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COVID-19 IN FOOD SAFETY AND ITS IMPORTANCE FOR PUBLIC HEALTH

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Abstract: The novel Coronavirus 2019 (2019-nCoV), which emerged in Wuhan, China, is included in the beta coronavirus family such as SARS-CoV (2002,) and MERS-CoV (2012) coronaviruses. The novel virus was defined as "severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)" on February 11, 2020 by International Committee on Taxonomy of Virus (ICTV) from the World Health Organization (WHO). This name was given to this virus because of its similarity to the coronavirus responsible for the 2003 SARS outbreak. Although these two viruses are related to each other, they differ. Contrary to gastrointestinal (GI) viruses that frequently cause disease, such as Norovirus and hepatitis A, from contaminated foods, SARS-CoV-2,that leads to COVID-19, is not a gastrointestinal virus but a disease-causing virus. The way of foodborne transmission of this virus is not known exactly. Although it is not known exactly what the foodborne route of transmission of this virus is, contamination is caused by infected and/or personnel who do not comply with hygiene rules (cough, contact, etc.) at food processing, production, marketing, and presentation points poses a risk. In this sense, it is stated by the WHO that it will be influential to provide 5 conditions which are;

1. Keeping the food clean
2. Separating raw and cooked food
3. Cooking food thoroughly (well penetrating inside)
4. Keeping food stored at safe temperatures

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5. Using safe water and raw ingredients so that foods are consumed more safely (1).

Keywords: Coronavirus, Covid-19, SARS-CoV-2, foodborne viruses, food safety, public health.

Introduction

Numerous human or animal-borne viruses may spread to the environment and infect people through water and food, mostly through digestion and sometimes through skin contact (1). These viruses have many different families and are usually enteric, and their source of transmission is the fecal-oral route (2, 3). They may cause hemiplegia and even rarely myocarditis and respiratory disease or hemorrhagic fever, which may range from mild diarrhea to severe neurological disorders associated with their infection. Nevertheless, the most frequently reported syndromes due to foodborne viruses are gastroenteritis and hepatitis (4, 5). Viruses that frequently cause various foodborne diseases, furthermore,

a. those with a high incidence of foodborne viral disease according to available data,

b. those causing serious diseases that are important in terms of mortality all around the world,

c. 10 virus families that pose a potential foodborne risk for public health and are important for the threat of poisoning, and the ways of causing infection are presented in (Table 1) (6).

Table 1. Viruses that are, or have the potential to be, transmitted via food and their site of infection in the human body.

Note: Enteric viruses can also be airborne, bloodborne (including vector-borne) or sexually transmitted. Furthermore, viruses are classified as Group 1 and Group 2 in Table 1 according to the criteria in (Table 2) (6).

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While the viruses that met one or more of these criteria were included in Group 1, in other words, in the priority group in terms of foodborne viral diseases, Group 2 viruses were not found to be suggestive in terms of foodborne diseases (6).

Table 2. Evaluation of potential foodborne viruses against the three pre-defined criteria to identify the viruses of main concern from a food safety perspective.

Important Foodborne Viruses and Transmission

Coronaviruses were identified as the agent of Infectious Bronchitis (IBV) in chickens by a Veterinarian Dr. Oskar Seifried for the first time in 1931, and it was reported that they seriously threatened animal health. IBV is genetically included in the Gamma coronavirus family. It affects not only the upper respiratory tract but also the reproductive system in chickens and sometimes causes nephritis. Interestingly, Sars-Cov-2 causes damage to the kidneys in severe patients (7, 8). In the middle of the 1960s, it was precisely identified that coronaviruses infected humans, birds, mammals and some other animals. In the development of the disease, the primary target of the agent is the epithelial cells in the respiratory system and gastrointestinal system. Seven coronaviruses have been shown to infect humans until today. While common human coronaviruses Betacoronavirus HCoVOC43 and HCoV-HKU1, as well as Alphacoronavirus HCoV-229E cause common cold and severe lower respiratory tract infections in infants and the elderly, the false croup and bronchiolitis caused by Alphacoronavirus HCoV-NL63 in children were found to be significant (9). New zoonotic coronaviruses, such as SARS-CoV (2002, Betacoronavirus, Sarbecovirus subgenus) and MERS-CoV (2012, Betacoronavirus, Merbecovirus subgenus), which cause outbreaks in humans, also appear over time. SARS-CoV-2 is closely related to SARS-CoV and is similar to the genetic structure of Sarbecovirus,

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a Betacoronavirus subgenus (9, 5). The viruses that are foodborne transmitted and may be related to all these described are presented in (Table 3) (5).

