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Disinfectants and Sprayers for Prevention of COVID-19 Pandemic in India

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Abstract

A novel coronavirus (nCoV), originating from Wuhan, China had begun as an epidemic in December 2019, declared as a pandemic in March and reiterated the call for countries to go for lock down mode and other strict measures. With the onset of winter, the threat of 2nd wave of infection is looming large over the Northern Hemisphere of the World. Virus is mainly transmitted through droplets and then by touching contaminated surfaces and mucous membranes with the hands. Though the virus survives on environmental surfaces for varied period of time; it gets easily inactivated by biological or chemical disinfectants. Alcohol based disinfectants viz. hand disinfectants, sprayers, mist blowers, cannon, and butterfly sprinklers etc. act as vital component in controlling the pandemic disease. Various biological and physical measures, such as self-disinfectant surfaces, UV-C sterilization, cold plasma technique etc. will assist in disinfecting the surfaces and materials. With unlocking underway, fast disinfection of the office space, meeting room, marketing spaces and even the areas in contaminant zones need quick disinfection through various sprayers, blowers and drones. This review emphasizes on the ongoing efforts to prevent the transmission of COVID-19 and can guide the public health responses, particularly in India.

Keywords: COVID-19, Sprayers, Disinfectant, Sanitizer, Self disinfectant

Background

Coronaviruses belongs to large group of viruses which cause the disease namely COVID-19 in humans or animals. There are selective viruses known to cause respiratory contaminations ranging from the viral fever to more severe diseases such as Middle East Respiratory Syndrome (MERS, out broke since 2015) and Severe Acute Respiratory Syndrome (SARS), out broke since 2003. The most recently virus discovered in China causes coronavirus disease COVID-19 (Yi-Chi et al, 2020, WHO, 2020a). Corona virus (COVID-

19) is a novel virus that was first recognized during an enquiry into an outbreak in Wuhan, China (Shereen et al., 2020). The first case in India was observed during 30 January 2020 in the state of Kerala, when a university student from Wuhan travelled back to the state (Sharma, 2020). In India the total no of cases has gone up to 4 millions with 50 thousand deaths as of end of August. Learning the lessons from the developed countries like Spain, USA and Italy, India put all its energy, equipment and technique into motion to break the chain of spreading of the disease. While countries across the globe are affected by the virus, are still struggling with elementary forms of responses, testing, contract tracing and isolation. India's presumed initial success based on comparative numerical cases, mostly due to strict lockdown, frequent testing and other measures, which need in-depth assessment. Considering the figures by end of August, India's total positive cases stood at 2.5 M in major six states (Maharashtra, Delhi, Tamil Nadu, Odisha, Madhya Pradesh and Gujarat) but the recovery cases is nearly 2.0 millions so far and total deaths stood at 40 thousands. In sum, India's response to the deadly pandemic has thus far shown reasonably good results which were under control in terms of no. of death and high recovery rate, thanks to the hard works of the government, doctors, police and different agencies. The awareness and resolved shown by the Indian citizens also assisted to break the chain of spreading. However, after the process of unlocking, the pandemic has come back again haunting India and other developing countries.
It was found that the virus is probably emerged from bat, but is now spreading from person to person (Shereen et al., 2020). The virus is supposed to spread when an infected person coughs or sneezes and his respiratory droplets come in contact between people who are in close contact with one another (within 6 feet distance). The virus mainly enters into human body through eye, mouth/nose. So, wearing of mask, cleaning of hands or using sanitizers can prohibit the virus to infect human body. The corona virus can survive on different surfaces from several hours (copper, cardboard) up to a few days (plastic and stainless steel), (Table 1). It is possible that a healthy person can be infected by touching a surface or object that has the virus on it. Commonly touched surfaces, such as handrails and road-crossing buttons are more likely sources of infection. As studies found, the virus can survive longer duration when came in contact with hard surfaces in the range above 72 hours (3 days), however, higher temperature somewhat hinders their growth and monitor their level of infection (van Doremalen, 2020). Hence, frequent spraying on these covering surfaces with disinfectant can be an effective control measure against spreading of the virus. This process would need to be repeated frequently as the next time an infected person touches the surface it can be re-contaminated, though cleaning were undertaken prior to sanitizing.

