

s an epidemiologist or "disease detective," a question I am frequently asked regarding SARS-CoV-2 (the virus that causes COVID-19 disease) is: "How does someone become infected?"

Everything we know about how this coronavirus behaves is based on data that has been collected in just a few months or has been hypothesized from the behavior of its relatives (SARS-CoV-1 from 2003 and MERS-CoV from 2012). How it spreads has generated significant debate. One reason for this is simply a lack of evidence.

SARS-CoV-2 virus transmission depends on the movement of people and spreads through close contact with a person who is infected with the virus. When an infected person coughs, talks, or breathes, they can release respiratory droplets that contain the virus. Other research has indicated that the virus may spread through indirect routes, such as by hands touching contaminated surfaces and then touching our eyes, nose, and mouth.

But understanding the mechanism of transmission is critical to ensure that the appropriate public health measures and workplace policies are implemented.

As Jonathan Kay stated in his article COVID-19 Superspreader Events in 28 Countries: Critical Patterns and Lessons:

• If large respiratory droplets are found to be a dominant mode of transmission, then the expanded use of masks and social distancing is critical.

- If small aerosol droplets are found to be a dominant mode of transmission, then we would need to prioritize the use of outdoor spaces, where aerosols are more quickly swept away, and improve the ventilation of indoor spaces.
- If contaminated surfaces are found to be the dominant mode of transmission, then we would need to continue, and even expand, our current practice of washing hands as well as cleaning and disinfection protocols for high-touch surfaces to reduce the viral load.

What we do know is that before SARS-CoV-2 can spread

to another person, it needs to be released into the environment from someone who is infected. Then, in order for someone else to get infected, they need to be exposed to an infectious dose of the virus.

How many SARS-CoV-2 virus particles are needed for an infectious dose is unknown. So how does an infected person spread a virus?

# Remember the formula: Successful Infection = Exposure to Virus x Time.

• **Droplet nuclei or aerosols:** Droplets that are < 5 µm in diameter are called droplet nuclei or aerosols. These particles can remain airborne for longer periods of time and travel further before evaporating. Transmission occurs when a person inhales aerosol that is suspended in the air.

### How much virus is released into the environment?

- Bathrooms: Bathrooms have many high-touch surfaces, such as door handles, faucets, and stall doors. And we know that toilet flushing without a lid can aerosolize many droplets.
  - Cough: A single cough by an infected person releases about 3,000 droplets and each droplet may contain as many as 200,000,000 (two hundred million) virus particles.
  - Breathing: A single breath releases 50-5,000 droplets. We don't have exact numbers for SARS-CoV-2 yet, but studies have shown that a person infected with influenza

can release up to 33 infectious viral particles per minute.

• **Speaking:** Speaking increases the release of respiratory droplets about 10-fold or approximately 200 virus particles per minute.

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This still needs to be determined experimentally, but if the infection could occur through 1,000 infectious viral particles you receive in one breath, or from one eye rub, or 100 viral particles inhaled with each breath over 10 breaths, or 10 viral particles with 100 breaths, then spending up to 10 minutes with someone in a face-to-face situation could potentially lead to being infected.

## **Step 1: Release**

SARS-CoV-2 is a respiratory virus. When air passes over a layer of fluid in a person's respiratory tract, small particles called droplets are naturally created. Virus particles cohabitating in the respiratory tract hitch a ride on those droplets and are released into the environment when an infected person talks, coughs, sneezes, or simply exhales.

It's important to recognize this process is not unique to SARS-CoV-2 but is common to other respiratory viruses, such as the influenza virus, respiratory syncytial virus (RSV), respiratory adenoviruses, and other coronaviruses like SARS-CoV and MERS-CoV.

## Step 2: Spread

How the expelled droplets impact disease transmission depends on the number of droplets produced, the size of the droplets, and the number of virus particles.

• Respiratory droplets: Droplets that are > 5 µm (micrometer or micron) in diameter are called respiratory droplets, and they can fall from the air before evaporating onto surfaces. Transmission from respiratory droplets occurs when a person touches a contaminated surface or gets caught directly in the spray zone of an infected patient.

#### What have we learned?

An article published in the March 4, 2020, Journal of the American Medical Association, found extensive environmental contamination from a SARS-CoV-2 patient with mild upper respiratory tract involvement.

Toilet bowl and sink samples were positive, suggesting that viral shedding in the stool could be a potential route of transmission. After cleaning the rooms with sodium dichloroisocyanurate, all surfaces tested negative for the virus and this supports the need for strict adherence to

appropriate cleaning and disinfection protocols.

An article published in the March 2020, Journal of Hospital Infection, reviewed the literature on all available information about the persistence of human and veterinary coronaviruses on inanimate surfaces as well as inactivation strategies with

biocidal agents used for chemical disinfection.

The analysis of 22 studies revealed that human coronaviruses, such as severe acute respiratory syndrome (SARS) coronavirus, Middle East Respiratory Syndrome (MERS) coronavirus, or endemic human coronaviruses (HCoV) can persist on inanimate surfaces like metal, glass, or plastic for up to 9 days, but can be efficiently inactivated by surface disinfection

Appropriate infection control guidelines and cleaning and disinfection protocols are necessary.

procedures with 62-71% ethanol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite within 1 minute. Other biocidal agents such as 0.05–0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate are less effective.

