DHS SCIENCE AND TECHNOLOGY

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

Weekly Report

18 March 2020

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Homeland Security

Science and Technology

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.

SARS-CoV-2 (COVID-19)	Infectious dose – how much agent will make a normal individual ill?	Transmissibility – How does it spread from one host to another? How easily is it spread?	Host range – how many species does it infect? Can it transfer from species to species?	Incubation period – how long after infection do symptoms appear? Are people infectious during this time?
What do we know?	• The human infectious dose of SARS-CoV-2, which causes coronavirus disease 19 (COVID-19) is currently unknown via all exposure routes. Animal data are used as surrogates. • Rhesus macaques are infected with SARS-CoV-2 via the ocular conjunctival and intratracheal route at a dose of 700,000 PFU (10^6 $TCID_{50}$).[51] • A total dose of 700,000 plaque-forming units (PFU) of SARS-CoV-2 infected cynomolgus macaques via a combination intranasal and intratracheal exposure (10^6 $TCID_{50}$ total dose).[109] Macaques did not exhibit clinical symptoms, but shed virus through the nose and throat.[109] • Nonhuman primate infection may not represent human infection. • 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: 10^5 $TCID_{50}$, approximately 70,000 PFU) causes light infection, however no virus was isolated from infected animals, and polymerase chain reaction (PCR) primers used in the study do not align well with SARS-CoV-2, casting doubt on this study.[14] • 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.[7, 41, 81, 150]	• Pandemic COVID-19 has caused 214,894 infections and 8,732 deaths[72] in at least 173 countries and territories (as of 3/18/2020).[27, 114, 135] • There are 7,769 SARS-CoV-2 cases across 50 US states, with 118 deaths. (as of 3/18/2020)[72]; there is sustained community transmission of COVID-19 in the US.[17] • High-quality estimates of human transmissibility (R_0) range from 2.2 to 3.1[93, 98, 106, 142, 149] Early estimates of the attack rate in China range from 3%-10%, mainly in households.[137] • SARS-CoV-2 is believed to spread through close contact and droplet transmission,[31] with fomite transmission[73], i.e., germs left on surfaces, and close-contact aerosol transmission also plausible.[22] • 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.[138] • Pre-symptomatic[151] or asymptomatic[12] patients can transmit SARS-CoV-2; between 12%[54] and 23%[90] of infections may be caused by asymptomatic or pre-symptomatic transmission. • SARS-CoV-2 is present in infected patient saliva,[124] lower respiratory sputum,[131] and feces. [86] • Social distancing and behavioral changes are estimated to have reduced COVID-19 spread by 44% in Hong Kong,[47] and a combination of non-pharmaceutical interventions (e.g., school closures, isolation) are likely required to limit transmission.[59] • Up to 86% of early COVID-19 cases in China were undiagnosed, and these infections were the source for 79% of documented cases.[84]	• Early genomic analysis indicates similarity to SARS,[154] with a suggested bat origin.[5,42, 154] • Analysis of SARS-CoV-2 genomes suggests that a non-bat intermediate species is responsible for the beginning of the outbreak.[108] The identity of the intermediate host remains unknown.[85, 87-88] • Positive samples from the South China Seafood Market strongly suggests a wildlife source,[33] though it is possible that the virus was circulating in humans before the disease was associated with the seafood market.[18, 43, 144, 148] • Experiments suggest that SARS-CoV-2 Spike (S) receptor-binding domain binds the human cell receptor (ACE2) stronger than SARS,[141] 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.[141] • 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.[129] • There is currently no experimental evidence that SARS-CoV-2 infects domestic animals or livestock, though it is expected that some animal species could be infected.	• 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.[79] Fewer than 2.5% of infected individuals show symptoms sooner than 2 days after exposure.[79] • The reported range of incubation periods is wide, with high-end estimates of 24,[60] 11.3,[11] and 18 days.[83] • Individuals can test positive for COVID-19 despite lacking clinical symptoms.[12, 35, 60, 120, 151] • Individuals can be infectious while asymptomatic,[31, 110, 120, 151] and asymptomatic individuals can have similar amounts of virus in their nose and throat as symptomatic individuals.[155] • Infectious period is unknown, but possibly up to 10-14 days [5, 84, 114] • On average, there are approximately 4[54] to 7.5[83] days between symptom onset in successive cases of a single transmission chain. • Most individuals are admitted to the hospital within 8-14 days of symptom onset.[153] • Patients are positive for COVID-19 via PCR for 8-37 days after symptom onset.[153] • Individuals may test positive via PCR for 5-13 days after symptom recovery and hospital discharge.[77] The ability of these individuals to infect others is unknown. • According to the WHO, there is no evidence of re-infection with SARS-CoV-2 after recovery.[78] • Experimentally infected macaques were not capable of being reinfected after their primary infection resolved.[13]

SARS-CoV-2 (COVID-19)	**Infectious dose – how much agent will make a normal individual ill?**	**Transmissibility – How does it spread from one host to another? How easily is it spread?**	**Host range – how many species does it infect? Can it transfer from species to species?**	**Incubation period – how long after infection do symptoms appear? Are people infectious during this time?**
What do we need to know?	• 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 • Updated person to person transmission rates (e.g., R_0) as control measures take effect • What is the underreporting rate?[71] • Can individuals become re-infected with SARS-CoV-2? • What is the difference in transmissibility among countries? • Is the R0 estimate higher in healthcare or long-term care facilities?	• 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)?	• 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?
Who is doing experiments/has capabilities in this area?	*Capable of performing work* - DHS National Biodefense Analysis and Countermeasures Center (NBACC)	*Performing work:* - 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)	*Capable of 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

SARS-CoV-2 (COVID-19)	Clinical presentation – what are the signs and symptoms of an infected person?	Clinical diagnosis – are there tools to diagnose infected individuals? When during infection are they effective?	Medical treatment – are there effective treatments? Vaccines?	Environmental stability – how long does the agent live in the environment?
What do we know?	• The majority of COVID-19 cases are mild (81%, N = 44,000 cases)[120] • Initial COVID-19 symptoms include fever (87.9% overall, but only 43.8% present with fever initially[60]), cough (67.7%[60]), fatigue, shortness of breath, headache, reduction in lymphocyte count.[32, 38, 68] Headache[37] and diarrhea are uncommon[68, 82] • Complications include acute respiratory distress (ARDS observed in 17-29% of hospitalized patients,[40, 67] which leads to death in 4-15% of cases[40, 68, 130]), pneumonia,[96] cardiac injury, secondary infection, kidney failure, arrhythmia, sepsis, and shock.[60,68,130, 153] • Approximately 15% of hospitalized patients were classified as severe,[60, 120] and approximately 5% of patients were admitted to the ICU.[60, 120] • Most deaths are caused by respiratory failure or respiratory failure combined with myocardial (heart) damage.[111] • The case fatality rate (CFR) depends on comorbidities; cardiovascular disease, hypertension, diabetes, and respiratory conditions all increase the CFR.[120, 153] • The CFR increases with age; individuals older than 60 are at higher risk of death,[120, 153] and >60% of confirmed fatalities have been male.[120] • Children of all ages are susceptible to COVID-19,[53] though generally present with milder symptoms.[39] Severe symptoms in children, however, are possible.[89] • In the US, 34% of hospitalizations have been individuals less than 44 years old.[4] Based on one patient, a productive immune response is generated and sustained for at least 7 days.[121]	• PCR protocols and primers have been widely shared among international researchers[26, 45, 83, 116, 132, 136] though PCR-based diagnostic assays do not differentiate between active and inactive virus. • A combination of pharyngeal (throat) RT-PCR and chest tomography are the most effective diagnostic criteria (correctly diagnosing 91.9% of infections).[104] Single throat swabs alone detect 78.2% of true infections, while duplicate tests identify 86.2% of infections.[104] • Nasal and pharyngeal swabs may be less effective as diagnostic specimens than sputum and bronchoalveolar lavage fluid.[131] • RT-PCR tests are able to identify asymptomatic cases; SARS-CoV-2 infection was identified in 2/114 individuals previously cleared by clinical assessment.[66] • The FDA released an Emergency Use Authorization enabling laboratories to develop and use tests in-house for patient diagnosis.[58] • Updated tests from the US CDC are available to states.[26, 31] • US CDC has expanded patient testing criteria to include symptomatic patients at clinician discretion.[16] • Several rapid or real-time test kits have been produced by universities and industry, including the Wuhan Institute of Virology,[48] BGI,[19] and Cepheid.[128] • The US CDC is developing serological tests to determine what proportion of the population has been exposed to SARS-CoV-2.[74] • Machine learning tools are being developed to predict severe and fatal COVID-19 cases based on CT scans.[117]	• Treatment for COVID-19 is primarily supportive care, including mechanical ventilation and antibiotics to prevent secondary infection as appropriate.[60] • Preliminary reports from two clinical trials in China suggest that favipiravir improves lung function and reduces recovery time in COVID-19 patients.[126] • Early results suggest that tocilizumab may be effective at treating severe COVID-19 cases.[145] • Press reports of a small clinical trial suggest that chloroquine is effective at reducing symptom duration.[1] • Combination lopinavir and ritonavir with standard care was no more effective than standard care alone.[24] • Corticosteroids are commonly given to COVID-19 patients[153] at risk of ARDS,[146] but their use is not recommended by the US CDC.[29] • Multiple entities are working to produce a SARS-CoV-2 vaccine,[8] including NIH/NIAID,[63, 80] Moderna Therapeutics and Gilead Sciences,[2-3, 94] and Sanofi with HHS.[21] Moderna has begun phase 1 clinical vaccine trials in humans in WA state.[107] • Regeneron Pharmaceuticals has developed potential SARS-CoV-2 antibody therapies.[99] • The development of a coronavirus fusion inhibitor in the lab suggests efficacy across multiple human coronaviruses.[143] • Takeda Pharma (Japan) is working to create antibody treatments based on infected patient plasma.[62]	*SARS-CoV-2 Data* • 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.[125] • SARS-CoV-2 has an aerosol half-life of 2.7 hours (particles <5 µm, tested at 21-23°C and 65% RH).[125] *Surrogate Coronavirus data*: • Studies suggest that other coronaviruses can survive on non-porous surfaces up to 9-10 days (MHV, SARS-CoV)[25, 36], and porous surfaces for up to 3-5 days (SARS-CoV)[56] in air conditioned environments (20-25°C, 40-50% RH) • Coronavirus survival tends to be higher at lower temperatures and lower relative humidity (RH),[25, 36, 102, 127] though infectious virus can persist on surfaces for several days in typical office or hospital conditions[127] • SARS can persist with trace infectivity for up to 28 days at refrigerated temperatures (4°C) on surfaces.[25] • Beta-coronaviruses (e.g., SARS-CoV) may be more stable than alpha-coronaviruses (HCoV-229E).[102] • No strong evidence for reduction in transmission with seasonal increase in temperature and humidity.[92] • One hour after aerosolization approximately 63% of airborne MERS virus remained viable in a simulated office environment (25°C, 75% RH)[100] • 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.[70] Both higher and lower RH reduced HCoV-229E survival; lower temperatures improved survival.[70]