Table 1: Survival of COVID-19 virus on various materials

Sl. No.	Materials	Threat duration (Hours)	Components or parts
1	Metal	120	Knobs, Jewelry
2	Glasses	120	Mirror, drinking glasses
3	Ceramics	120	Pots and utensils
	Wood	96	furniture
3	Plastics	72	Bottles, sheet, packets
4	Stainless steel	72	Utensils, washing machine

5	Cardboard	24	boxes
6	Copper	4	Wire, bottle
7	Aluminum	2-8	Tin foil
8	Paper	<1	News paper

Source: Nazario, 2020; van Doremalen, 2020

Symptoms and spread of COVID-19

Patients with COVID-19 positive vary in severity from having no symptoms at all (being asymptomatic) to having fever, cough, sore throat, general weakness and fatigue and muscular pain. Recently, anosmia – loss of the sense of smell – and loss of the sense of taste (Swain and Singha, 2020) and persistent skin rash have been reported as new symptoms of a COVID-19 infection. In severe cases, symptoms like severe pneumonia, acute respiratory distress syndrome, sepsis and septic shock, can lead to death. The severity rises manyfold with the presence of underlying medical conditions such as, cardiovascular disease, diabetes mellitus, chronic kidney disease, and chronic lung disease etc. Reports showed that clinical deterioration can occur rapidly, often during the second week of disease Chatterjee et al., 2020. The signs and symptoms of COVID-19 may appear from two to 14 days after exposure (Mayo Clinic Staff, 2020). This time after exposure and before having symptoms is called the incubation period. Common signs and symptoms can include fever (99%), fatigue (70%), dry cough (60%), Tiredness (44%). In addition, patients who are elderly, have more than one disease in the body viz. hypertension, diabetes, cardiovascular disease and cerebrovascular disease are more likely to have adverse outcomes (Elflein, 2020). The total mortality rate may vary around 3-5 percent, however, with large no. of infection, the total no. of death is rising at faster rate. So, there is a need for planned efforts for providing multidisciplinary care in an integrated, single-service area. In a country like India where the total population is 1.3 billion and 65% of the population are from rural areas, designing and building the isolation wards, testing the people, using humane and helpful esthetics, will be a challenging step in empowering health systems to support an adequate response to the surge in cases (WHO, 2020b).

Prevention of transmission

The virus spreads through respiratory droplets and physical contact. Precautionary measures like avoiding close contact with people who are sick, use of personal protective equipment (PPE) and respiratory and cough etiquettes, avoid touching your eyes, nose, and mouth with unwashed hands; Wash your hands frequently with soap and water for at least 20 seconds can help from spreading the virus. The alcohol-based hand sanitizers, containing 60-80 percent ethanol, should be used if soap-water is not available. Social distancing and lockdown guidelines by the government should be followed to break the chain of COVID-19 transmission. It is going to be very challenging to maintain the social distancing after the process of unlocking has begun due to economic stress (Rai, 2020).

Disinfectants used for control of Pandemic virus

Disinfectants are chemicals that destroy disease causing pathogens or other harmful microorganisms. Mostly chemical disinfectants are used for cleaning and disinfection of

surfaces (Table 2). Surfaces frequently touched by those who are suspected or confirmed to have COVID-19, need to be sanitized before reuse. For an effective disinfection, the whole surfaces have to be completely covered with disinfectant (McDonnell and Russell, 1999). Quick alcohol-based disinfectants are only effective as long as the surface is wet. Visible dirt or contaminations have to be cleaned off the surface before disinfection. Cleaning can help to disinfect the surface by 10 – 90 %, disinfecting after cleaning can be achieved up to >99.99 % in germ reduction (Birchmeier Manual, 2020). The individuals applying the disinfectant should also take safety measures, such as, PPE kit, gloves, mask and goggles etc. Modern technique should be used, so the individual should come least contact with the infected surfaces during cleaning process.

