Safer Chemicals

Antimicrobials in hospital furnishings:

Do they help combat COVID-19?

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Health Care Without Harm

Executive summary

No current high-quality evidence indicates that adding antimicrobial agents to the surfaces of products adds significant value beyond the array of the Center for Disease Control and Prevention's recommended procedures for preventing SARS-CoV-2 transmission or health care-associated infections. Risks associated with the practice are poorly studied and may include adverse human and environmental health impacts.

In 2016, Health Care Without Harm released a report on antimicrobials in hospital furnishings and whether they help reduce health care-associated infections. The research found little evidence that adding antimicrobials to furnishings helped reduce health care-associated infections. It also found limited data on the safety of a number of the technologies, as well as concern that the widespread use of antimicrobials in furnishings may contribute to antimicrobial resistance. This is an addendum to the 2016 report in light of the COVID-19 pandemic.

Antimicrobial-impregnated soft and solid surfaces are being requested by health care and other facilities and offered by companies as an added tool to reduce the burden of COVID-19 on frequently touched surfaces hoping this will help reduce viral transmission and infections. Products based on the antimicrobial properties of metals – particularly copper and silver – and antimicrobial polymers are most common.

While transmission via droplets and aerosols is most common, the relative contribution of surfaces contaminated with COVID-19 is unknown and likely to vary from place to place. Laboratory studies show that the capacity of viruses to remain infective on surfaces depends on the surface material – on copper for up to four hours, and on plastic and stainless steel for up to three to four days. On all surfaces, infectivity begins to decline fairly rapidly before tapering off more slowly. These findings are likely to vary under real-world circumstances.

Regular and routine cleaning and disinfection remains a cornerstone of CDC-recommended infection prevention and control programs. EPA-approved disinfectants disable and destroy the virus in one to several minutes when used as directed.

Advances in nanotechnology and other material sciences have led to new antimicrobial technologies and may prove useful in controlling the spread of coronaviruses and other pathogens when used on frequently touched surfaces. However, the impact of adding antimicrobials (other than disinfectants) to product surfaces on the infectivity of this coronavirus under experimental or real-world conditions is poorly studied. No high-quality evidence shows that adding antimicrobial properties to hospital furnishings, furniture, or building products reduces the incidence of health care-associated infections or transmission of COVID-19. Requests to add antimicrobial properties to immediate-use disposable products based primarily on hope rather than empirical data may be understandable. However, decisions about durable goods with longer lifespans should be delayed until they can be based primarily on data. These and other technologies should be evaluated for benefits, durability, and risks with validated methods and appropriate study design.

Summary reccomendation: Avoid purchasing furniture, furnishings, or building products containing antimicrobial technologies that are added for purposes other than product preservation without evidence that they help reduce health care-associated infections as part of a comprehensive infection prevention and control program.

Introduction

In 2019, a newly described coronavirus, SARS-CoV-2, emerged in China, causing a sometimes-fatal disease now called COVID-19. The virus is highly contagious and generally spreads through close contact with someone already infected, primarily through respiratory droplets from a cough or sneeze that can travel up to six feet. Smaller aerosolized droplets from talking or singing that remain airborne much longer and travel farther also contribute to spread.

In hospitals, procedures such as suctioning and endotracheal intubation of COVID-19 patients generate contaminated aerosols that can infect hospital personnel. Inhalation draws the virus into the mouth, nose, and airways, where it enters cells and reproduces in large numbers.

Airborne droplets also settle onto surfaces where the virus can potentially remain infectious for hours or a few days, depending on the material, temperature, and humidity. People touching contaminated surfaces can transfer the virus to their mouth, nose, or eyes or to another person through close contact, including shaking hands. The extent to which contaminated surfaces enable spread of the virus is not known but probably varies with specific circumstances.

Although data are still limited for COVID-19, experience with other viral illnesses – including those caused by coronaviruses – suggests the risk of infection with SARS-CoV-2 and the severity of illness are both likely to be increased by a higher viral load in the initial exposure.

ATTEMPTS TO LIMIT INFECTIONS DURING THE PANDEMIC

In addition to widespread lockdown of all but essential businesses and services, the pandemic has led to major changes in health care practices and procedures, including temporary closure of many outpatient facilities, cancellation or delay of non-urgent surgeries, adjustments to staffing patterns, changes in building design and ventilation, increased cleaning and disinfection, and widespread use of personal protective equipment.