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What do we need to know?	• How long does it take for infected individuals to recover outside of a healthcare setting? • Is the reduction in CFR through time an indication of better treatment, less overcrowding, or both?	• False positive/negative rates for tests • Eclipse phase of infection (time between infection and detectable disease) in an individual	• Is GS-5734 (remdesivir) effective in vivo (already used in clinical trials under Emergency Use Authorization)?[115] • Is the GLS-5000 MERS vaccine[147] cross-reactive against SARS-CoV-2? • Efficacy of antibody treatments developed for SARS[46, 119] and MERS[34] • What is the efficacy of various MERS and SARS Phase I/II vaccines and other therapeutics? • Are viral replicase inhibitors such as beta-D-N4-hydroxycytidine effective against SARS-CoV-2?[15]	• Stability of SARS-CoV-2 in aerosol, droplets, and other matrices (mucus/sputum, feces) • Particle size distribution (e.g., droplet, large droplet and true aerosol distribution) • Duration of SARS-CoV-2 infectivity via fomites and surface (contact hazard)? • Stability of SARS-CoV-2 on PPE (e.g., Tyvek, nitrile, etc.)
Who is doing experiments/has capabilities in this area?	- Jin Yin-tan Hospital, Wuhan, China - China-Japan Friendship Hospital, Beijing, China - Peking Union Medical College, Beijing, China - Capital Medical University, Beijing, China - Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China - Huazhong University of Science and Technology, Wuhan, China - The Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China - Tsinghua University School of Medicine, Beijing, China - Zhongnan Hospital of Wuhan University, Wuhan, China - Peking University First Hospital, Beijing, China - Peking University People's Hospital, Beijing, China - Tsinghua University-Peking University Joint Center for Life Sciences, Beijing, China - The Fifth Medical Center of PLA General Hospital, Beijing, China	*Performing work:* - CDC - Wuhan Institute of Virology - Public Health Agency of Canada - Doherty Institute of Australia - Cepheid - BGI - Fudan University	*Performing work:* - Peter Doherty Institute for Infection and Immunity - Academy of Military Medical Sciences, Beijing, China - Tim Sheahan (University of North Carolina) - Takeda Pharma. (Japan) - Regeneron Pharmaceuticals - CureVac (Germany) *Capable of performing work:* - Ralph Baric (University of North Carolina) - Matthew Frieman (University of Maryland Baltimore) - Sanofi, with BARDA - Janssen Pharma and BARDA[64] *Funded work:* CEPI ($24 million to seven groups): NIAID/NIH: - Moderna and Kaiser Permanente for mRNA vaccine Phase I trial.[3] - University of Nebraska Medical Center Trial (multiple therapeutics including Gilead's Remdesivir).[2]	*Capable of performing work*: - Mark Sobsey (University of North Carolina) - DHS National Biodefense Analysis and Countermeasures Center (NBACC) - Defence Science and Technology Laboratory (Dstl) - Public Health Agency of Canada - CDC - EPA - NIH

SARS-CoV-2 (COVID-19)	Decontamination – what are effective methods to kill the agent in the environment?	PPE – what PPE is effective, and who should be using it?	Forensics – natural vs intentional use? Tests to be used for attribution.	Genomics – how does the disease agent compare to previous strains?
What do we know?	*SARS-CoV-2* • Twice-daily cleaning with sodium dichloroisocyanurate decontaminated surfaces in COVID-19 patient hospital rooms.[95] • Alcohol-based hand rubs are effective at inactivating SARS-CoV-2 in liquid.[75] • EPA has released a list of SARS-CoV-2 disinfectants, but solutions were not tested on live virus.[6] *Other Coronaviruses* • Chlorine-based[134] and ethanol-based[44] solutions recommended. • Heat treatment at 56°C is sufficient to kill coronaviruses,[102, 152] though effectiveness depends in part on amount of protein in contaminated media[102] • 70% ethanol, 50% isopropanol, sodium hypochlorite [bleach, 200 ppm], and UV radiation are effective at inactivating several coronaviruses (MHV and CCV)[112] • Ethanol-based biocides are effective disinfectants against coronaviruses dried on surfaces, including ethanol containing gels similar to hand sanitizer.[69, 139] • Surface spray disinfectants such as Mikrobac, Dismozon, and Korsolex are effective at reducing infectivity of the closely related SARS-CoV after 30 minutes of contact.[101] • Coronaviruses may be resistant to thermal inactivation for up to 7 days when stabilized in stool.[122-123] • Additionally, coronaviruses are more stable in matrixes such as respiratory sputum.[55] • Hydrogen peroxide vapor is expected to be effective at repeated decontamination of N95 respirators based on other pathogens.[105]	• PPE effectiveness for SARS-CoV-2 is currently unknown; SARS is used as a surrogate. • Healthcare worker illnesses (over 1,000[120]) demonstrates human-to-human transmission despite isolation, PPE, and infection control.[113] • 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).[28] • "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)"[30] • WHO indicates healthcare workers should wear clean, non-sterile, long-sleeve gowns as well as gloves.[133] • Respirators (NIOSH-certified N95, EUFFP2 or equivalent) are recommended for those dealing with possible aerosols[134] • 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)[23] • SARS-CoV-2 transmission has occurred in hospitals inside[130] and outside of China,[61] including the US.[20] • Porous hospital materials, including paper and cotton cloth, maintain infectious SARS-CoV for a shorter time than non-porous material.[76] • Despite extensive environmental contamination, air sampling in patient rooms did not detect SARS-CoV-2.[95]	• 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.[52] • Genomic analysis suggest 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.[9, 154] • Some genomic evidence indicates a close relationship with pangolin coronaviruses[140]; data suggests that pangolins may be a natural host for beta-coronaviruses [87-88]. 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."[9] Either scenario is consistent 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,[9] 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."[9]	• 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.[10, 18, 103] • 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 1.04×10^{-3} substitutions per site per year (N = 116 genomes).[65] • 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.[97] • 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.[87-88] • The Spike protein of SARS-CoV-2, which mediates entry into host cells and is the major determinant of host range, is very similar to the Spike protein of SARS-CoV.[91] The rest of the genome is more closely related to two separate bat [91] and pangolin[88] coronavirus. • Analysis of SARS-CoV-2 sequences from Singapore has identified a large nucleotide (382 bp) deletion in ORF-8 that may result in an attenuated (less virulent) phenotype.[118]