Table 3. Viruses that may be foodborne transmitted

Noroviruses cause gastro-intestinal diseases in all age groups which are characterised by vomiting and diarrhoea. They are highly infectious and can be transmitted both directly from human to human and indirectly through contaminated surfaces or foods (10).

Rotaviruses are pathogens which cause diarrhoea. Mainly infants can have very severe courses of disease. Outbreaks frequently occur in day care centres. The virus is easily transmitted from human to human but also through contaminated foods (10).

Hepatitis A viruses cause acute inflammations of the liver (hepatitis). Their transmission is either directly from humans to humans or indirectly with contaminated foods serving as transmission vehicle (10).

The comparatively rare disease caused by hepatitis E viruses is very similar to hepatitis A. The virus is found in countries with a low hygiene standard in contaminated drinking water or foods but also in pigs and wild boar in Europe. The possibility of transmission from food made of them, which is insufficiently heated before consumption, is discussed (10).

The influenza A virus H5N1 – also known as "bird flu" – can cause severe general diseases and pneumonia in humans. It originates from infected poultry and can be transmitted through close contact with the latter in individual cases to humans. Transmissions via foods do not seem to play a role (10).

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The disease caused by the influenza A virus H1N1 – referred to as "swine flu" – has a slightly milder course**.** In most cases it causes a moderately developing general disease in humans affecting the respiratory tract. It is easily transmitted between humans by droplet infection. An involvement of foods at the transmission of this virus is so far not known (10).

Ways of SARS-CoV-2 Transmission to Foods and its Possibility of Infecting People

Towards the end of 2019, a poultry-induced pneumonia case was identified as a new source of coronavirus (2019-nCoV) in Wuhan, China. Then the disease was named COVID-19. The main source of this virus is a seafood market in Wuhan where different wild animals (snakes and marmots) and domesticated (poultry and bats) animals are illegally sold. Thus, it is estimated that the disease can be transmitted from animals to humans. So far, the specific source and reservoir of SARS-CoV-2 have not yet been fully explained (9). At the same time, the World Health Organization (WHO) states that COVID-19 looks like a zoonotic virus originating from bats, however, it passed through an intermediate species to infect humans. Zoonotic diseases are infectious diseases caused by bacteria, viruses and parasites that are directly transmitted from animals to humans. Approximately %75 of the emerging infectious agents are zoonotic. WHO emphasizes the importance of controlling zoonotic diseases by initiating the One Health initiative, however, most of these diseases are not prioritized internationally or by the health systems of most countries (8).

One of the important factors in viral transmission of diseases to people is foods and their contact with the environment (11, 12). Since one-third of the world's population is on lockdown (29 March 2020), global food security alerts have arisen. Various contaminated foods, water, disease-infected food processors, and environment-induced viral outbreaks are reported all around the world each year (13, 14, 15, 16). However, no sufficient evidence on how Sars-Cov-2 causes disease through foods has been found yet. The difficulties of the food industry during the Covid-19 pandemic are still being discussed internationally

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(17, 8). One of the main factors in the transmission of viruses to humans in zoonotic diseases is the transmission of the products infected with the target agent caused by the staff in production during the processing foods. Another reason is the contact of food with water contaminated with feces (3).

According to the Centers for Disease Control and Prevention (CDC), the possible transfer of the virus to the main route of transmission occurs by touching a contaminated surface and then touching the mouth, nose, or eyes. It is reported that consumers and employees must wash their hands with water and soap properly for 20 seconds without touching their hands, mouth, nose, and eyes after contacting with money and before eating (18, 19). According to the latest information, it is reported that the virus can live on hard surfaces for up to 72 hours (3 days), depending on the properties of the material (19).