In an April 16, 2020, New England Journal of Medicine article, the authors reported in an experimental setting, SARS-CoV-2 virus remained viable in aerosols for the duration of their 3-hour experiment, and when applied to plastic or stainless steel, the virus was detected up to 72 hours later.

These results indicated that transmission of SARS-Cov-2 from contaminated surfaces is plausible.

An article published in the March 15, 2016, Clinical Infectious Diseases journal, found that most of the touchable surfaces by patients or health care workers in MERS-CoV patients' rooms were contaminated. MERS-CoV viral RNA was detected up to five days from environmental surfaces following the last positive reverse transcription-polymerase chain reaction (RT-PCR) test from patients' respiratory specimens.

The coronavirus was detected in samples from anterooms, medical devices, air-ventilating equipment, bed sheets, bed rails, IV fluid hangars, and X-ray devices.

Similar findings were made during the 2003 severe acute respiratory syndrome (SARS) outbreak in Canada, in which PCR-positive swab samples were recovered from frequently touched surfaces in patient rooms, on patient care equipment, and ventilation-system components. This was published in the Journal of Infectious Diseases in 2005.

What remains unclear is the viral load required for infection.

Even though viral particles were identified on surfaces

such as cardboard, copper, plastic, and stainless steel, it is still unknown if the virus can then go on to infect the respiratory tract.

## The value of surface disinfection

Although more studies are needed, research has clearly demonstrated that actions by both patients and staff can potentially induce virus contamination of surfaces of various environments and equipment. The envi-

ronment around coronavirus patients has been shown to be contaminated.

Therefore, appropriate infection control guidelines and cleaning and disinfection protocols are necessary.

## Appropriate and safe use of PPE

Based on a risk assessment, personal protective equipment (PPE) may include gloves, protective clothing, eye protection, and nose and mouth protection.

In addition, areas where PPE is doffed or taken off may become contaminated, and there is a need for more careful and comprehensive procedures for putting on and removing PPE in order to improve infection control. An analysis of this should be considered with any subsequent necessary adjustments implemented in your organization's procedures and protocols.

Using mirrors and/or the "buddy system" (using an observer) can assist staff in checking their PPE status before entering a room that may be contaminated and during removal of PPE to avoid contamination.

A study published in May 2010 in the Infection Control & Hospital Epidemiology journal used a surrogate virus for SARS-CoV-1 and found detectable levels of the infectious virus on all PPE they evaluated, including isolation gowns, latex and nitrile gloves, N95 respirators, and hospital scrubs, for at least 4 hours.

If PPE becomes contaminated with infectious viruses there is a risk that the user's hands can become contaminated when doffing or removing PPE. Staff need to concentrate on hand hygiene as they doff PPE.

Frequent and thorough environmental cleaning and disinfection of high-touch points is critical to reduce the spread of highly contagious viruses.

Staff need to be trained and retrained on cleaning and disinfection protocols and appropriate PPE worn to protect workers from contaminated surfaces and disinfectant chemicals as per the Safety Data Sheets provided by the product manufacturer.

However, more research is necessary to further understand surface contamination with SARS-CoV-2 and to identify best methods for cleaning and disinfection.

## Safe and effective cleaning and disinfection

- 1. Develop a plan: This applies all the time, whether it's a pandemic or not. Develop and maintain a set of written standard operating procedures for cleaning and criteria for when to disinfect.
- 2. Start by asking: "What needs to be cleaned and disinfected?" Any sort of soap or detergent inactivates coronavirus by dissolving the lipid (fatty) membrane that envelops the virus. Frequently touched surfaces include workstations, countertops, light switches, railings, doorknobs, and equipment (such as steering wheels and machinery). Use cleaning agents and disinfectants and ensure you follow directions on the label for use, dwell or wet contact time, method of application, and safety directions. Use a clean surface of the cloth to prevent cross-contamination. Wipes, approved by the EPA, could be used on electronics.
- 3. Select a disinfectant: If you determine disinfection is necessary, use products registered by the U.S. Environmental Protection Agency's (EPA) List N: Disinfectants for Use Against SARS-CoV-2 (COVID-19). https://www.epa.gov/ pesticide-registration/list-n-disinfectants-use-against-sarscov-2-covid-19.
- 4. Provide information and training: Remember, employers must ensure workers are trained on the hazards of the cleaning chemicals used in the workplace in accordance with OSHA's Hazard Communication Standard (29 CFR 1910.1200). People need to know the right way to use the products and symptoms of possible harm. PPE, including gloves, need to be appropriate for the product. If you are unsure about how to safely use a product, then call the manufacturer (their phone number is listed on the product label) or visit their website.
- 5. Evaluate the plan: Get feedback from people using the products and equipment and from those in the spaces where they are used.

As we can see, we must examine the science behind coronavirus in order to identify the risks and how it is spread.

If we do this, we can fine-tune cleaning protocols to better protect all from the threat of infection.



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