Cleaning for Health Report 2011/2012

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On 9th February 2011, the World Federation of Building Service Contractors resolved to make Cleaning for Health a key priority in the coming years. The Cleaning for Health project has defined the role of the cleaning industry in the promotion of public health.

Cleaning is our first defence against the ongoing threat of 'super bugs', influenza viruses, and more recently *E.coli* outbreaks. In healthcare settings the importance of cleaning, disinfecting and sterilizing is widely accepted and its implementation is usually strictly enforced.

However, outside the healthcare environment, in our schools, offices and public transport systems for example; the value of cleanliness is less understood.

In this report you will find relevant information on each of the most prevalent disease causing microbes that threaten community health today and information on how to safely eliminate them from various surfaces and environments.

We provide two charts; one comparing the most commonly used disinfectants suitable for routine environmental cleaning; and the other providing important details on widespread and established community-associated infectious diseases.

As part of the written report we address important topics of concern such as; how do we know if an area or environment is clean? How do we measure cleanliness? What is an acceptable level of microbial contamination on an environmental surface?

We have also provided clarity on contentious issues such as when a detergent is sufficient to clean a particular environment or surface and when disinfection is required. Within this report and in the associated setting-specific guidelines which can be accessed through our website (www.cleaning-for-health.org); we have broken down environmental surfaces into two groups, noncritical surfaces and critical surfaces. Noncritical surfaces carry a low risk of infection transmission and generally can be cleaned with detergent alone. Critical surfaces however, which are often frequently touched, carry a high risk of infection and generally require low-level disinfection.

Another controversial issue that our research has unearthed is the use of sodium hypochlorite, or bleach in routine commercial cleaning. Bleach will kill most microorganisms, including spores at high concentrations, and its use as a routine disinfectant is recommended in several scientific texts. It works fast, effectively and is non-discriminatory between different microbes. However, cleaning contractors are reluctant to use bleach due to the health risks associated with chlorine inhalation and the long-term damage it can cause to surfaces. We have thoroughly assessed the advantages and disadvantages of using bleach and as part of the Disinfection Chart we have compared bleach alternatives.

Adherence to contact times is not always strictly enforced within the cleaning industry. The contact time of a disinfectant required to kill a population of microbes should be listed on the chemical container by the manufacturer. Contact times can vary however, dependent on different factors such as microbial loading. We have explored this issue and developed recommendations.

Contamination of cleaning equipment is a significant and often overlooked impediment to cleaning procedure. If cleaning solutions, particularly those only containing detergent, are used for more than one hour the likelihood of the procedure actually spreading infectious agents around the environment is high. In this report we have suggested practices to avoid this contamination.

In this project we aim to place the WFBSC as a central source of information on cleaning for the control of infection.

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The Value of Cleaning

In the event of an outbreak of a new pandemic strain of disease, it would be very unlikely that a specific vaccine would be ready to inoculate the public during the first wave of the pandemic. In addition, there may not be sufficient quantities of antiviral medications available. Instead governments and councils will have to focus their efforts on the prevention of transmission of the disease. This would involve rigorous cleaning and decontamination processes, not only in hospitals, but in public areas, which is vital to stemming the spread of infection.

Through our high-density living in urban areas and the increased resistance of microbes to antibiotics, the role of the cleaning industry in curtailing public health disasters has never been so important.

To reduce the risk of infection transmission within our public spaces we must combine good standards of personal hygiene such as washing our hands before we eat and covering our mouths when we cough with good standards of environmental cleanliness to prevent the initial contamination from unclean surfaces.

WFBSC Cleaning For Health Project

The WFBSC has amassed peer-reviewed scientific data from governmental bodies and international organisations, such as the CDC[1], WHO[2], HICPAC[3], OSHA[4], HSE[5] and HPA[6] among others; regarding the most effective methods to prevent the spread of infection in the community. We have identified gaps in our existing knowledge and have proposed further studies to address them.

In this report and on our website (www.cleaning-for-health.org), we provide evidence and advice to cleaning contractors and clients which they can implement into their procedures when required.

Centers for Disease Control and Prevention[1], World Health Organisation[2], Healthcare Infection Control Practices Advisory Committee[3], Occupational Safety & Health Administration[4], Health and Safety Executive[5], Health Protection Agency[6]

Pathogens Threatening Public Health:

Emerging pathogens are of growing concern to the general public and infection-control professionals. The Centers for Disease Control and Prevention have described several diseases as emerging pathogens, these are *Cryptosporidium parvum, Helicobacter pylori, E. coli* O157:H7, HIV, Hepatitis A virus, rotavirus, norovirus, severe acute respiratory syndrome (SARS) coronavirus, multidrug-resistant *M. tuberculosis*, and nontuberculous mycobacteria (e.g., *M. chelonae*).

All these diseases, with the exception of HIV, can be transferred between individuals indirectly through contact with a contaminated surface. The susceptibility of each of these pathogens to chemical disinfectants and sterilants has been studied and we have presented the data in an attached Pathogens Chart.

Other diseases of public concern which are also indirectly transferrable include the common cold, H1N1, H5N1 and other influenza viruses, Acinetobacter, Aspergillosis, community acquired MRSA, community acquired *Clostridium difficile*, Ringworm and other fungal infections (*tinea*), Scarlet Fever (*Streptococcus)* and Hand, foot and mouth disease (Coxsackievirus).

We are now facing novel threats to public health that have emerged from infections that were previously only contracted in hospitals such as community-acquired *Clostridium difficile* and community-acquired MRSA (CA-MRSA).

The CA-MRSA strain has become epidemic in many communities worldwide. The skin and soft tissue infection caused by CA-MRSA has been seen in young and healthy individuals, indicating that the strain could be more infectious than its healthcare-associated counterpart.

For detailed information on all of the pathogens listed, please refer to the pathogen chart attached.

Modes of Transmission:

There are several modes of transmission of these pathogens:

Droplet contact transmission: Some diseases can be transferred by infected droplets contacting surfaces of the eye, nose or mouth. Droplets containing microorganisms can be generated when an infected person coughs, sneezes or talks. Examples of diseases capable of droplet contact transmission include SARS, the common cold, Legionnaires', Hand foot and mouth disease and MRSA.

Airborne Transmission: Some droplet nuclei (residue from evaporated droplets), or dust particles containing microorganisms can remain suspended in the air for long periods of time. These organisms can enter the upper and lower respiratory tracts. Diseases capable of airborne transmission include chickenpox, measles, tuberculosis and Aspergillosis.

Faecal-oral transmission: Microorganisms can enter the body through ingestion of contaminated food and water. These may multiply within the digestive system and shed from the body in faeces. If effective hygiene and sanitation practices are not in place then these microorganisms may contaminate food, water or environmental surfaces. Examples of diseases and microbes that spread this way include *E.coli*, *Cryptosporidium, Clostridium difficile,* hand foot and mouth disease, *Helicobacter pylori*, rotavirus and hepatitis A virus.

Direct contact transmission: This requires physical contact between an infected person and a susceptible person and the physical transfer of microorganisms. This may be through kissing, sexual contact or just through close contact living i.e. between individuals of the same household. Examples of diseases transmitted in this way include Acinetobacter, *E.coli*, SARS, the common cold, ringworm and other fungal infections, scarlet fever, norovirus, hand foot and mouth disease, *Helicobacter pylori* , MRSA and hepatitis A virus.

Indirect contact transmission: This occurs when a susceptible person is infected from contact with a contaminated surface which they may touch with their hands, and then touch their face, eyes or mouth, allowing the pathogen can enter the body and cause illness. Examples of diseases and microbes transmitted in this way include norovirus, *Clostridium difficile,* MRSA, SARS*, E.coli, Cryptosporidium,* ringworm and other fungal infections, scarlet fever, hand foot and mouth disease, rotavirus, hepatitis A *,* influenza*,* Acinetobacter, the common cold, *Helicobacter pylori* and tuberculosis. These microbes can survive on surfaces for extended periods of time; therefore it is important to reduce surface contamination through cleaning and disinfection.

Achieving a Scientific Standard:

There is an abundance of evidence supporting the role of environmental cleaning in public areas to control the spread of infectious disease. However, what is lacking is a scientific standard to gauge the cleanliness of an environment. Currently the only measure of sanitation is through visual assessment which does not necessarily correspond to microbiological risk. Pathogenic microbes are microscopic; therefore a visually clean environment can still pose a health risk.

