Infection capability of SARS-CoV-2 on different surfaces
Ranjan K. Mohapatra*, Pradeep Kumar Das#, Lucia Pintiliec and Kuldeep Dhama bc d

Department of Chemistry, Government College of Engineering, Keonjhar, Odisha, India; #Department of Chemistry, N. C. (Autonomous) College, Jaipur, Odisha, India; cDepartment of Synthesis of Bioactive Substances and Pharmaceutical Technologies, National Institute for Chemical & Pharmaceutical Research and Development, Bucharest, Romania; dDivision of Pathology, ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh, India

ABSTRACT
The novel Coronavirus Disease 2019 (COVID-19) has emerged as a global pandemic and has posed serious health hazards for the humanity since December 2019. Over 2.5 million deaths have been reported worldwide till date mainly due to rapid human-to-human transmission of this virus while affecting millions of people. The widespread propagation of this disease has radically changed the common practice of human’s normal life. Numerous measures have been taken up by different health agencies and government bodies of several countries to combat the menace by attenuating the transmission of SARS-CoV-2. The emergence of a new UK variant B.1.1.7 of the virus in some countries has indeed aggravated the issue of tackling the disease. The virus mainly transmits through coughs, sneezes, talks, or breathes. The airborne transmission is also an alternate dominant route. This opinion focuses on the infection capability of SARS-CoV-2 on different surfaces and also other possible means of transmission.

Dear editor
There is no denying of the fact that the novel SARS-CoV-2 transmits through multiple routes and vehicles. According to CDC report, however, the potential carriers of virus are primarily coughs, sneezes, sings, talks, or breathes through which the infection propagates, via contaminated droplets and aerosols. The airborne transmission of SARS-CoV-2 is possible within a distance of 6 feet. The risk of virus propagation runs high in indoor environments without good ventilation. Furthermore, the possibility of rapid transmission of virus (Figure 1) cannot be ruled out owing to its long survival (hours to days) on different surfaces [1,2]. As per a report, the viral RNA of SARS-CoV-2 was detected in passengers of Diamond Princess Ship [3], 17 days after they disembarked the ship, though it is not clear whether the virus was potential enough to cause infection. Hence, we cannot underemphasize the risk of CoV transmission from multiple surfaces [4]. Suman et al. 2020 have discussed the sustainability of CoV on various surfaces, which are summarized in Table 1 [5]. Moriyama et al. 2020 have reported that the virus may survive nearly 3 days on plastic or stainless steel surfaces while 1 day on cardboard and 4 hours on copper surface [6]. The minimum survival time on copper surface has been ascribed to the destruction of the genetic material of the virus by Cu(II) as suggested by

CONTACT Ranjan K. Mohapatra ranjank_mohapatra@yahoo.com Department of Chemistry, Government College of Engineering, Keonjhar, Odisha, India
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**Figure 1.** Mode of SARS-CoV-2 entry in human body and affected organs.

**Table 1.** Infection capability of SARS-CoV-2 on different surfaces, (TCID$_{50}$) (TCID = Tissue Culture Infective Dose).

| Sl. No. | Materials                  | Persistence  | Complete decay | Reference       |
|--------|----------------------------|--------------|----------------|-----------------|
| 1      | Paper, Tissue paper        | 30 min       | 3 hours        | [9,10]          |
| 2      | Aerosol                    | 3 hours      | -              | [5,10,14]       |
| 3      | Copper                     | 4 hours      | 8 hours        | [5,6,10,14]     |
| 4      | Cardboard                  | 1 day        | 2 days         | [5,6,10,14]     |
| 5      | Cloth                      | 1 day        | 2 days         | [9,10]          |
| 6      | Wood                       | 1 day        | 2 days         | [9,10]          |
| 7      | Banknote paper             | 2 days       | 4 days         | [9,10]          |
| 8      | Glass                      | 2 days       | 4 days         | [9,10]          |
| 9      | Stainless steel            | 3 days, 4 days | 4 days, 7 days | [5,6,9,10,14]   |
| 10     | Plastic                    | 3 days, 4 days | 4 days, 7 days | [5,6,9,10,14]   |
| 11     | Surgical mask              | 4 days       | 7 days         | [9,10]          |
| 12     | Solid feces                | 72 h         | -              | [11]            |
| 13     | Urine                      | 3–4 days     | -              | [11]            |
| 14     | Smooth surfaces            | 7 days       | -              | [11]            |
W. Keevil [7]. But, according to E. Goldman 2020, ‘fomites that have not been in contact with an infected carrier for many hours do not pose a measurable risk of transmission’, though their activity on any undiagnosed asymptomatic carrier has yet to be ascertained [8].

The sustainability of the SARS-CoV-2 has also been investigated by Liu et al. 2020 on different surfaces. As per the study, the virus remains active on smooth surfaces (ceramics, clothes, wood, glass, latex gloves, and surgical mask) at room temperature up to 7 days [11]. The survival time of the virus in urine and fecal samples was also reported. As per the report, there is a longer survival time of the virus in the samples collected from children as compared to those in adults. A study also claimed longest survival (6 days) of SARS-CoV by placing large virus sample \(10^7\) infectious virus particles on a surface [12]. Duan et al. 2003 have also claimed survival of the SARS-CoV for four days using a similarly large sample \(10^6\) infectious virus particles on a surface [13]. The longevity of both SARS-CoV and SARS-CoV-2 for up to 3 days in aerosols and 2 days on other surfaces has been reported by van Doremalen et al. 2020 [14]. A study also established long survival of human Coronavirus (229E) on surfaces (5 days) with a large viral load [15]. The survival time of the virus on different surfaces largely hinges on factors such as volume of virus inoculation and titer of virus stock. However, these concentrations are a lot higher than those in droplets in real-life situations [16]. If this is the case and SARS-CoV-2 rarely infects through contaminated surfaces, then why we are still doing deep cleaning [17]. Moreover, Choi and coworkers have discussed a clear understanding of the transmission due to surface contamination of SARS-CoV-2 in healthcare settings [18].

