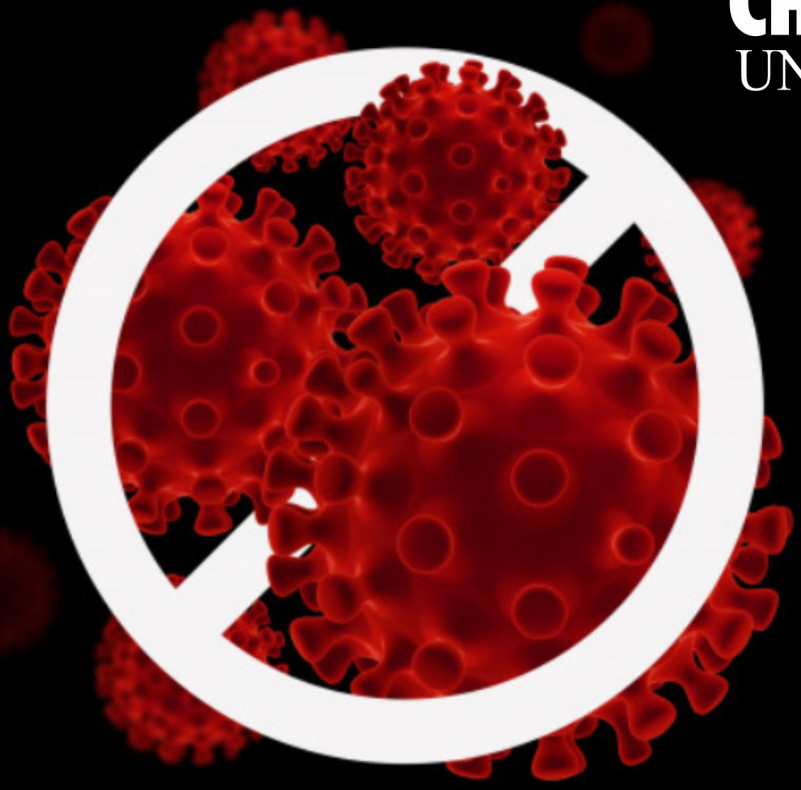
CHITKARA UNIVERSITY



CORONA VIRUS OUTBREAK

INSIGHTS ON COVID-19

Information leaflet

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AN EHS RESOURCE & UPDATE ON COVID-19, CHITKARA UNIVERSITY

INDEX

I: General Information

I.1 What is Coronavirus disease?

Coronavirus disease (COVID-19) is a viral respiratory disease that can spread from person to person. The severity of this disease ranges from common cold to **Severe Acute Respiratory Syndrome (SARS- CoV) and Middle East Respiratory Syndrome (MERS-CoV).**

I.2 What causes this disease?

- This disease is caused by a recently identified strain of virus named as COVID -19, which was identified in the year 2019.
- The coronaviruses are transmitted between animals and people.
- SARS-CoV was transmitted from civet cats to humans and MERS-CoV from dromedary camels to humans.

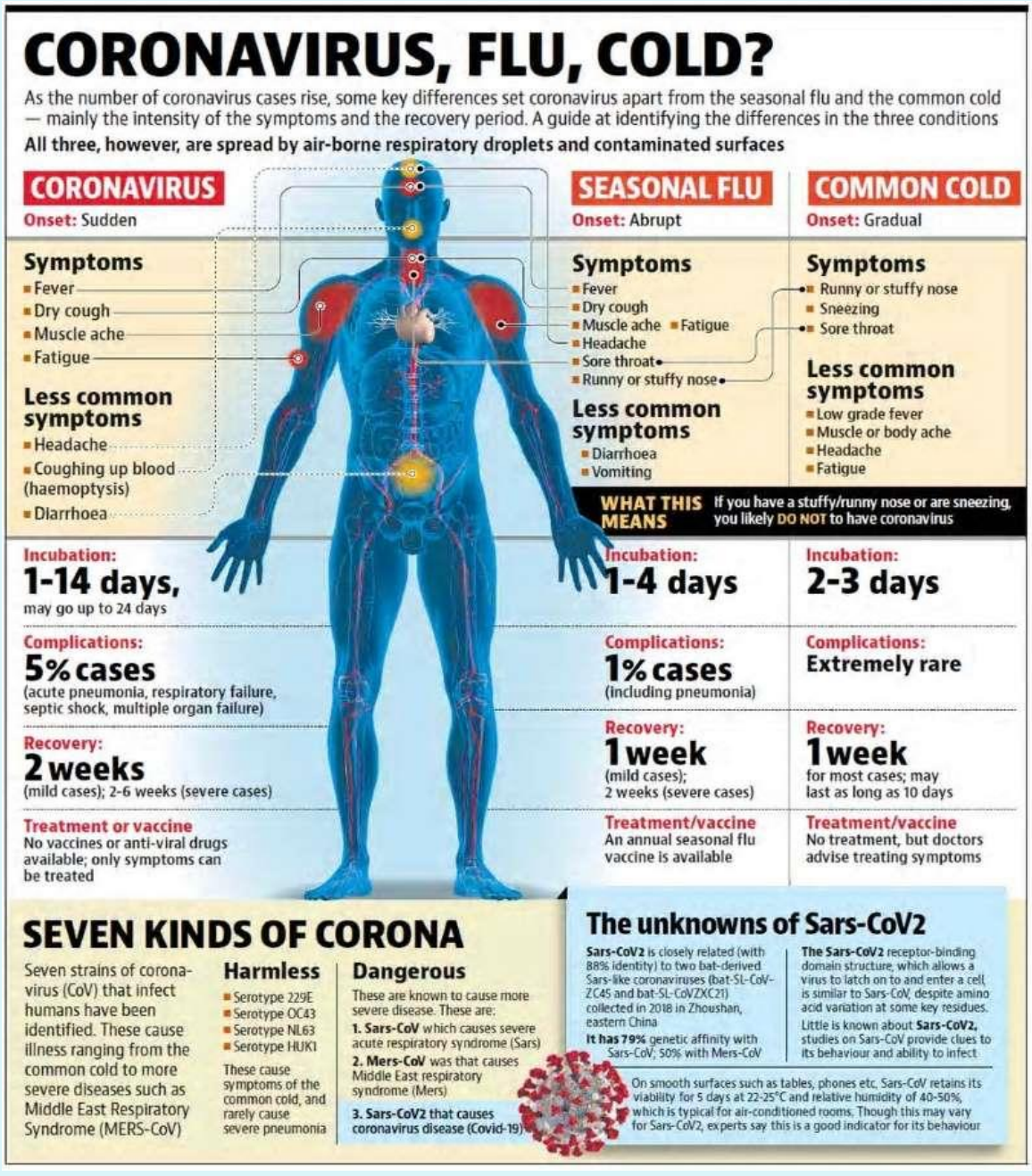
I.3 What are the symptoms of this disease?

- Reported illnesses have ranged from mild symptoms to severe illness and death for confirmed Coronavirus disease 2019 (COVID-19) cases.
- The following common symptoms may appear 2-14 days after exposure.
    - **Fever**
    - **Tiredness**
    - **Dry cough**
    - **Nasal congestion**
    - **Running nose**
    - **Sore throat**
    - **Diarrhea**
    - **Shortness of breath**
    - **In severe cases, infection can result in pneumonia, severe acute respiratory syndrome, kidney failure and even death.**

I.4 Emergency warning signs requiring immediate medical attention

- **Difficulty breathing or shortness of breath**
- **Persistent pain or pressure in the chest**
- **New confusion or inability to arouse**
- **Bluish lips or face**

I.5 Difference between Corona virus, Flu and Cold



I.6 Who is at higher risk to develop COVID-19?

- Older adults
- People who have serious chronic medical conditions like: Heart disease; Diabetes; Lung disease

I.7 Can COVID-19 spread from one individual to another?

- COVID-19 is highly communicable and is spreading worldwide.
- Risk of infection is higher among those who are in close contact of someone known to have COVID-19.
- The disease can spread from person to person through small droplets from the nose or mouth which are released when an infected person is coughing
- People can also get infected by touching the objects and COVID-19 contaminated surfaces and then touching their eyes, nose or mouth

I.8 How to protect yourself from getting infected?