Table 2: Disinfectants for control of COVID-19 spreading

Sl. No.	Active ingredient(s)	Contact time	Formulation type	Use site
1	Quaternary ammonium	5	Dilutable	Healthcare, Institutional, Residential
2	Citric acid	5	Wipe	Healthcare, Institutional, Residential
3	1,2-Hexanediol	10	RTU (Ready-to-use formulations)	Healthcare, Institutional
4	Hydrogen peroxide; Peroxyacetic acid	10	Dilutable	Healthcare, Institutional, Residential
5	Sodium Hypochlorite	5	Dilutable	Healthcare, Institutional, Residential
6	Hydrogen peroxide; Peroxyacetic acid	10	Dilutable	Healthcare, Institutional
7	Phenolic	5	Wipe	Healthcare, Institutional, Residential

Source: Saccucci, 2018; McDonnell and Russell, 1999

Disinfectants efforts across world to control COVID-19 transmission

Government around the world is trying to mobilize and halt the corona virus outbreak and spread. The Chinese government has been accessing ways to incorporate drones into their response to Coronavirus (Young and Reuter, 2020). Drone and small helicopters have been used for spraying pesticides in large agricultural fields. Look at the demand for surface sanitization, many countries including China are using Drone for spraying disinfectants. Apart from spraying, it is also used for delivery of food items in isolation units, transportation of medical samples and monitoring traffic during rush hours. Drone and small helicopters service may be explored for disinfection of large surfaces and platforms (Fig. 1). Even, canons, fire-brigade, fumes spray etc. are used in almost all countries to mitigate corona virus from its root (Young and Reuter, 2020). Public private partnership (PPP) initiatives need to be encouraged for mitigation of COVI-19 infection.

Disinfection process in Wuhan, China

Workers spray antiseptic solution along a street in Manila, Philippines

A worker disinfects a marble railing on the Rialto Bridge in Venice, Italy

Disinfection efforts are carried out by fire-brigade crew members in Tehran, Iran

Figure 1: Spraying of disinfectant in different parts of world (Young and Reuter, 2020; Taylor, 2020)

Disinfection Efforts in India

Large-scale disinfection efforts are underway by Governments around the world to deaccelerate the spread of COVID-19. Methods range from simple hand-wiping to mobile spray cannons, workers and volunteers are attempting to halt the transfer of the virus by touch (Bricknell and Trott, 2020). Apart from personal hygienic measures to avoid infection, the next step is the disinfection of surfaces which have a high risk of contamination, such as window and door handles, keyboards, touchscreens. Various surfaces with a lower risk of contamination can be disinfected afterwards. Public spaces (including streets, markets, shopping zones, community centres, parks, playgrounds, and neighborhood spaces in residential areas) should be well disinfected as these play a vital role in the social life of communities. Various types sprayers used are compression sprayers, battery operated Knapsack sprayer, Knapsak motor sprayers etc. (Fig. 2).

(a) (b) (c)

Figure 2: Various type of sprayers, a) Compression sprayers, b) Battery operated Knapsack sprayer, c) Knapsack power sprayer

The disinfectant sprayers can also be classified according to their usage such as: i) Hand disinfectant for small surfaces, ii) disinfectant for Medium size surface, iii) Disinfectant for large surface, iv) Special disinfection effort

I) Hand disinfectant and disinfection of small surfaces

For household use, disinfection of small surfaces is very important, as we have to reuse the surfaces frequently. Alcohol based disinfectants are particularly suitable, because they are effective quickly and are easily available at low price in the locality. The sanitizers may also content ethanol, isopropyl alcohol, n-propanol or a combination with water. Along with alcohol, hand disinfectants contain special additives, which protect the skin from drying out (Table 2) and also not harmful to our body. Effective way of applying alcohol-based disinfectants needs a minimum contact time of 30 seconds. As you know, the hand and exposed body part should be sanitized at least for 20 seconds for better protection. During the application of disinfectant, the surface has to remain wet. Complete coverage of the surface can be ensured if the surface is wiped initially. Surfaces need to be cleaned with help of wet clothes before sanitizing, so that viruses will come in direct contact of the disinfectant and wiped out.

II) Disinfection of medium-sized surfaces

For medium size surfaces, we use concentrated disinfectants which can be diluted with water as the area is more. Here agents used should be non-toxic or low in toxicity to human skin and surface materials (marbles, tiles etc.). Odour free quaternary ammonium compounds are mostly preferred for closed rooms as well as open surfaces. Chlorine based Agents (hypochlorites, javel) or peroxides and peracetic acids are also used. But they are less suitable for working in closed rooms, due to their bad odour (EPA, 2020). These disinfectants need a minimum contact time of around sixty seconds. During the application, the surface does not need to remain wet, as they are very effective for dry surfaces unlike hand sanitizers. Completely covering the surface is still necessary for direct contact of surface to the

disinfectant. Agricultural sprayers like compression sprayers, knapsack power sprayer, and battery operated knapsack sprayer (Fig. 2) are found very effective in controlling the virus.

