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Review article

Contamination of inert surfaces by SARS-CoV-2: Persistence, stability and infectivity. A review

Montse Marquès *, José L. Domingo

Laboratory of Toxicology and Environmental Health, School of Medicine, Universitat Rovira I Virgili, Sant Llorenç 21, 43201, Reus, Catalonia, Spain

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ABSTRACT

Undoubtedly, there is a tremendous concern regarding the new viral strain "Severe Acute Respiratory Syndrome Coronavirus-2" (SARS-CoV-2) and its related disease known as COVID-19. The World Health Organization has stated that SARS-CoV-2 is mainly transmitted from person-to-person close contact, as well as by small aerosol respiratory droplets. Moreover, the results of some recent studies about the role of air pollution on the spread and lethality of the novel coronavirus suggest that air contaminants could be also a transmission pathway of the virus. On the other hand, indirect transmission of the virus cannot be discarded. Among many sources of indirect transmission, there is the contamination of inert/inanimate surfaces. This manuscript was aimed at reviewing the scientific literature currently available in PubMed and Scopus. The results of the reviewed studies point out that SARS-CoV-2 can last on different surfaces from hours to a few days. However, rapid SARS-CoV-2 inactivation is possible by applying commonly available chemicals and biocides on inanimate surfaces. Consequently, although the presence of SARS-CoV-2 on inanimate surfaces can represent a potential route of transmission, appropriate disinfection measures should reduce the possibilities of coronavirus transmission, and hence, significantly decrease the risks of COVID-19.

1. Introduction

Nowadays, the potential transmission routes of the SARS-CoV-2 and the resulting infections are still not clear. However, the problem is not about the quantity of investigations that have been carried out. In November 21, 2020, the number of studies on COVID-19 available in PubMed (https://pubmed.ncbi.nlm.nih.gov/) raised to 76,103, with a continuous daily increase. The vast majority of documents have been published in 2020, with only a few papers belonging to 2019, while an increasing number are already dated in 2021. This scientific production is tremendously high when compared with other respiratory viruses, such as influenza. To date, there are 137,047 articles available at PubMed, which in turn have been published from the 19th century. Without any doubt, in the past no other disease has received so much attention in such a short space of time.

According to the World Health Organization (WHO, 2020a), SARS-CoV-2 is mainly transmitted through person-to-person close contact (<1.5–2.0 m), as well as by aerosol respiratory droplets smaller than 5 μm of diameter. Obviously, taking into account that SARS-CoV-2 is a respiratory virus, airways are key for the infection person-to-person (Rothan and Byrareddy, 2020). Moreover, several studies on the airborne transmission of this coronavirus have been also recently conducted (Buonanno et al., 2020; Morawska and Cao, 2020; Morawska et al., 2020; Yao et al., 2020a, 2020b). In particular, the transport of droplet aerosols generated by infected individuals is an issue of considerable concern and importance, which should be taken into account to reduce the risk of infections (Kohanski et al., 2020; Lee, 2020; Miller et al., 2020: Nissen et al., 2020; Zhou and Ji, 2021). On the other hand, recent studies on the role of air pollution on the spread and lethality of the coronavirus have also attracted a notable attention (Bontempi, 2020; Coccia, 2020; Copat et al., 2020; Domingo et al., 2020; Domingo and Rovira, 2020). It is hypothesized that certain air pollutants – mainly particulate matter ($PM_{2.5}$ and other small PMs) – can carry SARS-CoV-2 attached, which could be involved in the spread of COVID-19. In this sense, Setti et al. (2020a) raised the question whether 2 m of interpersonal distance would be enough to avoid the person-to-person transmission of the coronavirus. In recent months, a number of studies on this topic have been conducted (Adhikari and Yin, 2020; Comunian et al., 2020; Marquès et al., 2020; Setti et al., 2020b,c, d; Yao et al., 2020a, 2020b; Zoran et al., 2020).

* Corresponding author.
E-mail address: montserrat.marques@urv.cat (M. Marquès).

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resolve the pending issues. Meanwhile, handling of cash and coins should be done with precautions. Cashless and contactless transactions using online banking would be recommended, if possible.

5. Miscellaneous on COVID-19 and surfaces: mitigation of the coronavirus

The studies reviewed above suggest that, in general terms, SARS-CoV-2 – like other human coronaviruses – can remain infectious on dry inanimate/inert surfaces for periods between hours and a few days, at room temperature. To avoid the potential transmission of SARS-CoV-2 from surfaces, the WHO (WHO, 2020b) recommends cleaning surfaces with water, detergents and disinfectants usually effective to clean the environment. In relation to this, Akram (2020) has reported that disinfection of frequent touch surfaces with 62–71% ethanol, 0.1% sodium hypochlorite, and 0.5% hydrogen peroxide is effective against SARS-CoV-2, but ineffective with 1-min exposure time. Other biocidal agents such as 0.05–0.2% benzalkonium chloride, or 0.02% chlorhexidine digluconate, are less effective (Kampf et al., 2020a). Dev Kumar et al. (2020) have reviewed the effects of a number of biocides and antimicrobial agents for the mitigation of the coronavirus. It was noticed that ethanol at concentrations >70%, povidone iodine, hypochlorite, and quaternary ammonium compounds combined with alcohol, are effective against SARS-CoV-2 for surface disinfection. In turn, hydrogen peroxide vapor, chlorine dioxide, ozone, and UV light could be applied to reduce viral load present in aerosols. In this sense, Fathizadeh et al. (2020) also suggested the same disinfection practices against SARS-CoV-2 on inanimate surfaces.