- **One can reduce their chances of getting infected or spreading COVID-19 by taking some simple precautions:**
- **Regularly cleaning of hands with an alcohol-based sanitizer will help in killing the viruses that may be present on individual hands.**
- **Maintaining at least 1 meter (3 feet) distance between yourself and anyone who is coughing**
- **To the extent possible, avoid touching high-touch surfaces in public places – elevator buttons, door handles, handrails, handshaking with people, etc.**
- **Avoid touching eyes, nose and mouth.**
- **Avoid crowds, especially in poorly ventilated spaces.**

- **Be sure you have over-the-counter medicines and medical supplies to treat fever and other symptoms. Most people will be able to recover from COVID-19 at home.**
- **Have enough household items and groceries on hand so that you will be prepared to stay at home for a period of time.**

I.9 What to do if you get sick?

- Stay home: People who are mildly ill with COVID-19 are able to recover at home. Do not leave, except to get medical care. Do not visit public areas.

- Stay in touch with your doctor: Call before you get medical care. Be sure to get care if you feel worse or you think it is an emergency

- Avoid public transportation: void using public transportation, ride-sharing, or taxis.
- Undergo home isolation: As much as possible, you should stay in a specific "sick room" and away from other people in your home. Use a separate bathroom

- Limit contact with pets & animals: You should restrict contact with pets and other animals,
- Call ahead: If you have a medical appointment, call your doctor's office or emergency department, and tell them you have or may have COVID-19.
- Wear a facemask: You should wear a facemask when you are around other people and before you enter a healthcare provider's office.
- Cover: Cover your mouth and nose with a tissue when you cough or sneeze.
- Dispose: Throw used tissues in a lined trash can.
- Wash hands: Immediately wash your hands with soap and water for at least 20 seconds. If soap and water are not available, clean your hands with an alcohol-based hand sanitizer that contains at least 60% alcohol.
- Do not share: Do not share dishes, drinking glasses, cups, eating utensils, towels, or bedding with other people in your home.
- Wash thoroughly after use: After using these items, wash them thoroughly with soap and water or put in the dishwasher.

I.10 Can we treat a person infected with COVID-19?

- Most people (about 80%) recover from the disease without needing special treatment.
- Around 1 out of every 6 people who gets COVID-19 becomes seriously ill and develops difficulty breathing.
- Some western, traditional or home remedies may provide comfort and alleviate symptoms of COVID-19. However, there is no evidence that current medicine can prevent or cure the disease.

- There is no vaccine and no specific antiviral medicine to prevent or treat COVID-2019. However, possible vaccines and some specific drug treatments are under investigation.

I.11 Myth Busters on COVID-19

Can COVID-19 virus affect areas with hot and humid climates?

- COVID-19 virus can be transmitted in all areas, including areas with hot and humid weather.

Can cold weather and snow prevent the COVID-19?

- There is no reason to believe that cold weather can kill the new Coronavirus or other diseases.

Can taking a hot bath prevents the COVID-19?

- Taking a hot bath will not prevent you from catching COVID-19.

Are hand dryers effective in killing the COID-19?

- No. Hand dryers are not effective in killing the 2019-nCoV.

Can an ultraviolet disinfection lamp kill the COVID-19?

- UV lamps should not be used to sterilize hands or other areas of skin as UV radiation can cause skin irritation.

Can spraying alcohol or chlorine all over your body kill the COVID-19?

- No. Spraying alcohol or chlorine all over your body will not kill viruses that have already entered your body. Be aware that both alcohol and chlorine can be useful to disinfect surfaces.

Do vaccines against pneumonia protect you against the COVID-19?

- No. Vaccines against pneumonia, such as pneumococcal vaccine and Haemophilus influenza type B (Hib) vaccine, do not provide protection against the COVID-19.

Can eating garlic helps to prevent infection with the COVID-19?

- Garlic is a healthy food that may have some antimicrobial properties. However, there is no evidence from the current outbreak that eating garlic has protected people from the COVID-19.

Are antibiotics effective in preventing and treating the COVID-19?

- No, antibiotics do not work against viruses, only bacteria. The COVID-19 is a virus and, therefore, antibiotics should not be used as a means of prevention or treatment.

Are there any specific medicines to prevent or treat the COVID -19?

- Till date, there is no specific medicine recommended to prevent or treat the COVID-19.

I.12 Managing Fear and Anxiety

Managing Fears and Anxiety around COVID-19

As information about COVID-19- the illness associated with a new strain of coronavirus unfolds, there can be a wide range of thoughts, feelings and reactions. Below are some helpful information and resources.

Common Reactions

Please recognize that people can experience a wide range of reactions. Over the next few days or weeks, you may experience periods of:

- Anxiety, worry, panic
- Anger
- Difficulty concentrating and sleeping
- Feeling hopelessness
- Social withdrawal
- Hyper-vigilance to your health and body

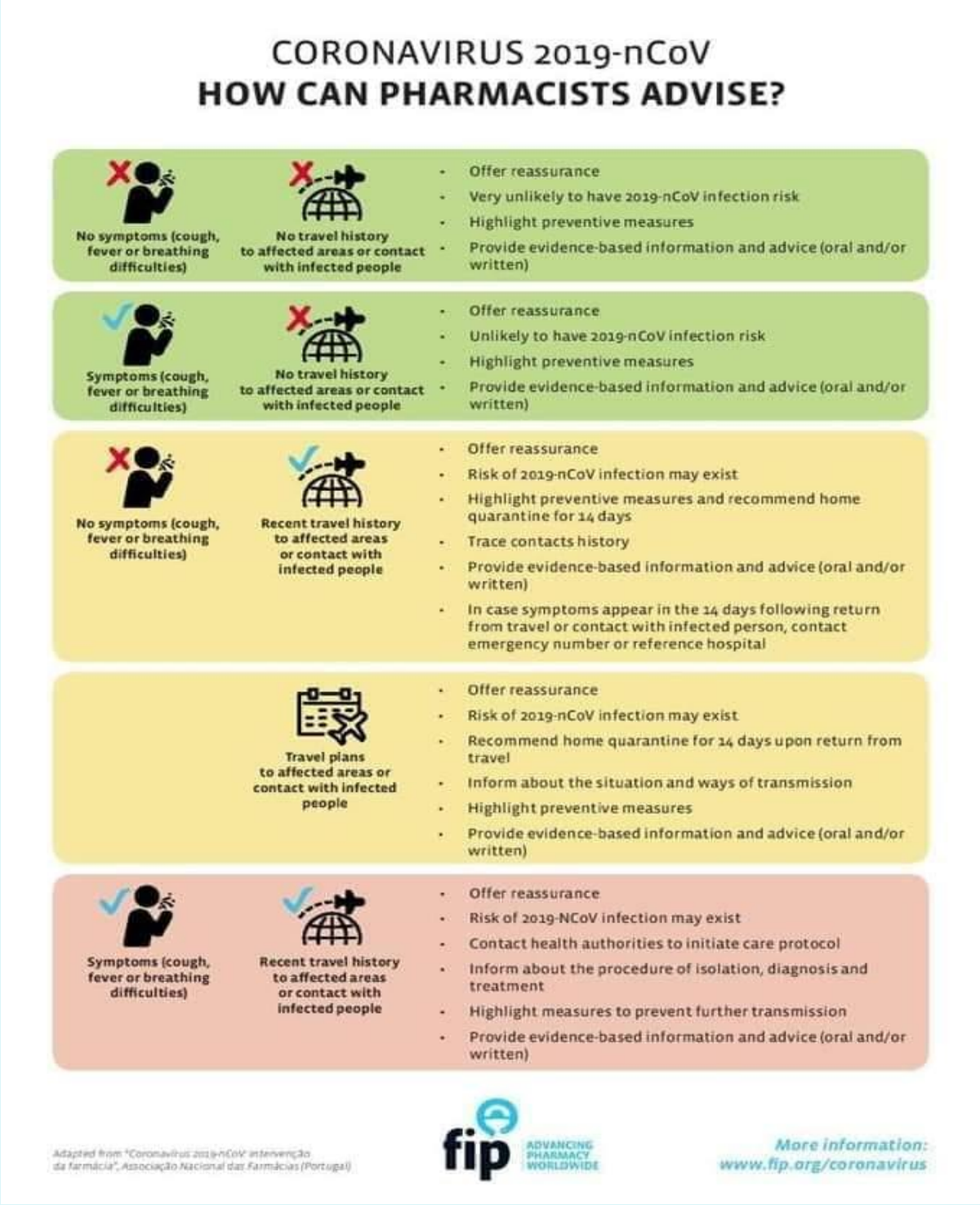
Ways to Manage Fears and Anxieties

Although COVID-19 is a health issue that is being taken very seriously by the university and public health authorities worldwide, do not let your worry about this virus control your life. There are many simple and effective ways to manage your fears and anxieties. Many of them are essential ingredients for a healthy lifestyle; adopting them can help improve your overall emotional and physical well-being.