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

Table 1. Definitions of commonly-used acronyms

Acronym/Term	Definition	Description
Attack Rate	Proportion of "at-risk" individuals who develop infection	Defined in terms of "at-risk" population such as schools or households, defines the proportion of individuals in those populations who become infected after contact with an infectious individual
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2	Official name for the virus previously known as 2019-nCoV.
COVID-19	Coronavirus disease 19	Official name for the disease caused by the SARS-CoV-2 virus.
CFR	Case Fatality Rate	Number of deaths divided by confirmed patients
PFU	Plaque forming unit	Measurement of the number of infectious virus particles as determined by plaque forming assay. A measurement of sample infectivity.
$TCID_{50}$	50% Tissue Culture Infectious Dose	The number of infectious units which will infect 50% of tissue culture monolayers. A measurement of sample infectivity.
HCW	Healthcare worker	Doctors, nurses, technicians dealing with patients or samples
SARS	Severe Acute Respiratory Syndrome	Coronavirus with over 8,000 cases in global 2002-2003 outbreak
MERS	Middle-East Respiratory Syndrome	Coronavirus with over 2,000 cases in regional outbreak since 2012
CoV	Coronavirus	Virus typified by crown-like structures when viewed under electron microscope
R_0	Basic reproduction number	A measure of transmissibility. Specifically, the average number of new infections caused by a typical infectious individual in a wholly susceptible population.
MHV	Mouse hepatitis virus	Coronavirus surrogate

CCV	Canine coronavirus	Canine coronavirus
Fomite	Inanimate vector of disease	Surfaces such as hospital beds, doorknobs, healthcare worker gowns, faucets, etc.
Droplet transmission	Sneezing, coughing	Transmission via droplets requires relatively close contact (e.g., within 6 feet)
Airborne transmission	Aerosolization of infectious particles	Aerosolized particles can spread for long distances (e.g., between hospital rooms via HVAC systems)
Transgenic	Genetically modified	In this case, animal models modified to be more susceptible to MERS and/or SARS by adding proteins or receptors necessary for infection
Intranasal	Agent deposited into external nares of subject	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.
Incubation period	Time between infection and symptom onset	Time between infection and onset of symptoms typically establishes guidelines for isolating patients before transmission is possible
Infectious period	Length of time an individual can transmit infection to others	Reducing the infectious period is a key method of reducing overall transmission; hospitalization, isolation, and quarantine are all effective methods
Serial interval	Length of time between symptom onset of successive cases in a transmission chain	The serial interval can be used to estimate R_0, and is useful for estimating the rate of outbreak spread
Superspreading	One individual responsible for an abnormally large number of secondary infections	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
Nosocomial	Healthcare- or hospital-associated infections	Characteristic of SARS and MERS outbreaks, lead to refinement of infection control procedures

ACE2	Angiotensin-converting enzyme 2	Acts as a receptor for SARS-CoV, allowing entry into human cells
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

Literature Cited:

1. (U) French researcher posts successful Covid-19 drug trial. Connexion: 2020.
2. (U) A Multicenter, Adaptive, Randomized Blinded Controlled Trial of the Safety and Efficacy of Investigational Therapeutics for the Treatment of COVID-19 in Hospitalized Adults 2020.
3. (U) Phase I, Open-Label, Dose-Ranging Study of the Safety and Immunogenicity of 2019-nCoV Vaccine (mRNA-1273) in Healthy Adults 2020.
4. (U) Severe Outcomes Among Patients with Coronavirus Disease 2019 (COVID-19) — United States, February 12–March 16, 2020. . *MMWR* **2020**.
5. (U) [Wuhan Pneumonia] The Hospital Authority stated that 2 critically ill patients needed external life support treatment. https://www.singtao.ca/4037242/2020-01-14/news-%E3%80%90%E6%AD%A6%E6%BC%A2%E8%82%BA%E7%82%8E%E3%80%91%E9%86%AB%E7%AE%A1%E5%B1%80%E6%8C%872%E5%90%8D%E9%87%8D%E7%97%87%E7%97%85%E6%82%A3%E9%9C%80%E9%AB%94%E5%A4%96%E7%94%9F%E5%91%BD%E6%94%AF%E6%8C%81%E6%B2%BB%E7%99%82/?variant=zh-hk.
6. (U) Agency, U. S. E. P., EPA's Registered Antimicrobial Products for Use Against Novel Coronavirus SARS-CoV-2, the Cause of COVID-19. https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2.
7. (U) Agrawal, A. S.; Garron, T.; Tao, X.; Peng, B. H.; Wakamiya, M.; Chan, T. S.; Couch, R. B.; Tseng, C. T., Generation of a transgenic mouse model of Middle East respiratory syndrome coronavirus infection and disease. *J Virol* **2015,** *89* (7), 3659-70.
8. (U) Amanat, F.; Krammer, F., SARS-CoV-2 vaccines: status report. *Journal of Immunology* **2020,** *Early View*.
9. (U) Andersen, K. G.; Rambaut, A.; Lipkin, W. I.; Holmes, E. C.; Garry, R. F., The proximal origin of SARS-CoV-2. *Nature Medicine* **2020**.
10. (U) Anderson, K., Estimates of the clock and TMRCA for 2019-nCoV based on 27 genomes. http://virological.org/t/clock-and-tmrca-based-on-27-genomes/347 (accessed 01/26/2020).
11. (U) Backer, J. A.; Klinkenberg, D.; Wallinga, J., The incubation period of 2019-nCoV infections among travellers from Wuhan, China. *medRxiv* **2020**, 2020.01.27.20018986.
12. (U) Bai, Y.; Yao, L.; Wei, T.; Tian, F.; Jin, D.-Y.; Chen, L.; Wang, M., Presumed Asymptomatic Carrier Transmission of COVID-19. *JAMA*.
13. (U) Bao, L.; Deng, W.; Gao, H.; Xiao, C.; Liu, J.; Xue, J.; Lv, Q.; Liu, J.; Yu, P.; Xu, Y.; Qi, F.; Qu, Y.; Li, F.; Xiang, Z.; Yu, H.; Gong, S.; Liu, M.; Wang, G.; Wang, S.; Song, Z.; Zhao, W.; Han, Y.; Zhao, L.; Liu, X.; Wei, Q.; Qin, C., Reinfection could not occur in SARS-CoV-2 infected rhesus macaques. *bioRxiv* **2020**, 2020.03.13.990226.
14. (U) Bao, L.; Deng, W.; Huang, B.; Gao, H.; Ren, L.; Wei, Q.; Yu, P.; Xu, Y.; Liu, J.; Qi, F.; Qu, Y.; Wang, W.; Li, F.; Lv, Q.; Xue, J.; Gong, S.; Liu, M.; Wang, G.; Wang, S.; Zhao, L.; Liu, P.; Zhao, L.; Ye, F.; Wang, H.; Zhou, W.; Zhu, N.; Zhen, W.; Yu, H.; Zhang, X.; Song, Z.; Guo, L.; Chen, L.; Wang, C.; Wang, Y.; Wang, X.; Xiao, Y.; Sun, Q.; Liu, H.; Zhu, F.; Ma, C.; Yan, L.; Yang, M.; Han, J.; Xu, W.; Tan, W.; Peng, X.; Jin, Q.; Wu, G.; Qin, C., The Pathogenicity of 2019 Novel Coronavirus in hACE2 Transgenic Mice. *bioRxiv* **2020**, 2020.02.07.939389.
15. (U) Barnard, D. L.; Hubbard, V. D.; Burton, J.; Smee, D. F.; Morrey, J. D.; Otto, M. J.; Sidwell, R. W., Inhibition of severe acute respiratory syndrome-associated coronavirus (SARSCoV) by calpain inhibitors and beta-D-N4-hydroxycytidine. *Antivir Chem Chemother* **2004,** *15* (1), 15-22.
16. (U) BBC, Coronavirus: California declares emergency after death. *BBC* 2020.