Some health care facilities are asking suppliers for furnishings and building products impregnated with antimicrobials – particularly on frequently touched surfaces – with the hope that this will reduce contamination with the coronavirus and other microbes and the incidence of health care-associated infections. Some product manufacturers have also started promoting items with antimicrobial properties during the pandemic. While these responses are understandable, their goals, effectiveness, and potential risks should be weighed before making product design and purchasing decisions, particularly those with long-term consequences.

Best practices for infection prevention and control

Health Care Without Harm's 2016 report on antimicrobials in hospital furnishings sees prevention, surveillance, and control of health care-associated infections as a systems problem needing system-level responses. (CDC guidelines for preventing transmission of infectious agents are summarized on pages 10-15 of the 2016 report.)

With the emergence of SARS-CoV-2 and COVID-19, the CDC has added more specific details and provides continuous updates to their infection prevention and control recommendations. They address:

- minimizing chances for exposure
- adherence to standard and transmission-based procedures, including hand hygiene and personal protective equipment
- patient placement
- precautions when performing aerosol-generating procedures
- managing visitor access
- engineering controls, such as physical barriers or partitions to guide patients through triage areas, curtains between patients in shared areas, air-handling systems (with appropriate directionality, filtration, and exchange rate) that are properly installed and maintained
- monitoring and training health care personnel
- environmental infection control
- reporting procedures

Environmental infection control emphasizes the critical importance of cleaning and disinfection. CDC's recommendations include:

- Dedicated medical equipment should be used when caring for patients with known or suspected COVID-19; it should be cleaned and disinfected according to manufacturer's instructions and facility policies.
- Environmental cleaning and disinfection procedures should be followed consistently and correctly.
    - » Routine cleaning and disinfection procedures (using cleaners and water to pre-clean frequently touched surfaces prior to applying an EPA-registered, hospital-grade disinfectant for appropriate contact times as indicated on the product's label) are appropriate for SARS-CoV-2 in health care settings, including those patient-care areas where aerosol-generating procedures are performed.
    - » Refer to List N on the EPA website for EPA-registered disinfectants that have qualified under EPA's emerging viral pathogens program for use against SARS-CoV-2.
- Management of laundry, food service utensils, and medical waste should be performed in accordance with routine procedures.

SARS-CoV-2 is a member of a family (Coronaviridae) of large, single-strand RNA viruses with a bilayer lipid (fatty) envelope studded with club-shaped spike proteins. The spike proteins attach to specific receptors on the surface of a host's cells, enabling the virus to enter and begin to reproduce.

Using soap and water to clean a surface before disinfecting not only removes oily film and organic matter but also significantly disrupts the lipid bilayer in the envelope of SARS-CoV-2, helping to render it non-infectious. This is one reason why soap-and-water hand washing and alcohol-based hand sanitizers are effective. Similarly, laundering textiles with detergent in warm water at the temperature appropriate for the fabric effectively destroys this virus.

The EPA's list of disinfectants includes products that destroy SARS-CoV-2 when used as directed, including leaving the disinfectant on the surface for the recommended period of time. Some are effective in as little as one minute. Appropriate concentrations of isopropyl alcohol, ethyl alcohol, hydrogen peroxide, citric acid, L-lactic acid, and thymol are among those least hazardous to humans, but whatever is used should be compatible with the material on which it is applied.

In summary, thorough and routine cleaning and disinfection with EPA-approved products effectively disable and destroy SARS-CoV-2. These are critical strategies for infection prevention and control, and ongoing, rigorous practice is essential, irrespective of the presence or absence of antimicrobial-impregnated surfaces.

Protocols for evaluating infectivity of COVID-19 on surfaces

According to the CDC, COVID-19 is spread primarily by close contact with someone who is already infected. Less commonly a person may become infected by touching a surface or object where the virus is present and then touching their mouth, nose, or eyes, but this transmission pathway is not well documented. Nonetheless, surfaces contaminated with the virus are a potential source of infection, particularly in settings where people with COVID-19 are present.