A Hong Kong-based study reveals no detection of virus from cotton clothes after four days and non recovery of virus after two days for other cloth surfaces [19]. Books and currency notes have different survival time of virus on their surfaces. While virus stays active for different time periods for inner pages of the book and outer glossy cover surface, the survival time on currency notes has been reported to be nearly seven days [11]. However, a detailed study is warranted to understand the viability with proper concentrations in real-life situations. Apart from coughs, sneezes, breathes etc., another carrier of SARS-CoV-2 whose role cannot be downplayed is fecal matters. Wu et al. 2020 have confirmed the presence of SARS-CoV-2 RNA in fecal samples for more than 11 days after the respiratory tract samples became negative, which clearly indicates the possibility of fecal–oral transmission [20]. The presence of SARS-CoV-2 in human excretions suggests the possibility of non-droplet transmission while SARS-CoV-2 RNA has also been detected in sewage and wastewater, and such spreading routes if could play role then may pose a high global public health concern, though detailed investigations are still needed [21,22].

Advances in nanotechnology have paved ways to design antiviral nanostructured and nanomaterials coated surfaces to reduce SARS-CoV-2 viability of upto and more than 90% in a short time of 10 minutes to 2 h. These include ACE2 coated nanoparticles, coating with magnetic nanomaterials (iron oxides nanoparticles), silica antiviral coating, silver nanoparticles and others. Using such nanocoatings has facilitated to provide protective antiviral respiratory masks, eye-protecting glasses, hand gloves, clothes, PPE as well as surface decontamination of stainless steel, fabrics, furniture, wall paints etc., designing antiviral sanitizers, disinfectant sprays to disinfect, and decontaminate various surfaces which should be promoted to safeguard from viral infection by limiting its transmission [23–27]. In this context, Hewawaduge and coworkers have reported the inactivation efficacy of CuS incorporated three-layer mask against SARS-CoV-2, which
will be a lifesaver during this current and future pandemic [28].

As adherence of virus to different surfaces that eventually propagates the transmission has been adequately established, it raises apprehension of possible virus transmission [29] through may be edibles such as vegetables, groceries etc. The researchers have summarized the surface interactions and viability of coronaviruses under different surrounding environmental conditions [29]. Moreover, Kwon and coworkers have reported the environmental stability of SARS-CoV-2 on various surfaces under indoor and seasonal climate conditions [30]. As per their study, SARS-CoV-2 survived longest time on surfaces under winter conditions. So, the vegetables and fruits brought from open markets have the risk of virus sticking to their surfaces. However, there is no evidence, as of now, the spread of virus through groceries, food containers, and food packaging. As a preventive measure, people elsewhere are treating the vegetables and fruits brought from open market with diluted disinfectants; commonly used ones are rock salts, baking soda, vinegar, KMnO₄, lemon juice, dettol, savlon or UV radiation treatments, etc. It is not yet clear whether the SARS-CoV-2 virus becomes inactive in such procedures. But none of these are recommended as washing agents for vegetables and fruits. Salt, baking soda, and KMnO₄ may remove pesticides from vegetables and fruits but there is no evidence to suggest that these can kill SARS-CoV-2. On the contrary, the process may create health issues latter. As we know the pericarp (exocarp) of the fruits and vegetables are porous and hence may absorb the treated chemicals which would enter to our body and would create health issues like vomiting, diarrhea, abdominal pain among many others. Some of these symptoms may be mistaken to be due to COVID-19. As per WHO, one should wash the hands with soap for 20 seconds before and after the wash of veggies and fruits. FDA is silent about use of soap or detergents for treatment of vegetables.

**Conclusion**

In view of the wide spread propagation and transmission of SARS-CoV-2, taking a heavy toll on the human lives and its adverse fall out on the global economy during the ongoing pandemic, researchers are working day in and day out to find ways for combating this menace. More and more research has been recommended to understand the survival capability of SARS-CoV-2 on various environmental matrices to mitigate the SARS-CoV-2 spread and of its new variants. Concurrent research is going on in unfolding other factors, if any, responsible for the spread of the COVID-19 and also in inventing the vaccine to put an end to its deadly transmission. Time will say when the humankind will be liberated from the clutch of this murderous monster. As of now, it has been established that the virus reaches on different surfaces in the form of aerosol. The general public touch surfaces such as door handles, stair rails etc, while doing their routine household chores, in their workplaces and in shopping centers [29], and so they must be adequately sensitized along with adopting regular hand washing practices and applying sanitizers, and wearing face mask in public places and those places must be disinfected regularly on a continuous basis to preclude the possibility of the transmission of virus through eye, nose and mouth that come in contact with our hands unconsciously. Decontamination of hospital surfaces including medical equipments, everyday objects, rooms of the patients and the air needs to be given priority to limit SARS-CoV-2 spread [31]. Surface disinfection could be performed with ethanol (62–71%) or sodium hypochlorite (0.1%) for 1 minute as suggested by Fiorillo and coworkers [32]. One must be careful on both direct transmission (respiratory
droplets) and indirect transmission (inanimate surfaces). So, comprehensive understanding of the disease transmission is a prerequisite for fighting out this deadly pandemic.

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**ORCID**

Kuldeep Dhama [http://orcid.org/0000-0001-7469-4752](http://orcid.org/0000-0001-7469-4752)

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