Master Question List for COVID-19 (caused by SARS-CoV-2)

Weekly Report

12 March 2020

For comments or questions related to the contents of this document, please contact the DHS S&T Hazard Awareness & Characterization Technology Center at HACTechnologyCenter@hq.dhs.gov.
FOREWORD

The Department of Homeland Security (DHS) is paying close attention to the evolving Coronavirus Infectious Disease (COVID-19) situation in order to protect our nation. DHS is working very closely with the Centers for Disease Control and Prevention (CDC), other federal agencies, and public health officials to implement public health control measures related to travelers and materials crossing our borders from the affected regions.

Based on the response to a similar product generated in 2014 in response to the Ebolavirus outbreak in West Africa, the DHS Science and Technology Directorate (DHS S&T) developed the following “master question list” that quickly summarizes what is known, what additional information is needed, and who may be working to address such fundamental questions as, “What is the infectious dose?” and “How long does the virus persist in the environment?” The Master Question List (MQL) is intended to quickly present the current state of available information to government decision makers in the operational response to COVID-19 and allow structured and scientifically guided discussions across the federal government without burdening them with the need to review scientific reports, and to prevent duplication of efforts by highlighting and coordinating research.

The information contained in the following table has been assembled and evaluated by experts from publicly available sources to include reports and articles found in scientific and technical journals, selected sources on the internet, and various media reports. It is intended to serve as a “quick reference” tool and should not be regarded as comprehensive source of information, nor as necessarily representing the official policies, either expressed or implied, of the DHS or the U.S. Government. DHS does not endorse any products or commercial services mentioned in this document. All sources of the information provided are cited so that individual users of this document may independently evaluate the source of that information and its suitability for any particular use. This document is a “living document” that will be updated as needed when new information becomes available.

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### What do we know?

- The human infectious dose for novel Wuhan coronavirus (SARS-CoV-2), which causes coronavirus disease 19 (COVID-19) is currently unknown via all exposure routes. Severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) coronaviruses (CoV) are used as surrogates.
- The infectious dose for SARS in mice is estimated to be between 67-540 PFU (average 240 PFU, intranasal route).\(^{49,50}\)
- Genetically modified mice exposed intranasally to doses of MERS virus between 100 and 500,000 PFU show signs of infection. Infection with higher doses result in severe syndromes.\(^{54,56,73}\)
- Initial experiments suggest that SARS-CoV-2 can infect genetically modified mice containing the human ACE2 cell entry receptor. Infection via the intranasal route (dose: 10^6 TCID50) causes light infection, however no virus was isolated from infected animals, and PCR primers used in the study do not align well with SARS-CoV-2, casting doubt on this study.\(^{12}\)

### Infectious dose – how much agent will make a normal individual ill?

- The infectious dose for SARS-CoV-2 is unknown due to lack of animal models.
- SARS-CoV-2 is believed to spread through close contact and droplet transmission.\(^{16}\)
- SARS-CoV-2 replicates in the upper respiratory tract (e.g., throat), and infectious virus is detectable in throat and lung tissue for at least 8 days.\(^{124}\)
- Viable SARS-CoV-2 has been isolated from human feces;\(^{79}\) fecal-oral transmission is possible.\(^{75,123,125}\)
- Transmission via fomites has not been confirmed for SARS-CoV-2, but occurred in prior SARS\(^{11}\) and MERS\(^{7}\) outbreaks.
- SARS-CoV-2 is consistently present in infected patient saliva\(^{12}\)
- Infants have been diagnosed with COVID-19, but no evidence exists for vertical transmission via intrauterine infection or through breastmilk.\(^{17,118}\)
- China reports no evidence of super-spreading events (SSES) within hospital patients or staff.\(^{109}\)

### Transmissibility – How does it spread?

- The WHO considers COVID-19 a pandemic, with 124,564 cases and 4,589 deaths\(^{87}\) in at least 114 countries (as of 3/11/2020).\(^{23,131,122}\)
- High-quality estimates of human transmissibility (Rt) range from 2.2 to 3.\(^{124,126,91,97,128,136}\)
- There are 1,110 SARS-CoV-2 cases across 39 US states, with 30 deaths. (as of 3/11/2020)\(^{27}\); there is sustained community transmission of COVID-19 in the US.\(^{15}\)
- SARS-CoV-2 transmission has occurred in hospitals inside\(^{17}\) and outside of China,\(^{27}\) including the US.\(^{18}\)
- Pre-symptomatic\(^{138}\) or asymptomatic\(^{131}\) patients in China can transmit SARS-CoV-2.
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### Host range – how many species does it infect? Can it transfer from species to species?

