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The Environmental Surveillance System of nCOVID-19 and Animal Coronaviruses (TGEV and MHV) for Mitigating the Further Spreading

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ABSTRACT

Coronavirus disease 2019 (nCOVID-19) is a newly emerging disease first discovered in Wuhan city, China, in December 2019. Currently, nCOVID-19 has become a global health concern causing severe respiratory tract infection besides animal coronaviruses includes transmissible gastroenteritis virus (TGEV) and mouse hepatitis virus (MHV). Implementing of surveillance system requires coordination and collaboration between the Centers for Disease Control and Prevention (CDC), local, and state public health authorities. Outbreak surveillance can help to mitigate the further spreading of coronaviruses in the environment. nCOVID-19 can persist on inanimate surfaces up to 9 days whilst animal coronaviruses (TGEV and MHV) can persist in the environment for ≥ 28 days at 4°C. Effective surface disinfection may help to ensure an early containment and prevention of further viral spread. Some biocidal agents efficiently inactivate coronavirus infectivity within minutes such as ethanol 70%, hydrogen peroxide (H_2O_2) 0.5%, and sodium hypochlorite ($NaOCl_2$) 0.1%. This review article was designed to address the environmental surveillance system focused on the persistence of new coronavirus (nCOVID-19) and animal coronaviruses (TGEV and MHV) on the environmental surfaces, factors affecting their survival, and assess the efficiency of different biocidal agents against coronaviruses to establish an efficient control strategy.

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Introduction

Coronavirus disease 2019 (nCOVID-19) is a serious viral disease and has become a global health pandemic with confirmed cases represented more than 4 million and about 290,000 deaths during 2 April 2020 (AVAC, 2020). Coronavirus is a newly emerging viral disease caused by virus belonged to the coronavirus family that called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), infecting animals and humans with such disease-causing varies symptoms ranging from cold to more severe illnesses such as Middle East Respiratory Syndrome (MERS-CoV) and Acute Respiratory Syndrome (SARS-CoV) (Chan *et al*., 2015; Al Hajjar *et al*., 2013; Mohd *et al*., 2016). This virus has the largest genome known among RNA viruses (Saif *et al*., 2019). The transmission route of the SARS-CoV2 to humans included an intermediate animal host, which has yet to be identified as opposed to direct bat to human transmission (OIE, 2020). So far, the coronavirus infection has only been seen in vertebrates, causing respiratory, gastrointestinal, and neurological diseases in humans and animals. The finest way to prevent or mitigate and slow down the viral transmission is to be fully aware of the nCOVID-19 virus, the survival rate in the environment, and how it spreads (Yari *et al*., 2020).

The new coronavirus (2019-nCoV) causes an ongoing outbreak of lower respiratory tract disease called novel coronavirus pneumonia (NCP) by the Chinese government initially. The disease name was subsequently recommended as COVID-19 by the World Health Organization. Meanwhile, 2019-nCoV was renamed SARS-CoV-2 by the International Committee on Taxonomy of Viruses. The epicenter of this ongoing outbreak is in the city of Wuhan in Hubei Province of central China and the Huanan seafood wholesale market was thought to be at least one of the places where SARS-CoV-2 from an unknown animal source might have crossed the species barrier to infect humans (Chan *et al*., 2020).

The surveillance system is an ongoing system includes data collection, analysis, and interpretation. Outbreak surveillance can help to mitigate the further spreading of coronaviruses in the environment. In addition, hand washing and/or disinfecting them with alcohol-based items repeatedly and