- **Get the facts.** It is helpful to stay up to date with credible news sources. The best places to get accurate, updated information on COVID-19 are:
  CSU information: safety.colostate.edu/coronavirus
  U.S. Centers for Disease Control and Prevention: cdc.gov/coronavirus/2019-ncov
- **Keep things in perspective.** Limit worry and agitation by lessening the time you spend watching or listening to upsetting media coverage. Although you'll want to keep informed — especially if you have loved ones in affected countries — remember to take a break from watching the news and focus on the things that are positive in your life and things you have control over.
- **Be mindful of your assumptions about others.** Someone who has a cough or a fever does not necessarily have COVID-19 - the nation is also experiencing a significant flu season. Self-awareness is important in not stigmatizing others in our community.
- **Stay healthy.** Adopt healthy hygienic habits such as regularly washing your hands with soap and water for 20 seconds, especially after sneezing or before/after touching your face or a sick person. Cover your mouth and nose with a tissue or your sleeve (not your hands) when coughing or sneezing. Avoid touching your eyes, nose and mouth. Avoid contact with others who are sick and stay home while sick. Try to get adequate sleep and eat healthy foods to support your immune system.
- **Keep connected.** Maintaining social networks can help maintain a sense of normalcy and provide valuable outlets for sharing feelings and relieving stress.
- **Seek additional help.** Individuals who feel an overwhelming worry or anxiety can seek additional professional mental health support.
- **Plan.** Creating a plan for yourself and your loved ones can help reduce stress and anxiety. For example, consider keeping extra supplies of food, pet food, cash, medical supplies and medication on hand. If you are experiencing food insecurity, resources are available to you at: ramsagainsthunger.colostate.edu

CSU HEALTH NETWORK
COLORADO STATE UNIVERSITY

I.13: Pharmacy Professionals: responsibilities



II: National and International Guiding resources

Interim Guidance for Implementing Home Care of People Not Requiring Hospitalization for Corona virus Disease 2019 (COVID-19)

Globally following organisations are coordinating the COVID outbreak management and providing authentic guidelines on identification, clinical management, safety and preventive guidelines and social guidelines

World Health Organisation: www.who.int

Centre for Disease Control (CDC), USA: www.cdc.gov

Indian Council of Medical Research, ICMR, India: www.icmr.nic.in

Department of Health Research, DHR, India: www.dhr.gov.in/www.mygov.in

Central Drug Standardisation and Control Organisation: www.cdsco.gov.in (Involved in evaluation and approvals of new drugs/devices for medical use)

Ministry of Health and Family Welfare, Govt of India:www.mohfw.gov.in

These agencies have been providing standard guidelines and information on all matters related to identification, tracking, regional/global spread, and management of the outbreak. CDC, for example has offered various guidelines as under.

CDC Guidelines

This interim guidance is for staff at local and state health departments, infection prevention and control professionals, and healthcare personnel who are coordinating the home care and isolation of people with confirmed or suspected COVID-19 infection, including persons under investigation (see **Criteria to Guide Evaluation of Persons under Investigation (PUI) for COVID-19**, in referenced resources). This includes patients evaluated in an outpatient setting who do not require hospitalization (i.e., patients who are medically stable and

can receive care at home) or patients who are discharged home following a hospitalization with confirmed COVID-19.

Referenced resources

Criteria to Guide Evaluation of Patients under Investigation (PUI) for Coronavirus Disease 2019 (COVID-19): www.cdc.gov/coronavirus/2019-nCoV/clinical-criteria.html

Interim Infection Prevention and Control Recommendations for Patients with Known or Patients under Investigation for Coronavirus Disease 2019 (COVID-19) in a Healthcare Setting: www.cdc.gov/coronavirus/2019-nCoV/infection-control.html

Interim Guidance for Preventing Coronavirus Disease 2019 (COVID-19) from Spreading to Others in Homes and Communities: www.cdc.gov/coronavirus/2019-ncov/,guidance-prevent-spread.html

Additional information on Interim Guidance for Healthcare Professionals on human infections with COVID-19 is available online at www.cdc.gov/coronavirus/2019-nCoV/clinical-criteria.html

III. COVID VIRUS: Scientific details

III.1 SARS-CoV-2 is part of the *Coronaviridae* family, which are named after their crown-like appearance under the under the electron microscope that is given by the surface glycoproteins that decorate the virus. The family includes two subfamilies: *Letovirinae* and *Orthocoronavirinae*. The *Orthocoronavirnae* include the genera *Alphacoronvirus*, *Betacoronavirus*, *Gammacoronavirus* and *Deltacoronavirus*. Alphacoronaviruses and betacoronaviruses typically infect only mammals, whereas gammacoronoviruses and deltacoronaviruses typically

infect avian species and sometimes mammals as well (Cui et al., 2019). Coronaviruses are common human pathogens and two types of alphacoronaviruses (229E, NL63) and two types of betacoronaviruses (OC43, HKU1) circulate in humans and cause common cold. More pathogenic coronaviruses for humans include SARS-CoV-1, the Middle Eastern Respiratory Syndrome (MERS) CoV and now SARS-CoV-2, which are all betacoronaviruses.

III.2: Genomic identity and source:

Since the COVID-19 virus has a genome identity of 96% to a bat SARS-like coronavirus and 86%-92% to a pangolin SARS-like coronavirus, an animal source for COVID-19 is highly likely. This was corroborated by the high number of RT-PCR positive environmental samples taken from the Huanan Seafood Market in Wuhan.

III.3 Clinical Symptoms:

People with COVID-19 generally develop signs and symptoms, including mild respiratory symptoms and fever, on an average of 5-6 days after infection (mean incubation period 5-6 days, range 1-14 days).

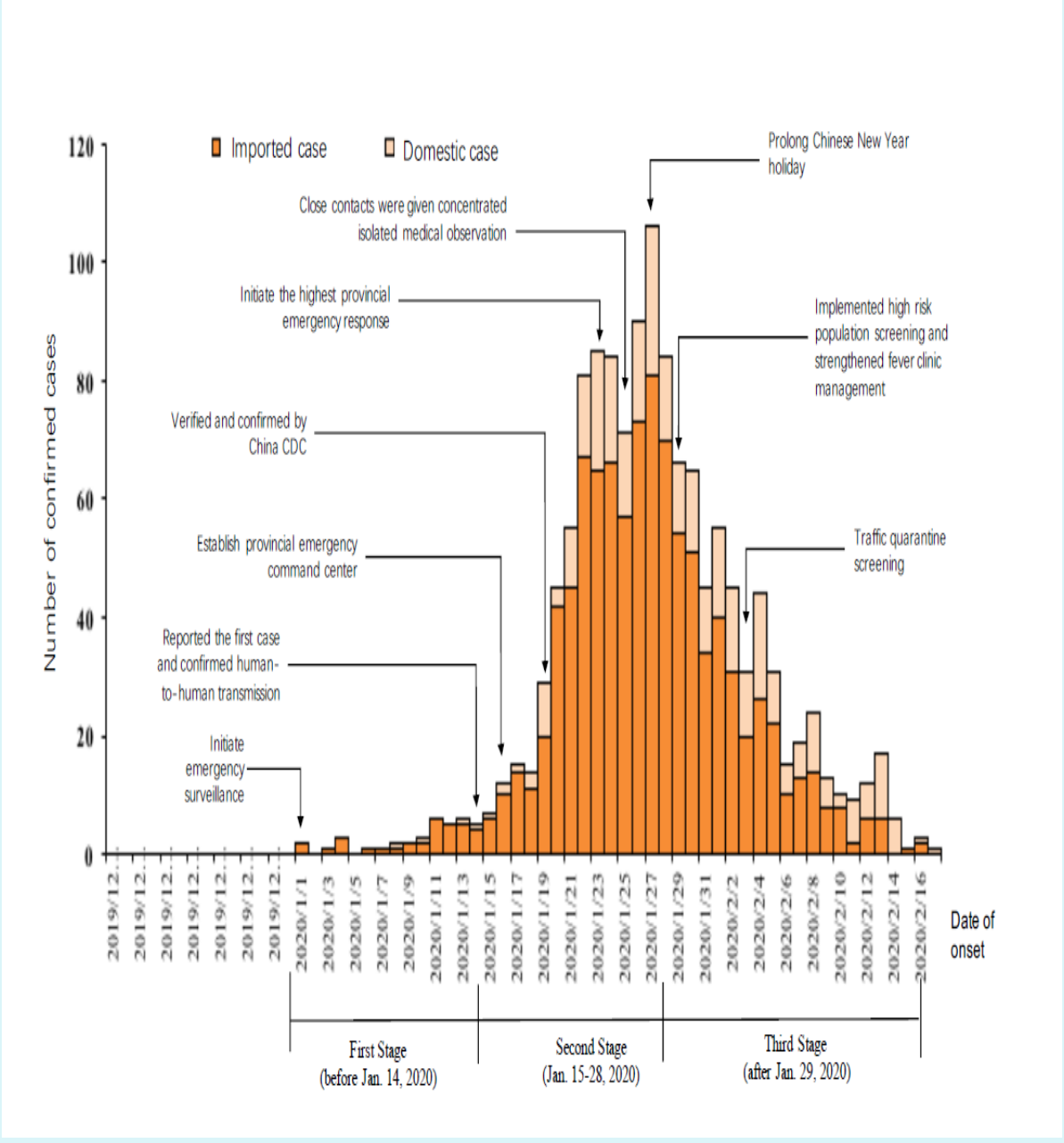
Most people infected with COVID-19 virus have mild disease and recover. Approximately 80% of laboratory confirmed patients have had **mild to moderate disease**, which includes non-pneumonia and pneumonia cases, 13.8% have **severe disease** (dyspnea, respiratory frequency ≥30/minute, blood oxygen saturation ≤93%, PaO2/FiO2 ratio <300, and/or lung infiltrates >50% of the lung field within 24-48 hours) and 6.1% are **critical** (respiratory failure, septic shock,

