Surface Contamination

How *long* do viruses and bacteria remain infectious?

By Dr. Gavin Macgregor-Skinner

One of the most common questions people are asking me these days is: How long do infectious viruses and bacteria live on surfaces? Like everything in life, the viability of a virus or bacteria is a function of molecular structure.

But viruses are not really "alive" because they cannot reproduce by themselves. So instead of asking how long a virus or a bacterium can live on a surface, we should be asking how long they *remain infectious*.

According to the Environmental Protection Agency (EPA), Americans spend 93% of their life indoors—87% of their life within a building, then another 6% within their vehicles. That's only 7% of your entire life spent outdoors—or only one half of one day per week in the fresh air.

The best reference for this statistic appears to be *The National Human Activity Pattern Survey* (NHAPS) published in 2001. From the data in this study and others available to us, we can conclude that we are basically an indoor species.

People often think that the reason we get colds and flu more often in the winter is that it's cold out. This is actually false. We get colds and flu more often in the winter because we are generally indoors, where the humidity is lower, and we are exposed to higher concentrations of airborne pollutants, including cold and flu viruses.

The potential for transmission of bacteria or viruses by indirect contact (i.e. via fomites) is linked to their ability to survive on commonly touched surfaces. However, although there have been studies, big gaps remain in knowledge, evidence, and data on this subject.

So, what's a fomite? A fomite is any inanimate object that may be contaminated with infectious agents and serve in their transmission and spread of disease. These inanimate objects carry germs that cause infection. And yet, many people have never heard of this word, nor do they know themselves about

the very objects—the cutting boards, kitchen sponges, toothbrushes, cups, etc—the ordinary devices of modern life that, when exposed to bacteria and viruses, increase the risk of serious infection for many individuals.

Bacteria and viruses can remain infectious for a surprisingly long time on almost anywhere you may touch—countertops, door handles, light switches, toys, computers, even inside refrigerators and freezers.

Contaminating a fomite surface

A surface or object can be initially contaminated by the depositing of bacteria or virus particles from the air, such as through coughing, sneezing, talking, breathing, vomiting, diarrhea incidents, toilet flushing, and hand touching.

Many studies exist on pathogen transfer between hands and surfaces. A study in 2000 showed that a hand contaminated with certain viruses can contaminate up to seven other surfaces.

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Mechanism of fomite spread

Although the initial contamination process appears straightforward, there is limited information about how surface contamination is transmitted by human touch. When we touch an object, we transfer bacteria or viruses to a surface or accumulate more bacteria or viruses on our hands. A contaminated surface can be touched by a number of people, and each of these individuals subsequently touch other surfaces as they move around. Each of these now contaminated surfaces can be touched again by other people, and so the touching sequence progresses.

The major physical processes involved in the fomite route include contamination of the initial surface, bacteria or virus survival on and transfer between the hand and surface during each subsequent touch, hand to mucous membrane transfer (eyes, nose, mouth), and finally exposure to a sufficient amount of a pathogen to establish an infection. This is called the "infectious dose."

If a person were to be exposed to exactly one copy of a SARS-CoV-2 virus that causes COVID-19 or a single Bartonella species bacterium that causes emerging infectious diseases that include cat scratch disease, Carrion's disease, and trench fever, it is unlikely they would become infected.

If the pathogen is in low levels in the area where you are exposed, you are less likely to be infected. But if the pathogen is available in large quantities, you are more likely to be infected.

We know that contaminated surfaces and objects can transmit disease agents, and that discarding contaminated objects, surface cleaning and disinfection, and handwashing with soap or hand sanitizer, can decrease the risk of infection.

Viruses on fomite surfaces

Viruses are probably the most common cause of infectious disease acquired indoors. The rapid spread of viral disease in crowded indoor establishments, including schools, day care facilities, nursing homes, business offices, and hospitals, consistently facilitates disease morbidity and mortality. Yet, fundamental knowledge concerning the role of surfaces and objects in viral disease transmission is lacking, and further investigation is needed.

The study of fomites has traditionally only involved determining whether the presence of specific potentially pathogenic organisms—primarily those of viruses or bacteria—resided on environmental surfaces.

Stephanie A. Boone and Charles P. Gerba, in their study *Significance of Fomites in the Spread of Respiratory and Enteric Viral Disease* (2007), sampled over 300 fomite surfaces from day care centers and homes to determine the presence of influenza A virus on each surface. During flu seasons, approximately half of all common building surfaces from both types of indoor environments had measurable levels of influenza virus, suggesting that contaminated fomite surfaces could play a role in influenza transmission.

