktonic cells of the same microorganism were.

The researchers emphasize that standard tests of biocide efficiency do not measure their efficiency against microbes in biofilm. This means that all the chemicals listed are recommended for combating microorganisms in the planktonic form only.

Robertson et al. (2019) investigated the functioning of microfibre cloths used with water, a sporicidal product, and a quaternary ammonium compound-based detergent/disinfectant with and without an organic load. They used a standard test method to measure the removal of bacteria and spores from stainless steel and PVC with PUR-coating and the transfer between the two surfaces.

The researchers found significant differences between the use with water alone and with the detergent/disinfectant product in the number of bacteria removed from the surfaces. Wiping with water reduced the bacterial counts mostly by 1-2 log10, but there was significant bacterial transfer from the microfibre to a different surface after the wiping.

Wiping with the detergent/disinfectant reduced the bacterial counts by 3-5 log10 and prevented the transfer of bacteria to a clean surface significantly. Similar results were obtained with the use of the sporicidal product. The level of organic load did not affect the efficacy of the test product and material performance.

As a conclusion, the researchers state that the use of water alone with a microfibre cloth is less effective and should not replace the use of biocidal products.

Recently, the debate on the negative effects of disinfectants has been raised. Stone et al. (2020) carried out a hospital study on the effects of a disinfectant (chlorine), a soap-based cleaner, and a probiotic on surface microbiota. As control, they used tap water. They compared different cleaning programmes by examining the type and amount of microbiome remaining after stainless steel, ceramic tile, and linoleum surfaces were cleaned for eight months. The cleaning wipes used were also examined.

The researchers found that after the use of the probiotic for cleaning, the microbiome on the surface was the highest. A rich microbiome can prevent growth of pathogens on the surfaces. However, when the soap-based cleaner was used, the microbiome was left more diverse than after cleaning with a probiotic. The disinfectant was the most effective in reducing the amount of microbiota on the surfaces, thus making room for the growth of pathogenic bacteria. The microbial levels in the cleaning wipes used were higher than on surfaces cleaned.

The researchers conclude that the surface microbiome can defeat pathogens but that both the number and the diversity of the microbiomes make a difference. The use of soap and probiotics is possible in certain hospital settings, but the probiotics should preferably contain more than one species of bacteria.

Chen et al. (2021) warn that high concentrations and high doses of disinfectants can promote an evolution towards antimicrobial resistance. Disinfectant by-products and antibiotic residues that exist in diverse environments permanently can promote bacterial evolution towards antimicrobial resistance. This may enable bacteria that carry antibiotic resistance genes to survive and persist in these contaminated environments.

Example

A survey of cleaning guidelines issued during the corona pandemic, carried out in 15 countries, showed that recommendations for cleaning agents to be used varied according to the use of the premises, the risk of disease, and the country. Almost all countries recommended an all-purpose cleaner for general use. A disinfectant or a disinfecting multi-purpose cleaner was recommended for toilet surfaces except floors. Spraying disinfectants on surfaces was not recommended. For places occupied by persons infected with Covid-19, disinfection was recommended for frequently touched surfaces, sanitary facilities, and visible stains of body fluids. For details, see https://pandemicclean.eu/best-practises/

Define the most effective cleaning methods and equipment

The cleaning equipment and methods used affect the cleaning result and can also spread microbes if the method is not dirt-binding and correct.

Bergen et al. (2008) and Ramm et al. (2015) showed that microorganisms can be spread via the cleaning cloths used. The right wiping technique is also crucial.

Smith et al. (2011) measured the capacity of nine reusable microfibre cloths and one disposable microfibre cloth to remove microorganisms associated with healthcare-related infections. Distilled water was used as a cleaning agent. The studies were conducted under controlled laboratory conditions.

The researchers did not find any significant differences among the reusable microfibre cloths, but the disposable microfibre cloth had a lower capacity to remove microbes. The mean reduction of microorganisms was 2.21 log10. In repeated washing, the performance of the reusable cloths improved up to 75 washes but diminished after 150 washes. Even so, the performance after 150 washes was mostly better than after the first wash.

Terpstra et al. (2015) conducted a laboratory study to compare reusable and disposable microfibre flat mops for cleaning action, cleaning exertion, dirt-binding capacity, and hygienic effectiveness.