Dr. Stephanie Dancer has recommended that hospitals should employ a similar approach to measuring and quantifying surface contamination as laid out by the Hazard Analysis Critical Control Point (HACCP) principles which the food industry uses to monitor food preparation surfaces. With the threat of emerging pathogens and traditionally healthcare-associated infections spreading into our communities, this approach could also be implemented in public settings by the cleaning industry.

Not only would the application of this strategy provide a healthier environment and reduce disease transmission, it is also economically beneficial to cleaning companies. It is false economy to wait until an outbreak occurs before an environment is properly cleaned and disinfected.

To apply a scientific standard to domestic surface cleaning an indicator organism of high risk should be identified. Dr. Stephanie Dancer recommends coagulase-positive staphylococci as a reliable indicator of environmental hygiene.

A quantitative assessment of microbial loading of a particular surface can then be measured and compared to a standard which it must not exceed. Environmental surface sampling may be carried out by microbiological or chemical (ATP bioluminescence) methods.

Microbiological methods require an environmental swab of a particular area then analysis of the swabs in a microbiological laboratory. Any private laboratory contracted by local councils to process food stuffs for environmental health officers would be able to enumerate microbe colony numbers from environmental samples at minimal cost. Dipslides may also be used. Each dipslide has a culture media on each side which can test for various organisms or be selective for only one type of bacteria.

ATP bioluminescence testing involves taking an environmental swab of a particular area with an ATP-free sterile swab. The swab can then be sent to a laboratory where it is placed in a trichloroacetic acid solution then placed in a luminometer to measure contamination.

The internationally specified acceptable microbial count on food-processing equipment is <5 cfu/cm^2. This could also be used in community settings on areas which pose the greatest risk to individuals such as high touch surfaces, particularly in bathrooms. This could be used to gauge the effectiveness of a certain cleaning procedure. If the microbial count exceeds this level then a review of cleaning and disinfection practices and frequencies can be conducted to improve the quality of service. A second sample could be taken after the revised cleaning procedure has been implemented to test its effectiveness.

This environmental screening ensures that resources are not wasted on areas of low infection-transmission risk, but instead attention is focussed only where it is necessary. This "targeted hygiene concept" is supported by the International Scientific Forum on Home Hygiene (IFH) as a means of reducing the social and economic burden of infectious disease.

Detergent or Disinfection:

A controversial issue in the cleaning industry which we wanted to address is when it is appropriate to use detergents or disinfectants in community settings.

Detergent-based cleaning will remove microbes if performed correctly, but will not necessarily kill them and can serve to spread them if cleaning equipment becomes contaminated.

Disinfectants are more effective at killing pathogens and are necessary to kill bacterial spores such as *Clostridium difficile*. However, disinfectants are more expensive, can be toxic to humans and the environment and are generally ineffective if organic matter is present on a surface therefore can require prior cleaning with detergent.

A comparison of disinfectants and detergents:

Detergents:

- Noncritical surfaces contribute minimally to infection transmission and may not require disinfecting.
- Minimal environmental impact and no issues with disposal.
- No occupational health exposure issues.
- Low costs.
- Minimal damage to surfaces.
- Detergents can quickly become contaminated.
- They do not have persistent antimicrobial activity and their residues can serve as food sources to bacteria.
- They will not necessarily kill microbes but will remove them. They require manual input involving rubbing and scrubbing for their full efficacy.
- They are not suitable for cleaning potentially infective material such as blood or other body fluids.
- They are unable to kill spores.

Disinfectants:

- Disinfectants are more effective than detergents in reducing microbial load.
- Disinfectants are needed for surfaces contaminated by potentially infective material such as blood or other body fluids.
- Some can kill spores.
- Some newer disinfectants have persistent antimicrobial activity.
- Higher costs.
- Can cause damage and degradation to surfaces.
- Can be toxic and pose occupational health risks.
- Can be damaging to the environment therefore some have disposal issues.

Guidelines for Decontaminating Environmental Surfaces:

These guidelines are suitable in office, school, nursery and crèche, care and nursing home, transport and retail settings in the event of a disease outbreak. Individual pdf documents summarising the cleaning of each of these environments can be found through our website (www.cleaning-for-health.org).

Noncritical Surfaces:

Not all areas in non-healthcare settings require disinfection and cleaning with a detergent can be sufficient. Minimal risk has been associated with transmission of infectious agents to individuals through noncritical environmental surfaces such as furniture and floors when they do not contact broken skin and/or mucous membranes.

However, detergent solutions are prone to becoming contaminated which can instead spread the pathogen around an environment. It is therefore it is important to regularly use fresh solutions, at least once an hour. Detergent residues that are left after cleaning can contain organic compounds which bacteria can thrive in. Moist environments also favour the growth and persistence of gram-negative bacilli and fungi therefore all areas must be thoroughly dried after cleaning.

Despite these risks, there are no studies which have found differences between infection rates when floors are cleaned with detergent rather than disinfectant. It can be concluded that routine cleaning with a detergent is sufficient to prevent disease transmission from noncritical environmental surfaces such as furniture and floors in most public spaces except those where there is frequent floor contact, such as in crèches and nurseries. In these settings low level disinfection is recommended.

Flooring:

Floors can become contaminated with microorganisms from settling airborne bacteria, or by contact with shoes, wheels and other objects. Spills of organic matter can become reservoirs for the microorganisms to colonize. Microbe removal is essential for maintaining a clean and safe environment for the public.

Cleaning a floor with detergent and water will reduce bacteria numbers by ~80%. However, the mop water becomes increasingly contaminated during cleaning and can actually serve to spread the microbes around the environment. Mop water should be changed for a fresh detergent solution hourly.

Using disinfectants to decontaminate flooring will achieve a higher microbial kill than using detergents alone. However, a few hours after disinfection, the microbes usually re-established themselves to pre-treatment levels. Therefore detergent cleaning of floors is sufficient provided fresh solutions are used regularly. If there is organic matter present, additional low-level disinfection is required after cleaning with a detergent to kill any microbes present in the soiling.

Hard Flooring:

- Methods for cleaning non-porous floors include wet mopping and wet vacuuming, dry dusting with electrostatic materials, and spray buffing.
- Floors should be vacuumed and wet mopped daily.
- Methods that produce mists, aerosols or cause dispersion of dust should be avoided as these can kick up pathogen-containing dust and allergens into the atmosphere which may be inhaled.
- It is advisable to equip vacuums with HEPA filters, especially for the exhaust. Bacterial and fungal contamination of filters in cleaning equipment is inevitable, and these filters should be cleaned regularly or replaced as per equipment manufacturer instructions.

Carpets:

- Carpets do harbour more pathogens than hard floors, but no studies show differences between infection rates associated with the surfaces.
- Carpets, especially those with high levels of activity in classrooms, office settings, conference rooms, shop floors and communal rooms in care homes require vacuuming daily and a full clean every six months or immediately after a spillage.
- Soiled carpeting that remains damp or wet provides an ideal setting for the proliferation and persistence of gram-negative bacteria and fungi.
- The soiling should be cleaned immediately. If organic matter is present it should be disinfected after removing the material mechanically with a detergent.
- Carpeting that remains damp for 72 hours should be removed.
- Wet vacuuming is more effective than dry cleaning at removing fungi such as aspergillosis.

Soft Furnishing:

Soft furnishings such as curtains and chair and pillow covers can harbour pathogens or allergens that have settled on their surface from airborne bacteria or from contact with people's hands or clothes or from spills of organic matter. In the event of an outbreak of disease these surfaces will require cleaning to remove harmful microbes from the environment.

- Soft furnishings that are likely to get soiled (e.g., in nursing homes, nurseries or schools) should be covered with material that is wipe-clean and impermeable. Chairs should be fully cleaned daily with a detergent. If soiling is present then the surface will require additional disinfection after removing the organic material mechanically with a detergent.

- Laundering on a thermal disinfection cycle that achieves a temperature of 65$_o$C for 10 minutes is the most effective method of decontamination.
- Soft furnishing that cannot be laundered should be steam cleaned or cleaned using a detergent solution then dried.
- If soiled, the fabric can be sprayed with 3% hydrogen peroxide after cleaning with a detergent.
- Allergens (e.g., dog and cat dander) have been detected in or on cloth furniture from visitor's clothes. Dust containing Acinetobacter, *community associated MRSA*, Aspergillosis and other fungi can also be found on cloth furnishing. Researchers have therefore suggested that cloth chairs should be vacuumed regularly to keep the dust and allergen levels to a minimum.
- Curtains should be commercially laundered every six months unless they are visibly soiled then they should be laundered.