17. (U) Bedford, T., Cryptic Transmission of novel coronavirus revealed by genomic epidemiology. https://bedford.io/blog/ncov-cryptic-transmission/.
18. (U) Bedford, T.; Neher, R., Genomic epidemiology of novel coronavirus (nCoV) using data from GISAID. https://nextstrain.org/ncov.
19. (U) BGI, BGI Responds to Novel Coronavirus with Real-Time Detection Kits, Deploys Emergency Team to Wuhan. 2020.
20. (U) Boodman, E.; Branswell, H., First Covid-19 outbreak in a U.S. nursing home raises concerns. *Stat* 2020.
21. (U) Branswell, H., Sanofi announces it will work with HHS to develop a coronavirus vaccine. Statnews, Ed. 2020.
22. (U) Brosseau, L. M., COMMENTARY: COVID-19 transmission messages should hinge on science. http://www.cidrap.umn.edu/news-perspective/2020/03/commentary-covid-19-transmission-messages-should-hinge-science.
23. (U) Brosseau, L. M.; Jones, R., Commentary: Protecting health workers from airborne MERS-CoV - learning from SARS. http://www.cidrap.umn.edu/news-perspective/2014/05/commentary-protecting-health-workers-airborne-mers-cov-learning-sars.
24. (U) Cao, B.; Wang, Y.; Wen, D.; Liu, W.; Wang, J.; Fan, G.; Ruan, L.; Song, B.; Cai, Y.; Wei, M.; Li, X.; Xia, J.; Chen, N.; Xiang, J.; Yu, T.; Bai, T.; Xie, X.; Zhang, L.; Li, C.; Yuan, Y.; Chen, H.; Li, H.; Huang, H.; Tu, S.; Gong, F.; Liu, Y.; Wei, Y.; Dong, C.; Zhou, F.; Gu, X.; Xu, J.; Liu, Z.; Zhang, Y.; Li, H.; Shang, L.; Wang, K.; Li, K.; Zhou, X.; Dong, X.; Qu, Z.; Lu, S.; Hu, X.; Ruan, S.; Luo, S.; Wu, J.; Peng, L.; Cheng, F.; Pan, L.; Zou, J.; Jia, C.; Wang, J.; Liu, X.; Wang, S.; Wu, X.; Ge, Q.; He, J.; Zhan, H.; Qiu, F.; Guo, L.; Huang, C.; Jaki, T.; Hayden, F. G.; Horby, P. W.; Zhang, D.; Wang, C., A Trial of Lopinavir–Ritonavir in Adults Hospitalized with Severe Covid-19. *New England Journal of Medicine* **2020**.
25. (U) Casanova, L. M.; Jeon, S.; Rutala, W. A.; Weber, D. J.; Sobsey, M. D., Effects of air temperature and relative humidity on coronavirus survival on surfaces. *Applied and environmental microbiology* **2010,** *76* (9), 2712-2717.
26. (U) CDC, 2019 Novel Coronavirus RT-PCR Identification Protocols. https://www.cdc.gov/coronavirus/2019-ncov/lab/rt-pcr-detection-instructions.html.
27. (U) CDC, Confirmed 2019-nCoV Cases Globally. https://www.cdc.gov/coronavirus/2019-ncov/locations-confirmed-cases.html.
28. (U) CDC, COVID-19 Frequently Asked Questions and Answers. https://www.cdc.gov/coronavirus/2019-ncov/faq.html.
29. (U) CDC, Interim Clinical Guidance for Management of Patients with Confirmed Coronavirus Disease 2019 (COVID-19). https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html.
30. (U) CDC, Interim healthcare infection prevention and control recommendations for patients under investigation for 2019 novel coronavirus. https://www.cdc.gov/coronavirus/2019-ncov/infection-control.html.
31. (U) CDC, Situation summary. https://www.cdc.gov/coronavirus/2019-nCoV/summary.html.
32. (U) CDC, Symptoms. https://www.cdc.gov/coronavirus/2019-ncov/about/symptoms.html.
33. (U) CDC, C., China's CDC detects a large number of new coronaviruses in the South China seafood market in Wuhan http://www.chinacdc.cn/yw_9324/202001/t20200127_211469.html (accessed 01/27/2020).
34. (U) CenterWatch, SAB Biotherapeutics wins BARDA MERS treatment contract. https://www.centerwatch.com/articles/14742.
35. (U) Chan, J. F.-W.; Yuan, S.; Kok, K.-H.; To, K. K.-W.; Chu, H.; Yang, J.; Xing, F.; Liu, J.; Yip, C. C.-Y.; Poon, R. W.-S.; Tsoi, H.-W.; Lo, S. K.-F.; Chan, K.-H.; Poon, V. K.-M.; Chan, W.-M.; Ip, J. D.; Cai, J.-P.; Cheng, V. C.-C.; Chen, H.; Hui, C. K.-M.; Yuen, K.-Y., A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *The Lancet* **2020**.

36. (U) Chan, K. H.; Peiris, J. S.; Lam, S. Y.; Poon, L. L.; Yuen, K. Y.; Seto, W. H., The Effects of Temperature and Relative Humidity on the Viability of the SARS Coronavirus. *Adv Virol* **2011,** *2011*, 734690.
37. (U) Chang, D.; Lin, M.; Wei, L.; Xie, L.; Zhu, G.; Dela Cruz, C. S.; Sharma, L., Epidemiologic and Clinical Characteristics of Novel Coronavirus Infections Involving 13 Patients Outside Wuhan, China. *JAMA* **2020**.
38. (U) Changzheng, L. J. L., Experts in the medical treatment team: Wuhan's unexplained viral pneumonia patients can be controlled more. https://www.cn-healthcare.com/article/20200110/content-528579.html.
39. (U) Chen, C.; Cao, M.; Peng, L.; Guo, X.; Yang, F.; Wu, W.; Chen, L.; Yang, Y.; Liu, Y.; Wang, F., Coronavirus Disease-19 Among Children Outside Wuhan, China. *SSRN* **2020**.
40. (U) Chen, N.; Zhou, M.; Dong, X.; Qu, J.; Gong, F.; Han, Y.; Qiu, Y.; Wang, J.; Liu, Y.; Wei, Y.; Xia, J.; Yu, T.; Zhang, X.; Zhang, L., Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* **2020**.
41. (U) Cockrell, A. S.; Yount, B. L.; Scobey, T.; Jensen, K.; Douglas, M.; Beall, A.; Tang, X.-C.; Marasco, W. A.; Heise, M. T.; Baric, R. S., A mouse model for MERS coronavirus-induced acute respiratory distress syndrome. *Nature microbiology* **2016,** *2* (2), 1-11.
42. (U) Cohen, J., Mining coronavirus genomes for clues to the outbreak's origins. *Science* 2020.
43. (U) Cohen, J., Wuhan seafood market may not be source of novel virus spreading globally. https://www.sciencemag.org/news/2020/01/wuhan-seafood-market-may-not-be-source-novel-virus-spreading-globally (accessed 01/27/2020).
44. (U) Control), E. E. C. f. D. P. a., *Interim guidance for environmental cleaning in non-healthcare facilities exposed to SARS-CoV-2*; European Centre for Disease Prevention and Control: European Centre for Disease Prevention and Control, 2020.
45. (U) Corman, V. M.; Landt, O.; Kaiser, M.; Molenkamp, R.; Meijer, A.; Chu, D. K.; Bleicker, T.; Brunink, S.; Schneider, J.; Schmidt, M. L.; Mulders, D. G.; Haagmans, B. L.; van der Veer, B.; van den Brink, S.; Wijsman, L.; Goderski, G.; Romette, J. L.; Ellis, J.; Zambon, M.; Peiris, M.; Goossens, H.; Reusken, C.; Koopmans, M. P.; Drosten, C., Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. *Euro Surveill* **2020,** *25* (3).
46. (U) Coughlin, M. M.; Prabhakar, B. S., Neutralizing human monoclonal antibodies to severe acute respiratory syndrome coronavirus: target, mechanism of action, and therapeutic potential. *Reviews in medical virology* **2012,** *22* (1), 2-17.
47. (U) Cowling, B. J.; Ali, S. T.; Ng, T. W. Y.; Tsang, T. K.; Li, J. C. M.; Fong, M. W.; Liao, Q.; Kwan, M. Y.; Lee, S. L.; Chiu, S. S.; Wu, J. T.; Wu, P.; Leung, G. M., Impact assessment of non-pharmaceutical interventions against COVID-19 and influenza in Hong Kong: an observational study. *medRxiv* **2020**, 2020.03.12.20034660.
48. (U) Daily, H., Wuhan Institute of Virology, Chinese Academy of Sciences and others have found that 3 drugs have a good inhibitory effect on new coronavirus. Chen, L., Ed. 2020.
49. (U) De Albuquerque, N.; Baig, E.; Ma, X.; Zhang, J.; He, W.; Rowe, A.; Habal, M.; Liu, M.; Shalev, I.; Downey, G. P.; Gorczynski, R.; Butany, J.; Leibowitz, J.; Weiss, S. R.; McGilvray, I. D.; Phillips, M. J.; Fish, E. N.; Levy, G. A., Murine hepatitis virus strain 1 produces a clinically relevant model of severe acute respiratory syndrome in A/J mice. *J Virol* **2006,** *80* (21), 10382-94.
50. (U) Dediego, M. L.; Pewe, L.; Alvarez, E.; Rejas, M. T.; Perlman, S.; Enjuanes, L., Pathogenicity of severe acute respiratory coronavirus deletion mutants in hACE-2 transgenic mice. *Virology* **2008,** *376* (2), 379-389.