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without touching your face can prevent its spread. SARS-CoV2 can be transmitted from 1 to 2 meters through different way such as coughing or sneezing, contact hands with the environment, and virus-infected surfaces such as stainless steel equipment, stair railings, door handles, desks and chairs, valves, switches, and electrical outlets, so it is important to wash hands and face with soap and water after contact with any person or suspicious objects (Biscayart *et al*., 2020; Jin *et al*., 2020; van Doremalen *et al*., 2020; WHO, 2020a). The virus had a potential persistence in the environment for several days whereas the premises and areas potentially contaminated with COVID-19 should be cleaned before their re-use, using antimicrobial products known to be effective against coronaviruses. Although there is a lack of specific evidence for their effectiveness against nCOVID-19 (Yari *et al*., 2020). From general precautionary cleaning measures using water, household detergents, and common disinfectant products might be sufficient. sodium hypochlorite is one of the disinfectants that proved the effectiveness against coronaviruses (Van Doremalen *et al*., 2013; Otter *et al*., 2016). The main goal of this review article was to discuss the role of surveillance system in monitoring and tracking of novel coronaviruses persistence on different environmental surfaces, microclimatic factors affecting their survival, and assess the efficiency of different biocidal agents against nCOVID-19 and animal coronaviruses to establish an efficient control strategy.

Detection protocol of coronaviruses and nCOVID-19 pandemic

Surveillance means the systematic collection, analysis, and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice (WHO, 2020b).

The main purpose of a surveillance protocol for nCOVID-19 is to describe the epidemiology, exposure characteristics and risk factors, as part of a case investigation. In nCOVID-19 surveillance, the primary intention of this case definitions is very important to maximize consistency, allowing agencies to track variations over time and by geographical region. The surveillance objectives according to WHO (2020b) as follows: a) Monitoring trends of the disease where" human-to-human" transmission occurs. b) Rapidly detection of new cases in countries where the "virus is not circulating". c) Provide epidemiological information to conduct hazard or risk assessment at the national, regional, and global level besides response measures.

Protocol design

The surveillance protocol is based on the questionnaire that includes the number of essential questions related to an interviewer, geographical area, risk factors, activities carried out during interaction with the nCOVID-19 patient (WHO, 2020c), microclimatic factors affecting the survival of COVID-19, personal protective equipment (PPE) use, disinfection and cleaning standard procedure (Fig.1).

Targeted population

All persons who test positive for COVID-19 regardless of their symptoms are the main target population. Some countries may decide to retrospectively administer the questionnaire to all infected persons, regardless of the time of infection. Investigators should also consider the risk of response bias regarding PPE use or close contact; this bias could be reduced by administering the questionnaire at the time of testing before the result becoming known.

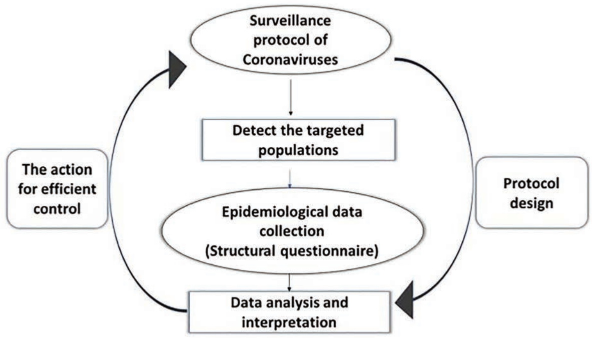

Fig.1 Environmental Surveillance protocol of coronaviruses.

Data collection, analysis, and interpretation

Each participating authority should identify a contact person for data collection, the surveillance process will need to complete the questionnaire. This questionnaire includes all information about an interviewer (First name, family name, sex, city, country, and contact email), demographic area, personal protective equipment (PPE) use. In addition, SARS-CoV2 persistence on the environmental surfaces, microclimatic factors affecting the survival of nCOVID-19, and their inactivation using different biocidal agents.