and/or multiple organ dysfunction/failure). **Asymptomatic infection** has been reported, but the majority of the relatively rare cases who are asymptomatic on the date of identification/report went on to develop disease. The proportion of truly asymptomatic infections is unclear but appears to be relatively rare and does not appear to be a major driver of transmission.

As opposed to Influenza A(H1N1)pdm09, **pregnant women** do not appear to be at higher risk of severe disease. In an investigation of 147 pregnant women (64 confirmed, 82 suspected and 1 asymptomatic), 8% had severe disease and 1% were critical.

Severe cases are defined as tachypnoea (≧30 breaths/ min) or oxygen saturation ≤93% at rest, or PaO2/FIO2 <300 mmHg. **Critical cases** are defined as respiratory failure requiring mechanical ventilation, shock or other organ failure that requires intensive care. About a quarter of severe and critical cases require mechanical ventilation while the remaining 75% require only oxygen supplementation.

III.4 Epidemiological infection phases as seen in China between 1st jan 2020 to 20th Feb 2020 when the diseases has trickled down



IV. Prevention of contamination, cross contamination, spread of infection and community spread:

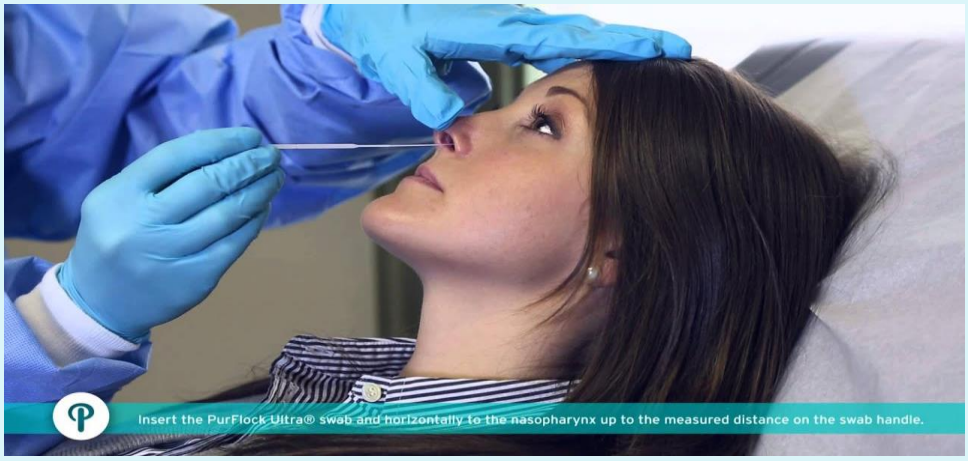
The conclusive steps in a CORONA pandemic are as follows:

1. **Prevention by social distancing (Separation by a distance of 2 meters in community area), regional, zonal or national lockdown to prevent social or community transfer by contact or through cough and respiratory drops while sneezing, when the virus is likely to remain in adjacent air or on nearby objects for a period of 4-8 hrs and may be transferred by touching these surfaces or by inhalation of contaminated air in that area..**
2. **Repeated personal sanitisation of hands and open body parts using scrubs, antimicrobial soap solutions, alcohol based santisers.**
3. **Use of Personal Protective equipment (PPE) by Healthcare team members while managing, testing or interaction with COVID patients.**
4. **Use of masks and respirators by public when in a zCommunity area to prevent transfer to respiratory system when in closs contact with probable patients.**
5. **Appropriate and timely testing when symptoms appear at authorised Testing labs**
6. **Home care if only mild flu symptoms and management with medicines for flu and fever**
7. **Hospitalisation in case of severe upper or lower respiratory tract infection or pneumonia to prevent respiratory complications and failure.**

8. **List N: Disinfectant Products and Bactericidal solutions listed with Emerging Viral Pathogens AND Human Coronavirus claims for use against SARS-CoV-2**

S No	Product Type	Formulation	Contact Time	For surfaces/ Body Parts
1	Hydrogen peroxide & Peroxyacetic aci products	Solution for dilution	10mins	For surfaces (Disinfectant)
2	Sodium Hypochlorite products	Solution for dilution	1-2 mins	Bleach or Surfaces (Disinfectant)
3	Isopropanol	Solution without dilution	2-4 mins	Antiseptic and bactericidal for hands and as scrub
4	Quarternary Ammonium	Solution	5-10 mins	
5	Chloroxylenol containing disinfectants and antiseptics	Solution for dilution	2-3 mins	Antispeptic

V. GETTING TESTED AND SUBMITTING SAMPLES FOR COVID TESTING GUIDELINES



The FDA, USA and CDSCO, India have updated their guidelines for COVID-19 testing procedures to make the process easier and less uncomfortable for patients, as well as to help limit the impact of testing on the supply of personal protective equipment (PPE) used by healthcare workers, including protective masks, face shields, gloves and gowns.

The change means that people taking a test will be able to conduct their own swab, which will involve swabbing shallowly in their nose. The existing process required a healthcare professional to take the swab, and to collect a sample from further up in the nasal cavity.

Called a nasopharyngeal swab or culture, it allows doctors to collect a sample of secretions from the uppermost part of the throat, behind the nose. A health care worker will gently insert what looks like a long Q-tip as far as it'll go into a person's nose, twirl the swab to get a good sample, then remove it and place it in a vial, which is then sent to a lab for testing.

This change does not mean there's any difference in the FDA's guidance regarding at-home sample collection – that is still specifically disallowed by the agency's rules, something the FDA clarified over the weekend in order to put an end to at-home test collection kits being distributed by diagnostic startups.

Individuals will still have to go to authorized clinical or drive-through testing sites, and will still have to meet the **Centers for Disease Control and Prevention** (CDC)'s FDA, USA or CDSCO, India screening requirements in order to get tested in the first place. But this will mean that testing conditions are safer for frontline medical personnel in addition to lowering the drain on PPE resources.