Special attention should be paid at medical and dental settings where disinfecting surfaces is one of the aspects of great importance. In clinical areas, the surfaces must be cleaned and the air exchanged at the end of each session. The same procedures should be adopted in the waiting room and in other areas where the patient might pass or touch objects (Fiorillo et al., 2020). With respect to preventive hospital measures, Chia et al. (2020) have indicated that the concentrations of SARS-CoV-2 in the air and high-touch surfaces in rooms of infected patients could be highest during the first week of COVID-19 illness. In turn, D'accolti et al. (2020) investigated the coronavirus contamination on surfaces of the acute COVID-19 ward of an Italian hospital. Ward surfaces, including 4 points inside and 6 points outside the patients' rooms, were sampled by swabs, 7 h after routine sanitation. SARS-CoV-2 contamination was only detected in 3 samples, suggesting that the occurrence of the coronavirus on hospital surfaces might be limited. Contrary, this virus persists for a longer duration on surfaces under controlled laboratory conditions. Anyway, effective transmission of SARS-CoV-2 by surfaces/fomites within the hospital ward might be rather a rare event. Recently, Kanamori et al. (2020) have reviewed survival and contamination of SARSCoV-2 in the healthcare environment, as well as healthcare-associated transmission and infections of SARS-CoV-2 through environmental surfaces and shared medical devices. It has been concluded that direct exposure to respiratory droplets is a main transmission route of SARS-CoV-2. However, it is essential to improve thoroughness of cleaning/disinfection practice in healthcare facilities in order to reduce the risk of healthcare-associated transmission of this coronavirus via the healthcare environment as a fomite.

In Korean hospitals, Lee et al. (2020) investigated the presence of SARS-CoV-2 on the surface of environmental materials contaminated by COVID-19 patients. In order to assess the spread of COVID-19, as well as the infection risk, the study was mainly focused on surfaces frequently touched by subjects testing positive for COVID-19, within the facilities where the outbreak occurred. The results of that investigation showed that a prompt disinfection and cleaning of potentially contaminated surfaces would be an effective infection control measure to reduce the infectivity of the coronavirus, blocking also the potential transmission in the congregate healthcare setting. With similar objectives, Razzini et al. (2020) evaluated the contamination of the air and surfaces by SARS-CoV-2 in the COVID-19 ward of an Italian hospital. The correlation between the coronavirus concentration and the distance from patients was also assessed. The results also showed that both air and surfaces within areas assigned to patients were contaminated by SARS-CoV-2. It suggests that strict structural and personal protection measures, as well as systematic disinfections should be implemented in order to reduce the infection risk for healthcare professionals in these areas.

On the other hand, Jamal et al. (2020) discussed the recommended equipment and settings for dental clinics that can attend confirmed COVID-19 patients. However, the use of household cleaning and disinfection for COVID-19 prevention has also raised some concerns. Thus, Gharpure et al. (2020) reported that the calls to poison centers regarding human exposure to cleaners and disinfectants increased since the onset of the COVID-19 pandemic. It includes applying household cleaning and disinfectant products to skin, and inhaling or ingesting cleaners and disinfectants.

Ratnesar-Shumate et al. (2020) found evidence that simulated sunlight might rapidly inactivate SARS-CoV-2 on surfaces, suggesting that surface persistence, and subsequently exposure risk, could significantly vary between indoor and outdoor environments. This is accordance with the results of Schuit et al. (2020). However, Ratnesar-Shumate et al. (2020) also remarked that in order to appropriately assess the risk of exposure in outdoor environments, information on the viral load present on surfaces, the transfer efficiency of virus from those surfaces upon contact, as well as the amount of virus needed to cause infection, are still needed. As above commented, increasing temperature and relative humidity also accelerates inactivation of SARS-CoV-2 on surfaces (Biryukov et al., 2020).

Very recently, Wilson et al. (2020) published the results of a quantitative microbial risk assessment to estimate and compare COVID-19 infection risks, after single hand-to-fomite-to-mucosal membrane contacts for high and low levels of viral bioburden, and variable disinfection efficacy. It was found that under low viral bioburden conditions, minimal log10 reductions might be needed to achieve risks less than 1:1,000,000. In turn, for higher viral bioburden conditions, log10 reductions of more than two might be needed to achieve median risks of less than 1:1,000,000 (especially assuming that 10% of gc/cm^2 represents infective virus). Data are still needed for: i) SARS-CoV-2 bioburden on different environment-specific (home or healthcare) fomites; and ii) fomite-specific touch frequencies. This information should allow improving the surface hygiene measures. Finally, regarding a frequent hand washing for the prevention of COVID-19, it has been reported that this routine implies a prolonged exposure to water and other chemical or physical agents, which can induce a number of adverse dermatologic effects. However, the hand washing should never be diminished by the eczematous changes that may occur in the hands (Beieu et al., 2020), which are perfectly manageable (Chang et al., 2020; Rundle et al., 2020).

6. Conclusions

Several investigations have shown that human coronaviruses such as endemic HCoV, MERS and SARS-CoV-1 may persist on inert/inanimate surfaces from some hours to a few days (Kampf et al., 2020a). Therefore, it might be expected that SARS-CoV-2 could show a similar behavior than SARS-CoV-1, the most closely related human coronavirus. In the early months of the current pandemic, the surface stability of the new coronavirus was already assessed. Thus, van Dorelamen et al. (2020) reported that fomite transmission of SARS-CoV-2 was plausible, with the virus being able to remain infectious on surfaces up to days, a time that would depend on the inoculum shed. In recent months, various studies on the stability and infectivity of SARS-CoV-2 on inert surfaces have been conducted (Biryukov et al., 2020; Carraturo et al., 2020; Chin et al., 2020; Colaneri et al., 2020; Morris et al., 2020). All of them agree with the fact that SARS-CoV-2 can last on different surfaces for times ranging