Unlike bacteria, which can survive and reproduce if they have access to appropriate nutrients and abiotic environmental conditions, viruses can only reproduce if they are able to gain access to the machinery and metabolism of suitable living host cells. Outside of living cells, viruses can only retain their infectivity for hours to days, depending on the virus and environmental conditions. A substance that inactivates a virus outside of a cell and renders it non-infective is a viricide.

*From Chin et al.; others (at 21 to 23°C and 40% relative humidity)

Material	Non-infectious in cell culture lab tests after
Plastic	3 - <7* days
Stainless steel	2 - <7* days
Glass	4* days
Wood or cloth	2* days
Copper	4 hrs.
Paper	3* hrs.
Cardboard	1 day
Paper money	up to 4* days
Aerosols	> 3 hrs.

Laboratory studies of SARS-CoV-2 show that it can potentially remain infectious on surfaces from hours to as long as 4-7 days, depending on the material and sampling strategy.

Determining how long a particular kind of virus remains infective outside of a living cell on surfaces or in the air currently requires a) culturing the virus in a cell culture, b) applying a known amount of a tissue-culture infectious viral dose to a surface or releasing it to air in an aerosol at a specified temperature and humidity, c) sampling from the surface or air at progressively longer times, and d) reintroducing the sample to a cell culture to see how much of the virus remains infectious. However, the U.S. EPA is developing a rapid viability reverse transcriptase polymerase chain reaction assay, which if successful will accelerate this process.

Studies of the persistence and infectivity of coronaviruses on surfaces – including SARS-CoV (the cause of the 2003 SARS outbreak), SARS-CoV-2, MERS-CoV (Middle East Respiratory Syndrome), HCoV-229E (an endemic human coronavirus that causes common colds), and veterinary coronaviruses TGEV (transmissible gastroenteritis virus), MHV (mouse hepatitis virus), and CCV (canine coronavirus) – show that human coronaviruses can remain infective on inanimate surfaces like metal, glass, or plastic for hours or up to nine days (SARS-CoV on plastic at room temperature), but can be efficiently inactivated by surface disinfection procedures with 62-71% ethanol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite within one minute. Other agents require longer dwell times (see List N).

Laboratory studies of SARS-CoV-2 show that it can potentially remain infectious on surfaces from hours to as long as four to seven days, depending on the material and sampling strategy. (Chin et al. did not sample plastic and stainless steel between days four and seven.) On all surfaces, infectivity begins to decline fairly rapidly before tapering off more slowly. These findings are also likely to vary under real-world circumstances.

The validity of these estimates and effectiveness of disinfectants and antimicrobial surfaces depends on study design. The most relevant evaluations should attempt to approximate real-world conditions in which pathogenic viruses actually occur on surfaces, although many do not. For example, disinfection studies often use liquid suspension methods for testing efficacy.

Viruses can be more resistant on surfaces when they become embedded in real-world thin films of organic matter. Many studies also do not say much about the durability and change in effectiveness of antimicrobial properties of a surface over time.

Appendix C in our 2016 report summarizes common test methods for the efficacy of antimicrobial properties in textiles and other materials, including their strengths, weaknesses, and simulation of real-world conditions.

Historically these tests have been used to evaluate antibacterial properties by killing or stopping the growth of certain bacteria. Some tests have been modified to evaluate viricidal properties of substances, although they have not been applied routinely for this purpose.

One example is the Japanese Industrial Standard test for determining antiviral activity of solid materials. Samples treated with viricidal substances and untreated control samples were inoculated with the test virus, which was held under a coverslip for a prescribed time and temperature.

Samples were then neutralized and assayed for viral infectivity in a cell culture appropriate for the test virus. The percent and log reduction in viral infectivity were calculated and compared to control. The tests also describe methods for evaluating antiviral activity of surfaces.

As of now, no antiviral claims for regulatory purposes can be made using these methods, but that will likely soon change as the U.S. EPA assesses technologies that may impart longer-lasting viricidal properties to soft and hard surfaces.