General Environmental Surfaces:

- It is important to physically remove microorganisms and soil by wiping or scrubbing in addition to using a cleaning agent. Spraying cleaning agents should only be used if it is impossible to reach a certain area.
- Dry conditions favour the persistence of gram-positive cocci (e.g., coagulase-negative *Staphylococcus* spp.), acinetobacter, community associated *MRSA*, aspergillosis and other fungi in dust and on surfaces. Wet-dusting using clean cloths moistened with detergent is recommended on noncritical surfaces.
- Moist environments favour the growth and persistence of gram-negative bacilli and fungi therefore after cleaning all surfaces must be thoroughly dried.

Specified Surfaces:

- All parts of radiators (including between panels) should be visibly clean and free from dust, dirt, debris and spillages. They should be fully cleaned weekly.

- All parts of fans and air conditioning units including the blades/fins and the underside, should be visibly clean and free from dust, dirt and debris. They should be dusted weekly and fully cleaned annually.

- All wall fixtures such as switches, sockets or data/computer points should be visibly clean and free from dust, dirt, debris and spillages.

- Doors should be visibly clean and free from dust, dirt, debris and spillages. High touch areas such as handles and push plates should be cleaned and disinfected daily. The door should be fully cleaned weekly.

- Ventilation grilles, extractors and inlets should be visibly clean and free from dust, dirt, debris, or cobwebs. They should be dusted weekly and fully washed annually.

- Kitchen cupboards should be visibly clean and free from dust, dirt, debris, or cobwebs. They should have a full external clean weekly and full internal clean monthly.

- Unused taps or shower heads should be run at least once a week for 10minutes for Legionnaires' risk control.

- Walls and ceilings do not need to be washed more than once every 6months with hot water and detergent unless they are visibly soiled.

Critical surfaces:

Environmental surfaces that do pose a risk of disease transmission and would require low-level disinfection are frequent hand-touch sites such as door handles, taps, keyboards, telephones, toys, light switches etc. These can be identified through environmental screening using a fluorescent marker. A paediatric unit seeded pieces of cauliflower mosaic virus onto a telephone and tracked its movement around the unit from hand-touch site to hand-touch site. This identified the areas that required disinfection.

The identification of high-risk areas follows the same principles laid out by Hazard Analysis Critical Control Point (HACCP) as used in the food industry as a method of infection prevention during production by eliminating risk.

Suitable Disinfectants for Routine Cleaning:

- Ethyl or isopropyl alcohol (70-90%).
- Sodium hypochlorite (5.25-6.15% household bleach diluted 1:500 provides >100 ppm available chlorine).
- Phenolic germicidal detergent solution (follow product label for use-dilution).
- Iodophor germicidal detergent solution (follow product label for use-dilution).
- Quaternary ammonium germicidal detergent solution (follow product label for use-dilution).
- Hydrogen peroxide (3-7.5%) is a high level disinfectant, but it is suitable for community environments.

For detailed information on these disinfectants see the disinfection chart attached.

This report focuses on chemical disinfectants and has not considered steam cleaning.

Choosing a Disinfectant:

Factors to be taken into account when choosing disinfectants include:

- Compliance with chemical safety regulations for the safety of cleaning personnel.
- Material compatibility- some disinfectants can corrode or discolour certain surfaces.
- Antimicrobial activity- does it have a wide antimicrobial spectrum?
- Contact times- what is the minimum exposure time a disinfectant requires to reduce a population of microbes by ~99.9%.
- Storage- Does it rapidly decay?
- Disposal- Are there disposal issues? Is it toxic to the environment?
- Prior-cleaning- Is it effective in the presence of organic matter?
- Temperature/pH- does temperature and pH affect the disinfection process?
- Cost
- Availability
- Contamination risk- how frequently will I need to use a fresh solution?

Frequent Hand-Touch Sites:

Frequently touched surfaces or items should be disinfected once a day. Bleach wipes have been recommended by researchers.

Here is a list of some of these surfaces listed by public setting:

Bathrooms:

Bleach solution is recommended for bathrooms as it is sporicidal and can kill *Clostridium difficile* at high concentrations.

Taps, flushes, toilet seats, door handles and locks, sinks, all dispensers and holders, wash basins, light switches, baby changing areas, shower heads, shower screens and bath tubs.

Kitchens:

Appliance buttons, cupboard handles, oven handles, drawers, countertops, eating utensils, dishes, taps, sinks, refrigerator handles, light switches and door handles.

Offices:

Desktops, computer keyboards, door handles, waste receptacles, dispensers and holders, buttons on copy machines or printers, desk drawers, telephones, railings on staircases, elevator buttons and light switches.

Schools:

Desks, toys, sport equipment, eating utensils, dishes, waste receptacles, drawers, countertops, computer keyboards, hands-on learning items, door handles, railing on staircases, lockers, playground equipment, light switches and drinking foundations.

Retail and airports:

Trolley and basket handles, check-out areas, 'chip and pin' readers, door handles (i.e. in changing rooms), railings on staircases or escalators, elevator buttons, glass food cabinets, ATMs, information desks, light switches, petrol pumps and drinking fountains.

Transport systems:

Trains:
Railings, grab-handles, poles, door buttons, arm rests, ticket machines, barriers/gates/turnstiles, luggage storage areas, escalator and staircase railings and elevator buttons.

Buses/trams:
Ticket machines, grab handles, poles, arm rests, stop buttons.

Airplanes:
Overhead lockers, fold-out tables, arm rests and buttons, window shutters, overhead air-conditioning and light switches, trolley handles and door handles.
Note: HVAC systems should be regularly cleaned from dust, debris and contamination.

Cruise ships/Hotels:

Railings, door handles, arm rests, elevator buttons, desktops, computer keyboards, drawers, bedside tables, light switches, room basins, cupboard handles, restaurant bars, information desks, dispensers and holders, waste receptacles and remote controls.

Resistance of Microbes:

Decreasing order of resistance of microorganisms to disinfection and sterilization and the level of disinfection or sterilization.

Resistant	Level
Prions (Creutzfeldt-Jakob Disease)	Prion reprocessing
Bacterial spores (*Bacillus atrophaeus*)	Sterilization
Coccidia (*Cryptosporidium*)	
Mycobacteria (*M. tuberculosis, M. terrae*)	High
Nonlipid or small viruses (polio, coxsackie)	Intermediate
Fungi (*Aspergillus, Candida*)	
Vegetative bacteria (*S. aureus, P. aeruginosa*)	Low
Lipid or medium-sized viruses (HIV, herpes, hepatitis B)	
Susceptible	

Source: CDC Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008.

Microorganisms vary greatly in their resistance to chemical germicides . Intrinsic resistance mechanisms in microorganisms to disinfectants vary. For example, spores are resistant to disinfectants because the spore coat and cortex act as a barrier. Mycobacteria have a waxy cell wall that prevents disinfectant entry, and gram-negative bacteria possess an outer membrane that acts as a barrier to the uptake of disinfectants.

The Disinfectant Chart attached provides information on the efficacies of the most commonly used disinfectants for routine cleaning against these different microbes.

Spores are resistant to commonly used surface disinfectants such as quaternary ammonium compounds and alcohol based disinfectants. In fact, spore production can actually increase when exposed to nonchlorine-based cleaning agents. There are currently no EPA-registered surface disinfectants with label claims for inactivation of *C. difficile* spores. The use of dilute solutions of hypochlorite (1,600 ppm [0.16%] available chlorine) for routine environmental disinfection in the event of a *C.difficile* outbreak is currently recommended.

2% glutaraldehyde, peracetic acid and *ortho*-Phthalaldehyde can reliably kill *C. difficile* spores however these are high level disinfectants and can be toxic therefore may not be suitable in public environments.

The elderly are particularly susceptible to acquiring *C.difficile* infection, and they become the most ill. Care home and hospice settings are advised to use sodium hypochlorite solutions, at the dilution listed above to clean target areas such as bathrooms and frequent hand-touch sites.

Further research is required to identify an effective, cheap and non-toxic sporicide that can be used routinely to inactivate spore producing microbes such as *C.difficile*.

Bleach:

There seems to be a disparity between the use of sodium hypochlorite, or bleach, recommended by government guidelines, and the avoidance of its routine use by cleaning contractors and clients.

Bleach is widely endorsed by national and international guidelines due to its wide antimicrobial spectrum which can be altered through dilution depending on its application. A solution of low concentration of available chlorine (2 to 500 ppm), is active against vegetative bacteria, fungi and most viruses. Rapid sporicidal action can be obtained at around 1600-2500 ppm. The removal of dried on organisms or biofilms requires 1000-1500ppm.