CoV infections cause winter dysentery in beef, respiratory CoVs in dairy cattle and bronchitis, a bird infection in poultry. Nevertheless, the transmission of CoV from animals to humans was strong in SARS and MERS outbreaks. It is suspected of zoonotic involvement (bats and pangolins) similar to current COVID-19. Therefore, it is emphasized that there is a need for more studies to ensure food safety before eliminating the potential risk of SARS-CoV2 during animal production. Because meat dishes (beef, pork, poultry, seafood, etc.) are rich in heparan sulfate (glycosaminoglycans). They highly interact with SARS-CoV2 against tissue epithelial cells. Considering that the viral pathogen can survive for days, even on nonviable surfaces such as cardboard, plastic and stainless steel, is better understood how animal (meat) tissue surfaces can pose critical risks for foodborne transmission of COVID-19. It is considered necessary to evaluate the possibility of transmission of COVID-19 through meat (food) processing by additional studies (20, 21). The control strategies based on internal and external factors such as pH, water activity (aw), redox potential, temperature of foods usually affect the bacterial growth in foods and are used to keep food microbiologically safe. Nevertheless, some of these control measures can be difficult to apply to viruses (21). Because when viral factors are involved in food, viruses can survive in many adverse

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conditions such as the acidic state of the stomach, digestive enzymes and alkaline conditions of the intestines and host defense system (22). Therefore, it is important to directly protect foods from virus contamination in virus infections (18, 20) (Figure 1) (23).

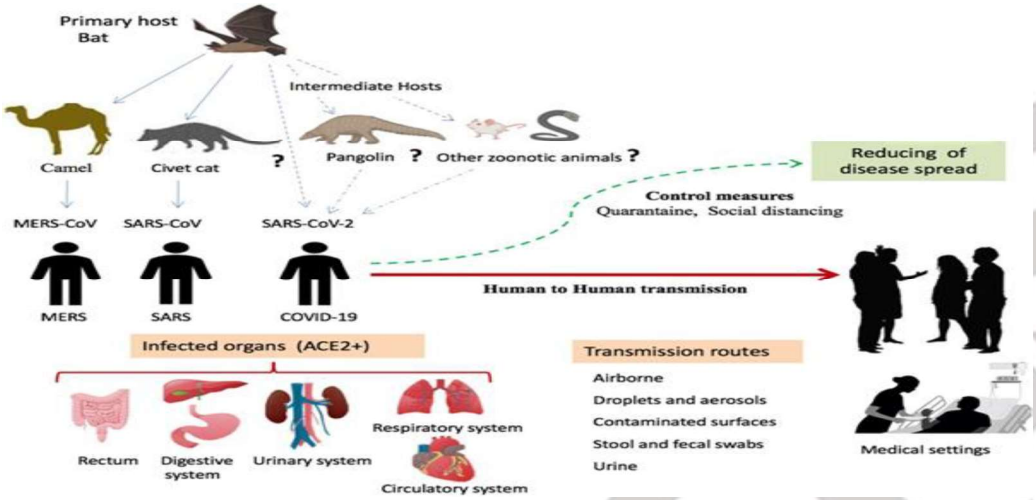

Figure 1. SARS-CoV-2 pass on to humans from bats directly or indirectly ways hosts like rats, pangolins, snakes, and rats. The virus is spread among humans by different routes including droplets, aerosols, *(so risks to food and food safety)* direct contact, and other potential routes like urine, stool, and fecal swabs. Human organs expressing the ACE2 receptor are targets for infection. Abbreviation: infected organs ACE2+, organs having ACE2 receptor.

Considerations Before and During the Consumption of Foods

Unlike bacteria, viruses cannot reproduce in food, therefore, the viral load is expected to decrease over time rather than increasing. According to the results of 22 studies that have been conducted so far, up to 9 days of human CoV on inanimate surfaces such as metal, glass or plastic, surface disinfection Quaternary Ammonium Compounds 200 ppm**.,** peroxide with 0.1% sodium hypochlorite (bleach), 0.5% hydrogen peroxide with 35% vapor is personal hygiene, hand rub or 62-71% ethanol can significantly reduce CoV infection on surfaces (hand rub, food contact surfaces) within 1 minute. In a recent study, it

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has been shown that SARS-CoV-2 can last up to 3 hours in the air, up to 4 hours in copper, 24 hours in cardboard, and 72 hours in plastic and stainless steel (18) (Table 4) (23).

Furthermore, the processing of foods by processes such as SARS-CoV ultraviolet light (hard surfaces, packaging film, etc. 200–280 nm; ~10.6 mJ/cm2), exposure to ≥ 75°C hot water, steam, etc. (hard surfaces, food contact surfaces) exposure to ≥ 65°C heat, treatment, exposure to ≥ 65°C heat, treatment and cooking in an alkaline pH (>12) or acidic pH (<3) environment to prevent contaminated food supply is one of the points to be considered to minimize the risk of potential transmission of SARS-CoV-2 (18, 24).