- Early genomic analysis indicates similarity to SARS\(^{141}\); with a suggested bat origin.\(^{5,41,141}\)
- Analysis of SARS-CoV-2 genomes suggests that a non-bat intermediate species is responsible for the beginning of the outbreak.\(^{98}\)
- Although the identity of the intermediate species remains unconfirmed, pangolins may be a natural host of related viruses possibly including SARS-CoV-2.\(^{30-81}\)
- Positive samples from the South China Seafood Market strongly suggests a wildlife source,\(^{86}\) though it is possible that the virus was circulating in humans before the disease was associated with the seafood market.\(^{4,42,130,154}\)
- Experiments suggest that SARS-CoV-2 Spike (S) receptor-binding domain binds the human cell receptor (ACE2) stronger than SARS,\(^{127}\) potentially explaining its high transmissibility; the same work suggests that differences between SARS-CoV-2 and SARS-CoV Spike proteins may limit the therapeutic ability of SARS antibody treatments.\(^{127}\)
- Modeling between SARS-CoV-2 Spike and ACE2 proteins suggests that SARS-CoV-2 can bind and infect human, bat, civet, monkey and swine cells.\(^{116}\)

### Incubation period – how long after infection do symptoms appear? Are people infectious during this time?

- The best current estimate of the COVID-19 incubation period is 5.1 days, with 99% of individuals exhibiting symptoms within 14 days of exposure.\(^{72}\) Fewer than 2.5% of infected individuals show symptoms sooner than 2 days after exposure.\(^{72}\)
- The reported range of incubation periods is wide, with high-end estimates of 24,\(^{46}\) 11.3,\(^{10}\) and 18 days.\(^{78}\)
- Individuals can test positive for COVID-19 despite lacking clinical symptoms.\(^{71,32,56,109,138}\)
- Individuals can be infectious while asymptomatic,\(^{78,93,109,138}\) and asymptomatic individuals can have similar amounts of virus in their nose and throat as symptomatic individuals.\(^{142}\)
- Incubation period is unknown, but possibly up to 10-14 days.\(^{4,105}\)
- On average, there are 7.5 days between symptom onset in successive cases of a single transmission chain (i.e., the serial interval).\(^{78}\)
- Most individuals are admitted to the hospital within 8-14 days of symptom onset.\(^{140}\)
- Patients are positive for COVID-19 via PCR for 8-37 days after symptom onset.\(^{140}\)
- Individuals may test positive via PCR for 5-13 days after symptom recovery and hospital discharge,\(^{70}\) despite the absence of clinical symptoms. The ability of these “test-positive” individuals to infect others is unknown.
- According to the WHO, there is no evidence of re-infection with SARS-CoV-2 after recovery.\(^{71}\)
### What do we need to know?

**SARS-CoV-2 (COVID-19)**

- Human infectious dose by aerosol route
- Human infectious dose by surface contact (fomite)
- Human infectious dose by fecal-oral route
- Capability of SARS-CoV-2 to be transmitted by contact with fomites (doorknobs, surfaces, clothing, etc.)—see also Experimental Stability
- Superspreading capacity needs to be refined
- What is the extent of asymptomatic transmission?
- Updated person to person transmission rates (e.g., \( R_0 \)) as control measures take effect
- What is the underreporting rate?²⁶⁵
- Can individuals become re-infected with SARS-CoV-2?
- What is the difference in transmissibility among countries?
- Is the \( R_0 \) estimate higher in healthcare or long-term care facilities?
- How effective are social distancing measures at reducing spread?
- What is the intermediate host(s)?
- What are the mutations in SARS-CoV-2 that allowed human infection and transmission?
- What animals can SARS-CoV-2 infect (e.g., pet dogs, potential wildlife reservoirs)?
- How early does asymptomatic transmission begin?
- What is the average infectious period during which individuals can transmit the disease?
- Are individuals infectious after hospital discharge and clinical recovery, or are positive PCR tests only detecting non-infectious virus?
- Can individuals become re-infected after recovery? If so, how long after?²⁶⁶