Mi Fogger (Faith Micro Solution, New Delhi, India; Fig. 3) is used in closed rooms for fogging all types of water-based disinfectants. Mi-Foger ultra low volume (ULV) fogger breaks the disinfecting liquid into very fine droplets in the range of 0.1-10 microns, which remain suspended in the air for a long time. This increases the contact time of the disinfectant within the micro-organisms in the air (Sams, 2020). The tank capacity of the sprayer is 5 litres and droplet diameter less than 1 micron. It is portable and can be used for Aerial Sterilization of Operation theater, Room and Laboratories and libraries (Birchmeier Manual, 2020).

(a) (b)

(c) (d)

Figure 3: Various spraying equipment, a) Hand sprayer; b) Fogger used in library; c) Mist cannons; d) Air assisted sprayer

III) Disinfection of large surfaces and rooms

For disinfecting large surfaces and rooms, backpack sprayers are especially suitable, disinfection of rooms and areas or surfaces, should not remain wet. The fine hollow cone, solid cone or fan type nozzles can be used for disinfecting the surfaces. The fine particles and

the low quantity allow a uniform distribution of disinfectant over the surfaces, without soaking them. Therefore, the surfaces can be reused after a short time (Taylor, 2020).
Misting cannons (Fig. 3) offers a unique decontaminating and disinfecting technology. Mist cannons, having huge blowers, are mounted on trucks, move around in downtown areas with spraying disinfectant fumes and in other containment zones in addition to localities of positive patients. The sprayer uses a pump to pressurize the solution, and fan (3-4 bar air pressure) to atomize the droplets (10 to 50 microns), maximizes the surface area of the disinfectant, and projects the disinfectant over large areas. The machine is completely remote controlled, including starting and stopping the fan and pump motor, as well as the barrel angle and 180 degrees of operation. Many countries across the world, such as India, China, Italy, Spain, Iran, Korea, and the Philippines are using water cannons and misting cannons to spray disinfectant onto outdoor surfaces (Lantagne et al., 2018).

An air assisted sprayer operated by tractor power take off (PTO) is another option used for disinfecting the virus infected large surfaces (Fig. 3). The sprayer is attached to tractor drawbar for transportation. The sprayer consists of parts like plastic tank of 1000 litre capacity, a no. of nozzles, long hose pipe, hydraulic pump, direction control lever, pressure regulator and pressure relief valve, overflow and cut off valves. There are seven twin headed anti- drip nozzles on each side of the blower having diameter of 1.2 and 1.8 mm, respectively with various swath width (Yasin, 2012). The nozzles are independently operated set for 20^0, 35^0 and 45^0 angles, to cover uneven shape surfaces A pressure relief valve is provided to monitor the sprayer at desired level according to the field conditions. Nozzles and blower break the particles to required size for effective spraying. The air assisted sprayer employs a blower to produce air stream of sufficient volume and velocity to carry the spray droplets at the nozzle outlet (Yasin, 2012).
Cities in India like Rajkot, Gujarat is seen using high-clearance boom sprayers for disinfection of public streets and public places. Four High Clearance Boom Sprayers mostly used in agricultural fields, are being used by Rajkot Municipal Corporation to spray disinfectants on the roads and streets of Rajkot (MHUA, 2020). Cities are taking up innovative approaches for disinfecting public places by using sodium hypochlorite, for example Tripura has recently implemented a disinfection tunnel, which is now used in numerous cities at their agricultural/ vegetable markets, offices etc. Modeled on this, various establishments entrusted with provision of essential services are deploying the disinfection chambers. City administration with cooperation with Fire Departments used fire-tenders, water washes pumps etc., to sanitize all the streets in the city by spraying disinfectants (EPA, 2020).