Other similar studies targeting influenza and other viruses have shown more results, such as:

- Norovirus and influenza A virus were found on frequently used fomites (e.g., desktops, faucet handles, and paper towel dispensers) in elementary school classrooms.
- Widespread norovirus contamination was found on fomite surfaces in houseboats, aircraft, and cruise ships on which an outbreak of norovirus gastroenteritis occurred.
- Picornavirus (including rhinovirus and/or enterovirus) was detected on approximately 20% of toys in pediatric office waiting rooms.
- Human rhinovirus was detected on 5% of clothing samples from teachers working in child care centers.
- Rotavirus was detected on about 20% of fomite samples

in day care centers, including on telephone receivers, drinking fountains, water-play tables, and toilet handles.

• Severe acute respiratory syndrome (SARS) coronavirus RNA was found on 30% of surface swab samples in hospitals, including in patient rooms, on computer mice at nurse stations, and on the handrails in the public elevators.

• Human parainfluenza virus (HPIV-1) was detected on 37% of a total of 328 fomites from 12 different office buildings, most frequently isolated on desktops.

• Middle East respiratory syndrome coronavirus (MERS-CoV) was detected on high-touch surfaces in patient rooms with laboratory-confirmed MERS-CoV patients.

These studies and many others confirm that viruses that are known to cause communicable diseases in humans are commonly found on surfaces, but it then must be determined whether they are viable and potentially infectious to humans.

Virus viability and infectiousness outside the body

In general, infectious viruses prefer a human or animal body first, followed by hard non-porous surfaces at room temperature. The smallpox virus, for example, can remain viable for months—even years—on a tabletop. That is why it caused a devastating epidemic before the smallpox vaccine was developed.

Some viruses are viable and infectious for shorter periods outside the body, although "shorter" is often still long enough to infect other people. Hepatitis B and C virus can remain viable between 16 hours and one week. Cold viruses up to one week and flu viruses about 24 hours. Human immunodeficiency virus (HIV) is an example of a virus that dies almost instantly outside the body.

A study entitled *Survival of influenza viruses on environmental surfaces* in the *Journal of Infectious Diseases* of July 1, 1982, tracked the viability of influenza viruses on various surfaces, finding that they remained infectious up to 48 hours on hard, non-porous surfaces, such as stainless steel and plastic and up to 12 hours on porous surfaces, such as cloth, paper, and tissues. Moreover, fomite transmission of influenza viruses was considered possible because influenza virus could be transferred from stainless steel surfaces to hands for up to 24 hours after contamination, and from tissues to hands for up to 15 minutes after contamination.

The viruses then subsequently survived on hands for an additional five minutes after transfer from the tested fomite surfaces.

Others have found that influenza virus can remain viable and/or potentially infectious much longer on fomite surfaces, using a variety of approaches. Thomas et al. in their study of *Survival of Influenza Virus on Banknotes* found on the Applied and Environmental Microbiology (AEM) website (2008) tested the survival of influenza A viruses on banknotes after intentional contamination, finding viruses could survive up to three days after inoculation at high concentrations. Additionally, when the virus was encapsulated in respiratory mucus, which may more realistically reflect human contributes to fomite surfaces, viability was as high as 17 days. And when nasopharyngeal secretions from naturally infected children were used to inoculate banknote surfaces, influenza virus survived at least two days in one-third of the test cases.

Similarly, in a study of *The survival of influenza A(H1N1) pdm09 virus on 4 household surfaces* in the *American Journal of Infection Control* (2014), Oxford et al. found that influenza A virus remained infectious for up to 48 hours on a wooden surface, for 24 hours on stainless steel and plastic surfaces, and for eight hours on a cloth surface.

Also, Thompson et al. in their study *Persistence of influenza on surfaces* in the *Journal of Hospital Infection* (2017) tested the viability of five influenza strains seeded on three surfaces (cotton, microfiber, and stainless steel) over time, finding that viable virus was detected for up to two weeks on stainless steel and up to one week on cotton and microfiber samples. Times to achieve 99% reductions in viability were 18 hours for cotton, 34 hours for microfiber, and 175 hours for stainless steel.

Specific to materials used in personal protective equipment (PPE), Sakaguchi et al. in a study of *Maintenance of influenza virus infectivity on the surfaces of personal protective equipment and clothing used in health care settings* in *Environmental Health and Preventative Medicine* (2010) found that the infectivity of influenza A virus was maintained for 8 hours on the surface of an N95 particulate respirator, a non-woven fabric surgical mask, a Tyvek gown, a coated wooden desk, and stainless steel, and for 24 hours on a rubber glove, suggesting that frequent replacement of PPE and clothing worn by health care professionals is warranted to minimize cross-infection.

Caliciviruses that can infect humans and animals are very stable in the environment and difficult to inactivate. Norovirus is a common cause of diarrhea and vomiting in people and can remain viable for days or weeks outside the body, depending on the surface and environment. Rabbit hemorrhagic disease virus is a highly infectious and fatal disease that affects wild and domestic rabbits and is a very hardy virus, remaining viable in the environment outside of the body for 105 days at 68 F on fabric, 225 days at 39 F just above freezing temperatures, and one hour at a temperature of 122 F. Products commonly used for household disinfection do not work against caliciviruses. Studies have shown that many quaternary ammonium compound-based disinfectants do not inactivate caliciviruses. A list of disinfectants that are effective against caliciviruses can be found on the EPA website.