51. (U) Deng, W.; Bao, L.; Gao, H.; Xiang, Z.; Qu, Y.; Song, Z.; Gong, S.; Liu, J.; Liu, J.; Yu, P.; Qi, F.; Xu, Y.; Li, F.; Xiao, C.; Lv, Q.; Xue, J.; Wei, Q.; Liu, M.; Wang, G.; Wang, S.; Yu, H.; Liu, X.; Zhao, W.; Han, Y.; Qin, C., Rhesus macaques can be effectively infected with SARS-CoV-2 via ocular conjunctival route. *bioRxiv* **2020**, 2020.03.13.990036.
52. (U) Dong, N.; Yang, X.; Ye, L.; Chen, K.; Chan, E. W.-C.; Yang, M.; Chen, S., Genomic and protein structure modelling analysis depicts the origin and infectivity of 2019-nCoV, a new coronavirus which caused a pneumonia outbreak in Wuhan, China. *bioRxiv* **2020**, 2020.01.20.913368.
53. (U) Dong, Y.; Mo, X.; Hu, Y.; Qi, X.; Jiang, F.; Jiang, Z.; Tong, S., Epidemiological Characteristics of 2143 Pediatric Patients With 2019 Coronavirus Disease in China. *Pediatrics* **2020**, e20200702.
54. (U) Du, Z.; Xu, X.; Wu, Y.; Wang, L.; Cowling, B. J.; Meyers, L. A., The serial interval of COVID-19 from publicly reported confirmed cases. *medRxiv* **2020**, 2020.02.19.20025452.
55. (U) Duan, S.; Zhao, X.; Wen, R.; Huang, J.-j.; Pi, G.; Zhang, S.; Han, J.; Bi, S.; Ruan, L.; Dong, X.-p., Stability of SARS coronavirus in human specimens and environment and its sensitivity to heating and UV irradiation. *Biomedical and environmental sciences: BES* **2003,** *16* (3), 246-255.
56. (U) Duan, S. M.; Zhao, X. S.; Wen, R. F.; Huang, J. J.; Pi, G. H.; Zhang, S. X.; Han, J.; Bi, S. L.; Ruan, L.; Dong, X. P., Stability of SARS coronavirus in human specimens and environment and its sensitivity to heating and UV irradiation. *Biomed Environ Sci* **2003,** *16* (3), 246-55.
57. (U) Fang, L.; Karakiulakis, G.; Roth, M., Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? *The Lancet Respiratory Medicine*.
58. (U) FDA, Policy for Diagnostics Testing in Laboratories Certified to Perform High Complexity Testing under CLIA prior to Emergency Use Authorization for Coronavirus Disease-2019 during the Public Health Emergency; Immediately in Effect Guidance for Industry and Food and Drug Administration Staff. 2020.
59. (U) Ferguson, N.; Laydon, D.; Nedjati-Gilani, G.; Imai, N.; Ainslie, K.; Baguelin, M.; Bhatia, S.; Boonyasiri, A.; Cucunuba, Z.; Cuomo-Dannenburg, G.; Dighe, A.; Dorigatti, I.; Fu, H.; Gaythorpe, K.; Green, W.; Hamlet, A.; Hinsley, W.; Okell, L.; van Elsland, S.; Thompson, H.; Verity, R.; Volz, E.; Wang, H.; Wang, Y.; Walker, P.; Walters, C.; Winskill, P.; Whittaker, C.; Donnelly, C.; Riley, S.; Ghani, A., *Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand*; 2020.
60. (U) Guan, W.-j.; Ni, Z.-y.; Hu, Y.; Liang, W.-h.; Ou, C.-q.; He, J.-x.; Liu, L.; Shan, H.; Lei, C.-l.; Hui, D. S.; Du, B.; Li, L.-j.; Zeng, G.; Yuen, K.-Y.; Chen, R.-c.; Tang, C.-l.; Wang, T.; Chen, P.-y.; Xiang, J.; Li, S.-y.; Wang, J.-l.; Liang, Z.-j.; Peng, Y.-x.; Wei, L.; Liu, Y.; Hu, Y.-h.; Peng, P.; Wang, J.-m.; Liu, J.-y.; Chen, Z.; Li, G.; Zheng, Z.-j.; Qiu, S.-q.; Luo, J.; Ye, C.-j.; Zhu, S.-y.; Zhong, N.-s., Clinical characteristics of 2019 novel coronavirus infection in China. *medRxiv* **2020**, 2020.02.06.20020974.
61. (U) Guardian, New virus cases in UK are closely linked, official says – as it happened. The Guardian: 2020.
62. (U) Herper, M.; Feurerstein, A., How blood plasma from recovered patients could help treat the new coronavirus. *STAT* 2020.
63. (U) HHS, 2019-nCoV Update. 2020.
64. (U) HHS, HHS, Janssen Collaborate To Develop Coronavirus Therapeutics. Services, U. D. o. H. a. H., Ed. 2020.
65. (U) Hill, V.; Rambaut, A., Phylodynamic analysis of SARS-CoV-2 | Update 2020-03-06. Virological: 2020.
66. (U) Hoehl, S.; Berger, A.; Kortenbusch, M.; Cinatl, J.; Bojkova, D.; Rabenau, H.; Behrens, P.; Böddinghaus, B.; Götsch, U.; Naujoks, F.; Neumann, P.; Schork, J.; Tiarks-Jungk, P.; Walczok, A.; Eickmann, M.; Vehreschild, M. J. G. T.; Kann, G.; Wolf, T.; Gottschalk, R.; Ciesek, S., Evidence of SARS-CoV-2 Infection in Returning Travelers from Wuhan, China. *New England Journal of Medicine* **2020**.