Table 4 Persistence of human and animal coronaviruses on inanimate surfaces, food matrices and in water

Coronavirus is an enveloped virus and covered with an oily membrane. Soap or a suitable hand-washing dishwashing detergent are very effective at dissolving the oil on the surface of the virus, and water is very effective at removing the virus. Products such as fresh vegetables and fruits consumed without cooking should be washed thoroughly under water. If desired, the surfaces can be washed by using a small amount of soap and water and rubbing with a vegetable brush. However, fruits and vegetables that are washed using a little soap should not be consumed without rinsing very well. This method is effective for removing the pathogens on the surface. It is not known whether popular domestic practices such as vinegar are effective in killing the virus (18).

The BfR is not aware of any infections with SARS-CoV-2 via this transmission path. Coronaviruses can generally reach surfaces through an infected person sneezing or coughing directly on them and they can survive there for some time (10, 25). A smear infection to another person appears to be possible if the virus is transmitted shortly afterwards via the hands to the mucous membranes of the nose, eyes, mouth or throat. For protection against virus transmission via

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contaminated surfaces, it is important to comply with the general hygiene rules, such as washing hands regularly and keeping hands away from the face (10, 26).

Coronaviruses can generally reach bakery products or fruit and vegetables through an infected person sneezing or coughing directly on them. They cannot multiply in food as they need a living animal or human host to do this. A smear infection to another person then appears to be possible if the virus is transmitted shortly afterwards via the hands or the food itself to the mucous membranes of the nose or eyes. The BfR is not yet aware of any SARS-CoV-2 infections via consumption of meat products or contact with contaminated meat products. According to the current state of knowledge, farm animals used for meat production cannot be infected with SARS-CoV-2 and, therefore, cannot transmit the virus to humans via this pathway. However, contamination of meat or meat products with coronaviruses could happen during slaughter or during meat cutting and processing. Transmission of SARS-CoV-2 via milk, as for other foods, is unlikely on the basis of current knowledge. The BfR is not aware of any infections with SARS-CoV-2 via this transmission method. And there is no evidence that animal feed is a vehicle for coronaviruses (10).

So far there is no evidence of chains of infection for SARS-CoV-2 through food consumption, including frozen food. The previous coronaviruses SARS and MERS are resistant to cold and can remain infectious at minus 20°C for up to 2 years in a frozen state. According to a new study, SARS-CoV-2 also lost only little of its infectivity after 3 weeks on frozen meat. General rules of hygiene when preparing food should be observed (27).

The World Health Organization (WHO) warns that the hunting of shellfish, especially from water sources contaminated with viruses, should be prevented, hygienic drinking and potable water should be provided, sewage water should not be used in plant growing, sale and consumption of raw

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or undercooked contaminated shellfish should be avoided, cooking should be done at least at 90°C for 1.5 minutes, the patients and porter people working in food companies and having a great importance in transmission should be identified and treated, great importance should be given to personnel hygiene, effective cleaning and disinfection programs should be implemented in businesses, precise, fast and economical methods (PCR, Elisa, RIA, ..) should be used to detect viruses from food, and consumers should be informed frequently about food viral infections. The factors affecting the activity of viruses in foods such as heat inactivation, drying, irradiation, inactivation of viruses with chemicals are also important for safe food production (22).

Conclusion

There is still no study reporting that COVID-19 is transmitted via food. According to available epidemiological data, it is reported that this virus is not foodborne. But according to data of the CDC and European Centers for Disease Control (ECDC), it has been indicated that there is no evidence that foodstuffs imported from China will carry the risk of spreading COVID-19 to other countries (8). The WHO says it is "highly unlikely that people can contract Covid-19 from food or food packaging." According to the CDC, the risk of infection by the virus from food products, food packaging, or bags is "thought to be very low." (28).

Furthermore, it has been emphasized that generally all cooked foods are safe because active viruses become inactive after heat treatment, which makes food consumption safe, and that the consumption of raw or undercooked animal products should also be avoided (8). The measures taken to prevent bacterial contamination in order to prevent food infections via viral route may be insufficient, and different measures are required in this sense (28).

