SARS Wars: the Fomites Strike Back

Emanuel Goldman

Microbiology, Biochemistry & Molecular Genetics, New Jersey Medical School, Rutgers University, Newark, New Jersey, USA

ABSTRACT Controversy continues about the significance of fomite transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Recent papers continue to advocate concern. However, designs of studies showing virus survival on surfaces under laboratory conditions are unsuitable for extrapolation to real life. Although viral RNA is frequently found on real-life surfaces, actual tests for infectious virus are almost entirely negative, even in hospitals with COVID-19 patients. Fomite transmission should be regarded as no more than a very minor component of this pandemic.

KEYWORDS SARS-CoV-2, COVID-19, absence of fomite transmission, respiratory viruses

From the beginning of the COVID-19 pandemic, there has been disagreement between those who believed that the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was primarily airborne and those who argued fomite transmission was significant. Although laboratory studies showed the survival of infectious virus for days following inoculation of various surfaces, there were no publications demonstrating fomite transmission. Evaluating the data through May 2020, I argued that the possibility of fomite transmission of COVID-19 was exaggerated (1). Since then, many in the field appear to agree; guidelines (updated 28 October 2020) from the CDC state “Spread from touching surfaces is not thought to be a common way that COVID-19 spreads” (2), a more recent update (5 April 2021) goes even further (3), and a recent editorial in Nature reiterates this point (4).

Nevertheless, salvos in this skirmish continue to be fired; examples include a report of up to 28 days of survival of infectious SARS-CoV-2 on some surfaces (5), a comprehensive review article that “uncovers the high potential for SARS-CoV-2 transmission through contaminated surfaces” (6), and isolation of infectious SARS-CoV-2 from imported frozen cod packaging (7). Modeling the Diamond Princess cruise ship outbreak suggests that 30% of the cases were from fomites (8). A hamster model supports fomite transmission, albeit less than aerosols (9).

The first problem with laboratory studies showing long-term survival of virus on surfaces is that inoculums used were orders of magnitude too large compared with what would be encountered on surfaces in a nonhospital, real-life setting (1). Defending the amounts of virus used, fomite advocates argue that these levels are comparable to those found in secretions from actual patients in hospitals, but those levels were mostly determined by assays for viral RNA and not for infectious virus. One study also assayed for infectious virus but could not determine a relationship between viral RNA levels and infectious virus, actually noting “the virus could not be isolated after day 8 in spite of ongoing high viral loads of approximately 10^5 RNA copies/ml of sample” (10). Thus, the presence of viral RNA is not a valid surrogate for the presence of infectious virus. In contrast, experiments that assay infectious virus from hospital surfaces have generally found none (11, 12), with one exception (13). Testing for viral RNA on high-touch public surfaces led to a conclusion that “fomites play a minimal role in SARS-CoV-2 community transmission” (14). Furthermore, a comprehensive review of published studies assessing SARS-CoV-2 RNA and/or infectious virus on surfaces in hospitals has generally found none (15, 16), with one exception (17).
surfaces also leads to the conclusion that surfaces are not relevant sources for transmission (34). Another meta-analysis concludes that the "Lack of positive viral cultures and variation in cycle thresholds create uncertainty about fomites as a mode of transmission" (15).

Of possibly even greater consequence, a study of SARS-CoV-1 on surfaces (16) found that virus survival on paper, cotton gowns, and disposable gowns was 2 to 3 orders of magnitude greater for a $10^6$ inoculum compared with $10^4$. At a $10^4$ inoculum, the virus half-life was less than 1 minute on paper and cotton since infectious virus was gone by 5 minutes. If the same half-life had been the case with the $10^6$ inoculum, infectious virus would have been gone in 20 minutes or less, but a 24-hour survival time was found for the higher inoculum, demonstrating that the virus half-life is greatly extended with larger amounts of input virus. In my laboratory, we have reached a similar conclusion with enveloped bacterial virus Phi6 (35), a nonpathogenic surrogate for SARS-CoV-2. Thus, it is even more imperative to design experiments with realistic levels of input virus if the results are to be clinically relevant.