On average, the reusable mop was better in removing the test dirt, but there were differences among the mops tested. There were significant intra-group differences in frictional resistance among both reusable and disposable mops. The highest cleaning resistances were measured in the disposable mops and the lowest in the reusable ones. All the mops except one removed a stain with a substantial concentration of bacteria. The log reduction was from 2.0 to 2.7 (99.0 to 99.8 % of bacteria present).

Terpstra (2021) also examined whether medium-sized single-disc scrubber driers spread microorganisms removed from the floor into the air. Substantial numbers of microorganisms were found in all wastewater tanks investigated, but the results imply that scrubber driers do not spread microorganisms removed from the floor into the ambient air.

Terpstra, van Kessel and Engelbertink (2021) tested the hygiene of refillable spray bottles. They found that the liquid in refillable spray bottles may get microbially contaminated, especially where pH-neutral detergents are used. Germs were found in 33 of the 55 spray bottles examined. The bottles contained both free and bound germs (biofilm) in roughly the same proportions. Even a daily cleaning with chlorine was not always enough to remove the germs from the spray bottles.

Edwards et al. (2020) studied how the surface, the fibre type of the cleaning cloth, and the presence of liquid biocide affected the degree of recontamination. Two different wipe compositions (hygroscopic and hydrophilic) were tested with and without liquid biocide on metal, ceramic, and plastic healthcare surfaces.
Despite the initial removal capacity of >70 % in the initial wiping, all surfaces were recontaminated with *E. coli*, *S. aureus* and *E. faecalis* when wiped with the same wipe more than once. This happened regardless of the fibre composition of the wipe or the presence of a liquid biocide. The extent of recontamination increased when the metal surfaces examined had a higher microscale roughness (<1 μm). The researchers conclude that a policy of "one wipe, one surface, one direction, dispose" should be implemented and rigorously enforced.

Berendt et al. (2011) measured the ability of various wipes to reduce the bacterial count when used to swipe across a plastic surface 1, 3, or 5 times. They found that when the wiping was done 3 or more times, a saline-moistened wipe appeared to be just as effective as disinfectant wipes. They suggest that when a surface is wiped only once, a disinfectant wipe should be used.

Edwards et al. (2018) tested how the cleaning cloth, the cleaning agent solution, and the wiping pressure affected the removal of bacterial pathogens. They found that the heaviest wipes, 150 g/m^2, yielded better efficiency in bacteria removal than the 50 and 100 g/m^2 wipes, possibly because more fibres meant more contacts with the surface. They conclude that the best results may be achieved by using heavier wipes with the heaviest possible wiping pressure.

Andersen et al. (2009) tested the efficiency of different floor-cleaning methods in removing bacteria and organic materials from hospital rooms. They reported large day-to-day variations in the number of organic materials and bacteria. They compared the dry, the moist, and the wet mopping methods with the spray mopping method and found that cleaning with the first three methods could remove 5-36% of the organic material and around 60 % of the bacteria, while 30% could be removed with the spray mopping method.

Sattar & Maillard (2013) remind us that there are several factors that influence the efficiency of wiping. These factors include e.g. the material, properties, and moisture of the cleaning cloth, wiping action and pressure, the surface to be cleaned, the dirt on it, and the chemical used. They also stress also human factor. Even when the most effective products are used, the success of the wiping action is determined by the diligence of the cleaner.

Example

The guidelines for cleaning during the corona pandemic rarely handled cleaning methods and equipment. If there was a guideline for cleaning tools, mention was made of microfibre cloths and mops. The importance of using only clean equipment was emphasised. For cleaning methods, the general guidance was to have proper, careful cleaning, but it was not clarified what that means in practice.
For details, see https://pandemicclean.eu/best-practises/

Control the thoroughness of cleaning

It is well acknowledged that the cleaning of high-touch surfaces is important in pandemic situations. However, several studies have shown that there are deficiencies in the cleaning of contact surfaces.