Microclimatic factors affecting survival /persistence of nCOVID-19

Persistence of nCOVID-19 on environmental surfaces depends on environmental conditions such as ambient temperature and relative humidity (RH) (Chan *et al*., 2011; Casanova *et al*., 2010). The effect of temperature on the virus's survival is more significant than that of RH. Some available data showed that at room temperature SARS-CoV2 persists better at a RH 50% compared to persistence at RH 30%. Whilst a shorter persistence of highly pathogenic MERS-CoV was observed when exposed to a higher temperature at s 30°C or 40°C (Kampf *et al*., 2020). On the other hand, TGEV and MHV were used as conservative surrogates for modeling exposure to determine the effects of ambient temperature, and relative humidity on the survival of coronaviruses on stainless steel (Casanova *et al*., 2010). The infectious virus: Transmissible gastroenteritis virus (TGEV) and Mouse hepatitis virus (MHV) persisted for 28 days at 4°C and the lowest level of inactivation occurred at low RH (20%). Ren *et al*., (2020) showed that high numbers of TGEV and MHV may survive for days on surfaces at ambient temperature (AT) and relative humidity (RH) typical of indoor environments. Both viruses were inactivated more rapidly at 40°C than at 20°C. Under various environmental conditions, the stability of SARS-CoV-2 has been simulated to help with optimizing standard disinfection methods. The SARS-CoV-2 was found to be highly stable at 4°C but it was inactivated at 70°C after 5 min. If a small droplet (5µL) containing coronaviruses was inoculated onto different surfaces, then no viral infection could be recovered on paper or tissue paper after 3 hr, whilst wood and cloth after 2 days, glass and banknotes after 4 days, stainless steel, plastic and the inner layer of masks after 7 days but the masks outer layer remained infectious even after 7 days (Chin *et al*., 2020).

Tracking of SARS-CoV2, and animal coronaviruses persistence on inanimate surfaces

Most data confirmed that SARS-CoV2 can persist on different inanimate surfaces and room temperature and remain up to 9 days but the evidence of true transmissibility of new

Table 1. Monitoring the persistence of different coronaviruses (MERS-CoV, TGEV, MHV, SARS-CoV, and H-CoV) on inanimate surfaces.

Surface type	Coronaviruses			Temperature	Persistency/ time	References
	Name	Strain	Inoculum (viral titer)			
Stainless-steel	MERS-CoV	H-CoV-EMC/2012	10^5	20˚C 30˚C	48 h 8-24 h	van Doremalen *et al*. (2013)
	TGEV	Unknown	10^6	4˚C 20˚C	≥ 28 day 3-28 day	Casanova *et al*. (2010)
	MHV	Unknown	10^6	40˚C 4˚C	4-96 h ≥ 28 day	Casanova *et al*. (2010)
Aluminium	H-CoV	229E and OC43	5×10^3	21˚C	2-8 h	Sizun *et al*. (2000)
Plastic	SARS-CoV	HKU39849	10^5	22-25˚C	5 days	Chan *et al*. (2011)
	MERS-CoV	H-CoV- EMC/2012	10^5 10^5	20˚C 30˚C	48 h 8-24 h	van Doremalen *et al*. (2013)
Metal	SARS-CoV	P9	10^5	R T	5 days	Duan *et al*. (2003)
Wood	SARS-CoV	P9	10^5	R T	4 days	Duan *et al*. (2003)
cardboard	SARS-CoV	HKU39849	10^5	22˚C	24 h	Chan *et al*. (2011)
Copper	SARS-CoV	HKU39849	10^5	22-25˚C	4 h	Chan *et al*. (2011)

-MERS: Middle East Respiratory Syndrome; H-CoV: Human coronavirus; SARS: Severe Acute Respiratory Syndrome; TGEV: Transmissible gastroenteritis virus; MHV: Mouse hepatitis virus; RT: Room temperature.

Table 2. Summarize the nCOVID-19 persistence on inanimate surfaces.