THE COVID TEST ON THE NASOPHARYNGEAL SWAB

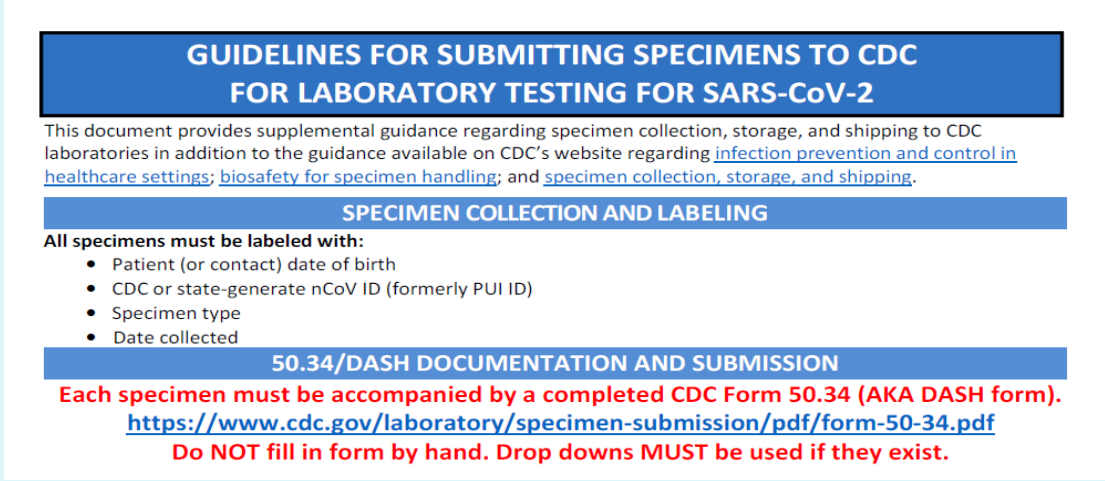
Detection of antibodies

Part of the immune response to infection is the production of antibodies including IgM and IgG. These can be used to detect infection in individuals, to determine immunity, and in population surveillance

Assays can be performed in central laboratories (CLT) or by point-of-care testing(PoCT). The high-throughput automated systems in many clinical laboratories will be able to perform these assays but their availability will depend on the rate of production for each system. For CLT a single specimen of peripheral blood is commonly used, although serial specimens can be used to follow the immune response. For PoCT a single specimen of blood is usually obtained by skin puncture. Unlike PCR methods an extraction step is not needed before assay.

It is hoped that a point of care test will be avaliable in the United States and subsequently in India by March 30th.

A blood test to detect antibodies is being developed as of March 9, 2020. It will allow the determination of whether a person has ever been infected and will work regardless of whether the person developed symptoms.It is hoped that it can return results in 15 minutes by detecting both IgM and IgG antibodies.



GUIDELINES FOR SUBMITTING SPECIMENS TO CDC FOR LABORATORY TESTING FOR SARS-CoV-2

This document provides supplemental guidance regarding specimen collection, storage, and shipping to CDC laboratories in addition to the guidance available on CDC's website regarding infection prevention and control in healthcare settings; biosafety for specimen handling; and specimen collection, storage, and shipping.

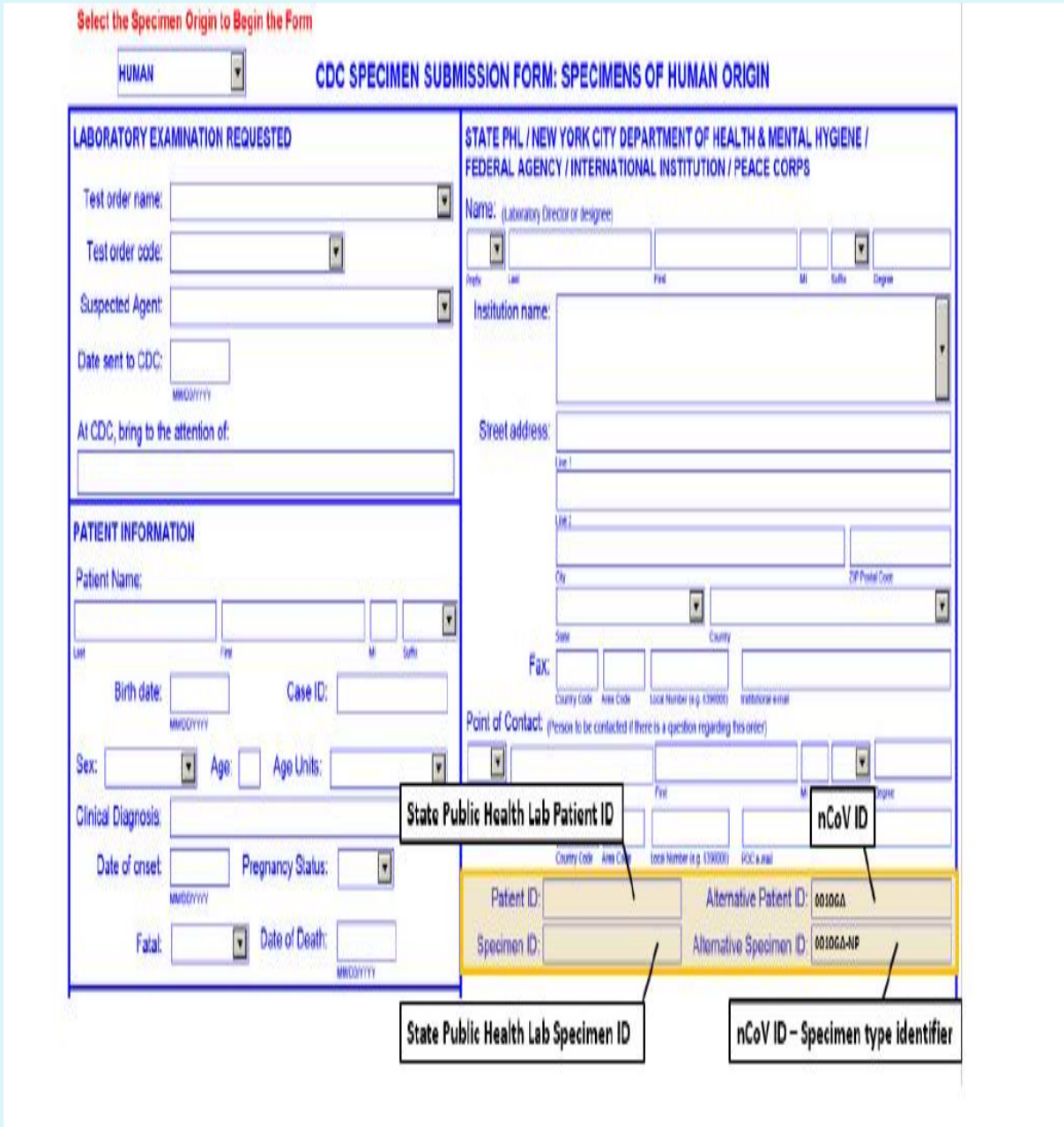
SPECIMEN COLLECTION AND LABELING

All specimens must be labeled with:

- Patient (or contact) date of birth
- CDC or state-generate nCoV ID (formerly PUI ID)
- Specimen type
- Date collected

50.34/DASH DOCUMENTATION AND SUBMISSION

Each specimen must be accompanied by a completed CDC Form 50.34 (AKA DASH form).
https://www.cdc.gov/laboratory/specimen-submission/pdf/form-50-34.pdf
Do NOT fill in form by hand. Drop downs MUST be used if they exist.


Select the Specimen Origin to Begin the Form
HUMAN
CDC SPECIMEN SUBMISSION FORM: SPECIMENS OF HUMAN ORIGIN
LABORATORY EXAMINATION REQUESTED
Test order name:
Test order code:
Suspected Agent:
Date sent to CDC:
MMDDYYYY
At CDC, bring to the attention of:
PATIENT INFORMATION
Patient Name:
Last
First
MI
Suffix
Birth date:
MMDDYYYY
Case ID:
Sex:
Age:
Age Units:
Clinical Diagnosis:
Date of onset:
MMDDYYYY
Pregnancy Status:
Fatal:
Date of Death:
MMDDYYYY
STATE PHL / NEW YORK CITY DEPARTMENT OF HEALTH & MENTAL HYGIENE / FEDERAL AGENCY / INTERNATIONAL INSTITUTION / PEACE CORPS
Name: (Laboratory Director or designee)
Prefix
Last
First
MI
Suffix
Degree
Institution name:
Street address:
Line 1
Line 2
City
ZIP Postal Code
State
Country
Fax:
Country Code
Area Code
Local Number (e.g. 4780000)
Institutional e-mail
Point of Contact: (Person to be contacted if there is a question regarding this order)
First
MI
Degree
Country Code
Area Code
Local Number (e.g. 4780000)
PGC e-mail
Patent ID:
Alternative Patent ID:
00100A
Specimen ID:
Alternative Specimen ID:
00100A-NP
State Public Health Lab Patient ID
nCoV ID
State Public Health Lab Specimen ID
nCoV ID – Specimen type identifier

Patient information on the specimen tube and 50.34/DASH form must match exactly to prevent delays.