McKinley et al. (2023) observed surface cleaning thoroughness during daily cleaning in patient rooms. They found out that only 33.6% of all environmental surfaces and 60.0% of high-touch surfaces were cleaned. Higher cleaning rates were observed with bathroom surfaces, high-touch surfaces and reusable medical equipment. Patient absence from the room cleaned was associated with higher cleaning rates for high-touch surfaces. Bathroom surfaces were cleaned more frequently than bedroom surfaces and private rooms more frequently than semi-private rooms.

Parry et al. (2022) used a fluorescent targeting method to evaluate the thoroughness of cleaning in a hospital. In medical-surgical units, 74.7% of marked surfaces were cleaned. After four years of a continuous development programme, the target level of 90% was reached.

Controlling the thoroughness of cleaning should be part of the quality assessment.

Define the cleaning frequencies required

The type of microorganism can affect cleaning frequency. It may be wise to increase the cleaning frequency if the microorganism is able to multiply on surfaces. Bacteria can do that, viruses cannot.

The cleaning frequency may also depend on the use of the premises. If there is heavy use and the microorganism causes severe illnesses, it may be good to increase the cleaning frequency.

Kwan et al. (2018) investigated the reestablishment of microbial communities after surface cleaning in schools. They noted that cleaning the desks physically removed c. 50% of bacteria, fungi, and human cells. A full recovery of the surface microbial concentrations occurred within 2–5 days. Thus, the cleaning interval would need to be less than this period to result in a significantly lower exposure to children.

Example

There was considerable variation in the recommendations for cleaning frequencies issued in the 15 countries surveyed. Mostly, the advice given to prevent the spreading of the coronavirus was to continue regular cleaning and shift to more frequent cleaning if the rooms were visibly soiled or poorly ventilated, if they were used repeatedly by several people or there was no access to washing or sanitizing hands, or if there were spillages or the space was occupied by people at increased risk levels for severe cases of Covid-19.
For details, see https://pandemicclean.eu/best-practises/

Define the order and timing of the cleaning

It is well accepted that the correct cleaning order goes from less dirty to more dirty targets. This applies to whole cleaning areas as well as individual rooms or surfaces. Where this is not possible, hygienic cleaning practices are needed to avoid spreading dirt and microbes while cleaning.

In a pandemic situation, the timing of the cleaning should also be considered if the room has been occupied by infected people. It may make sense to postpone the cleaning if the microorganism is very infectious.

Example

The basic message in corona-time cleaning instructions was to start the cleaning from cleaner areas and proceed towards dirtier areas. Recommendations for the cleaning order in rooms and toilets were also given. There was variable guidance given about the timing of the cleaning.
For details, see https://pandemicclean.eu/best-practises/.

Review the current waste management procedures

Microbes can also spread via waste. Therefore, waste management procedures should be reviewed. A good practice is to empty the waste bins daily and to close the bin bags tightly, especially in public premises.

Yadav, Mann and Balyan (2022) studied the waste management policies adopted in some countries during the Covid-19 pandemic. They found out that the WHO recommendations were well followed and that some other preventive measures were also taken. These included the use of separate garbage bins and trolleys for Covid-19 waste, labelling the waste bags, and giving special guidance to medical staff, residents, and sanitation workers.

Example

The guidance material collected from 15 countries emphasized such things as emptying the waste bins daily and closing the bin bags tightly.
For details, see https://pandemicclean.eu/best-practises/

Give feedback

In a pandemic situation, where microbes can be spread and transmitted via surfaces, it is important to ensure that the cleaning methods and working practices adequately remove microbial contamination. This requires that the cleaning organisation is aware of the effectiveness of cleaning, that cleaning staff receives feedback, and that training and guidance are provided when necessary.

Several scientific studies show the importance of measurements and feedback.

Rupp et al. (2014) tested how to maintain improvement in cleaning practices after the education and training of cleaners. During five years, several feedback strategies were tested. This involved sampling with a fluorescent marker and instant or monthly feedback to cleaners, supervisors and / or administration. The best results could be achieved by a combination of immediate individual feedback and monthly reporting in direct face-to-face meetings with frontline personnel. In the beginning, the cleaning compliance was 47% and after different feedback strategies, it varied from 55.8% to over 80%.