67. (U) Huang, C.; Wang, Y.; Li, X.; Ren, L.; Zhao, J.; Hu, Y.; Zhang, L.; Fan, G.; Xu, J.; Gu, X., Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet* **2020,** *395* (10223), 497-506.
68. (U) Huang, C.; Wang, Y.; Li, X.; Ren, L.; Zhao, J.; Hu, Y.; Zhang, L.; Fan, G.; Xu, J.; Gu, X.; Cheng, Z.; Yu, T.; Xia, J.; Wei, Y.; Wu, W.; Xie, X.; Yin, W.; Li, H.; Liu, M.; Xiao, Y.; Gao, H.; Guo, L.; Xie, J.; Wang, G.; Jiang, R.; Gao, Z.; Jin, Q.; Wang, J.; Cao, B., Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet* **2020**.
69. (U) Hulkower, R. L.; Casanova, L. M.; Rutala, W. A.; Weber, D. J.; Sobsey, M. D., Inactivation of surrogate coronaviruses on hard surfaces by health care germicides. *American journal of infection control* **2011,** *39* (5), 401-407.
70. (U) Ijaz, M. K.; Brunner, A. H.; Sattar, S. A.; Nair, R. C.; Johnson-Lussenburg, C. M., Survival characteristics of airborne human coronavirus 229E. *J Gen Virol* **1985,** *66 (Pt 12)*, 2743-8.
71. (U) Imai, N.; Dorigatti, I.; Cori, A.; Riley, S.; Ferguson, N., Estimating the potential total number of novel Coronavirus cases in Wuhan City, China. https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/2019-nCoV-outbreak-report-17-01-2020.pdf
72. (U) JHU, Coronavirus COVID-19 Global Cases by Johns Hopkins CSSE. https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6.
73. (U) Jing, C.; Wenjie, S.; Jianping, H.; Michelle, G.; Jing, W.; Guiqing, H., Indirect Virus Transmission in Cluster of COVID-19 Cases, Wenzhou, China, 2020. *Emerging Infectious Disease journal* **2020,** *26* (6).
74. (U) Joseph, A., CDC developing serologic tests that could reveal full scope of U.S. coronavirus outbreak. *STAT* 2020.
75. (U) Kratzel, A.; Todt, D.; V'kovski, P.; Steiner, S.; Gultom, M. L.; Thao, T. T. N.; Ebert, N.; Holwerda, M.; Steinmann, J.; Niemeyer, D.; Dijkman, R.; Kampf, G.; Drosten, C.; Steinmann, E.; Thiel, V.; Pfaender, S., Efficient inactivation of SARS-CoV-2 by WHO-recommended hand rub formulations and alcohols. *bioRxiv* **2020**, 2020.03.10.986711. https://www.biorxiv.org/content/10.1101/2020.03.10.986711v1
76. (U) Lai, M. Y.; Cheng, P. K.; Lim, W. W., Survival of severe acute respiratory syndrome coronavirus. *Clinical Infectious Diseases* **2005,** *41* (7), e67-e71.
77. (U) Lan, L.; Xu, D.; Ye, G.; Xia, C.; Wang, S.; Li, Y.; Xu, H., Positive RT-PCR Test Results in Patients Recovered From COVID-19. *Jama* **2020**.
78. (U) Lau, S., Coronavirus: WHO official says there's no evidence of 'reinfected' patients in China https://www.scmp.com/news/china/society/article/3074045/coronavirus-who-official-says-theres-no-evidence-reinfected.
79. (U) Lauer, S. A.; Grantz, K. H.; Bi, Q.; Jones, F. K.; Zheng, Q.; Meredith, H. R.; Azman, A. S.; Reich, N. G.; Lessler, J., The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application. *Annals of Internal Medicine* **2020**.
80. (U) Levine, J., Scientists race to develop vaccine to deadly China coronavirus. https://nypost.com/2020/01/25/scientists-race-to-develop-vaccine-to-deadly-china-coronavirus/.
81. (U) Li, K.; Wohlford-Lenane, C.; Perlman, S.; Zhao, J.; Jewell, A. K.; Reznikov, L. R.; Gibson-Corley, K. N.; Meyerholz, D. K.; McCray, P. B., Jr., Middle East Respiratory Syndrome Coronavirus Causes Multiple Organ Damage and Lethal Disease in Mice Transgenic for Human Dipeptidyl Peptidase 4. *J Infect Dis* **2016,** *213* (5), 712-22.
82. (U) Li, Q.; Guan, X.; Wu, P.; Wang, X.; Zhou, L.; Tong, Y.; Ren, R.; Leung, K. S.; Lau, E. H.; Wong, J. Y., Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. *New England Journal of Medicine* **2020**.

83. (U) Li, Q.; Guan, X.; Wu, P.; Wang, X.; Zhou, L.; Tong, Y.; Ren, R.; Leung, K. S. M.; Lau, E. H. Y.; Wong, J. Y.; Xing, X.; Xiang, N.; Wu, Y.; Li, C.; Chen, Q.; Li, D.; Liu, T.; Zhao, J.; Liu, M.; Tu, W.; Chen, C.; Jin, L.; Yang, R.; Wang, Q.; Zhou, S.; Wang, R.; Liu, H.; Luo, Y.; Liu, Y.; Shao, G.; Li, H.; Tao, Z.; Yang, Y.; Deng, Z.; Liu, B.; Ma, Z.; Zhang, Y.; Shi, G.; Lam, T. T. Y.; Wu, J. T.; Gao, G. F.; Cowling, B. J.; Yang, B.; Leung, G. M.; Feng, Z., Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. *New England Journal of Medicine* **2020**.
84. (U) Li, R.; Pei, S.; Chen, B.; Song, Y.; Zhang, T.; Yang, W.; Shaman, J., Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV2). *Science* **2020**, eabb3221.
85. (U) Li, X.; Zai, J.; Zhao, Q.; Nie, Q.; Li, Y.; Foley, B. T.; Chaillon, A., Evolutionary history, potential intermediate animal host, and cross-species analyses of SARS-CoV-2. *Journal of Medical Virology* **2020,** *n/a* (n/a).
86. (U) Ling, Y.; Xu, S. B.; Lin, Y. X.; Tian, D.; Zhu, Z. Q.; Dai, F. H.; Wu, F.; Song, Z. G.; Huang, W.; Chen, J.; Hu, B. J.; Wang, S.; Mao, E. Q.; Zhu, L.; Zhang, W. H.; Lu, H. Z., Persistence and clearance of viral RNA in 2019 novel coronavirus disease rehabilitation patients. *Chin Med J (Engl)* **2020**.
87. (U) Liu, P.; Chen, W.; Chen, J.-P., Viral Metagenomics Revealed Sendai Virus and Coronavirus Infection of Malayan Pangolins (Manis javanica). *Viruses* **2019,** *11* (11), 979.
88. (U) Liu, P.; Jiang, J.-Z.; Wan, X.-F.; Hua, Y.; Wang, X.; Hou, F.; Chen, J.; Zou, J.; Chen, J., Are pangolins the intermediate host of the 2019 novel coronavirus (2019-nCoV) ? *bioRxiv* **2020**, 2020.02.18.954628.
89. (U) Liu, W.; Zhang, Q.; Chen, J.; Xiang, R.; Song, H.; Shu, S.; Chen, L.; Liang, L.; Zhou, J.; You, L.; Wu, P.; Zhang, B.; Lu, Y.; Xia, L.; Huang, L.; Yang, Y.; Liu, F.; Semple, M. G.; Cowling, B. J.; Lan, K.; Sun, Z.; Yu, H.; Liu, Y., Detection of Covid-19 in Children in Early January 2020 in Wuhan, China. *New England Journal of Medicine* **2020**.
90. (U) Liu, Y.; Funk, S.; Flasche, S., *The Contribution of Pre-symptomatic Transmission to the COVID-19 Outbreak*; London School of Hygiene and Tropical Medicine: 2020.
91. (U) Lu, R.; Zhao, X.; Li, J.; Niu, P.; Yang, B.; Wu, H.; Wang, W.; Song, H.; Huang, B.; Zhu, N.; Bi, Y.; Ma, X.; Zhan, F.; Wang, L.; Hu, T.; Zhou, H.; Hu, Z.; Zhou, W.; Zhao, L.; Chen, J.; Meng, Y.; Wang, J.; Lin, Y.; Yuan, J.; Xie, Z.; Ma, J.; Liu, W. J.; Wang, D.; Xu, W.; Holmes, E. C.; Gao, G. F.; Wu, G.; Chen, W.; Shi, W.; Tan, W., Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *The Lancet* **2020**.
92. (U) Luo, W.; Majumder, M. S.; Liu, D.; Poirier, C.; Mandl, K. D.; Lipsitch, M.; Santillana, M., The role of absolute humidity on transmission rates of the COVID-19 outbreak. *medRxiv* **2020**, 2020.02.12.20022467.
93. (U) Majumder, M.; Mandl, K., Early transmissibility assessment of a novel coronavirus in Wuhan, China. *SSRN* **2020**.
94. (U) NIH, NIH clinical trial of remdesivir to treat COVID-19 begins https://www.nih.gov/news-events/news-releases/nih-clinical-trial-remdesivir-treat-covid-19-begins.
95. (U) Ong, S. W. X.; Tan, Y. K.; Chia, P. Y.; Lee, T. H.; Ng, O. T.; Wong, M. S. Y.; Marimuthu, K., Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient. *Jama* **2020**.
96. (U) Pan, F.; Ye, T.; Sun, P.; Gui, S.; Liang, B.; Li, L.; Zheng, D.; Wang, J.; Hesketh, R. L.; Yang, L.; Zheng, C., Time Course of Lung Changes On Chest CT During Recovery From 2019 Novel Coronavirus (COVID-19) Pneumonia. *Radiology 0* (0), 200370.