Laboratory conditions favored virus survival on fomites, such as optimal temperature and humidity (17), whereas these are variables in the real world. In one study (5), samples were kept in the dark to avoid UV light, which rapidly kills SARS-CoV-2 (18). Samples were placed in medium containing bovine serum albumin (BSA) (5) which protects SARS-CoV-2 from environmental decay (19), with the authors noting "Our data showed that SARS-CoV-2 infectivity was remarkably preserved in the presence of proteins, regardless of the type of surface." Defending this choice, fomite advocates argue they were trying to mimic an environment similar to human secretions; however, respiratory mucous is actually a hostile environment for virus survival (20). Measurements of SARS-CoV-2 survival in mucous show a half-life of approximately 3 hours at room temperature in 40% humidity (21).

The isolation of live virus from imported frozen cod packaging (7) is the most persuasive argument for possible fomite transmission, via so-called "cold chain" transmission (22). However, all the other tests the Chinese have done further downstream after receipt of imported packages have been negative for live virus (23). The report is more a proof of principle; yes, live virus could be on surfaces, but it is still very rare. Note that no evidence of COVID-19 transmission has been found from food or food surfaces (23).

If fomites were a significant source of transmission in the real world, mask use in Asian countries would not have controlled the spread of the virus as well as it has (24). Many more persons would have been infected in a mixed-use building in South Korea where a call center had a COVID-19 outbreak, and hardly anyone else of the ~1,000 occupants in the building caught the virus (25).

An experimental paradigm for respiratory viruses proved that rhinoviruses (major cause of the common cold) are almost entirely transmitted by aerosols but not fomites. Two groups of volunteers played poker, including one group sick with rhinovirus and the other group healthy but restrained to not touch their faces. Cards and chips from the poker game were transferred to other healthy volunteers who were instructed to touch their faces frequently while playing. The aerosol-exposed group got sick, while the fomite-exposed group did not (26). There is no reason to expect that SARS-CoV-2 would behave differently. If anything, enveloped coronaviruses are even more fragile in the environment than nonenveloped rhinoviruses.

The putative route of infection from fomites alleges the following sequence of events: first, a surface is freshly contaminated by a cough or sneeze from a carrier; second, subjects touch that contaminated surface within an hour or two; and third, without washing their hands, subjects touch their eyes, nose, or mouth within another hour or two. In addition to disproving this route to a first approximation for rhinovirus (26), there is little if any direct experimental evidence for most other respiratory viruses (27), with the exception of respiratory syncytial virus (28). Furthermore, this alleged method of self-inoculation depends upon the successful transfer of virus by fingers from the surface to the subject’s face, which has also been challenged (29).
That said, SARS-CoV-2 does present clinical manifestations that might support fomite transmission, especially gastrointestinal involvement in many cases (30). Viral RNA has been detected in stool specimens from a number of patients, raising the possibility of a fecal-oral route of transmission. However, documented detection of infectious virus in stool specimens has been rare, and most attempts to find infectious virus in stool have been unsuccessful (31).

A more plausible alternative route of infection from fomites has been proposed from an animal model of influenza virus, via “aerosolized fomites” (32), in which live virus on surfaces are taken up into the air and breathed in by recipients. However, ultimately, the delivery of the virus occurs through breathing and depends on virus survival on the surface prior to being aerosolized.

Although the possibility of fomite transmission remains hypothetical, it should be considered no more than a very minor component of this pandemic. It is a terrible waste and sometimes even dangerous (33) to continue expensive and time-consuming surface disinfection, and this is obstructing efforts to control the pandemic. Normal routine hygiene is all that is needed.

ACKNOWLEDGMENTS

Funding sources for this work include grants from the New Jersey Alliance for Clinical and Translational Science (NJ ACTS) and the Rutgers Research Council.

I declare no competing interests.

REFERENCES