Confirm prioritized items below were electronically entered in the 50.34/DASH in proper location displayed above:

- State Public Health Lab Patient ID
- State Public Health Lab Specimen ID
- CDC or state-generated nCoV ID (i.e. 0001021 or NC101847794)

Complete the remaining required fields in the 50.34/DASH:

- Patient first name and last name
- Patient date of birth
- State Public Health Laboratory contact information including full name, title, complete mailing address, email address, telephone, and fax number of the submitter
- Specimen collected date
- Specimen source (type)
- State of Illness

In the upper left-hand corner of the form, to ensure proper routing:

- For "**Test order name"**, select "Respiratory virus molecular detection (non-influenza)" (CDC-10401)
- For "**Suspected Agent**", select "Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2)"

You must include the 50.34/DASH form in the package and send a **secure** email with the 50.34/DASH form to: vtw6@cdc.gov, zbg7@cdc.gov, DSRstat@cdc.gov, eocevent185@cdc.gov, eocevent331@cdc.gov, eocevent177@cdc.gov

Include tracking number and nCoV IDs in the body of the email.

SPECIMEN SHIPPING

Specimens can be received at CDC seven days a week, but the specific instructions below should be followed for weekend deliveries in order to ensure receipt.

Monday – Thursday Shipments:
Ship overnight using your usual courier such as FedEx or UPS to the following address:

ATTN: STATT Lab: COVID 2019
Centers for Disease Control and Prevention
1600 Clifton Road, NE
Atlanta, Georgia, 30333
Telephone: 404-639-3931
Email: dsrstat@cdc.gov

Friday, Saturday, Sunday, or holiday shipments:

- Email the following information to CDC IMS Logistics Transportation (eocevent306@cdc.gov) and CDC IMS Logistics Section Chief (CDC) (eoclogchief@cdc.gov)
  - Name and contact information for the person who will be handing the package to the courier
  - Address of where the package will be picked up
  - Estimated time the package will be ready
  - Number, rough dimensions, and rough weight of the package(s)
  - Whether package contains cold pack, dry ice, or other
  - CDC nCoV ID or state generated nCoV ID
- Email the above information to CDC IMS Logistics Transportation (eocevent306@cdc.gov) and CDC IMS Logistics Section Chief (CDC) (eoclogchief@cdc.gov)
- Call the CDC Emergency Operations Center (770-488-7100) to arrange weekend-specific overnight specimen logistics. Please indicate that the call is about coronavirus specimen shipping and please have the CDC nCoV ID or state generated nCoV ID number.

PREPARING SPECIMENS FOR SHIPMENT

For specimens stored at 2-8°C, all laboratory testing must occur within 72 hours of collection. If a delay in shipping is expected, store specimens at -70°C or below. Refrigerated specimens received outside of this 72 hour window will be rejected.

Specimens should be packed according to International Air Transport Association (IATA) regulations. SARS-CoV-2 specimens should be packed in compliance with regulations for UN3373 Biological Substance, Category B. A packaging checklist is available for reference. For specific instructions, refer to CDC's Packing, Shipping, and Transport guidance (last section).

Version 1.2, March 9, 2020

CDC 2019-Novel Coronavirus (2019-nCoV) Real-Time RT-PCR Diagnostic Panel

1. PREPARATION OF SAMPLE

2. PROCESSING FOR NUCLEIC ACID EXTRACTION
3. ESTIMATION

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES — Public Health Service

Centers for Disease Control and Prevention (CDC)
Atlanta GA 30329-4027

Processing of Sputum Specimens for Nucleic Acid Extraction

PURPOSE

Sputum specimens collected from patients for molecular diagnostic testing frequently contain mucoid or mucopurulent material that make the specimen too viscous for efficient processing for downstream nucleic acid extraction.

This procedure provides guidance for liquification of sputum specimens prior to downstream nucleic acid extraction and molecular testing.

MATERIALS (Disclaimer: Names of vendors or manufacturers are provided as examples of suitable product sources. Inclusion does not imply endorsement by the Centers for Disease Control and Prevention.)

- Nuclease-free PCR grade water
- Thermo Scientific™ Pierce™ DTT (Dithiothreitol), No-Weigh™ Format (Fisher Scientific catalog A39255)
- Sterile, 0.01 M Phosphate Buffered Saline (PBS), pH 7.2
- Micropipettes
- Aerosol barrier pipette tips
- 1.5 mL or 2.0 mL microcentrifuge tubes (DNase/RNase free)
- 10 mL or 15mL, sterile screw cap tubes (polypropylene)

PRECAUTIONS

- Handling and processing specimens should be performed in accordance with national biological safety guidelines. Refer to the following: https://www.cdc.gov/labs/pdf/CDC-BiosafetyMicrobiologicalBiomedicalLaboratories-2009-P.PDF
- Handle specimens carefully to avoid cross-contamination, including changing gloves between samples. All specimens should be kept cold during processing.

PREPARING SPUTUM SAMPLES BEFORE EXTRACTION

- Rehydrate Thermo Scientific™ Pierce™ DTT (Dithiothreitol) by adding 100 µL of nuclease-free water to one microtube containing DTT and gently mix with pipette tip to completely dissolve (500 mM final concentration).
- Add the entire 100 µL of freshly prepared DTT to 5mL of cold sterile 0.01 M PBS (pH 7.2) and mix briefly.

The CDC 2019-Novel Coronavirus (2019-nCoV) Real-Time RT-PCR Diagnostic Panel is a real-time RT-PCR test intended for the qualitative detection of nucleic acid from the 2019-nCoV in upper and lower respiratory specimens (such as nasopharyngeal or oropharyngeal swabs, sputum, lower respiratory tract aspirates, bronchoalveolar lavage, and nasopharyngeal wash/aspirate or nasal aspirate) collected from individuals who meet 2019-nCoV clinical and/or epidemiological criteria (for example, clinical signs and symptoms associated with 2019-nCoV infection, contact with a probable or confirmed 2019-nCoV case, history of travel to geographic locations where 2019-nCoV cases were detected, or other epidemiologic links for which 2019-nCoV testing may be indicated as part of a public health investigation). Testing in the United States is limited to laboratories certified under the Clinical Laboratory Improvement Amendments of 1988 (CLIA), 42 U.S.C. § 263a, to perform high complexity tests.

Results are for the identification of 2019-nCoV RNA. The 2019-nCoV RNA is generally detectable in upper and lower respiratory specimens during infection. Positive results are indicative of active infection with 2019-nCoV but do not rule out bacterial infection or co-infection with other viruses. The agent detected may not be the definite cause of disease. Laboratories within the United States and its territories are required to report all positive results to the appropriate public health authorities.

Negative results do not preclude 2019-nCoV infection and should not be used as the sole basis for treatment or other patient management decisions. Negative results must be combined with clinical observations, patient history, and epidemiological information.

Testing with the CDC 2019-nCoV Real-Time RT-PCR Diagnostic Panel is intended for use by trained laboratory personnel who are proficient in performing real-time RT-PCR assays. The CDC 2019-Novel Coronavirus (2019-nCoV) Real-Time RT-PCR Diagnostic Panel is only for use under a Food and Drug Administration's Emergency Use Authorization

Summary

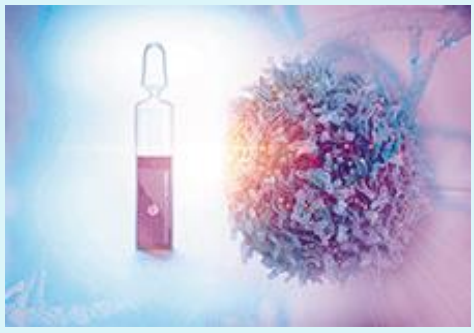
An outbreak of pneumonia of unknown etiology in Wuhan City, Hubei Province, China was initially reported to WHO on December 31, 2019. Chinese authorities identified a novel coronavirus (2019-nCoV), which has resulted in thousands of confirmed human infections in multiple provinces throughout China and many countries including the United States. Cases of asymptomatic infection, mild illness, severe illness, and some deaths have been reported.