### Who is doing experiments/has capabilities in this area?

**Capable of performing work**

- DHS National Biodefense Analysis and Countermeasures Center (NBACC)
- Christian Althaus (Bern)
- Neil Ferguson (MRC)
- Gabriel Leung, Joseph Wu (University of Hong Kong)
- Sara Del Valle (Los Alamos)
- Maimuna Majumder (Boston Children’s Hospital)
- Trevor Bedford (Fred Hutchinson Cancer Center)
- Sang Woo Park (Princeton)

**Performing work**

- Vincent Munster (Rocky Mountain National Laboratory)
- Matthew Frieman (University of Maryland Baltimore)
- Ralph Baric (University of North Carolina)
- Stanley Perlman (University of Iowa)
- Susan Baker (Loyola University Chicago)
- Mark Denison (Vanderbilt University)
- Vineet Menachery (University of Texas Medical Branch)
- Jason McLellan, Daniel Wrapp, Nianshuang Wang (University of Texas)
- David O’Conner (U. Wisconsin, Madison)

**Performing work**

- Chaolin Huang (Jin Yin-tan Hospital, Wuhan, China)
- The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team

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### SARS-CoV-2 (COVID-19) – What do we know?

<table>
<thead>
<tr>
<th>Required Information for Effective Infectious Disease Outbreak Response</th>
<th>SARS-CoV-2 (COVID-19)</th>
<th>Updated 3/11/2020</th>
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</thead>
<tbody>
<tr>
<td><strong>Clinical presentation – what are the signs and symptoms of an infected person?</strong></td>
<td>• The majority of COVID-19 cases are mild (81%, N = 44,000 cases)(^2).(^8)</td>
<td>• SARS-CoV-2 can persist on plastic and stainless steel surfaces for up to 3 days (at 21-23°C, 40% RH), with a half-life of 13-16 hours.(^1)(^{13})</td>
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<td>• Initial COVID-19 symptoms include fever (87.9% overall, but only 43.8% present with fever initially)(^1), cough (67.7%)(^4), fatigue, shortness of breath, headache, reduction in lymphocyte count, 29, 35, 63 Headache(^4) and diarrhea are uncommon(^3), (^7)</td>
<td>• SARS-CoV-2 has an aerosol half-life of 2.7 hours (particles &lt;5 μm, tested at 21-23°C and 65% RH).(^1)(^{13})</td>
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<td>• Complications include acute respiratory distress syndrome (ARDS) observed in 17-29% of hospitalized patients,(^4), (^6), (^7) which leads to death in 4-15% of cases.(^3), (^6), (^11)</td>
<td>Surrogate Coronavirus data:</td>
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<td>• Other complications include pneumonia,(^8) cardiac injury, secondary infection, kidney failure, arrhythmia, sepsis, and shock, 56,65,117, (^140)</td>
<td>• Studies suggest that other coronaviruses can survive on nonporous surfaces up to 9-10 days (MHV, SARS-CoV)(^7), (^3), and porous surfaces for up to 3-5 days (SARS-CoV)(^9) in air conditioned environments (20-25°C, 40-50% RH)</td>
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<td>• Most deaths are caused by respiratory failure or respiratory failure combined with myocardial (heart) damage.(^1)(^{10})</td>
<td>• Coronavirus survival tends to be higher at lower temperatures and lower relative humidity (RH),(^2), (^3), (^9), (^4), (^15) even though infectious virus can persist on surfaces for several days in typical office or hospital conditions(^14)</td>
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<td>• Approximately 15% of hospitalized patients were classified as severe,(^5), (^10) and approximately 5% of patients were admitted to the ICU(^5), (^10)</td>
<td>• SARS can persist with trace infectivity for up to 28 days at refrigerated temperatures (4°C) on surfaces.(^2)</td>
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<td>• Between 23-32% of cases that include pneumonia required intensive respiratory support.(^6), (^17)</td>
<td>• Beta-coronaviruses (e.g., SARS-CoV) may be more stable than alpha-coronaviruses (HCoV-229E).(^9)</td>
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<td>• The case fatality rate (CFR) depends on patient comorbidities; cardiovascular disease, hypertension, diabetes, and respiratory conditions all increase the CFR.(^10), (^14)</td>
<td>• No strong evidence for reduction in transmission with seasonal increase in temperature and humidity.(^8)</td>
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<td>• The CFR increases with age; individuals older than 60 are at higher risk of death,(^10), (^14) and &gt;60% of confirmed fatalities have been male.(^10)</td>
<td>• One hour after aerosolization approximately 63% of airborne MERS virus remained viable in a simulated office environment (25°C, 75% RH)(^9)</td>
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<td>• Approximately 1% of hospitalizations occur in children &lt; 19 years old.(^5), (^10)</td>
<td>• The aerosol survival of related human coronavirus (229E) was relatively high, (half-life of ~67 hours at 20°C and 50% RH), indicating ~20% of infectious virus remained after 6 days.(^6) Both higher and lower RH reduced HCoV-229E survival; lower temperatures improved survival.(^5)</td>
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<td>• Children appear susceptible to SARS-CoV-2, but show milder clinical symptoms than adults.(^5)</td>
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<td>• Recovery occurs in ~22 days, while death occurs in ~18 days.(^1)(^{10})</td>
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<td><strong>Clinical diagnosis – are there tools to diagnose infected individuals? When during infection are they effective?</strong></td>
<td>• Updated tests from the US CDC are available to states.(^2), (^28)</td>
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<td>• The FDA released an Emergency Use Authorization enabling laboratories to develop and use tests in-house for patient diagnosis.(^5)</td>
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<td>• US CDC has expanded patient testing criteria to include symptomatic patients at clinician discretion.(^14)</td>
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<td>• SARS-CoV-2 is consistently present in infected patient saliva, suggesting that saliva may be an effective diagnostic specimen.(^11)</td>