Finally, a real-world concern involves the safety of studying these viruses. Coronaviruses like SARS-CoV, SARS-CoV-2, and MERS are highly infectious and can cause serious illnesses. They must be handled by experienced technicians in biosafety labs. For that reason, less dangerous surrogate coronaviruses with similar structural properties (enveloped RNA viruses) like HCoV-229E, TGEV, or MHV are sometimes used in laboratory tests in order to approximate the impact of antimicrobial agents or materials on coronavirus infectivity more generally.

Does adding antimicrobials to products and materials add value? More research is needed.

Frequently touched surfaces are potential sources of pathogens that can be transferred from person to person, increasing the risk of health care-associated infections. Those of highest concern are bed rails, intravenous poles, overbed tables, chair arms, light switches, door knobs, toilet flush handles, computer mouses, keyboards, and touchscreens.

Routine cleaning and disinfection of environmental surfaces are essential for health care-associated infection prevention and control, and frequently touched surfaces need particular attention. New technologies like ultraviolet germicidal irradiation and vaporized hydrogen peroxide for terminal cleaning may further reduce risk. Adding antimicrobials to frequently touched surfaces has also been used to supplement routine infection prevention and control measures.

Antimicrobial coatings and surface technologies, along with potential risks and benefits, are summarized on pages 18-26 of Health Care Without Harm's report on antimicrobials in hospital furnishings. Newer products have been developed in the past few years. While some significantly reduce the total microbial burden on surfaces, there is virtually no evidence that any reduce health care-associated infections with the possible exception of copper alloys, though evidence is inconsistent and limited.

COVID-19 has stimulated new interest in this approach. Antimicrobial-impregnated soft and solid surfaces are increasingly being requested by health care facilities and offered by companies as an added tool to reduce the burden of SARS-CoV-2 on frequently touched surfaces. Products based on the antimicrobial properties of metals – particularly copper and silver – and antimicrobial polymers are most common.

SARS-CoV-2 is inactivated on a solid copper surface within four hours, more rapidly than on other materials. In another laboratory study, a different coronavirus, HCoV-229, was rendered non-infectious on a range of copper alloys (60-95% copper) in less than 60 minutes, with more rapid inactivation at the higher copper concentrations. This compares to inactivation by some disinfectants on List N within one minute.

A number of products feature various forms of silver as an antibacterial and antiviral agent. Silver zeolites, with controlled release of silver ions over time, have shown antiviral activity against coronaviruses in some product applications. Silver nanoparticles show antiviral activity against a range of enveloped and non-enveloped viruses during laboratory tests utilizing

Rina Begum, 35, works as a ward cleaner at the Narayanganj-based Sajida Foundation hospital's isolation unit for coronavirus-infected patients. (UN Women)

solutions in test tubes, and interest in applying nanotechnology to combat SARS-CoV-2 transmission is rapidly growing. Copper, silver, and perhaps zinc nanoparticles in composites are also being developed, as some have previously shown antiviral properties.

Antimicrobial polymers, some containing quaternary ammonium compounds, are also being promoted for antiviral activity. The antimicrobial functional group can either be incorporated into a polymer chain or attached by a covalent bond so it does not leach. If quaternary ammonium compounds are added to textiles without a physical bond, they will leach and require replenishment, particularly after laundering.

As these technologies are further developed, they will need to be evaluated not only for their initial antiviral activity but also durability and how well they stand up to repeated cleaning and disinfection.

Maintenance of stringent and effective cleaning regimens will always be necessary since deposits of organic debris could effectively insulate the virus or other microbes from an antimicrobial surface. If cleaning and disinfecting regimens become less frequent or rigorous because of a false sense of security that an antimicrobial surface may create, the effectiveness of the antimicrobial properties can be greatly diminished.

Nanomaterials also need to be evaluated for potential exposures and human and ecosystem toxicity, as their physicochemical properties can allow unique interactions with cells and tissues that have unexpected toxic consequences. Their safety is understudied and poorly understood.

We will surely learn more in the months to come. The U.S. EPA's Science Advisory Board is putting together a research agenda to provide more guidance, including exploring long-term disinfectants. As yet, however, there is no evidence that adding antimicrobial agents to the surfaces of products adds value to the array of recommended procedures for preventing SARS-CoV-2 transmission or health care-associated infections.

Conclusion

The emergence of SARS-CoV-2 and the COVID-19 pandemic has reignited interest in the value of adding antimicrobials active against coronaviruses to frequently touched surfaces in hospitals and other settings.