It is fast acting, inexpensive, does not leave toxic residues, is unaffected by water hardness (unlike Quaternary Ammonium Compounds) and there are minimal disposal issues.
However, it also comes with plenty of draw backs which is why its routine use is currently avoided:

- Sodium hypochlorite at the concentration used in household bleach can irritate mucous membranes, eyes, skin and can trigger asthmatic symptoms through prolonged exposure.
- If mixed with ammonia or acid, (e.g., other household cleaning agents) toxic chlorine gas is released, which is very harmful upon inhalation.
- It is toxic to aquatic organisms.
- It is corrosive to metals in high concentrations (>500 ppm) and will discolour fabrics.
- It is inactivated by organic matter therefore prior cleaning with a detergent is essential for full efficacy.
- Chlorine compounds are rapidly inactivated by light and some metals therefore fresh solutions should be regularly made up, at least every 24 hours. A hypochlorite solution in tap water at a pH >8 stored at room temperature (23ºC) in closed, opaque plastic containers can lose up to 40%–50% of their free available chlorine level over 1 month.

Through our research we have found that most settings do not require routine disinfection on noncritical surfaces such as floors and furniture (except nurseries and crèches where there is high floor contact). Detergent is normally sufficient unless there is a spillage of organic matter. Low level disinfection, such as that of bleach, is only required on frequent hand-touch sites and critical surfaces such as those found in bathrooms. Therefore problems associated with exposure to toxic chemicals could be avoided through rotation of staff and appropriate use of personal protective equipment. It is essential the area being cleaned is well ventilated and a COSHH assessment must be carried out when using toxic chemicals such as bleach.

There is still a great need for an inexpensive, non-toxic, efficient disinfectant with sporicidal activity for use as an alternative to bleach for routine disinfection.
The disinfectant chart attached compares bleach alternatives already on the market, including the relatively new, superoxidised water.
Superoxidised water carries less health hazards than bleach and is also sporicidal at high concentrations. However, the equipment required to produce the product can be expensive.

Contact times:

The contact time of a disinfectant is the length of time the surface needs to remain wet with the chemical to achieve inactivation of the most resistant types of microbes.

A study tested whether or not contact times were met when using practices that are routinely used in facilities today- wipe once and allow the surface to air dry.
Six different disinfectants were tested: a Quaternary Ammonium Compound, a Quat-Alcohol blend, a Phenol, an Alcohol-Phenol blend, Bleach and Accelerated Hydrogen Peroxide. The drying time was compared to the label contact time. It was found that products with contact times of 10 minutes (Quat, Phenol and Bleach) all dried within 3 – 4 minutes. Accelerated Hydrogen Peroxide formulations with 1 minute and 5 minute contact times dried within 3 – 4 minutes. As the Quat, Phenol, Bleach and some of the Hydrogen Peroxide solutions dried before their contact times were completed, they did not achieve their claimed disinfection activity. To overcome this, more disinfectant solution could be used to extend contact for the recommended period of time, or the surface could be wiped again with the disinfectant after the initial wipe has dried.

Another factor affecting contact times is microbial load present. In highly soiled areas the contact times increase. It is therefore important to mechanically remove organic matter from a surface before disinfecting.

It is also important to ensure that all surfaces are in contact with the disinfectant. Only the surfaces directly in contact with the chemical will be disinfected, so there must be no air pockets and the surface must be completely immersed for the entire exposure period stated by the manufacturer.

Environmentally Safe Disinfectants:

Some environmental groups advocate ‘environmentally safe’ products as alternatives to commercial germicides in the home-care setting. These alternatives (e.g., ammonia, baking soda, vinegar, Borax, liquid detergent) are not registered with the Environmental Protection Agency (EPA) and should not be used for disinfecting because they are ineffective against *S. aureus*. Borax, baking soda, and detergents also are ineffective against *Salmonella* Typhi and *E.coli*; however, undiluted vinegar and ammonia are effective against *S.* Typhi and *E.coli*.

Avoiding Contamination:

Mop water becomes increasingly dirty during cleaning and becomes contaminated if detergent and water is used rather than a disinfectant. Heavy microbial contamination of wet mops and cleaning cloths can seed an environment with bacteria and other microbes. Wiping hard surfaces with contaminated cloths can contaminate hands, equipment, and other surfaces. It is important to regularly change cleaning solutions no less often than at 60-minute intervals. Decontamination of reusable mops and cleaning cloths is also essential for efficient cleaning practice.

Heat is the most reliable treatment of cleaning cloths. Detergent washing followed by drying at 80°C for 2 hours produced elimination of contamination. However, the dry heating process might be a fire hazard if the mop head contains petroleum-based products or lint builds up within the equipment or vent hose.

Alternatively, immersing the cloth in hypochlorite (4,000 ppm) for 2 minutes will produce the same result.

Researchers have recommended the use of microfiber materials to clean all surfaces including floors. Microfibers are positively charged and attract dust (which has a negative charge) making them more absorbent than a conventional, cotton-loop mop. Microfiber materials also can be wet with disinfectants, such as quaternary ammonium compounds, but not chlorine based compounds such as bleach.

A study showed that the microfiber system demonstrated superior microbial removal compared with conventional string mops when used with a detergent cleaner (94% vs 68%).
Microfiber pads should be regularly changed and decontaminated in an industrial washing machine with a thermal disinfection cycle that achieves a temperature of 65^{o}C for 10 minutes.
Microfiber cloths are less effective when used on old and damaged surfaces because of repeated snagging and perform best in the routine maintenance of surfaces which are not heavily soiled.

Removal of Airborne Microbes:

A variety of airborne microbes can be released into the air when environmental reservoirs (i.e., soil, water, dust, and decaying organic matter) are disturbed such as *Aspergillus fumigatus*. Once these materials are brought indoors by any of a number of vehicles (e.g., people, air currents, water, construction materials, and equipment); the microbes can proliferate and, serve as a source for airborne infections.

Microbes that spread through droplet contact transmission are generally transferred between individuals directly as the droplets tend to fall out of the air quickly. Therefore no extra cleaning measures are required to remove these droplets from the atmosphere.

Airborne transmission of droplet nuclei however does pose a health risk as the nuclei can remain in the air for extended periods of time.

Disinfectant spray-fog techniques for antimicrobial control are not recommended in public settings as the chemicals used can cause mucous membrane and respiratory irritation.

HVAC systems are recommended as they can remove contaminated air and minimize the risk of transmission of airborne pathogens from infected patients. HEPA filters can be fixed into HAVAC systems which are at least 99.97% efficient for removing particles.
Decreased performance of HVAC systems, filter inefficiencies, improper installation, and poor maintenance can contribute to the spread of airborne infections therefore regular maintenance is required.

Ultraviolet Germicidal Irradiation (UVGI) has shown to be effective in reducing the transmission of airborne bacterial and viral infections in military housing and classrooms, but it has only a minimal inactivating effect on fungal spores.
UV lamps can be placed inside ducts that remove air from rooms to disinfect the air before it is recirculated or they can be mounted on a wall. Maintenance of UVGI systems consists of keeping the bulbs free of dust and replacing old bulbs as necessary.

Alternatively, public settings not served by central HVAC systems can use through-the-wall or fan coil air conditioning units as the sole source of room ventilation.

Antibacterial Coating of Surfaces:

There are antimicrobial coatings available for linen (curtains); furniture (lockers and bedside tables); office equipment (computers and printers); hand-touch sites (door handles and taps) and general surfaces (floors, walls and doors). Practically anything that can be impregnated or coated with microbicidal paint or chemicals could potentially be marketed as 'antibacterial'. Bioactive surfaces or coatings can contain heavy metals such as copper, zinc, silver or titanium, or antiseptics and biocides. There are electrostatic and inhibitory surfaces that repel microbial adhesion.

An example of this is a coating of nano-silver particles combined with titanium dioxide to form highly reactive $Ti\ O_2\ Ag$ particles. This invisible protective nanocoating can be applied onto a range of surfaces under low temperatures, which means that virtually all environmental surfaces could be treated.

Since frequently touched sites rapidly become recontaminated, coatings with prolonged biocidal activity might be useful for inhibiting further recontamination. However, there is little scientific evidence to support manufacturer's claims of the efficacy of these products. Also, the effectiveness of these coatings can degrade over time or in the presence of organic loading. Further research into the effectiveness of these products is required.