Van Arkell et al. (2021) studied if feedback from ATP measurements decreases environmental contamination. ATP measurements were made in nine hospitals at random times. After the first measurement, feedback on the results was given to the cleaners. At this time, 37.7% of surfaces were assessed to be dirty. The second measurements were made after a year, showing that 13.1% of surfaces were dirty. The researchers concluded that receiving feedback on ATP measurements can reduce surface contamination significantly.

Mitchell et al. (2019) evaluated the effectiveness of an environmental cleaning program to reduce healthcare-associated infections in hospitals. The program focused on optimising product use, technique, staff training, auditing with feedback, and communication. As a result, hospital-acquired infections caused by vancomycinresistant enterococci decreased significantly. Also, an improvement in the cleaning of high-touch surfaces was observed: in bathrooms from 55 % to 76 % and in bedrooms from 64% to 86%.

Knelson et al. (2015) point out that the measurement results may vary depending on who is making the assessment. They compared surface cleanliness results checked by cleaning supervisors versus study personnel (validators). The cleaning supervisors determined 82.5% of surfaces to be clean. Meanwhile, the study personnel found 52.4% of surfaces to be clean. It was concluded that self-monitoring of hospital room cleanliness may not accurately measure how well high-touch surfaces are cleaned.

How to assess the result of cleaning

There are various control systems in the cleaning industry that are used to map out the quality of cleaning maintenance. Visual inspection is a common way to assess the amount of visible dirt. For the detection of dirt invisible to the eye, ATP and microbiological measurements and UV blacklight lamps are the most common methods in real-life situations.

Visual inspection

In the case of measurement systems, you also must keep a close eye on what you are measuring. Is the measurement topic the execution of the work, or the disruptions found, or the lack thereof? Or does the measurement concern whether something is acceptable or not?

These aspects are often confused with each other in the quality assessment. It is therefore important to know what and why you want to measure or assess quality. It will be clear that objectivity is sometimes difficult to establish. In order to be considered an acceptable objective quality measurement system, it must meet three important criteria:
- the system must be accessible to all;
- it must be scientifically proven;
- all data within the system must be reproducible.

There is no such thing as a completely objective control system for visually measuring the quality of cleaning maintenance. In Europe, there are only a few systems that meet the aforementioned three requirements. These include NEN-2075, CE-13549, and INSTA 800.

Ultraviolet light

With ultraviolet (UV) light, invisible dirt can be made visible when the room is dark. Some contaminants that are invisible to the naked eye fluoresce when illuminated with a UV light. These include e.g. urine and other body fluids, sebum, various (dyed) textiles, animal or plant dirt, dust, and detergent and lime deposits.

A UV lamp can be used to detect, for example, shortcomings in wiping techniques, areas that have not been cleaned at all, dirt accumulation at edges or corners, and cleaning residues deposited on surfaces.

In addition to assessing the cleaning result, UV light is a good tool for training cleaning staff.

ATP measurements

ATP measurements can indicate the amount of organic dirt on surfaces.

Adenosine Triphosphate (ATP) is the substance in which living cells store their energy. ATP occurs in all living organisms. By releasing this substance from a sample with chemicals and reacting with an enzyme complex, luciferin/luciferase, light is created. This light is measured with a luminometer and expressed in RLU, Relative Light Units. The more ATP, the higher the RLU values.

VSR, the Dutch Association for Cleaning Research (2012), highlights that only in very clean environments, such as in the meat processing and dairy industry (after cleaning), there is a relationship between the amount of ATP and the number of microorganisms. Outside of that, the presence of other debris disrupts the relationship between the amount of ATP and the number of bacteria.

The ATP method is insensitive to micro-organisms and sensitive to organic dirt. Therefore, the method cannot be used to measure surface hygiene. Regularly performing ATP measurements by the same person at fixed places and times can give an impression of the changes in the quality of cleaning. However, it should be remembered that changes in the supply of dirt (such as the number of people using a space) will certainly be visible. It is therefore recommended to perform the measurements before and after cleaning.

Many factors can influence the results of an ATP measurement: place, time, time after cleaning, the person doing the sampling, type of equipment and chemicals, fungus, coloured dirt and pollution in the luminometer.