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<td>• Several RT-PCR assays have been developed to detect SARS-CoV-2 in humans.(^1), (^4), (^5), (^12), (^13)</td>
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<td>• PCR protocols and primers have been widely shared among international researchers.(^2), (^22), (^46), (^78), (^106), (^119), (^123)</td>
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<td>• Several rapid or real-time test kits have been produced by universities and industry, including the Wuhan Institute of Virology,(^4), BGI,(^4) and Cepheid.(^13)</td>
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<td>• RT-PCR tests are able to identify asymptomatic cases; SARS-CoV-2 infection was identified in 2/114 individuals previously cleared by clinical assessment.(^8)</td>
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<td>• A combination of pharyngeal (throat) RT-PCR and chest tomography are the most effective diagnostic criteria (correctly diagnosing 91.9% of infections).(^9) Single throat swabs alone detect 78.2% of true infections, while duplicate tests identify 86.2% of infections.(^9)</td>
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<td>• The US CDC is developing serological tests to determine what proportion of the population has been exposed to SARS-CoV-2.(^8)</td>
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<td>• Machine learning tools are being developed to predict severe and fatal COVID-19 cases based on CT scans.(^10)</td>
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<td>• The efficacy of antivirals (lopinavir, ritonavir, ribavirin, oseltamivir) is unknown; however several therapeutics [Remdesivir(^10) and chloroquine(^10)] inhibit SARS-CoV-2 infection in human cells in vitro(^7) and are undergoing clinical trials in China(^4) and the US.(^3), (^8), (^7)</td>
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<td>• Multiple entities are working to produce a SARS-CoV-2 vaccine, including NIH/NIAD,(^10), (^75) Moderna Therapeutics and Gilead Sciences,(^7), (^8), (^7) and Sanofi with HHS.(^19)</td>
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<td>• The hospitalized case-fatality rate in China has decreased from 14.4% to 0.8% as of between December, 2019 and February, 2020,(^10) suggesting improved treatment or capacity.</td>
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<td>• Approximately 38% of COVID-19 patients in China received oxygen therapy. 6.1% received mechanical ventilation, 57.5% received IV antibiotics, and 35.8% received the antiviral oseltamivir.(^9)</td>
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<td>• A clinical report (one patient) suggested that corticosteroids should be considered for severe patients to prevent ARDS,(^13) and corticosteroids are given to approximately 30% of COVID-19 patients.(^14) However, US CDC recommends avoiding steroid use due to an increase in viral replication in MERS patients.(^7)</td>
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<td>• Similarity in the spike proteins of SARS-CoV-2 and SARS-CoV might offer target for therapeutics.(^13), (^51), (^74), (^127), (^141) as vaccines derived from spike proteins are effective at inhibiting MERS symptoms in mice.(^4)</td>
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<td>• Takeda Pharma (Japan) is working to create antibody treatments based on infected patient plasma.(^13)</td>
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<td>• Over 80 clinical trials are set to run on various treatments in China.(^4)</td>
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<tr>
<td><strong>What do we need to know?</strong></td>
<td>• How long does it take for infected individuals to recover outside of a healthcare setting?</td>
<td>• False positive/negative rates for tests</td>
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<td>• How does the CFR vary between countries?</td>
<td>• Eclipse phase of infection (time between infection and detectable disease) in an individual</td>
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<td>• Is the reduction in CFR through time an indication of better treatment, less overcrowding, or both?</td>
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<td><strong>Who is doing experiments/has capabilities in this area?</strong></td>
<td>- Jin Yin-tan Hospital, Wuhan, China</td>
<td>Performing work:</td>
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<td>- China-Japan Friendship Hospital, Beijing, China</td>
<td>- CDC</td>
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<td>- Peking Union Medical College, Beijing, China</td>
<td>- Wuhan Institute of Virology</td>
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<td>- Capital Medical University, Beijing, China</td>
<td>- Public Health Agency of Canada</td>
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<td>- Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China</td>
<td>- Doherty Institute of Australia</td>
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<td>- Huazhong University of Science and Technology, Wuhan, China</td>
<td>- Cepheid</td>
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<td>- The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China</td>
<td>- BGI</td>
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<td>- Tsinghua University School of Medicine, Beijing, China</td>
<td>- Fudan University</td>
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<td>- Zhongnan Hospital of Wuhan University, Wuhan, China</td>
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<td>- Peking University First Hospital, Beijing, China</td>
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<td>- Tsinghua University-Peking University Joint Center for Life Sciences, Beijing, China</td>
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<td>- The Fifth Medical Center of PLA General Hospital, Beijing, China</td>
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### REQUIRED INFORMATION FOR EFFECTIVE INFECTIOUS DISEASE OUTBREAK RESPONSE