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Food industries should have Food Safety and Management Systems (FSMS) based on Hazard Analysis Critical Control Point (HACCP) principles in order to manage the risks related to food safety, in which all kinds of public health are taken as criteria even in our homes where food consumption is the most common way of processing, transporting, distributing, storing, selling food and even one of the ways to survive, and to prevent food contamination. Food industries are supported by FSMS, good hygiene practices, cleaning and sanitation, zoning of processing areas, supplier control, storage, distribution and transportation, personnel hygiene and job preconditioning, prerequisite programs that include all essential conditions and activities for hygienic care.

Food processing environments provide a solid basis for the implementation of key hygiene controls at every stage of the food processing, production and marketing chain to prevent food contamination with the Codex General Principles of Food Hygiene 2 (6).

In this sense, it is stated by the World Health Organization (WHO) that it will be influential to provide 5 conditions which are; 1. keeping the food clean, 2. separating raw and cooked food, 3. cooking food thoroughly (well penetrating inside), 4. keeping food stored at safe temperatures, 5. using safe water and raw ingredients so that foods are consumed more safely (29).

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Table 1. Viruses that are, or have the potential to be, transmitted via food and their site of infection in the human body.

Site of Infection	**Virus**
Neural tissue and nervous system	Enterovirus (EVs), Nipah virus, Poliovirus*, Parechovirus*, Tick-borne encephalitis virus*
Respiratory system	Highly Pathogenic Asian Avian Influenza A virus (HPAI-H5N1), SARS-CoV
Liver	Hepatitis A virus (HAV), Hepatitis E virus (HEV)
Intestinal system	Nörovirus (NoV), Human Rotavirus (HRV), Sapovirus (SAV), Human Astrovirus (HastVs), Adenovirus (Hadv), Aichi virus

* While these viruses have the potential to be transmitted via food they were not considered further by the WHO meeting (2008).

Table 2. Evaluation of potential foodborne viruses against the three pre-defined criteria to identify the viruses of main concern from a food safety perspective.

Clinical syndrome	**Priority group***	**Basis of priority ranking (based on current level of knowledge)**
Gastroenteritis		
Norovirus	1	High incidence, most common foodborne virus
Group A Rotavirus	1	Sometimes foodborne, severe infection in infants/children
Group B, C Rotavirus	2	
Enteric Adenovirus	2	
Sapovirus	2	
Astrovirus	2	
Aichi virus	2	
Hepatitis		
Hepatitis A	1	Sometimes foodborne, severe infection
Hepatitis E	1	Potential public health impact, emerging infection in developed countries, plausible foodborne transmission as potential foodborne zoonoses from pigs
Neurological infection		Bat virus, can cause emerging infections in pigs, humans,

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Enterovirus	2	
Nipah virus	1	foodborne transmission
Respiratory infection		
HPAI virus H5N1	1	Potential public health impact, emerging infection, plausible foodborne transmission but direct exposure to infected chickens main risk factor
SARS Coronavirus	1	Potential public health impact, emerging infection, foodborne transmission

NOTES: * Group 1 viruses met one or more of the pre-defined criteria. Group 2 viruses met none of the pre-defined criteria.

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Table 3. Viruses that may be foodborne transmitted

Virus	Genus	Family	Genome	Common Diseases	Transmissions
Human Norovirus	Norovirus	Caliciviridaes	sRNA	Gastroenteritis	Oral-fecal route, PtP contact, aerosol, FBO, WBO
Human Sapovirus	Sapovirus	Caliciviridaes	sRNA	Gastroenteritis	Oral-fecal route, PtP contact, aerosol, FBO, WBO
Aichivirus	Kobuvirus	Picornaviridaes	sRNA	Gastroenteritis	Oral-fecal route FBO, WBO
Human Astrovirus	Mamastrovirus	Astroviridaes	sRNA	Gastroenteritis	Oral-fecal route, PtP contact, aerosol, FBO
Echovirus	Enterovirus	Picornaviridaes	sRNA	Gastroenteritis meningitis,,her pangina, flaccid paralysis, cranial nerve disfunction encephalitis	Recreational waters WBO
Coxsackievirus	Enterovirus	Picornaviridaes	sRNA	Meningitis, herpangina flaccid paralysis, cranial nerve disfunction, pharyngitis, conjunctivitis	Recreational waters WBO
Hepatitis A virüs	Hepatovirus	Picornaviridaes	sRNA	Hepatitis	Oral-fecal route, PtP contact, FBO, WBO
Hepatitis E virus	Hepevirus	Hepeviridaes	sRNA	Hepatitis	Zoonotic, Oral-fecal route, FBO, WBO
Human Picorbirnavirus	Picorbirnavirus	Picobirnavirdae	dsRNA	Gastroenteritis	Recreational waters WBO
Human bocavirus	Bocavirus	Parvoviridaes	sDNA	Gastroenteritis	Respiratory droplets, Airborne,Oral-fecal route
Norovirus	Norovirus	Caliciviridaes	sRNA	Gastroenteritis	Oral-fecal route, PtP contact, aerosol, FBO, WBO
Sapovirus	Sapovirus	Caliciviridaes	sRNA	Gastroenteritis	Oral-fecal route, PtP contact, aerosol, FBO, WBO
Rotavirus	Rotavirus	Reoviridae	dsRNA	Gastroenteritis	Oral-fecal route, WBO