Immediately after wet cleaning, more ATP is often found than before cleaning. After that, the values drop again. Perhaps this effect is because cleaning knocks apart clusters of microorganisms and damages individual cells. ATP is then much more available and so there seems to be more dirt. Some of the dismembered or broken cells die and ATP disappears after two hours. This can explain the decrease.

The ATP method produces semi-quantitative results, which can be strongly influenced by the dirt supply, method errors and other conditions. Research carried out in the Netherlands (VSR) recommends using this measurement method only to detect trends in cleaning quality. No limit values are known – and they differ per type of measuring device. There are no statistical and scientifically proven methodologies that indicate how often ATP measurements must be carried out to make reliable statements. A direct link with microbiological hygiene should not be established.

It is worth mentioning that Scandinavian countries use ATP for measuring the quality of cleaning. In some Western European countries, ATP has not been adopted as a leading method for measuring the quality of cleaning.

Microbiological measurements

Microbiological cultivation methods give the most accurate results on the number of microbes on the surface. The method involves transferring microbes from the surface to the culture medium, for example by pressing contact plates or slides on the surface. The culture medium is chosen according to the microbes to be examined on the surface.

Depending on the medium, the microbiological method can be used to measure, for example, total microbial counts or the counts of yeasts, moulds or intestinal microbes. The result is counted as culturable colony-forming units (CFU), Depending on the test, the result is obtained within 1 to 5 days. There are no uniform limits for the results.

Keep up to date with other means

Cleaning and disinfection are important when the aim is to reduce the number of microbes on surfaces. Salonen et al. (2023) note that these manual methods are often not sufficient to fully eliminate harmful micro-organisms because of poor cleaning practices, overwhelming bioburden, and disinfectant tolerance. Because cleaning is often not performed immediately after contamination, there is time for infection transmission before cleaning.

Besides cleaning and disinfection, there are other ways to fight microbes on premises. For example, antimicrobial coatings and UV-C light have been studied a lot and have shown encouraging results. Also, replacing touch surfaces with touchless options, such as touchless faucets, soap containers, and automatic doors and lights, helps to decrease human contact with surfaces.

There are many kinds of antimicrobial materials. Their ability to destroy microbes is based on different modes of action. Antimicrobial material can be used as the surface itself, such as copper, or can be added, for example, to a fabric, paint, or coating.

UV-C disinfection is a relatively new development of disinfection in the cleaning market. UV-C disinfection (most robots) works by emitting a high-intensity UV-C light, which can penetrate the cell walls of microorganisms, damaging their DNA and RNA and rendering them unable to reproduce and infect. This process has been proven to be highly effective in killing a wide range of microorganisms, including bacteria, viruses, and fungi.

Palma et al. (2022) conclude in their literature review article that UV-C LED irradiation represents a valid, eco-sustainable sanitisation method that could be exploited as an alternative to chemical compounds to contain indoor microbiological pollution in living and working environments.

However, it is good to keep in mind that cleaning is needed even when antimicrobial materials or UV-C light is used. Dirtiness may hinder the function of antimicrobial surfaces. The cleaning method should be suitable for the material to retain its desired function. Also, proper cleaning should be carried out before disinfecting with UV-C.

PROTECTING AND GUIDING THE CLEANING STAFF

A pandemic raises fear and uncertainty among everyone at risk of contracting the disease, including the cleaning staff. To reduce the fears, it is vital to train and inform the cleaners. In particular, employers must ensure the safety and health of their cleaning staff in a pandemic situation.

Carry out a risk assessment

In the beginning of a pandemic, it is important to review the risk assessment made for the cleaning services in each workplace and identify any new hazards the new situation might cause.

Hazards may be caused, among others, by the following:
- a microorganism
- cleaning chemicals
- waste
- lack of personal protective equipment.

After identifying the risks, the employer needs to find out what measures are needed to control them. These may include instructions on the use of personal protective equipment, on safe cleaning methods, on the timing of the cleaning, and on waste management. Separate risk assessments should be carried out at each workplace because the risk of infection may vary in premises of different kinds, depending on the activity and the users of the space.

Risk assessments shall be documented and, of course, shared with the cleaners working at each workplace.

As mentioned before, the properties of microorganisms can change, which calls for periodic reviewing of the risk assessments during the pandemic.