IV) Special disinfection efforts

Use of drones in disinfection process

Team Dhaksha students of Anna University, Chennai developed a spraying drone for disinfection of corona virus (Fig. 4). The drone sprayer was demonstrated and tested at the Ripon building, Chennai (TN, 2020). Four drones were seen flying over the city to carry out disinfection. Each drone covers 80,000 sq m per day and can fly for two to three acres in one ride. The drone is unmanned and controlled by remote-operated joystick. Spraying is possible

on all sides at a minimum of 5 m and a maximum height of 100-150 m. The spraying is efficient when flown at 20-25 m. Besides China and Germany, only India is using drones to battle COVID-19. The Indian Institute of Technology (IIT) Guwahati has taken the lead in development of various drones to aid the fight. Another group has come up with thermal screening with the help of drone equipped infrared camera. The drone can be used to scan group of people without human intervention and identify suspected COVID-19 cases at an early stage (MHUA, 2020).

Figure 4: Drones used by Chennai students (TN, 2020)

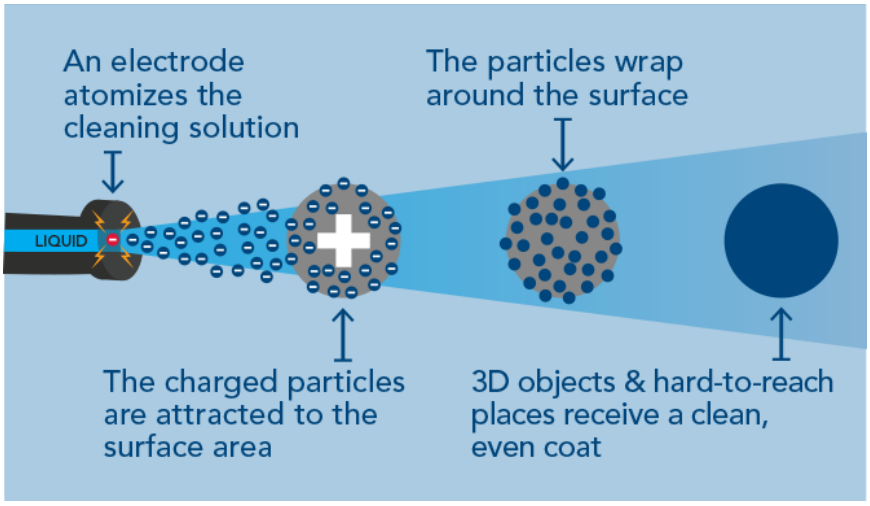

Figure 5: Principle of electrostatic spraying (CCC, 2020)

Electrostatic disinfection

It is an alternative to traditional cleaning techniques and cleaning solution. This innovative method saves time, energy and costs because of its efficient applications. It works on the Coulomb's Law principle - "Opposite charges attract each other and due to the effect of induction an opposite charge is induced on target". The tip of the nozzle is attached with an

electrode and disinfectants coming out of the nozzle are atomized. Positively charged ions attached to atomized particles. These particles gravitate to grounded, negatively charged are attracted towards the metal (CCC, 2020; Fig. 5).

The electrostatic sprayers are very effective and time efficient, roughly save 50% total time required by traditional system. It optimized the total spray use at reduced operational cost and cost of the raw material. It prevents cross contamination and ensures safety of the operator. (CCC, 2020)

Apart from sprayers the fire tenders used sodium hypochlorite (bleach) solution for comprehensive disinfection of public places. Disinfectants containers connected to jet spray guns are taken in light cargo vehicles to easily navigate narrow lanes in city neighborhoods.

Self-disinfecting surfaces

Surfaces with anti-adhesive properties with incorporated antimicrobial substances or modified with biological active metals are some of the strategies recently proposed (Querido et al., 2019), for smart surface securing against COVID-19 contamination. Here antimicrobial surfaces are in constant process of activity oppositely to no-touch technologies or conventional cleaning. This way the antimicrobial charge on the surfaces is reduced immediately after contact preventing its propagation and consequent contamination of surrounding surfaces or people. This can be of three types, i) Chemical modification, ii) Physical modification, iii) Plasma technology.

Chemical modification: Coating with polymeric brushes will prevent adhesion of microorganisms. The polymers used for brushes are usually hydrophilic, so water will be attracted into the brush forming a repellent layer in aqueous environment (Gao et al., 2011). So, there will be no direct contact of microorganisms and the hard surface. Chemical modification has already been introduced and used in different cities.