Investigated surface	Virus	Persistency/ time	Results note on reduction	References
stainless steel	2019-nCOV	48 h	Reduction from $10^{3.7}$ to $10^{0.6}$ TCID 50 Per millimeter	Van Doremalen *et al*. (2020)
plastic		72 h	Reduction from $10^{3.7}$ to $10^{0.6}$ TCID 50 Per millimeter	
copper		4 h 8 h	No viable SARS-CoV-2 No viable SARS-CoV-1	
cardboard		24 h 8 h	No viable SARS-CoV-2 No viable SARS-CoV-1	
Aerosols		3 h	from $10^{4.3}$ to $10^{3.5}$ TCID50 per liter of air	

TCID50: Tissue-culture infectious dose 50%

coronavirus under such conditions still unclear. To reduce the viral load on different surfaces, disinfection process was suggested to be a plausible method and provided that the disinfection of environmental surfaces and medical equipment would be an effective measure in reducing the risk of exposure to workers of healthcare and inhibiting the spread of nCOVID-19 (Kampf *et al*., 2020). Another study clarified that coronavirus could survive on a plastic and stainless-steel surface for three days whilst it can persist on cardboard for one day compared to it sustain on a copper surface for 4 hours (Moriyama *et al*., 2020). The persistence of Transmissible gastroenteritis virus (TGEV) and Mouse hepatitis virus (MHV) can be increased at 4°C to 28 days. However, the persistence duration of highly pathogenic strains (MERS-CoV) was reduced at 30°C of temperature for 8-24h (van Doremalen *et al*., 2013) whilst both TGEV, and MHV was reduced at a higher temperature (30°C or 40°C) for ≥28 days (Casanova *et al*., 2010). On the other hand, few data on SARS-CoV indicated that persistence was longer with higher inocula as shown in Table 1. In addition, it has been found that Human CoV-229E persists better at relative humidity 50% compared to 30% at room temperature (Ijaz *et al*., 1985). van Doremalen *et al.* (2020) evaluated the stability of SARS-CoV-2 and SARS-CoV-1 in air and on various surfaces and found that SARS-CoV-2 viability in the air was maintained for at least 3 hr. while on the surface SARS-Co-V2 virus titer was more stable on both stainless steel and plastic surface (3 days) than on copper (< 1 day) and/or cardboard (1-2 days). As shown in Table 2, Van Doremalen *et al*., (2020) evaluated the stability of SARS-CoV-2 and SARS-CoV-1 in aerosols and different surfaces. They evaluated these viruses' decay rates using Bayesian linear regression and conducted their experiment using aerosols < 5μm containing SARS-CoV-2 (105.25 tissue-culture infectious dose 50% (TCID50) per milliliter) or SARS-CoV-1 (106.75-7.00 TCID50 per milliliter). The limit of detection for this experiment was 3.33 x$10^{0.5}$ TCID50 per liter of air for aerosols; $10^{0.5}$ TCID50 per milliliter of medium for steel, plastic, and cardboard; while for copper, $10^{1.5}$ TCID50 per milliliter of medium.

Standard cleaning procedure of infected surfaces

World Health Organization (WHO) and Centers for Disease Prevention and Control in the US (CDC) recommended the routine cleaning and disinfection process of different surfaces potentially contaminated by nCOVID-19 followed by application of disinfectant (CDC, 2020). Potentially infected surfaces should be initially cleaned using water and detergent to ensure the area is free from any organic materials. The presence of organic materials suggested that it inhibits the effectiveness of disinfectants used such as sodium hypochlorite through a mechanism of oxidant demand created by the proteinaceous medium in which the virus would naturally be found (Hulkower *et al*., 2011) and also the presence of organic matter might coat the virus and hinder the effect of disinfectant. Thereafter, surfaces should be dried then disinfectant applied with a contact time of at least one minute as reported by ECDC (2020).

Table 3. Reduction of different coronaviruses infectivity using different disinfectant agents.