The CDC 2019-nCoV Real-Time RT-PCR Diagnostic Panel is a molecular *in vitro* diagnostic test that aids in the detection and diagnosis 2019-nCoV and is based on widely used nucleic acid amplification technology. The product contains oligonucleotide primers and dual-labeled hydrolysisprobes (TaqMan®) and control material used in rRT-PCR for the *in vitro* qualitative detection of 2019-nCoV RNA in respiratory specimens.

The term "qualified laboratories" refers to laboratories in which all users, analysts, and any person reporting results from use of this device should be trained to perform and interpret the results from this procedure by a competent instructor prior to use.

VI. Ongoing research areas for tackling and managing CORONAVIRUS EPIDEMIC

Medications under Trial for COVID 19



WHO AS THE GLOBAL COORDINATOR FOR COVID 19 RESEARCH: WHO R AND D BLUEPRINT

COVID 2019 PHEIC
Global research and innovation forum: towards a research roadmap

R&DBlueprint
Powering research to prevent epidemics

Powering research to control the epidemic

Over the first 6 weeks of the new decade, the novel coronavirus, known as COVID-19, has spread from the People's Republic of China to 20 other countries.

On 30 January 2020 following the recommendations of the Emergency Committee, the WHO Director General declared that the outbreak constitutes a Public Health Emergency of International Concern (PHEIC).

In view of the urgency of this outbreak, the international community is mobilising to find ways to significantly accelerate the development of interventions. The WHO R&D Blueprint is a global strategy and preparedness plan that allows the rapid activation of R&D activities during epidemics. Its aim is to fast-track the availability of effective tests, vaccines and medicines that can be used to save lives and avert large scale crisis.

World experts on COVID-19 met at the World Health Organization's Geneva headquarters from 11 to 12 February 2020 to assess the current level of knowledge about the new virus, agree on critical research questions that need to be answered urgently and ways to work together to accelerate and fund priority research that can contribute to curtail this outbreak and prepare for future outbreaks.

The global imperative for the research community is to maintain a high-level discussion platform which enables consensus on strategic directions, nurtures scientific collaborations and, supports optimal and rapid research to address crucial gaps, without duplication of efforts.

"We need our collective knowledge, insight and experience to answer the questions we don't have answers to, and to identify the questions we may not even realize we need to ask."
Dr Tedros
WHO Director General

The meeting organized by the World Health Organization, in collaboration with the GloPID-R (the Global Research Collaboration for Infectious Disease Preparedness) brought together over 300 scientists, researchers, national public health experts from a large variety of disciplines as well as major research funders to discuss a research map for COVID 19.

Research topics discussed included: virus: natural history, transmission and diagnostics; animal and environmental research on the virus origin, and management measures at the human-animal interface, epidemiological studies; clinical characterization and management, infection prevention and control, including health care workers' protection; candidate therapeutics R&D; candidate vaccines R&D; ethical considerations for research and; integrating social sciences in the outbreak response.

Over 2 days of intense discussion, facilitated group work, research priorities were captured and distilled, and research priorities identified. Experts discussed a wide range of aspects of the outbreak and identified immediate concrete actions and priorities across the ten thematic areas.

Experts identified key knowledge gaps, and research priorities and shared scientific data on ongoing research, thereby accelerating the generation of critical scientific information to contribute to the control the COVID 19 emergency.

Research & Development

The government of China has initiated a series of major emergency research programs on virus genomics, antivirals, traditional Chinese medicines, clinical trials, vaccines, diagnostics and animal models. Research includes fundamental basic research and human subjects research. For the purpose of this report, human studies are limited to those involving IRB approval and informed consent. Other forms of human subjects investigations are included in the sections on epidemiology in this report. Well-focused, robust research conducted in the setting of an outbreak has the potential of saving many lives by identifying the most effective ways to prevent, diagnose and treat disease.

At least 8 **nucleic acid-based methods** for direct detection of COVID-19 and two colloidal gold antibody detection kits have been approved in China by the NMPA. Several other tests are close to approval. It will be important to compare the sensitivities and specificities of these and future serologic tests. Development of rapid and accurate **point-of-care tests** which perform well in field settings are especially useful if the test can be incorporated into presently commercially available multiplex respiratory virus panels. This would markedly improve early detection and isolation of infected patients and, by extension, identification of contacts. **Rapid IgM and IgG antibody testing** are also important ways to facilitate early diagnosis. Standard serologic testing can be used for retrospective diagnoses in the context of serosurveys that help better understand the full spectrum of COVID-19 infection. A variety of **repurposed drugs and investigational drugs** have been identified. Screening NMPA approved drug libraries and other chemical libraries have identified novel agents. Hundreds of clinical trials involving remdesivir, chloroquine, favipiravir,

chloroquine, convalescent plasma, TCM and other interventions are planned or underway. Rapid completion of the most important of these studies is critical to identifying truly effective therapies. However, evaluation of investigational agents requires adequately powered, randomized, controlled trials with realistic eligibility criteria and appropriate stratification of patients. It is important for there to be a degree of coordination between those conducting studies within and beyond China.

The development of a safe and effective **vaccine** for this highly communicable respiratory virus is an important epidemic control measure. Recombinant protein, mRNA, DNA, inactivated whole virus and recombinant adenovirus vaccines are being developed and some are now entering animal studies. Vaccine safety is of prime concern in the area of coronavirus infection in view of the past experience of disease enhancement by inactivated whole virus measles vaccine and similar reports in animal experiments with SARS coronavirus vaccines. It will be important that these vaccine candidates rapidly move into appropriate clinical trials.

The ideal **animal model** for studying routes of virus transmission, pathogenesis, antiviral therapy, vaccine and immune responses has yet to be found. The ACE2 transgenic mouse model and Macaca Rhesus model are already used in research laboratories. Systematically addressing which models can accurately mimic human infection is required.

V.1 HYDROXYCHLOROQUINE

Recommendation for the empiric use of Hydroxy-chloroquine for prophylaxis of SARS-CoV-2 infection.

Background:

Hydroxy-chloroquine is found to be *effective* against corona virus in laboratory studies and in-vivo studies. Its use in prophylaxis is derived from available evidence of benefit as treatment and supported by pre-clinical data.

The following recommendation for the use of hydroxy-chloroquine as a prophylactic agent against SARS-CoV-2infection is based on these considerations, as well as risk-benefit consideration, under exceptional circumstances that call for the protection of high-risk individuals. The National Taskforce for COVID-19 recommends the use of hydroxy-chloroquine for prophylaxis of SARS-CoV-2 infection for selected individuals as follows:

Eligible Individuals:

• Asymptomatic healthcare workers involved in the care of suspected or confirmed cases of COVID-19
• Asymptomatic household contacts of laboratory confirmed cases

Dose:

• Asymptomatic healthcare workers involved in the care of suspected or confirmed cases of COVID-19: 400 mg twice a day on Day 1, followed by 400 mg once weekly for next 7 weeks to be taken with meal.

• Asymptomatic household contacts of laboratory confirmed cases: 400 mg twice a day on Day 1, followed by 400mg once weekly for next 3 weeks; to be taken with meals

Contraindications:

• The drug is not recommended for prophylaxis in children under 15 years of age.