Surface modification with zwitterionic polymers (family of materials having equal number of cations and anions) is found useful to reduce microorganisms' adhesion to the surfaces (Schlenoff, 2014). Even the antimicrobial materials such as silver, zinc, coper and chitosan etc. may be analyzed and used for self-disinfecting surfaces (Querido et al., 2019).

Physical modification: Physical modification is preferred over chemical modification. However, limited research is carried out on physical modification for self disinfcation. Structure modification is the application of superficial nanostructures reducing the area available for microorganisms to attach. Sharks skin have a special scale micropattern, which consist of a rectangular base embedded with tiny spines on the surface. The ribbed texture of these scales assists in possessing self-cleaning, anti-biofouling, hydrophobic and drag reducing properties of shark skin Jaggessar et al., 2017). Though this is suitable for surfaces but, may be not viable economically and unacceptable socially. Even lotus leaves have micropapillae structures covered by nanostructures with fine branch-like shape, though need more research for their application.

Plasma technology: Plasma technology of bringing high energy ionized stage to the matter, can be used in surface disinfection. Cold plasma technology has recently been applied for

surface disinfection. This technology has already been tested in food industry to decontaminate vegetables (Oh et al., 2017) and meat (Han et al., 2016) with good results. It has also been used to decontaminate surfaces as packaging materials. This technology is effective in inactivating pathogens (bacteria, fungi and viruses) on the surfaces of various instruments.

V) Disinfection of materials and books

UV-C (Ultraviolet radiation of C-type) radiation disinfection was created to increase the efficiency of manual disinfection (Yin et al., 2013). Ultraviolet radiation comprises the fraction of the electromagnetic spectrum that includes wavelengths below visible light and uses no chemicals. The UV-A (95%) and UV-B (5%) type light comes from sunlight through the ozone layer, which is harmful for human skin. But, UV-C type (short wave) could not pass through ozone layer, but can be produced artificially for the purpose of disinfection. It is produced by mercury lamps and welding torches. This system is considered an effective technology to decrease contamination and the potential to prevent infection. It has also been proven to inactivate up to 99.9% of viruses, bacteria and fungi in the environment (Fig. 6). These disinfection systems use lamps that emit low and continuous doses of ultraviolet light, which is capable of killing most viruses and bacteria without harming the skin, eyes and other human tissues.

(a) (b)

Figure 6: Ultraviolet radiation based disinfection systems a) disinfectant box for house hold goods; b) UV ray shelf for books (Hyboxuv, 2020).

Conclusion

As the fear of COVID 19 pandemic is wide spread across the globe, Government of the all the countries including India have been taking a lot of initiative to eradicate the COVID-19 by making realistic efforts in medical assistance, testing, financial reforms, infrastructure development etc. Clinical trials have begun in several countries to identify vaccines and effective and safe treatment regimens. The lack of a reliable forecasting about the novel corona virus, inability to stand distinct containment measures, lack of community

engagement for home isolation, and overdependence on quarantining measures have exposed the cracks in the ability of health systems of India and across the world. It has clearly validated the weak preparedness against emerging and re-emerging hazardous pathogens across the world. Delay in supply of vaccines forced us to relay on preventive measures to limit the infection due to COVID-19.

The use of disinfectant and sprayers can make the flooring, walls, tables and sitting places sanitized and prepared for reuse safely. The sprayers mentioned above can be carefully chosen from systems like knapsack sprayers, boom sprayers, drone sprayers, mist cannons etc. based on the requirements for an effective control over the virus. Various biological and physical measures, such as self-disinfectant surfaces, UV-C sterilization etc. will assist in disinfecting the surfaces and materials. With the unlocking of industries and offices, there is huge demand for surface disinfectant for large scale and frequent cleaning. The proposed, equipments, machineries and techniques will be useful in containing the spread of COVID-19 virus until the development of vaccine.

List of Abbreviations

COVID-19	Corona virus disease
IIT	Indian institute of Technology
MERS	Middle East respiratory syndrome
nCOV	Coronavirus
PPE	Personal protective equipment
PTO	Power take off
SARS	Severe acute respiratory syndrome
ULV	Ultra low volume
UV	Ultra violet
UV-C	Ultraviolet radiation of C-type
WHO	World health organization

Declaration of Conflicting Interests

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