Conclusion:

The cleaning industry has a vital role in the promotion of healthy and hygienic everyday environments within our communities. This role has become more complex and challenging within recent years due to an increase in the prevalence of multi-drug resistant organisms in non-healthcare settings and the emergence of new pandemic strains of influenza viruses.

The industry must keep up with the rapid advances in science and technology regarding effective cleaning and decontamination processes; and update its practices to match the increasing demands from society to keep our communities healthy.

We have identified several gaps in the existing research on infection control that require further study. Firstly, and maybe most importantly, it is vital that a scientific standard is applied to the cleaning process. In establishing an appropriate level of cleanliness of an environmental surface, we can determine what cleaning methods need to be revised to meet those standards.

Secondly, we have ascertained the importance of using bleach in routine cleaning due to its wide antimicrobial spectrum. At high concentrations it is sporicidal which cannot be said for most other low/ intermediate level disinfectants. However, as mentioned above it does come with plenty of drawbacks, most importantly the serious health risk associated with chlorine gas inhalation. Therefore it is vital that the cleaning industry finds a safer and equally effective alternative to bleach. The Disinfectant Chart attached compares currently available alternatives, and it can be seen that the most likely successor of bleach is superoxidised water.

Lastly, the use of antibacterial coating on environmental surfaces has potential to aid cleaning practices. If these surfaces could reliably inhibit contamination they could help to sustain a higher standard of hygiene. However, the coatings currently available suffer a lack of scientific evidence supporting their efficacy to warrant their installation as standard.

For more information and resources please visit www.cleaning-for-health.org

On this site you will find a series of pdf documents which clearly explain how to safely and effectively clean and decontaminate particular environments during an outbreak of a pandemic disease within the vicinity. The environments we cover are office settings, transport systems, retail settings, childcare settings and care homes and nursing homes and hotels and cruise ships.

Glossary:

Biofilm: accumulated mass of bacteria and extracellular material that is tightly adhered to a surface and cannot be easily removed.

Cleaning: Cleaning is the removal of foreign material, such as soil and organic matter from surfaces. This can be accomplished manually or mechanically using water with detergents or enzymatic products.

Contact time: time a disinfectant is in direct contact with the surface or item to be disinfected. For surface disinfection, this period is framed by the application to the surface until complete drying has occurred.

Contaminated: state of having actual or potential contact with microorganisms. The term generally refers to the presence of microorganisms that could produce disease or infection.

Decontamination: according to OSHA, "the use of physical or chemical means to remove, inactivate, or destroy bloodborne pathogens on a surface or item to the point where they are no longer capable of transmitting infectious particles and the surface or item is rendered safe for handling, use, or disposal". However, the term generally refers to all pathogenic organisms.

Detergent: cleaning agent that makes no antimicrobial claims on the label. They comprise a hydrophilic component and a lipohilic component and can be divided into four types: anionic, cationic, amphoteric, and non-ionic detergents.

Disinfection: Disinfection is the process that eliminates many or all pathogenic microorganisms on inanimate objects. Methods of disinfection involve liquid chemicals or wet pasteurisation.

- **High-level disinfectants:** can kill all microorganisms except large numbers of bacterial spores. Examples of these are >2.4% glutaraldehyde, 0.55% ortho-phthalaldehyde (OPA), 0.95% glutaraldehyde with 1.64% phenol/phenate, 7.35% hydrogen peroxide with 0.23% peracetic acid, 1.0% hydrogen peroxide with 0.08% peracetic acid and 7.5% hydrogen peroxide. Most of these can cause degradation to surfaces through long-term use and are highly toxic, so Personal Protective Equipment is necessary.
- **Intermediate-level disinfectants:** should kill mycobacteria, vegetative bacteria, most viruses, and most fungi but do not necessarily kill bacterial spores. Examples of these are sodium hypochlorite, alcohols, some phenolics, and some iodophors.
- **Low-level disinfectants**: can kill most vegetative bacteria, some fungi, and some viruses. Examples of these are quaternary ammonium compounds, some phenolics, and some iodophors.

Germicides: A germicide is an agent that can kill pathogenic microorganisms. The term *germicide* includes disinfectants and antiseptics.

- *Antiseptics* are germicides applied to living tissue and skin.
- *Disinfectants* are antimicrobials applied only to inanimate objects.
- Virucides, fungicides, bactericides, sporicides, and tuberculocides can kill the type of microorganism identified by the prefix. For example, a bactericide is an agent that kills bacteria.

Inanimate surface: nonliving surface (e.g., floors, walls, furniture).

Inorganic and organic load: naturally occurring or artificially placed inorganic (e.g., metal salts) or organic (e.g., proteins) contaminants on a medical device before exposure to a microbicidal process.

Lipid virus: virus surrounded by an envelope of lipoprotein in addition to the usual core of nucleic acid surrounded by a coat of protein. This type of virus (e.g., HIV) is generally easily inactivated by many types of disinfectants. Also called *enveloped* or *lipophilic viruses*.

Microorganisms or microbes: animals or plants of microscopic size. This generally refers to bacteria, fungi, viruses, and bacterial spores.

Mycobacteria: bacteria with a thick, waxy coat that makes them more resistant to chemical germicides than other types of vegetative bacteria.

Nonlipid viruses: generally considered more resistant to inactivation than lipid viruses. Also called nonenveloped or hydrophilic viruses.

Parts per million (ppm): common measurement for concentrations by volume of trace contaminant gases in the air (or chemicals in a liquid); 1 volume of contaminated gas per 1 million volumes of contaminated air. Parts per million = µg/mL or mg/L.

Pathogen or infectious agent: (or a germ) is a microbe or microorganism such as a virus, bacterium, prion, or fungus that causes disease in its animal or plant host.

Personal protective equipment (PPE): specialized clothing or equipment worn by an employee for protection against a hazard. General work clothes (e.g., uniforms, pants, shirts) not intended to function as protection against a hazard are not considered to be PPE.

Sanitizer: an agent that reduces the number of bacterial contaminants to safe levels as judged by public health requirements. According to the protocol for the official sanitizer test, a sanitizer is a chemical that kills 99.999% of the specific test bacteria in 30 seconds under the conditions of the test.

Sterilization: Sterilization is the process that eliminates all forms of microbial life by physical or chemical methods.

Vegetative bacteria: bacteria that are devoid of spores and usually can be readily inactivated by many types of germicides.

References:

Infection Control:

Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. Journal of Hospital Infection (2004) 56, 10–15
http://www.ncbi.nlm.nih.gov/pubmed/14706265

Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21499954

Al-Hamad A, Maxwell S. How clean is clean? Proposed methods for hospital cleaning assessment. J Hosp Infect. 2008 Dec;70(4):328-34.
http://www.ncbi.nlm.nih.gov/pubmed/18848370

Curtis V, Schmidt W, Luby S, Florez R, Touré O, Biran A. Hygiene: new hopes, new horizons. Lancet Infect Dis. 2011 Apr;11(4):312-21.
http://www.ncbi.nlm.nih.gov/pubmed/21453872

Dancer SJ. J Hosp Infect. The role of environmental cleaning in the control of hospital-acquired infection. 2009. Dec;73(4):378-85.
http://www.ncbi.nlm.nih.gov/pubmed/19726106

Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008 Feb;8(2):101-13.
http://www.ncbi.nlm.nih.gov/pubmed/17974481

Dancer SJ. Mopping up hospital infection. J Hosp Infect. 1999 Oct;43(2):85-100.
http://www.ncbi.nlm.nih.gov/pubmed/10549308

Anderson KL. Norovirus outbreak management in a resident-directed care environment. Geriatr Nurs. 2009 Sep-Oct;30(5):318-28.
http://www.ncbi.nlm.nih.gov/pubmed/19818267

Guidance on infection control in schools and other childcare settings. Health Protection Agency. 2010.
http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947358374

Australian Government. Department of Agriculture, Fisheries and Forestry. Australian aquatic veterinary emergency plan. Aquavetplan. Operational procedures manual decontamination version 1.0, 2008.
http://www.daff.gov.au/__data/assets/pdf_file/0008/617183/decontamination-manual.pdf

Infection prevention & Control Cleaning Manual & Room Specifications. Independent Contractors. NHS South East Essex. 2010.
http://www.see.nhs.uk/content/file/gp%20zone/ip&c/see%20cleaning%20manual.pdf

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC) 2003.
http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_hcf_03.pdf

Health Protection Agency South West Community Infection Control Guidelines 2nd edition (2007)
http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947417368

William A. Rutala, David J. Weber and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008.
http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