Disinfectant agent	Testing Concentration	Virus	Contact time	Viral infectivity reduction (log10)	References
Ethanol	95%	SARS-CoV	30 sec.	≥ 5.5	Rabenau *et al*. (2005a)
	80%	MERS-CoV	30 sec	> 4.0	Siddharta *et al*. (2017)
	70%	MHV	10 min.	> 3.9	Saknimit *et al*. (1988)
	70%	H-CoV	1 min.	> 3.0	Sattar *et al*. (1989)
	62%	nCOID-19	1 min.	> 4.0	Kampf *et al*. (2020)
	62%	TGEV	1 min.	> 4.0	Hulkower *et al*. (2011)
Sodium hypochlorite	0.50%	H-CoV	1 min.	> 3.0	Sattar *et al*. (1989)
	0.10%	H-CoV	1 min.	> 3.0	Hulkower *et al*. (2011)
	0.06%	TGEV	1 min.	0.4	Sattar *et al*. (1989)
Hydrogen peroxide (H_2O_2)	0.50%	H-CoV	1 min.	> 4.0	Kampf *et al*. (2020)
	0.001%	CCV	10 min.	0.9	Omidbakhsh *et al*. (2006)
Formaldehyde	1%	SARS-CoV	12 min.	> 3.0	Rabenau *et al*. (2005b)
	0.70%	MHV	10 min.	> 3.5	Saknimit *et al*. (1988)
Glutardialdehyde	2.50%	SARS-CoV	5 min.	> 4.0	Kariwa *et al*. (2006)
	0.50%	SARS-CoV	12 min.	> 4.0	Rabenau *et al*. (2005b)

- SARS: Severe Acute Respiratory Syndrome; MERS: Middle East Respiratory Syndrome; H-CoV: Human coronavirus; TGEV: Transmissible gastroenteritis virus; MHV: Mouse hepatitis virus.

Inactivation of coronaviruses using different types of biocidal agents

The Environmental Protection Agency (EPA) recommended a list of different disinfectant types and approved for use against nCOVID-19 however, the listed disinfectants have not been directly tested against nCOVID-19 and have only proven effective against killing hardier virus or other similar human coronaviruses (EPA, 2020). Thoroughly cleaning and disinfection of environmental surfaces besides using effective disinfectants such as sodium hypochlorite at 0.05% (1:100 dilution of 5.0%) and/or ethanol at 70% are sufficient procedures that recommend by WHO for disinfecting small surfaces (WHO 2014, 2020d). Furthermore, Kampf *et al*. (2020) suggested that a dilution 1:50 of standard bleach of sodium hypochlorite (0.1%) is effective at 1 min against new coronavirus. Moreover, the efficiency of ethanol at 62-71%, hydrogen peroxide 0.5%, and sodium hypochlorite 0.1% was highly effective to prevent a human coronaviruses growth for one minute of exposure after thorough decontamination procedure as shown in Table 3 (Kampf *et al*., 2020). Other studies found that the use of common disinfectants such as sodium hypochlorite and sodium lauryl ethyl sulfate was effective in inhibiting SARS-CoV-1 from surfaces after five minutes of exposure (Lai *et al*., 2005). Sodium hypochlorite at a concentration of 0.1-0.5% and glutardialdehyde 2% were also quite effective with log10 reduction (>3.0) in viral titer. In contrast, benzalkonium chloride at 0.04% concentration, sodium hypochlorite 0.06%, and orthophtalaldehyde 0.55% were less effective (Kampf *et al*., 2020).

Conclusion

Coronaviruses are affected highly by different environmental conditions. New human coronaviruses (nCOVID-19) can persist on different environmental surfaces at room temperature for up to 9 days. On the other hand, animal coronaviruses (TGEV and MHV) can remain on the different surfaces up to 28 days at 4°C. An outbreak surveillance system of coronaviruses can help in mitigating the further spreading of viruses in the geographical area according to epidemiological data collection, analysis, and interpretation for taking a decision and/or an action. Disinfection of the environmental surfaces is one of the key essential elements to efficiently control viruses after detergent used for decontamination, besides the use of suitable PPE to prevent the transmission of viral infection as possible. There are different biocidal agents that showed their efficiency to inactivate coronaviruses includes ethanol at 62-71%, hydrogen peroxide 0.5%, and sodium hypochlorite 0.1% was highly effective to prevent a human and animal coronaviruses growth after one minute of exposure after thorough decontamination procedure.

Conflict of interest

The Author declares that there is no conflict of interest.

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