Bacteria on fomite surfaces

Bacteria have been found on fomite surfaces, including potentially pathogenic and antibiotic-resistant bacteria, which are often not mutually exclusive.

Salmonella and Campylobacter, which can cause severe diarrhea and vomiting, can survive about one to four hours on hard surfaces and fabrics. On a dry surface, most Salmonella strains will remain infectious for up to four hours. Keeping kitchen surfaces clean is especially important to reduce the spread of foodborne pathogens, and soft surfaces like kitchen sponges and towels are particularly bacteria-friendly and should be cleaned, disinfected, or even disposed of frequently.

Staphylococcus aureus, the bacterium that causes methicillin-resistant Staphylococcus aureus (MRSA) infections, can live for many weeks on surfaces because it thrives without moisture. These are of particular concern at hospitals and food service establishments. Public transit can also play an important role, as handrails of public buses, as well as the hands of bus riders, in two cities in Portugal tested positive for MRSA.

> Bacteria and viruses are diverse and have a variety of surface survival rates.

You can get bacteria on your skin relatively easily by touching somebody with it, by sharing towels, bed sheets or clothes with somebody with it, or by touching surfaces with it. However, getting MRSA on your skin alone isn't enough to make you ill. Often, it will leave your skin without you ever knowing you had it. This can be as quick as a few hours or could take a couple of weeks. But to make you ill, it needs to get deeper into your skin for example, via a wound or sore.

Two strains of Streptococcus that cause ear and throat infections, skin infections, pneumonia and sepsis, Streptococcus pneumoniae and Streptococcus pyogenes have been found to survive more than 24 hours on soft and hard toys like stuffed animals and books. The researchers of the study *Biofilm Formation Enhances Fomite Survival of Streptococcus pneumoniae and Streptococcus pyogenes* from Infection and Immunity (February 2014) also found that month-old biofilms of S. pneumoniae and S. pyogenes from contaminated surfaces readily colonize mice. When this study by the University of Buffalo was published in 2014 the results were much longer than previously thought, and significant because many public places—including day care centers and schools—based their cleaning procedures on the idea that those bacteria couldn't survive overnight. Anders Hakanson, senior author, concluded that "commonly handled objects contaminated with these biofilm bacteria could act as reservoirs of bacteria for hours, weeks, or months, being vehicles of spread upon contact."

SARS-Cov-2 virus and COVID-19 disease

A study published in February 2020 in the *Journal of Hospital Infection* entitled *Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents*, concluded that human coronaviruses can remain infectious on surfaces, outside the body, at room temperature for up to nine days and also mentions that animal coronaviruses can remain viable for up to 28 days. Kampf et al. stated contamination of frequent touch surfaces is a potential source of viral transmission.

Another study in March 2020 by the U.S. National Institute of Allergy and Infectious Diseases found that how long the virus can survive depends on the surface and that the human coronavirus can survive for up to three days on stainless steel and plastic, four hours on copper, and up to 24 hours on cardboard. However, the amount of viable virus decreased much more quickly than that, and we all need to be exposed to a certain "dose" before any of us become infected. But sometimes only small amounts of a virus are needed to infect someone, and we lack data to quantify this amount.

The CDC study published in March 2020 found that on the Diamond Princess and Grand Princess cruise ships that SARS-CoV-2 RNA was identified on a variety of surfaces in cabins of both symptomatic and asymptomatic infected passengers up to 17 days after cabins were vacated and before disinfection procedures had been conducted. The CDC team stated that this "data cannot be used to determine whether transmission occurred from contaminated surfaces, and further study of fomite transmission of SARS-CoV-2 is warranted."

We need more research

The aforementioned studies confirm that not only do viruses and bacteria deposit and exist on surfaces indoors of virtually any facility, but they can also remain viable for hours, or even days, dependent upon the fomite material, microorganism type, and indoor environmental characteristics. But we need more research to determine:

- From what surfaces does contact transmit bacteria and

viruses to humans and to what extent does it occur and, if so, what the implications are of fomites for human health.

• The frequency of hands becoming contaminated with viruses or bacteria, or the "infectious dose" load on hands after touching contaminated surfaces.

• How temperature and humidity affect survival time on surfaces, which has been studied for some viruses and bacteria, but many knowledge gaps still exist.

• How much virus or bacteria on a surface influences the viability time and for how long it remains infectious.

Part of the uncertainty is because bacteria and viruses are diverse and have a variety of surface survival rates. There isn't a hard-and-fast rule for how long they survive outside the body in the environment. The type of surface, temperature, and humidity are all influencers. The commonly repeated advice to "wash hands frequently" may be replaced in the future by more strategic advice such as "clean surfaces right now," or advice based on who should wash their hands, and when. We all need to identify which surfaces we touch and decide how often do we need to clean and disinfect them.

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