97. (U) Paraskevis, D.; Kostaki, E. G.; Magiorkinis, G.; Panayiotakopoulos, G.; Sourvinos, G.; Tsiodras, S., Full-genome evolutionary analysis of the novel corona virus (2019-nCoV) rejects the hypothesis of emergence as a result of a recent recombination event. *Infect Genet Evol* **2020,** *79*, 104212.
98. (U) Park, S. W.; Champredon, D.; Earn, D. J. D.; Li, M.; Weitz, J. S.; Grenfell, B. T.; Dushoff, J., Reconciling early-outbreak preliminary estimates of the basic reproductive number and its uncertainty: a new framework and applications to the novel coronavirus (2019-nCoV) outbreak. **2020**, 1-13.
99. (U) Pharmaceuticals, R., Regeneron has identified hundreds of virus-neutralizing antibodies; plans to initiate large-scale manufacturing mid-April with antibody cocktail therapy. PR Newswire: 2020.
100. (U) Pyankov, O. V.; Bodnev, S. A.; Pyankova, O. G.; Agranovski, I. E., Survival of aerosolized coronavirus in the ambient air. *Journal of Aerosol Science* **2018,** *115*, 158-163.
101. (U) Rabenau, H.; Kampf, G.; Cinatl, J.; Doerr, H., Efficacy of various disinfectants against SARS coronavirus. *Journal of Hospital Infection* **2005,** *61* (2), 107-111.
102. (U) Rabenau, H. F.; Cinatl, J.; Morgenstern, B.; Bauer, G.; Preiser, W.; Doerr, H. W., Stability and inactivation of SARS coronavirus. *Med Microbiol Immunol* **2005,** *194* (1-2), 1-6.
103. (U) Rambaut, A., Phylodynamic analysis of nCoV-2019 genomes - 27-Jan-2020. http://virological.org/t/phylodynamic-analysis-of-ncov-2019-genomes-27-jan-2020/353.
104. (U) Ren, X.; Liu, Y.; Chen, H.; Liu, W.; Guo, Z.; Chen, C.; Zhou, J.; Xiao, Q.; Jiang, G.-M.; Shan, H., Application and Optimization of RT-PCR in Diagnosis of SARS-CoV-2 Infection. *medRxiv* **2020**.
105. (U) Richter, W.; Hofacre, K.; Willenberg, Z., *Final Report for the Bioquell Hydrogen Peroxide Vapor (HPV) Decontamination for Reuse of N95 Respirators*; Battelle Memorial Institute: 2016.
106. (U) Riou, J.; Althaus, C. L., Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020. *Eurosurveillance* **2020,** *25* (4), 2000058.
107. (U) Roberts, M., Coronavirus: US volunteers test first vaccine. *BBC* 2020.
108. (U) Robertson, D., nCoV's relationship to bat coronaviruses & recombination signals (no snakes) **2020**.
109. (U) Rockx, B.; Kuiken, T.; Herfst, S.; Bestebroer, T.; Lamers, M.; de Meulder, D.; van Amerongen, G.; van de Brand, J.; Okba, N.; Schipper, D.; van Run, P.; Leijten, L.; Verschoor, E.; Verstrepen, B.; Langermans, J.; Drosten, C.; Fentener van Vlissingen, M.; Fouchier, R.; de Swart, R. L.; Koopmans, M.; Haagmans, B., Comparative Pathogenesis Of COVID-19, MERS And SARS In A Non-Human Primate Model. *bioRxiv* **2020**, 2020.03.17.995639.
110. (U) Rothe, C.; Schunk, M.; Sothmann, P.; Bretzel, G.; Froeschl, G.; Wallrauch, C.; Zimmer, T.; Thiel, V.; Janke, C.; Guggemos, W.; Seilmaier, M.; Drosten, C.; Vollmar, P.; Zwirglmaier, K.; Zange, S.; Wölfel, R.; Hoelscher, M., Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany. *New England Journal of Medicine* **2020**.
111. (U) Ruan, Q.; Yang, K.; Wang, W.; Jiang, L.; Song, J., Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. *Intensive Care Medicine* **2020**.

112. (U) Saknimit, M.; Inatsuki, I.; Sugiyama, Y.; Yagami, K., Virucidal efficacy of physico-chemical treatments against coronaviruses and parvoviruses of laboratory animals. *Jikken Dobutsu* **1988,** *37* (3), 341-5.
113. (U) Schnirring, L., New coronavirus infects health workers, spreads to Korea. http://www.cidrap.umn.edu/news-perspective/2020/01/new-coronavirus-infects-health-workers-spreads-korea.
114. (U) Security, J. C. f. H., 2019-nCoV resources and updates on the emerging novel coronavirus. **2020**.
115. (U) Sheahan, T. P.; Sims, A. C.; Graham, R. L.; Menachery, V. D.; Gralinski, L. E.; Case, J. B.; Leist, S. R.; Pyrc, K.; Feng, J. Y.; Trantcheva, I.; Bannister, R.; Park, Y.; Babusis, D.; Clarke, M. O.; Mackman, R. L.; Spahn, J. E.; Palmiotti, C. A.; Siegel, D.; Ray, A. S.; Cihlar, T.; Jordan, R.; Denison, M. R.; Baric, R. S., Broad-spectrum antiviral GS-5734 inhibits both epidemic and zoonotic coronaviruses. *Sci Transl Med* **2017,** *9* (396).
116. (U) Sheridan, C., Coronavirus and the race to distribute reliable diagnostics. https://www.nature.com/articles/d41587-020-00002-2.
117. (U) Shi, W.; Peng, X.; Liu, T.; Cheng, Z.; Lu, H.; Yang, S.; Zhang, J.; Li, F.; Wang, M.; Zhang, X.; Gao, Y.; Shi, Y.; Zhang, Z.; Shan, F., Deep Learning-Based Quantitative Computed Tomography Model in Predicting the Severity of COVID-19: A Retrospective Study in 196 Patients. *SSRN* **2020**.
118. (U) Su, Y. C.; Anderson, D. E.; Young, B. E.; Zhu, F.; Linster, M.; Kalimuddin, S.; Low, J. G.; Yan, Z.; Jayakumar, J.; Sun, L.; Yan, G. Z.; Mendenhall, I. H.; Leo, Y.-S.; Lye, D. C.; Wang, L.-F.; Smith, G. J., Discovery of a 382-nt deletion during the early evolution of SARS-CoV-2. *bioRxiv* **2020**, 2020.03.11.987222.
119. (U) ter Meulen, J.; van den Brink, E. N.; Poon, L. L.; Marissen, W. E.; Leung, C. S.; Cox, F.; Cheung, C. Y.; Bakker, A. Q.; Bogaards, J. A.; van Deventer, E.; Preiser, W.; Doerr, H. W.; Chow, V. T.; de Kruif, J.; Peiris, J. S.; Goudsmit, J., Human monoclonal antibody combination against SARS coronavirus: synergy and coverage of escape mutants. *PLoS Med* **2006,** *3* (7), e237.
120. (U) The Novel Coronavirus Pneumonia Emergency Response Epidemiology, T., The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020. *China CDC Weekly* **2020,** *2*, 1-10.
121. (U) Thevarajan, I.; Nguyen, T. H. O.; Koutsakos, M.; Druce, J.; Caly, L.; van de Sandt, C. E.; Jia, X.; Nicholson, S.; Catton, M.; Cowie, B.; Tong, S. Y. C.; Lewin, S. R.; Kedzierska, K., Breadth of concomitant immune responses prior to patient recovery: a case report of non-severe COVID-19. *Nature Medicine* **2020**.
122. (U) Thomas, P. R.; Karriker, L. A.; Ramirez, A.; Zhang, J.; Ellingson, J. S.; Crawford, K. K.; Bates, J. L.; Hammen, K. J.; Holtkamp, D. J., Evaluation of time and temperature sufficient to inactivate porcine epidemic diarrhea virus in swine feces on metal surfaces. *Journal of Swine Health and Production* **2015,** *23* (2), 84.
123. (U) Thomas, P. R.; Ramirez, A.; Zhang, J.; Ellingson, J. S.; Myers, J. N., Methods for inactivating PEDV in Hog Trailers. *Animal Industry Report* **2015,** *661* (1), 91.
124. (U) To, K. K.-W.; Tsang, O. T.-Y.; Yip, C. C.-Y.; Chan, K.-H.; Wu, T.-C.; Chan, J. M.-C.; Leung, W.-S.; Chik, T. S.-H.; Choi, C. Y.-C.; Kandamby, D. H.; Lung, D. C.; Tam, A. R.; Poon, R. W.-S.; Fung, A. Y.-F.; Hung, I. F.-N.; Cheng, V. C.-C.; Chan, J. F.-W.; Yuen, K.-Y., Consistent Detection of 2019 Novel Coronavirus in Saliva. *Clinical Infectious Diseases* **2020**.
125. (U) van Doremalen, N.; Bushmaker, T.; Morris, D.; Holbrook, M.; Gamble, A.; Williamson, B.; Tamin, A.; Harcourt, J.; Thornburg, N.; Gerber, S.; Lloyd-Smith, J.; de Wit, E.; Munster, V., Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1. *medRxiv* **2020**, 2020.03.09.20033217.