The extent to which contaminated surfaces are involved in transmission of this virus is unknown. Direct or close contact with someone infected with the virus is the primary pathway, with airborne aerosols also contributing.

The impact of adding antimicrobials other than disinfectants to product surfaces on the infectivity of this coronavirus under experimental or real-world conditions is poorly studied and now receiving more attention.

In laboratory studies, pure copper surfaces inactivate SARS-CoV-2 within four hours, while it can persist and remain infectious on plastic and stainless steel for up to a few days. However, cleaning and disinfection with any of EPA's List N products, when used properly, can destroy SARS-CoV-2 and render it non-infectious within one to several minutes.

Advances in nanotechnology and material sciences have led to a proliferation of new methods for deploying copper, silver, and zinc as well as antimicrobial polymers that may prove useful in controlling the spread of coronaviruses and other pathogens when used on frequently touched surfaces. However, these and other technologies should be evaluated for benefits, durability, and risks with validated methods and appropriate study design.

As yet, no high-quality evidence shows that adding antimicrobial properties to hospital furnishings, furniture, or building products reduces the incidence of health care-associated infections or transmission of SARS-CoV-2.

Considerations for making purchasing and manufacturing decisions

During these early months of a pandemic that is likely to continue for a prolonged period of time, product purchasing decisions in hospitals and elsewhere may be influenced by values and perceptions other than empirical data.

An employer wanting to make employees feel safer might be inclined to use antimicrobials in products to demonstrate concern even if they are of unproven value, but if this has the unintended effect of reducing strict attention to cleaning and disinfection, it could actually increase risk.

Considerations prior to making a purchasing decision

- What are the reasons for considering this product? To reduce transmission of the virus? To provide reassurance to staff or patients? Would this add measurably to what you are already doing?
- What are potential risks associated with this product?
  - Potential human toxicity from exposure to nanoparticles or other antimicrobial technologies should be considered. Apart from their small size, the consequences of exposure to metal nanoparticles also depend on chemical composition, structure, shape, and solubility. They can be absorbed via inhalation, ingestion, and through the skin.
  - Impacts of antimicrobials released from products into the general environment may also be a concern, depending on the agent, amount, fate, and transport through environmental media. For example, silver is an aquatic toxicant and can foster antibiotic resistance by facilitating horizontal transfer of antibiotic resistance genes.
  - Effective antimicrobial surface technologies require direct contact of the virus or other microbe with the surface. This requires maintenance of stringent and effective cleaning regimens for all surfaces, since deposits of organic debris could effectively insulate the virus from the surface. If cleaning and disinfecting regimens become less frequent or rigorous because of a false sense of security that an antimicrobial surface may create, the effectiveness of the antimicrobial properties can be greatly diminished. Ongoing rigorous cleaning and disinfection programs are essential.

Products with antimicrobial properties should be studied not only for their initial impacts on coronaviruses but also for the durability of those impacts over time under conditions of use. This will often include regular cleaning and disinfecting. Antiviral properties may be lost from surfaces, resulting in diminished activity over days to weeks.

Decisions about requesting antimicrobial properties in disposable products and materials that are needed immediately might understandably be based primarily on hope of efficacy rather than empirical data. But decisions about durable goods with much longer lifespans should be delayed until they can be based primarily on data.

Recomendations

Whereas benefits, risks, tradeoffs, and cost implications of adding antimicrobials to furnishings are active areas of research, the following recommendations are based on a current evaluation of the science, with the expectation that more objective data will aid in making informed design and purchasing decisions.

Based on the lack of evidence that adding antimicrobial agents to surfaces of products adds significant value to recommended procedures for reducing infectious viral loads or health care-associated infections, including strict attention to cleaning and disinfection, Health Care Without Harm recommends the following:

For health care

Avoid purchasing furniture, furnishings, or building products containing antimicrobial technologies that are added for purposes other than product preservation without evidence that they further reduce health care-associated infections as part of a comprehensive infection prevention and control program.

Because of the pandemic, health care purchasers, architects, and designers must make decisions with imperfect information about a highly transmissible viral disease. When choosing to purchase furniture, furnishings, or building products with added antimicrobial properties because they may further reduce the viral load, look for evidence of efficacy before making a decision.