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Enteric - SARS coronavirus	Coronavirus	Coronaviridaes	sRNA	Pleomorphic Respiratory, Gastroenteritis	Respiratory Droplets, PtP contact,Oral-fecal route
Ebolavirus	Ebolavirus	Floviridae	ssRNA	Gastroenteritis Hemorrhagic fever	Blood or body fluids, Semen from a man who recovered from EVD, Objects, Infected fruit bats or nonhuman primates
Human Enteric Adenovirus	Mastadenovirus	Adenoviridae	dsRNA	Gastroenteritisfever, respiratory disease	Respiratory droplets, Oral-fecal route WBO
Human Parvovirus	Parvovirus	Parvoviridae	ssRNA	Gastroenteritis	Respiratory secretions, blood and blood products
Poliovirus	Enterovirus	Picornaviridaes	ssRNA	Gastroenteritis flaccid paralysis,fever	fecal-oral route, via salivary and respiratory droplets, and in some cases via conjunctival secretions and skin lesion exudates.
Nipahvirus	Henipavirus	Paramyxoviridae	ssRNA	Encephalitis, respiratory disease	Contaminated food or directly between people
Tick-borne Encephalitis virus	Ravivirus	Flaviridae	ssRNA	Encephalitis, Meningitis,	Woodland ticks, including *Ixodes scapularis*, *I. ricinus* and *I. persulcatus*,[9] or (rarely) through the non-pasteurized milk of infected cows
Human Coronovirus (SARS, MERS CoV)	Betacoronovirus	Coronoviridae	ssRNA	Respiratory disease, SARS, MERS, Gastroenteritis	Through contacting with stool, vomitus, urine, serum and cerebrospinal fluid
Avian Influenza virus	Influenzavirus	Ortomyxoviridae,	ssRNA	Influenza, Respiratory Disease	Intranasal or conjunctival inoculation while swimming in contaminated water or, inhalation or ingestion of wateR.

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Table 4 Persistence of human and animal coronaviruses on inanimate surfaces, food matrices and in water 171. (30, 31, 32, 33, 34, 35)

Virus	Surface	Time	Inoculumb (viral titer)	Conditions	References
SARS-CoV-2	Copper	4 h	10^5	21–23°C, 40%	(30)
SARS-CoV-2	Cardboard	24 h			
SARS-CoV-2	Stainless steel	48 h			
SARS-CoV-2	Plastic	72 h			
SARS-CoV-2	Nitrile glove	7 d	$7.5x10^5$	Room temperature	(31)
SARS-CoV-2	Chemical resistant glove	4 d			
SARS-CoV-2	N95 mask	21d			
SARS-CoV-2	N100 mask	21d			
SARS-CoV-2	Tyvek coverall	14d			
SARS-CoV-2	Plastic face shield	21d			
SARS-CoV-2	Cotton	24d			
SARS-CoV	Stainless steel	14d			
SARS-CoV	Plastic plate	5-13d	10^5	22–25°C, 40–50%	(32)
SARS-CoV	Polystyrene plate	9d	10^7	21–25°C	(33)
SARS-CoV	Metal	5d	10^5	Room temperature	(34)
SARS-CoV	Wood	4d			
SARS-CoV	Paper	4-5d			
SARS-CoV	Glass	4d			
SARS-CoV	Paper	24d	10^6	Room temperature	(35)
SARS-CoV		3d	10^5		
SARS-CoV		<5d	10^4		
SARS-CoV	Disposable gown	2d			
SARS-CoV		24h			
SARS-CoV		1h			
SARS-CoV	Cotton gown	24h			
SARS-CoV		1h			
SARS-CoV		5min			