#### SARS-CoV-2 (COVID-19)

**What do we know?**

- No decontamination data for SARS-CoV-2 have been identified. SARS-CoV provides a plausible surrogate, as it is a close genetic relative of SARS-CoV-2 in the beta-coronavirus clade.
- EPA has released a list of SARS-CoV-2 disinfectants, but solutions were not tested on live virus.¹
- Chlorine-based¹¹¹ and ethanol-based¹ solutions recommended, and the European CDC has released disinfectant guidelines for non-healthcare facilities.²
- Heat treatment at 56°C is sufficient to kill coronaviruses,³⁴ though effectiveness depends in part on amount of protein in contaminated media.⁴
- 70% ethanol, 50% isopropanol, sodium hypochlorite ([bleach], 200 ppm), and UV radiation are effective at inactivating several coronaviruses (MHV and CCV)¹⁰¹.
- Ethanol-based biocides are effective disinfectants against coronaviruses dried on surfaces, including ethanol containing gels similar to hand sanitizer.⁵⁶,¹¹¹
- Surface spray disinfectants such as Mikrobac, Dismazon, and Korsolex are effective at reducing infectivity of the closely related SARS-CoV after 30 minutes of contact.⁹³
- Coronaviruses may be resistant to thermal inactivation for up to 7 days when stabilized in stool.¹¹⁰-¹¹¹
- Additionally, coronaviruses are more stable in matrices such as respiratory sputum.⁸²
- Twice-daily cleaning with sodium dichloroisocyanurate decontaminated surfaces in COVID-19 patient hospital rooms.⁸⁸