Evidence to look for:

- Studies of efficacy in destroying coronavirus infectivity; what methods were used, and are they validated?
- What were the experimental conditions? How do they compare to real-world conditions of use?
- How long do the viricidal properties in this product last under conditions of use?
- What are the implications for proven cleaning and disinfection protocols?
- Are there potential adverse human and environmental health impacts of adding antimicrobial properties to this product throughout its lifespan?

Our 2016 recommendations are reproduced here and remain unchanged with the exception of recognizing that some manufacturers will want to respond to customer requests for antimicrobial technologies not yet proven to reduce SARS-CoV-2 infections:

- Ask suppliers to disclose any antimicrobials added to materials and products, even if they are used for the purpose of material preservation, odor control, or some other aesthetic reason.
- Take the lead or collaborate in the design and execution of a research agenda intended to address data gaps related to efficacy and risks associated with adding antimicrobials to furnishings.
- Examine antibiotic stewardship programs in your institution for opportunities to reduce the risk of generating antimicrobial resistance.
- Examine antibiotic stewardship programs in your community for opportunities to reduce the risk of generating antimicrobial resistance, including in animal agriculture. Help make the case that antibiotic stewardship to address the growing problem of antimicrobial resistance is a community-wide responsibility.

For furnishings and building products manufacturers

- Do not make antimicrobials the standard option for any product, with the exception of antimicrobials that are used solely for product protection. Antimicrobials should be a “must select” option in order to make the decision clear and track the demand for products containing antimicrobials.
- Use only antimicrobials that have undergone EPA evaluation and registration under FIFRA and been shown to reduce the risk of health care-associated infections in a clinical setting, unless using them in a research program to examine their efficacy. If antiviral properties are added to high-touch surfaces on request because of COVID-19, use technologies that are proven in reducing the infectivity of coronaviruses under conditions of use.
- Take the lead or collaborate in the design or execution of a research agenda intended to fill data gaps related to efficacy and risks associated with adding antimicrobials to furnishings.
- Require full toxicity testing, studies of potential leaching, and evaluations of potential human or environmental exposure to any antimicrobials used in products.
- Align sales and marketing claims with EPA FIFRA labeling requirements.
- Investigate and make publicly available information about all antimicrobials in products, including antimicrobials that are exempt from full FIFRA evaluation and registration because of the treated articles exemption.

For manufacturers of antimicrobial technologies

- Conduct full toxicity testing, including environmental toxicity, fate, and transport, as well as life-cycle assessment of any antimicrobials, including antimicrobials used for purposes of preserving the product. Make results publicly available.
- Collaborate to develop clinically relevant testing methods to determine efficacy in the clinical setting.
- Align sales and marketing claims with EPA FIFRA labeling requirements.
- Commit to transparency in toxicity and efficacy testing for all antimicrobials.

For the research community

- Prioritize research to determine efficacy, risks throughout the life cycle, trade-offs, and cost implications of the use of antimicrobials in furnishings in clinical settings.
- Research hazard profiles and potential human and environmental exposures to antimicrobials used for purposes of preserving the product.
- Research whether the addition of antimicrobials in products changes the microbial ecology (microbiome) of a building or spaces within a building and whether those changes have clinical or public health significance.

Glossary

Antimicrobial – a general term describing substances that kill or slow the growth of at least some kinds of microbes

Bacteria – single cell organisms without an organized, membrane-bound nucleus that can thrive and reproduce in a variety of environmental conditions

Microbe – collective name for microscopic organisms including bacteria, viruses, fungi, and some parasites

Virus – a submicroscopic infectious agent with either RNA or DNA genetic material that replicates only inside the living cells of an organism

Health Care Without Harm seeks to transform the health sector worldwide, without compromising patient safety or care, so that it becomes ecologically sustainable and a leading advocate for environmental health and justice.

This report was produced by Health Care Without Harm's Safer Chemicals program, which helps to drive the design of materials so they are safer for people and the planet,and supports public and institutional policies that advance health.

Disclaimer: The COVID-19 pandemic is rapidly evolving, and new research may lead to revised conclusions and recommendations.

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