Jane D. Siegel, Emily Rhinehart, Marguerite Jackson, Linda Chiarello and the Healthcare Infection Control Practices Advisory Committee. Multidrug-Resistant Organisms In Healthcare Settings, 2006.
http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroguideline2006.pdf

Parliamentary Office of Science and Technology postnote. Infection Control in Healthcare Settings. 2005. Number 247.
http://www.parliament.uk/documents/post/postpn247.pdf

Yamamoto T, Nishiyama A, Takano T, Yabe S, Higuchi W, Razvina O, Shi D. Community-acquired methicillin-resistant Staphylococcus aureus: community transmission, pathogenesis, and drug resistance. J Infect Chemother. 2010 Aug;16(4):225-54.
http://www.ncbi.nlm.nih.gov/pubmed/20336341

National Institute for Health and Clinical Excellence. Infection Control. Prevention of healthcare-associated infections in primary and community care. 2003
http://www.nice.org.uk/nicemedia/live/10922/29119/29119.pdf

Management of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infections Federal Bureau of Prisons Clinical Practice Guidelines. 2011.
http://www.bop.gov/news/PDFs/mrsa.pdf

Health Protection Agency: Guidance for the Management of Norovirus Infection in Cruise Ships. 2010.
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1206520183347

Occupational Safety & Health Administration Factsheet. General Decontamination. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/general_decontamination_fact.pdf

Occupational Safety & Health Administration Factsheet. Food Cleanup. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/floodcleanup.pdf

Occupational Safety & Health Administration Factsheet. Fungi Hazards and Food Cleanup. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/Bulletin3.pdf

Andrej Trampuz, Rajesh M. Prabhu, Thomas F. Smith And Larry M. Baddour. Avian Influenza: A New Pandemic Threat? *Mayo Clin Proc*. 2004;79:523-530
http://www.mayoclinicproceedings.com/content/79/4/523.full.pdf

Infection Transmission:

Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. Journal of Hospital Infection (2004) 56, 10–15
http://www.ncbi.nlm.nih.gov/pubmed/14706265

Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011. http://www.ncbi.nlm.nih.gov/pubmed/21499954

Al-Hamad A, Maxwell S. How clean is clean? Proposed methods for hospital cleaning assessment. J Hosp Infect. 2008 Dec;70(4):328-34. http://www.ncbi.nlm.nih.gov/pubmed/18848370

Curtis V, Schmidt W, Luby S, Florez R, Touré O, Biran A. Hygiene: new hopes, new horizons. Lancet Infect Dis. 2011 Apr;11(4):312-21. http://www.ncbi.nlm.nih.gov/pubmed/21453872

Dancer SJ. J Hosp Infect. The role of environmental cleaning in the control of hospital-acquired infection. 2009. Dec;73(4):378-85. http://www.ncbi.nlm.nih.gov/pubmed/19726106

Scott E, Duty S, mccue K. A critical evaluation of methicillin-resistant Staphylococcus aureus and other bacteria of medical interest on commonly touched household surfaces in relation to household demographics. Am J Infect Control. 2009 Aug;37(6):447-53. http://www.ncbi.nlm.nih.gov/pubmed/19361887

Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008 Feb;8(2):101-13. http://www.ncbi.nlm.nih.gov/pubmed/17974481

Dancer SJ. Mopping up hospital infection. J Hosp Infect. 1999 Oct;43(2):85-100. http://www.ncbi.nlm.nih.gov/pubmed/10549308

Anne-Catrin Uhlemann, Justin Knox, Maureen Miller, Cory Hafer, Glenny Vasquez, Megan Ryan, Peter Vavagiakis, Qiuhu Shi, and Franklin D. Lowy. (10)The Environment as an Unrecognized Reservoir for Community-Associated Methicillin resistant*staphylococcus aureus* USA300: A Case-Control Study. Plos One. 2011; 6(7): e22407. http://www.ncbi.nlm.nih.gov/pmc/articles/pmc3144231/

Infection prevention & Control Cleaning Manual & Room Specifications. Independent Contractors. NHS South East Essex. 2010. http://www.see.nhs.uk/content/file/gp%20zone/ip&c/see%20cleaning%20manual.pdf

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC) 2003. http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_hcf_03.pdf

Health Protection Agency South West Community Infection Control Guidelines 2nd edition (2007) http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947417368

William A. Rutala, David J. Weber and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008. http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

Jane D. Siegel, Emily Rhinehart, Marguerite Jackson, Linda Chiarello and the Healthcare Infection Control Practices Advisory Committee. Multidrug-Resistant Organisms In Healthcare Settings, 2006.
http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroguideline2006.pdf

Yamamoto T, Nishiyama A, Takano T, Yabe S, Higuchi W, Razvina O, Shi D. Community-acquired methicillin-resistant Staphylococcus aureus: community transmission, pathogenesis, and drug resistance. J Infect Chemother. 2010 Aug;16(4):225-54.
http://www.ncbi.nlm.nih.gov/pubmed/20336341

National Institute for Health and Clinical Excellence. Infection Control. Prevention of healthcare-associated infections in primary and community care. 2003
http://www.nice.org.uk/nicemedia/live/10922/29119/29119.pdf

Management of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infections Federal Bureau of Prisons Clinical Practice Guidelines. 2011.
http://www.bop.gov/news/PDFs/mrsa.pdf

Centers for Disease Control and Prevention. Morbidity and Morality Weekly Report. Updated Norovirus Outbreak Management and Disease Prevention Guidelines. 2011.
http://www.cdc.gov/mmwr/pdf/rr/rr6003.pdf

Occupational Safety & Health Administration Factsheet. General Decontamination. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/general_decontamination_fact.pdf

Occupational Safety & Health Administration Factsheet. Food Cleanup. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/floodcleanup.pdf

Occupational Safety & Health Administration Factsheet. Fungi Hazards and Food Cleanup. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/Bulletin3.pdf

Andrej Trampuz, Rajesh M. Prabhu, Thomas F. Smith And Larry M. Baddour. Avian Influenza: A New Pandemic Threat? *Mayo Clin Proc*. 2004;79:523-530
http://www.mayoclinicproceedings.com/content/79/4/523.full.pdf

Infectious Agents:

MRSA, *Clostridium difficile*, Acinetobacter, VRE, Influenza, *E.coli*, Norovirus:

Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. Journal of Hospital Infection (2004) 56, 10–15
http://www.ncbi.nlm.nih.gov/pubmed/14706265

Dancer SJ. J Hosp Infect. The role of environmental cleaning in the control of hospital-acquired infection. 2009. Dec;73(4):378-85.
http://www.ncbi.nlm.nih.gov/pubmed/19726106

Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008 Feb;8(2):101-13.
http://www.ncbi.nlm.nih.gov/pubmed/17974481

Dancer SJ. Mopping up hospital infection. J Hosp Infect. 1999 Oct;43(2):85-100.
http://www.ncbi.nlm.nih.gov/pubmed/10549308

Jane D. Siegel, Emily Rhinehart, Marguerite Jackson, Linda Chiarello and the Healthcare Infection Control Practices Advisory Committee. Multidrug-Resistant Organisms In Healthcare Settings, 2006.
http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroguideline2006.pdf

MRSA, *Clostridium difficile*, Tuberculosis, VRE, Influenza, *E.coli*, SARS, Coxsackie virus, Coronavirus, Rotavirus:
Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infect Dis. 2006 Aug 16;6:130.
http://www.ncbi.nlm.nih.gov/pubmed/16914034

***Clostridium difficile*:**
Centers for Disease Control and Prevention (CDC): Information on *Clostridium difficile Infection.*
http://www.cdc.gov/hai/organisms/cdiff/cdiff_infect.html

Cryptosporidium:
Centers for Disease Control and Prevention (CDC): Recommendations for Aquatics Operators of Treated Venues. Hyperchlorination to kill *Cryptosporidium*
2011.
http://www.cdc.gov/healthywater/pdf/swimming/pools/hyperchlorination-to-kill-cryptosporidium.pdf

Health Protection Agency- Gastrointestinal infections – Cryptosporidium. 2010
http://www.hpa.org.uk/topics/infectiousdiseases/infectionsaz/travelhealth/epidemiologicaldata/gastrointestinalinfections/travcryptosporidium/

Hand, Foot and Mouth Disease:
Centers for Disease Control and Prevention (CDC): National Center for Immunization and Respiratory Diseases. Division of Viral Diseases. Hand, Foot, & Mouth Disease (HFMD).
http://www.cdc.gov/ncidod/dvrd/revb/enterovirus/hfhf.htm#8