#### Decontamination – what are effective methods to kill the agent in the environment?

- PPE effectiveness for SARS-CoV-2 is currently unknown; SARS is used as a surrogate.
- US CDC does not recommend the use of facemasks for healthy people. Facemasks should be used by people showing symptoms to reduce the risk of others getting infected. The use of facemasks is crucial for health workers and people in close contact with infected patients [at home or in a health care facility].²⁴
- “Healthcare personnel entering the room [of SARS-CoV-2 patients] should use standard precautions, contact precautions, airborne precautions, and use eye protection (e.g., goggles or a face shield)”²⁷
- WHO indicates healthcare workers should wear non-sterile, long-sleeve gowns as well as gloves.¹²⁸
- Respirators (NIOSH-certified N95, EUPP2 or equivalent) are recommended for those dealing with possible aerosols.¹²¹
- Additional protection, such as a Powered Air Purifying Respirator (PAPR) with a full hood, should be considered for high-risk procedures (i.e., intubation, ventilation).³⁸
- Healthcare worker illnesses (over 1,000²⁹) demonstrates human-to-human transmission despite isolation, PPE, and infection control.¹⁰²
- Porous hospital materials, including paper and cotton cloth, maintain infectious SARS-CoV for a shorter time than non-porous material.⁹⁰
- CDC recommends facemasks for individuals attempting to prevent spread of SARS-CoV-2 in the home.⁹⁸
- Despite extensive environmental contamination, air sampling in patient rooms did not detect SARS-CoV-2.⁸⁸

#### PPE – what PPE is effective, and who should be using it?

- Genomic analysis places SARS-CoV-2 into the beta-coronavirus clade, with close relationship to bat viruses. The SARS-CoV-2 virus is distinct from SARS and MERS viruses.⁵¹
- Genomic analysis suggests that SARS-CoV-2 is a natural variant, and is therefore unlikely to be human-derived or otherwise created by “recombination” with other circulating strains of coronavirus.⁷,¹⁴¹
- Some genomic evidence indicates a close relationship with pangolin coronaviruses¹²⁶; data suggests that pangolins may be a natural host for beta-coronaviruses.⁸⁰-⁸¹. Additional research is needed.
- Genomic data support at least two plausible origins of SARS-CoV-2: “(i) natural selection in a non-human animal host prior to zoonotic transfer, and (ii) natural selection in humans following zoonotic transfer.” Either scenario is consistent with the observed genetic changes found in all known SARS-CoV-2 isolates.
- Additionally, “[... SARS-CoV-2 is not derived from any previously used virus backbone,” reducing the likelihood of laboratory origination,” and “[...] genomic evidence does not support the idea that SARS-CoV-2 is a laboratory construct, [though] it is currently impossible to prove or disprove the other theories of its origin.”⁹⁹

#### Forensics – natural vs intentional use?

- There have been no documented cases of SARS-CoV-2 prior to December 2019.
- Preliminary genomic analyses, however, suggest that the first human cases of SARS-CoV-2 emerged between 10/19/2019 – 12/17/2019.³,⁸,⁹⁵
- The mutation rate of SARS-CoV-2 is estimated to be similar to other RNA viruses (e.g., SARS, Ebola, Zika), and is currently calculated to be between 3.29 x 10⁻⁴ – 2.03 x 10⁻³ substitutions per site per year (median 1.07 x 10⁻³),⁸ though this estimate may change as more genomes are sequenced.
- Preliminary phylogenetic analysis identified a very close genetic similarity between SARS-CoV-2 and a Bat coronavirus (RaTG13) isolated from Yunnan Province, China; suggesting that SARS-CoV-2 originated from bats.⁹⁰
- Pangolin coronaviruses are closely related to both SARS-CoV-2 and the closely related Bat coronavirus (RaTG13); phylogenetic analysis suggested that SARS-CoV-2 is of bat origin, but is closely related to pangolin coronavirus.⁹⁰-⁸¹
- The Spike protein of SARS-CoV-2, which mediates entry into host cells and is the major determinant of host range, is similar to the Spike protein of SARS-CoV.⁸² The rest of the genome is more closely related to two separate bat origins and pangolin⁸³ coronavirus.
- Protein modeling and preliminary laboratory studies suggest that SARS-CoV-2 binds to the human ACE2 receptor,⁸⁶,¹⁰⁷ the same cellular entry receptor used by SARS and other beta-coronaviruses.
### What do we need to know?