Dias et al. (2022) interviewed 436 female cleaners about their perceptions of the risks during the Covid-19 pandemic. The results show that the most worrying things for the respondents were the fear of infecting other people (85.5% of them agreed with this) and of causing death among people close to them (86.0%), the need to be alert all the time (56.2%), and the fear of not getting medical care (60.7%). The researchers point out that cleaners themselves may have diseases that make them vulnerable to contracting a disease. This is worth remembering when carrying out risk assessments.

Plan the necessary communication and the channels for it

The cleaning staff should be informed all the time on the pandemic situation in the premises, so that they can take that into account in their work. For that purpose, every employer must have effective and rapid communication channels for keeping the cleaning staff informed on the situation at each workplace.

Dias et al. (2022) emphasize the importance of using ‘easily understandable, (in)formative digital resources’ for communication.

Provide training

In the beginning of a pandemic, it is advisable to review the factors affecting the safety and efficiency of cleaning work. This can involve points such as safe and correct wiping methods, safe ways to choose, dose, and use detergents and disinfectants for each task, the correct cleaning order, correct identification of contact surfaces, safe use of personal protective equipment (PPE), and proper disposal of waste and used PPE.

By using PPE, the cleaners protect themselves and the users of the premises.

People may be infected via direct person-to-person contact, via indirect surface-to-person contact, or via the air. Disposable protective gloves, masks or respirators, and aprons are the most common protective equipment used in pandemic situations. If reusable equipment is used, proper cleaning after use is important.

In a pandemic situation, cleaners may need extra personal protective equipment. Hazards can be caused by strong cleaning chemicals, for example. Guidance is needed on the safe use of chemicals and safe use of protective equipment so that the cleaners will not spread microbes or get infected themselves.

Cleaning agents may cause skin irritation and, when inhaled, have respiratory effects. Clausen et al. (2020) point out in a review article that spray-generated aerosols, including corrosive chemicals such as strong acids and bases, ammonia, and hypochlorite, have respiratory effects. Quaternary ammonium compounds may also be hazardous when sprayed, but the evidence for their respiratory effects is ambiguous. The authors point out that cleaning and disinfectant products are complex chemical mixtures and that studying them all would require resources that are currently unaffordable.

Svanes et al. (2018) state that cleaning work may cause impairment of long-term respiratory health after 10-20 years. In a study of women who did cleaning work either occupationally or at home, they found accelerated lung function decline. The effect size was comparable to that of 10-20 pack-years of cigarette smoking.

In a study comparing the number of cases of work-related asthma among cleaners in 1998–2012 and in 1993–1997, Rosenman et al. (2020) found the situation unchanged. They conclude that “continued and additional prevention efforts are needed to reduce unnecessary use, identify safer products, and implement safer work processes.”

Example

In the cleaning instructions during the corona pandemic, disposable gloves were recommended. Depending on the cleaning task or the space, the recommendations also included a face mask or FFP2 respirator without ventilation, a disposable coat or plastic apron, and protective glasses or a face shield.
The instructions also included some suggestions for training the cleaners.
For details, see https://pandemicclean.eu/best-practises/.

Ensure correct hand hygiene and use of protective gloves

It is well known that hand hygiene is the most efficient means of preventing the spread of diseases. Cleaners should therefore practise good hand hygiene.

Good hygiene practices must also be observed in the use of protective gloves. Otherwise, cleaners may spread microbes via the gloves.

Tahir et al. (2018) tested whether healthcare personnel could spread bacteria associated with healthcare-related infections by touching a dry-surface biofilm with nitrile, latex, and surgical gloves. They also tested whether the result was different if the biofilm was first treated with a neutral detergent simulating cleaning. The results showed that enough *Staphylococcus aureus* bacteria were transferred in one dry-surface biofilm touch, up to 19 consecutive touches, to cause infection. With nitrile and surgical gloves, six times as many bacteria were transferred as with latex gloves. When the biofilm was treated with a 5%-solution of neutral detergent (simulating cleaning), the transmission rate of bacteria increased tenfold.

Inform the cleaners on the procedure to follow when they feel sick

Cleaners need to be aware of the symptoms of pandemic diseases. It is a good practice for employers to prepare guidance materials for the procedures to follow when a cleaner feels sick.

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