MRSA:
Al-Hamad A, Maxwell S. How clean is clean? Proposed methods for hospital cleaning assessment. J Hosp Infect. 2008 Dec;70(4):328-34.
http://www.ncbi.nlm.nih.gov/pubmed/18848370

Scott E, Duty S, mccue K. A critical evaluation of methicillin-resistant Staphylococcus aureus and other bacteria of medical interest on commonly touched household surfaces in relation to household demographics. Am J Infect Control. 2009 Aug;37(6):447-53.
http://www.ncbi.nlm.nih.gov/pubmed/19361887

Anne-Catrin Uhlemann, Justin Knox, Maureen Miller, Cory Hafer, Glenny Vasquez, Megan Ryan, Peter Vavagiakis, Qiuhu Shi, and Franklin D. Lowy. (10)The Environment as an Unrecognized Reservoir for Community-Associated Methicillin resistant*staphylococcus aureus* USA300: A Case-Control Study. Plos One. 2011; 6(7): e22407.
http://www.ncbi.nlm.nih.gov/pmc/articles/pmc3144231/

Yamamoto T, Nishiyama A, Takano T, Yabe S, Higuchi W, Razvina O, Shi D. Community-acquired methicillin-resistant Staphylococcus aureus: community transmission, pathogenesis, and drug resistance. J Infect Chemother. 2010 Aug;16(4):225-54.
http://www.ncbi.nlm.nih.gov/pubmed/20336341

Management of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infections Federal Bureau of Prisons Clinical Practice Guidelines. 2011.

http://www.bop.gov/news/PDFs/mrsa.pdf

Norovirus:
Anderson KL. Norovirus outbreak management in a resident-directed care environment. Geriatr Nurs. 2009 Sep-Oct;30(5):318-28.
http://www.ncbi.nlm.nih.gov/pubmed/19818267

SJ Dancer. Norovirus: an established viral plague. J R Coll Physicians Edinb 2008; 38:314–6
http://www.rcpe.ac.uk/journal/issue/journal_38_4/dancer.pdf

Occupational Safety & Health Administration Factsheet. Noroviruses. 2008
http://www.osha.gov/Publications/norovirus-factsheet.pdf

Hepatitis A Virus:
J N Mbithi, V S Springthorpe, and S A Sattar. Chemical disinfection of hepatitis A virus on environmental surfaces. Appl Environ Microbiol. 1990 November; 56(11): 3601–3604.
http://www.ncbi.nlm.nih.gov/pmc/articles/pmc185032/

Helicobacter pylori:
Health Protection Agency- Helicobacter pylori. 2009.
http://www.hpa.org.uk/web/hpaweb&hpawebstandard/hpaweb_c/1195733787873

Rotavirus:
Centers for Disease Control and Prevention (CDC): Rotavirus.
http://www.cdc.gov/rotavirus/index.html

Tuberculosis:
Health Protection Agency- Tuberculosis (TB).
http://www.hpa.org.uk/topics/infectiousdiseases/infectionsaz/tuberculosis/

World Health Organization: Media Centre. Tuberculosis- Fact sheet N°104. November 2010.
http://www.who.int/mediacentre/factsheets/fs104/en/

National Institute for Health and Clinical Excellence. Clinical guideline 117. Tuberculosis: Clinical diagnosis and management of tuberculosis, and measures for its prevention and control. Developed by the National Collaborating Centre for Chronic Conditions and the Centre for Clinical Practice at NICE March 2011
http://www.nice.org.uk/nicemedia/live/13422/53642/53642.pdf

Aspergillosis and other fungi:
National Guidelines for the Prevention of Nosocomial Invasive Aspergillosis During Construction/Renovation Activities. National Disease Surveillance Centre 2002. ISBN 0-9540177-3-0.
http://www.hpsc.ie/hpsc/a-z/respiratory/aspergillosis/guidance/file,896,en.pdf

The Leeds Teaching Hospital NHS Trust. Infection Control Guidelines. Guideline No.1. Control and Prevention of Aspergillosis and other Invasive Fungal Infections during Building Work. 2002.
http://www.leedsth.nhs.uk/sites/infection_control/documents/aspergillusaugust07.pdf

Occupational Safety & Health Administration Factsheet. Fungi Hazards and Food Cleanup. 2005
http://www.osha.gov/OshDoc/data_Hurricane_Facts/Bulletin3.pdf

SARS:
World Health Organization: Global Alert and Response (GAR). First data on stability and resistance of SARS coronavirus compiled by members of WHO laboratory network.
http://www.who.int/csr/sars/survival_2003_05_04/en/index.html

Centers for Disease Control and Prevention. Severe Acute Respiratory Syndrome (SARS) Information.
http://www.cdc.gov/ncidod/sars/

Acinetobacter:
Health Protection Agency. Infectious Diseases. *Acinetobacter* species.
http://www.hpa.org.uk/topics/infectiousdiseases/infectionsaz/acinetobacter/

Centers for Disease Control and Prevention (CDC): Diseases and Organisms. *Acinetobacter.*
http://www.cdc.gov/hai/organisms/acinetobacter.html

What is Multi-resistant Acinetobacter (MRAB)? Patient Information Leaflet. Buckinghamshire Hospitals NHS Trust.
http://www.buckshealthcare.nhs.uk/downloads/patient-leaflets-infection-control/mrab%20pt%20info%20leaflet%20-%20mar%2010.pdf

Salmonella:
Centers for Disease Control and Prevention (CDC): *Salmonella*
http://www.cdc.gov/salmonella/general/index.html

Waterborne Diseases:
Centers for Disease Control and Prevention (CDC): Water-related Hygiene. Hygiene-related Diseases. 2009.
http://www.cdc.gov/healthywater/hygiene/disease/athletes_foot.html

Ringworm:
National Health Service. Choices. Health A-Z. Ringworm. 2010.
http://www.nhs.uk/conditions/ringworm/pages/introduction.aspx

Influenza:
Centers for Disease Control and Prevention (CDC): Seasonal Influenza: Flu Basics. 2011.
http://www.cdc.gov/flu/about/disease/

Community Strategy for Pandemic Influenza Mitigation. February 2007.
http://www.flu.gov/professional/community/commitigation.html

Andrej Trampuz, Rajesh M. Prabhu, Thomas F. Smith And Larry M. Baddour. *Mayo Clin Proc*. 2004;79:523-530. Avian Influenza: A New Pandemic Threat?
http://www.mayoclinicproceedings.com/content/79/4/523.full.pdf

All Prevalent Disease-Causing Microbes in Community Settings:
William A. Rutala, David J. Weber and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008.
http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC) 2003.

http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_hcf_03.pdf

Health Protection Agency South West Community Infection Control Guidelines 2nd edition (2007)
http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947417368

Detergents & Disinfectants:

Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21499954

Kim PJ, Cederberg RA, Puttaiah R. A pilot study of 2 methods for control of dental unit biofilms. Quintessence Int. 2000 Jan;31(1):41-8.
http://www.ncbi.nlm.nih.gov/pubmed/11203905

Norwood DE, Gilmour A. The growth and resistance to sodium hypochlorite of Listeria monocytogenes in a steady-state multispecies biofilm. J Appl Microbiol. 2000 Mar;88(3):512-20.
http://www.ncbi.nlm.nih.gov/pubmed/10747232

National Oceanic and Atmospheric Administration. Disinfectants and Antiseptics.

http://www.icm.tn.gov.in/drug%20formulary/DISINFECTANTS%20&%20ANTISEPTICS(13).htm

National Oceanic and Atmospheric Administration. Database of Hazardous Materials
http://cameochemicals.noaa.gov/

Australian Government. Department of Agriculture, Fisheries and Forestry. Australian aquatic veterinary emergency plan. Aquavetplan. Operational procedures manual decontamination version 1.0, 2008.
http://www.daff.gov.au/__data/assets/pdf_file/0008/617183/decontamination-manual.pdf

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC) 2003.
http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_hcf_03.pdf

William A. Rutala, David J. Weber and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008.
http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

J N Mbithi, V S Springthorpe, and S A Sattar. Chemical disinfection of hepatitis A virus on environmental surfaces. Appl Environ Microbiol. 1990 November; 56(11): 3601–3604.
http://www.ncbi.nlm.nih.gov/pmc/articles/pmc185032/

Patel SS, Pevalin DJ, Prosser R, Couchman A. Comparison of detergent-based cleaning, disinfectant-based cleaning, and detergent-based cleaning after enhanced domestic staff training within a source isolation facility. British Journal of Infection Control 2007 8: 20
http://bji.sagepub.com/content/8/3/20.short