<table>
<thead>
<tr>
<th>SARS-CoV-2 (COVID-19)</th>
<th>Decontamination – what are effective methods to kill the agent in the environment?</th>
<th>PPE – what PPE is effective, and who should be using it?</th>
<th>Forensics – natural vs intentional use? Tests to be used for attribution.</th>
<th>Genomics – how does the disease agent compare to previous strains?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who is doing experiments/has capabilities in this area?</strong></td>
<td>• What is the minimal contact time for disinfectants?</td>
<td>• Mode of aerosol transmission? Effective distance of spread via droplet or aerosol?</td>
<td>• What tests for attribution exist for coronavirus emergence?</td>
<td>• Are there similar genomic differences in the progression of coronavirus strains from bat to intermediate species to human?</td>
</tr>
<tr>
<td></td>
<td>• Are antiseptic wipes effective for cleaning hard, non-porous surfaces?</td>
<td>• How effective are barriers such as N95 respirators or surgical masks?</td>
<td>• What is the identity of the intermediate species?</td>
<td>• Are there different strains or clades of circulating virus? If so, do they differ in virulence?</td>
</tr>
<tr>
<td></td>
<td>• Does contamination with human fluids/waste alter disinfectant efficacy profiles?</td>
<td>• What is the appropriate PPE for first responders? Airport screeners?</td>
<td>• Are there closely related circulating coronaviruses in bats or other animals with the novel PRRA cleavage site found in SARS-CoV-2?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• How effective is air filtration at reducing transmission in healthcare, airplanes and public spaces?</td>
<td>• Proper procedures for reducing spread in medical facilities / transmission rate in medical settings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Who is doing experiments/has capabilities in this area?**

- DHS National Biodefense Analysis and Countermeasures Center (NBACC)
- Generating recommendations:
  - WHO
  - CDC
  - Pan-American Health Organization
- Performing genomic investigations:
  - Kristian Andersen, Andrew Rambaut, Ian Lipkin, Edward Holmes, Robert Garry (Scripps, University of Edinburgh, Columbia University, University of Sydney, Tulane, Zalgen Labs [Germantown, MD])
  - Pacific Northwest National Laboratory
  - DHS National Biodefense Analysis and Countermeasures Center (NBACC)
- Performing work:
  - Trevor Bedford (Fred Hutchinson Cancer Research Center)
  - Ralph Baric, UNC
  - National Institute for Viral Disease Control and Prevention, Chinese Center for Disease Control and Prevention
  - Shandong First Medical University and Shandong Academy of Medical Sciences
  - Hubei Provincial Center for Disease Control and Prevention
  - Chinese Academy of Sciences
  - BGI PathoGenesis Pharmaceutical Technology, Shenzhen, China
  - People’s Liberation Army General Hospital, Wuhan, China
  - Wenzhou Medical University, Wenzhou, China
  - University of Sydney, Sydney, NSW, Australia
  - The First Affiliated Hospital of Shandong First Medical University (Shandong Provincial Qianfoshan Hospital), Jinan, China
**REQUIRED INFORMATION FOR EFFECTIVE INFECTIOUS DISEASE OUTBREAK RESPONSE**  
**SARS-CoV-2 (COVID-19)**  
Updated 3/11/2020