126. (U) van Doremalen, N.; Bushmaker, T.; Morris, D. H.; Holbrook, M. G.; Gamble, A.; Williamson, B. N.; Tamin, A.; Harcourt, J. L.; Thornburg, N. J.; Gerber, S. I.; Lloyd-Smith, J. O.; de Wit, E.; Munster, V. J., Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *New England Journal of Medicine* **2020**.
127. (U) van Doremalen, N.; Bushmaker, T.; Munster, V. J., Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions. *Euro Surveill* **2013,** *18* (38).
128. (U) Verdict, Cepheid to develop automated molecular test for coronavirus. Verdict Medical Devices: 2020.
129. (U) Wan, Y.; Shang, J.; Graham, R.; Baric, R. S.; Li, F., Receptor recognition by novel coronavirus from Wuhan: An analysis based on decade-long structural studies of SARS. *Journal of Virology* **2020**, JVI.00127-20.
130. (U) Wang, D.; Hu, B.; Hu, C.; Zhu, F.; Liu, X.; Zhang, J.; Wang, B.; Xiang, H.; Cheng, Z.; Xiong, Y.; Zhao, Y.; Li, Y.; Wang, X.; Peng, Z., Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China. *JAMA* **2020**.
131. (U) Wang, W.; Xu, Y.; Gao, R.; Lu, R.; Han, K.; Wu, G.; Tan, W., Detection of SARS-CoV-2 in Different Types of Clinical Specimens. *JAMA* **2020**.
132. (U) WHO, Diagnostic detection of Wuhan coronavirus 2019 by real-time RTPCR -Protocol and preliminary evaluation as of Jan 13, 2020. https://www.who.int/docs/default-source/coronaviruse/wuhan-virus-assay-v1991527e5122341d99287a1b17c111902.pdf?sfvrsn=d381fc88_2 (accessed 01/26/2020).
133. (U) WHO, *Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected*; 2020.
134. (U) WHO, Laboratory testing for 2019 novel coronavirus (2019-nCoV) in suspected human cases.
135. (U) WHO, Novel Coronavirus (2019-nCoV) Situation Report-5 25 January 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200125-sitrep-5-2019-ncov.pdf?sfvrsn=429b143d_4.
136. (U) WHO, Novel Coronavirus (2019-nCoV) technical guidance: Laboratory testing for 2019-nCoV in humans. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/laboratory-guidance.
137. (U) WHO, *Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)*; World Health Organization: 2020.
138. (U) Woelfel, R.; Corman, V. M.; Guggemos, W.; Seilmaier, M.; Zange, S.; Mueller, M. A.; Niemeyer, D.; Vollmar, P.; Rothe, C.; Hoelscher, M.; Bleicker, T.; Bruenink, S.; Schneider, J.; Ehmann, R.; Zwirglmaier, K.; Drosten, C.; Wendtner, C., Virological assessment of hospitalized cases of coronavirus disease 2019. **2020**.
139. (U) Wolff, M. H.; Sattar, S. A.; Adegbunrin, O.; Tetro, J., Environmental survival and microbicide inactivation of coronaviruses. In *Coronaviruses with special emphasis on first insights concerning SARS*, Springer: 2005; pp 201-212.
140. (U) Wong, M. C.; Javornik Cregeen, S. J.; Ajami, N. J.; Petrosino, J. F., Evidence of recombination in coronaviruses implicating pangolin origins of nCoV-2019. *bioRxiv* **2020**, 2020.02.07.939207.
141. (U) Wrapp, D.; Wang, N.; Corbett, K. S.; Goldsmith, J. A.; Hsieh, C.-L.; Abiona, O.; Graham, B. S.; McLellan, J. S., Cryo-EM Structure of the 2019-nCoV Spike in the Prefusion Conformation. *bioRxiv* **2020**, 2020.02.11.944462.
142. (U) Wu, J. T.; Leung, K.; Leung, G. M., Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. *The Lancet*.

143. (U) Xia, S.; Liu, M.; Wang, C.; Xu, W.; Lan, Q.; Feng, S.; Qi, F.; Bao, L.; Du, L.; Liu, S.; Qin, C.; Sun, F.; Shi, Z.; Zhu, Y.; Jiang, S.; Lu, L., Inhibition of SARS-CoV-2 infection (previously 2019-nCoV) by a highly potent pan-coronavirus fusion inhibitor targeting its spike protein that harbors a high capacity to mediate membrane fusion. *bioRxiv* **2020**, 2020.03.09.983247.
144. (U) Xinhua, China detects large quantity of novel coronavirus at Wuhan seafood market http://www.xinhuanet.com/english/2020-01/27/c_138735677.htm.
145. (U) Xu, X.; Han, M.; Li, T.; Sun, W.; Wang, D.; Fu, B.; Zhou, Y.; Zheng, X.; Yang, Y.; Li, X.; Zhang, X.; Pan, A.; Wei, H., Effective Treatment of Severe COVID-19 Patients with Tocilizumab. *ChinaXiv* **2020**.
146. (U) Xu, Z.; Shi, L.; Wang, Y.; Zhang, J.; Huang, L.; Zhang, C.; Liu, S.; Zhao, P.; Liu, H.; Zhu, L.; Tai, Y.; Bai, C.; Gao, T.; Song, J.; Xia, P.; Dong, J.; Zhao, J.; Wang, F.-S., Pathological findings of COVID-19 associated with acute respiratory distress syndrome. *The Lancet Respiratory Medicine*.
147. (U) Yoon, I.-K.; Kim, J. H., First clinical trial of a MERS coronavirus DNA vaccine. *The Lancet Infectious Diseases* **2019,** *19* (9), 924-925.
148. (U) Yu, W.-B.; Tang, G.-D.; Zhang, L.; Corlett, R. T., Decoding evolution and transmissions of novel pneumonia coronavirus using the whole genomic data. *ChinaXiv* **2020**.
149. (U) Zhao; Musa; Lin; Ran; Yang; Wang; Lou; Yang; Gao; He; Wang, Estimating the Unreported Number of Novel Coronavirus (2019-nCoV) Cases in China in the First Half of January 2020: A Data-Driven Modelling Analysis of the Early Outbreak. *Journal of Clinical Medicine* **2020,** *9* (2), 388.
150. (U) Zhao, G.; Jiang, Y.; Qiu, H.; Gao, T.; Zeng, Y.; Guo, Y.; Yu, H.; Li, J.; Kou, Z.; Du, L.; Tan, W.; Jiang, S.; Sun, S.; Zhou, Y., Multi-Organ Damage in Human Dipeptidyl Peptidase 4 Transgenic Mice Infected with Middle East Respiratory Syndrome-Coronavirus. *PLoS One* **2015,** *10* (12), e0145561.
151. (U) Zhen-Dong, T.; An, T.; Ke-Feng, L.; Peng, L.; Hong-Ling, W.; Jing-Ping, Y.; Yong-Li, Z.; Jian-Bo, Y., Potential Presymptomatic Transmission of SARS-CoV-2, Zhejiang Province, China, 2020. *Emerging Infectious Disease journal* **2020,** *26* (5).
152. (U) Zhongchu, L., The sixth press conference of "Prevention and Control of New Coronavirus Infected Pneumonia". Hubei Provincial Government: 2020.
153. (U) Zhou, F.; Yu, T.; Du, R.; Fan, G.; Liu, Y.; Liu, Z.; Xiang, J.; Wang, Y.; Song, B.; Gu, X.; Guan, L.; Wei, Y.; Li, H.; Wu, X.; Xu, J.; Tu, S.; Zhang, Y.; Chen, H.; Cao, B., Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet*.
154. (U) Zhou, P.; Yang, X.-L.; Wang, X.-G.; Hu, B.; Zhang, L.; Zhang, W.; Si, H.-R.; Zhu, Y.; Li, B.; Huang, C.-L.; Chen, H.-D.; Chen, J.; Luo, Y.; Guo, H.; Jiang, R.-D.; Liu, M.-Q.; Chen, Y.; Shen, X.-R.; Wang, X.; Zheng, X.-S.; Zhao, K.; Chen, Q.-J.; Deng, F.; Liu, L.-L.; Yan, B.; Zhan, F.-X.; Wang, Y.-Y.; Xiao, G.; Shi, Z.-L., Discovery of a novel coronavirus associated with the recent pneumonia outbreak in humans and its potential bat origin. *bioRxiv* **2020**, 2020.01.22.914952.
155. (U) Zou, L.; Ruan, F.; Huang, M.; Liang, L.; Huang, H.; Hong, Z.; Yu, J.; Kang, M.; Song, Y.; Xia, J.; Guo, Q.; Song, T.; He, J.; Yen, H.-L.; Peiris, M.; Wu, J., SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. *New England Journal of Medicine* **2020**.