Departments for Environment, Food and Rural Affairs. Sustainable Cleaning. A guide for users of professional cleaning products. 2008.
http://www.ukcpi.org/documents/Sustainable_Cleaning.pdf

Deza MA, Araujo M, Garrido MJ. Inactivation of Escherichia coli, Listeria monocytogenes, Pseudomonas aeruginosa and Staphylococcus aureus on stainless steel and glass surfaces by neutral electrolysed water. Lett Appl Microbiol. 2005;40(5):341-6.
http://www.ncbi.nlm.nih.gov/pubmed/15836736

Surface Disinfectants and label claims: Realistically can contact times be met to achieve antimicrobial efficacy? CJIC 2008;23:49
http://www.viroxtech.com/download.aspx?ItemInfoID=341

Health Protection Agency. Sodium hypochlorite- General Information. 2007. Version 1.
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947350070

Kim PJ, Cederberg RA, Puttaiah R. Baylor. A pilot study of methods for control of dental unit biofilms. Quintessence Int. 2000 Jan;31(1):41-8.
http://www.ncbi.nlm.nih.gov/pubmed/11203905

D.E. Norwood and A. Gilmour. The growth and resistance to sodium hypochlorite of Listeria monocytogenes in a steady-state multispecies biofilm. Journal of Applied Microbiology 2000, 88, 512–520
http://www.ncbi.nlm.nih.gov/pubmed/10747232

Chemical Cleaners: The EPA had compiled lists of registered antimicrobial products effective against certain blood borne/body fluid pathogens:

The EPA registered products:
List A: EPA's Registered Antimicrobial Products as Sterilizers (PDF)
List B: EPA Registered Tuberculocide Products Effective Against *Mycobacterium tuberculosis* (PDF)
List C: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 Virus (PDF)
List D: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 and Hepatitis B Virus (PDF)
List E: EPA's Registered Antimicrobial Products Effective Against *Mycobacterium tuberculosis* Human HIV-1 and Hepatitis B Virus (PDF)
List F: EPA's Registered Antimicrobial Products Effective Against Hepatitis C Virus (PDF)
List G: EPA's Registered Antimicrobial Products Effective Against *Norovirus* (PDF)
List H: EPA's Registered Antimicrobial Products Effective Against Methicillin Resistant *Staphylococcus aureus (MRSA)* and Vancomycin Resistant *Enterococcus faecalis* or *faecium* (VRE) (PDF)
List J: EPA's Registered Antimicrobial Products for Medical Waste Treatment (PDF)

Environmental Surfaces:

Scott E, Duty S, mccue K. A critical evaluation of methicillin-resistant Staphylococcus aureus and other bacteria of medical interest on commonly touched household surfaces in relation to household demographics. Am J Infect Control. 2009 Aug;37(6):447-53.
http://www.ncbi.nlm.nih.gov/pubmed/19361887

Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008 Feb;8(2):101-13.
http://www.ncbi.nlm.nih.gov/pubmed/17974481

Anne-Catrin Uhlemann, Justin Knox, Maureen Miller, Cory Hafer, Glenny Vasquez, Megan Ryan, Peter Vavagiakis, Qiuhu Shi, and Franklin D. Lowy. (10)The Environment as an Unrecognized Reservoir for Community-Associated Methicillin resistant*staphylococcus aureus* USA300: A Case-Control Study. Plos One. 2011; 6(7): e22407.
http://www.ncbi.nlm.nih.gov/pmc/articles/pmc3144231/

Infection prevention & Control Cleaning Manual & Room Specifications. Independent Contractors. NHS South East Essex. 2010.
http://www.see.nhs.uk/content/file/gp%20zone/ip&c/see%20cleaning%20manual.pdf

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC) 2003.
http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_hcf_03.pdf

Health Protection Agency South West Community Infection Control Guidelines 2nd edition (2007)
http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947417368

William A. Rutala, David J. Weber and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008.
http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf

Troko J, Myles P, Gibson J, Hashim A, Enstone J, Kingdon S, Packham C, Amin S, Hayward A, Nguyen Van-Tam J. Is public transport a risk factor for acute respiratory infection? BMC Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21235795

Centers for Disease Control and Prevention: Interim Guidance for Cruise Ships during the 2009-10 Influenza Season. 2010.
http://www.cdc.gov/h1n1flu/guidance/cruiseships.htm

Dr. Eugene Cole. Cleaning and Special Environments. 2011.
http://www.ciriscience.org/a_290-cleaning_and_special_environments

Frequent Hand-Touch Sites:

Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. Journal of Hospital Infection (2004) 56, 10–15
http://www.ncbi.nlm.nih.gov/pubmed/14706265

Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21499954

Dancer SJ. J Hosp Infect. The role of environmental cleaning in the control of hospital-acquired infection. 2009. Dec;73(4):378-85.
http://www.ncbi.nlm.nih.gov/pubmed/19726106

Jane D. Siegel, Emily Rhinehart, Marguerite Jackson, Linda Chiarello and the Healthcare Infection Control Practices Advisory Committee. Multidrug-Resistant Organisms In Healthcare Settings, 2006.
http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroguideline2006.pdf

Assessing Cleanliness:

Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. Journal of Hospital Infection (2004) 56, 10–15
http://www.ncbi.nlm.nih.gov/pubmed/14706265

Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21499954

Al-Hamad A, Maxwell S. How clean is clean? Proposed methods for hospital cleaning assessment. J Hosp Infect. 2008 Dec;70(4):328-34.
http://www.ncbi.nlm.nih.gov/pubmed/18848370

Dancer SJ. J Hosp Infect. The role of environmental cleaning in the control of hospital-acquired infection. 2009. Dec;73(4):378-85.
http://www.ncbi.nlm.nih.gov/pubmed/19726106

Scott E, Duty S, mccue K. A critical evaluation of methicillin-resistant Staphylococcus aureus and other bacteria of medical interest on commonly touched household surfaces in relation to household demographics. Am J Infect Control. 2009 Aug;37(6):447-53.
http://www.ncbi.nlm.nih.gov/pubmed/19361887

Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008 Feb;8(2):101-13.
http://www.ncbi.nlm.nih.gov/pubmed/17974481

Anderson RE, Young V, Stewart M, Robertson C, Dancer SJ. Cleanliness audit of clinical surfaces and equipment: who cleans what? J Hosp Infect. 2011 Jul;78(3):178-81.
http://www.ncbi.nlm.nih.gov/pubmed/21497943

Health and Safety Executive. COSHH Essentials. Exposure Measurement: Air Sampling. 2006.
http://www.hse.gov.uk/pubns/guidance/g409.pdf

Cleaning Locations:

Guidance on infection control in schools and other childcare settings. Health Protection Agency. 2010.
http://www.hpa.org.uk/web/hpawebfile/hpaweb_c/1194947358374

Dancer SJ. Norovirus: an established viral plague. J R Coll Physicians Edinb 2008; 38:314–6
http://www.rcpe.ac.uk/journal/issue/journal_38_4/dancer.pdf

Troko J, Myles P, Gibson J, Hashim A, Enstone J, Kingdon S, Packham C, Amin S, Hayward A, Nguyen Van-Tam J. Is public transport a risk factor for acute respiratory infection? BMC Infect Dis. 2011.
http://www.ncbi.nlm.nih.gov/pubmed/21235795

Centers for Disease Control and Prevention: Interim Guidance for Cruise Ships during the 2009-10 Influenza Season. 2010.
http://www.cdc.gov/h1n1flu/guidance/cruiseships.htm

Centers for Disease Control and Prevention : Interim Guidance for Management of Influenza-Like Illness aboard Commercial Aircraft during the 2009-10 Influenza Season.
2009.
http://www.cdc.gov/h1n1flu/guidance/air-crew-dom-intl.htm

Dr. Eugene Cole. Cleaning and Special Environments. 2011.
http://www.ciriscience.org/a_290-cleaning_and_special_environments

China.org.cn. Advice for Public Transport Operators
http://www.china.org.cn/english/features/sars/63444.htm

China.org.cn. Advice for the Users of Public Transport
http://www.china.org.cn/english/features/sars/63446.htm

Health Protection Agency: Guidance for the Management of Norovirus Infection in Cruise Ships. 2010.
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1206520183347

Management of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infections Federal Bureau of Prisons Clinical Practice Guidelines. 2011.
http://www.bop.gov/news/PDFs/mrsa.pdf