**Table 1. Definitions of commonly-used acronyms**

<table>
<thead>
<tr>
<th>Acronym/Term</th>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SARS-CoV-2</td>
<td>Severe acute respiratory syndrome coronavirus 2</td>
<td>Official name for the virus previously known as 2019-nCoV.</td>
</tr>
<tr>
<td>COVID-19</td>
<td>Coronavirus disease 19</td>
<td>Official name for the disease caused by the SARS-CoV-2 virus.</td>
</tr>
<tr>
<td>CFR</td>
<td>Case Fatality Rate</td>
<td>Number of deaths divided by confirmed patients</td>
</tr>
<tr>
<td>PFU</td>
<td>Plaque forming unit</td>
<td>Measurement of the number of infectious virus particles as determined by plaque forming assay. A measurement of sample infectivity.</td>
</tr>
<tr>
<td>TCID&lt;sub&gt;50&lt;/sub&gt;</td>
<td>50% Tissue Culture Infectious Dose</td>
<td>The number of infectious units which will infect 50% of tissue culture monolayers. A measurement of sample infectivity.</td>
</tr>
<tr>
<td>HCW</td>
<td>Healthcare worker</td>
<td>Doctors, nurses, technicians dealing with patients or samples</td>
</tr>
<tr>
<td>SARS</td>
<td>Severe Acute Respiratory Syndrome</td>
<td>Coronavirus with over 8,000 cases in global 2002-2003 outbreak</td>
</tr>
<tr>
<td>MERS</td>
<td>Middle-East Respiratory Syndrome</td>
<td>Coronavirus with over 2,000 cases in regional outbreak since 2012</td>
</tr>
<tr>
<td>CoV</td>
<td>Coronavirus</td>
<td>Virus typified by crown-like structures when viewed under electron microscope</td>
</tr>
<tr>
<td>R&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Basic reproduction number</td>
<td>A measure of transmissibility. Specifically, the average number of new infections caused by a typical infectious individual in a wholly susceptible population.</td>
</tr>
<tr>
<td>MHV</td>
<td>Mouse hepatitis virus</td>
<td>Coronavirus surrogate</td>
</tr>
<tr>
<td>CCV</td>
<td>Canine coronavirus</td>
<td>Canine coronavirus</td>
</tr>
<tr>
<td>Fomite</td>
<td>Inanimate vector of disease</td>
<td>Surfaces such as hospital beds, doorknobs, healthcare worker gowns, faucets, etc.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Transmission Type</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Droplet transmission</td>
<td>Sneezing, coughing</td>
<td>Transmission via droplets requires relatively close contact (e.g., within 6 feet)</td>
</tr>
<tr>
<td>Airborne transmission</td>
<td>Aerosolization of infectious particles</td>
<td>Aerosolized particles can spread for long distances (e.g., between hospital rooms via HVAC systems)</td>
</tr>
<tr>
<td>Transgenic</td>
<td>Genetically modified</td>
<td>In this case, animal models modified to be more susceptible to MERS and/or SARS by adding proteins or receptors necessary for infection</td>
</tr>
<tr>
<td>Intranasal</td>
<td>Agent deposited into external nares of subject</td>
<td>Simulates inhalation exposure by depositing liquid solution of pathogen/virus into the nose of a test animal, where it is then taken up by the respiratory system.</td>
</tr>
<tr>
<td>Incubation period</td>
<td>Time between infection and symptom onset</td>
<td>Time between infection and onset of symptoms typically establishes guidelines for isolating patients before transmission is possible</td>
</tr>
<tr>
<td>Infectious period</td>
<td>Length of time an individual can transmit infection to others</td>
<td>Reducing the infectious period is a key method of reducing overall transmission; hospitalization, isolation, and quarantine are all effective methods</td>
</tr>
<tr>
<td>Serial interval</td>
<td>Length of time between symptom onset of successive cases in a transmission chain</td>
<td>The serial interval can be used to estimate R₀, and is useful for estimating the rate of outbreak spread</td>
</tr>
<tr>
<td>Superspreading</td>
<td>One individual responsible for an abnormally large number of secondary infections</td>
<td>Superspreading can be caused by high variance in the distribution of secondary cases caused by a single individual; most individuals infect very few people, while some infect a large number, even with the same average number of secondary infections</td>
</tr>
<tr>
<td>Nosocomial</td>
<td>Healthcare- or hospital-associated infections</td>
<td>Characteristic of SARS and MERS outbreaks, lead to refinement of infection control procedures</td>
</tr>
<tr>
<td>ACE2</td>
<td>Angiotensin-converting enzyme 2</td>
<td>Acts as a receptor for SARS-CoV, allowing entry into human cells</td>
</tr>
</tbody>
</table>
### ARDS
- **Acute respiratory distress syndrome**
- Leakage of fluid into the lungs which inhibits respiration and leads to death

### PPE
- **Personal protective equipment**
- Gowns, masks, gloves, and any other measures used to prevent spread between individuals

### PCR
- **Polymerase chain reaction**
- PCR (or real-time [RT] or quantitative [Q] PCR) is a method of increasing the amount of genetic material in a sample, which is then used for diagnostic testing to confirm the presence of SARS-CoV-2
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