• The drug is contraindicated in persons with known case of retinopathy, known hypersensitivity to hydroxychloroquine, 4-aminoquinoline compounds

V.2 . USE OF ANTIRETROVIRALS AS POSSIBLE THERAPEUTICS: CLINICAL TRIAL STATUS

Clinical trials with the nucleotide analog remdesivir (NCT04280705 etc.) and protease inhibitors as well as other treatment options are currently ongoing in China and the US and trial results are expected within weeks. Remdesivir works against coronaviruses closely related to SARS-CoV-2 in animal models as well as against the related MERS CoV including in non-human primates. Remdesivir was also tested for treatment of ebolavirus infections in humans (and found less successful than other treatments (Mulangu et al., 2019)), and therefore safety data already exists for this therapeutic agent; this should accelerate the process of clinical testing against SARS-CoV-2. Remdesivir's mechanism of action as nucleotide analogue is not completely clear but it likely either terminates RNA synthesis or leads to incorporation mutagenesis, or both (Agostini et al., 2018). In addition, a combination of the two licensed HIV inhibitors, lopinavir and ritonavir, is also being tested in clinical trials (e.g. NCT04264858 etc.). Lopinavir is a *bona fide* protease inhibitor while ritonavir was initially designed

as protease inhibitor but was found to boost the half-life of lopinavir by inhibiting cytochrome P450 (Hull and Montaner, 2011). The combination was compassionately used as treatment for SARS-CoV-1 in 2003-2004 and showed some promise (Chu et al., 2004). Effectiveness of the combination was limited in mice but appreciable in non- human primate models of MERS-CoV. The mechanism of action of lopinavir is not completely clear but it likely inhibits one or more of the coronavirus proteases. Other treatment options with ongoing or planned clinical trials include dosing of recombinant human ACE2 to neutralize the virus and prevent lung damage (NCT04287686) as well as the use of the antiviral arbidol, a fusion inhibitor. Another interesting option is the use of convalescent serum as treatment and clinical trials to test this are currently ongoing in China (NCT04264858, placebo control, not recruiting yet). Similarly, polyclonal human IgG derived from transgenic cows could be used as well since this strategy has been successful for MERS-CoV in animal models and was tested for safety in clinical trials already (NCT02788188). Many of these trials will have results within months and if remdesvir (produced by Gilead) and/or lopinavir-plus-ritonavir (produced by AbbVie as

V.3 Vaccines under development

What do we know about betacoronavirus vaccine design?

During the 2009 H1N1 influenza virus pandemic, vaccine producers switched their production pipelines quickly from producing trivalent seasonal influenza virus vaccines to monovalent pandemic vaccines. This was basically just a change of strains and established and approved processes, established release criteria and existing correlates of protection could be used. Still, it took six months until the vaccine was ready to be distributed and used and came too late to make an impact on the second pandemic wave which took place in the US in

Fall of 2009. This time we are facing a new challenge in the form of a virus that has just now emerged in humans, and the response will be more complex since there are no existing vaccines or production processes for coronavirus vaccines.

Vaccine technology has significantly evolved in the last decade including the development of several RNA and DNA vaccine candidates, licensed vectored vaccines (e.g. Ervebo, a vesicular stomatitis virus vectored ebolavirus vaccine, licensed in the European Union), recombinant protein vaccines (e.g. Flublok, an influenza virus vaccine made in insect cells, licensed in the US) and cell NCT04255017, NCT04276688 etc. Kaletra and Aluvia, respectively) show effectiveness, they could potentially be used NCT04257656, NCT04252664, widely within a short time frame. Compassionate use of these drugs has already been reported for

Several vaccines for SARS-CoV-1 were developed and tested in animal models including recombinant spike protein-based vaccines, attenuated and whole inactivated vaccines as well as vectored vaccines. The majority of these vaccines protect animals from challenge with SARS-CoV-1, although most do not induce sterilizing immunity. In some cases, vaccination with the live virus results in complications, including lung damage and infiltration of eosinophils in the mouse model and liver damage in ferrets. In another study vaccination with inactivated SARS-CoV-1 led to enhancement of disease in one nonhuman primate while it protected 3 animals from challenge (Wang et al., 2016). The same study identified certain epitopes on S as protective while immunity to others seemed to be enhancing. However, in almost all cases vaccination is associated with greater survival, reduced virus titers and/or less morbidity as compared to unvaccinated animals. Similar findings have been reported for MERS-CoV vaccines. Therefore, while vaccines for related coronaviruses are

efficacious in animal models, we need to ensure that the vaccines which are developed for SARS-CoV-2 are sufficiently safe.

Another consideration for effective coronavirus vaccine development might be waning of the antibody response. Infection with human coronaviruses does not always induce long-lived antibody responses and re-infection of an individual with the same virus is possible as shown in human challenge studies. Antibody titers in individuals that survived SARS- CoV-1 or MERS-CoV infections often waned after 2-3 years or were weak to begin with. Despite that, re-infections are unlikely in the short term. Of note, reinfections after days of recovery have been reported recently but appear to be the consequences of false negatives. However, they could happen when humoral immunity wanes over months and years. An effective SARS-CoV-2 vaccine will need to overcome these issues in order to protect in a scenario where the virus becomes endemic and causes recurrent seasonal epidemics.

SARS-CoV-2 infection causes the most several pathology in individuals above 50 years of age. The reason for this is not completely clear but many infections have milder manifestations in naïve younger individuals than in naïve older individuals. Since older individuals are more affected, it will be very important to develop vaccines that protect this segment of the population. Unfortunately, older individuals typically respond less well to vaccination due to immune-senescence. For influenza – which is also problematic for older adults - there are specific formulations for this segment of the population that include more antigen or an adjuvant. Protection in older individuals appear to require higher neutralization titers against influenza virus as compared to younger individuals (Benoit et al., 2015), and this issue might also need to be addressed for SARS-CoV-2. In case vaccination in older individual is not effective, they could still

benefit indirectly if vaccination is able to stop transmission of the virus in younger individuals.

Only a small number of SARS-CoV-1 vaccines made it to phase I clinical trials before funding dried up due to the eradication of the virus from the human population due to non-pharmaceutical interventions when case numbers were still small. Results from these trials, performed with an inactivated virus vaccine and a spike-based DNA vaccine, are encouraging since the vaccines were safe and induced neutralizing antibody titers Some neutralizing monoclonal antibodies isolated against SARS-CoV-1, like CR3022 can cross-react to the receptor binding domain of SARS-CoV-2. This suggests that SARS-CoV-1 vaccines might cross-protect against SARS-CoV-2. However, since these vaccines have not been developed further than phase I, they are currently not available for use. Vaccines against MERS-CoV, also targeting the MERS-CoV spike protein, are in pre-clinical and clinical development including vaccines based on Modified Vaccinia Ankara vectors, adenovirus vectors and DNA-based vaccines and several of them are supported by the Coalition for Epidemic Preparedness Innovation (CEPI). However, it is unlikely that MERS-CoV vaccines induce strong cross-neutralizing antibodies to SARS-CoV-2 due the phylogenetic distance between the two viruses. Nevertheless, we can still learn a lot from these vaccines about how to move forward with SARS-CoV-2 vaccine design.

The development of vaccines for human use can take years, especially when novel technologies are used that have not been extensively tested for safety or scaled up for mass production. Since no coronavirus vaccines are on the market and no large scale manufacturing capacity for these vaccines exists yet (**Table**

1), we will need to build these processes and capacities. Doing this for the first time can be tedious and time-consuming (**Figure 1**). CEPI has awarded funds to several highly innovative players in the field and many of them will likely succeed in eventually making a SARS-CoV-2 vaccine. However, none of these companies and institutions have an established pipeline to bring such a vaccine to late stage clinical trials that allow licensure by regulatory agencies and they also do not currently have the capacity to produce the number of doses needed. An mRNA-based vaccine, which expresses target antigen *in vivo* in the vaccine after inhjection of mRNA encapsulated in lipid nanoparticles, co-developed by Moderna and the Vaccine Research Center at the National Institutes of Health is currently the furthest along with a phase I clinical trial recently started (NCT04283461). Curevac is working on a similar vaccine but is still in the pre-clinical phase. Additional approaches in the preclinical stage include recombinant protein based vaccines (focused on the spike protein, e.g. ExpresS2ion, iBio, Novavax, Baylor College of Medicine, University of Queensland, Sichuan Clover Biopharmaceuticals etc.), viral vector based vaccines (focused on the spike protein, Vaxart, Geovax, University of Oxford, Cansino Biologics etc.), DNA vaccines (focused on the spike protein, Inovio, Applied DNA Sciences etc.), live attenuated vaccines (Codagenix with Serum Institute of India etc.) and inactivated virus vaccines (**Figure 1 and Table 1**). All of these platforms have advantages and disadvantages (**Table 1**) and it is currently not possible to predict which strategy will be faster or more successful. Johnson&Johnson and Sanofi recently joined efforts to develop SARS-CoV-2 vaccines. However, J&J is using an experimental adenovirus vector platform that has not resulted in a licensed vaccine yet. Sanofi's vaccine, to be made using a process similar to the process used for their approved FluBlok recombinant

influenza virus vaccine (Zhou et al., 2006), is also months – if not years – away from being ready to be used in the human population.

Understanding the timeframes

Why does this take so long? As mentioned above, there are currently no approved human coronavirus vaccines. In addition, many technologies used (production platforms, vectors etc.) are new and need to be tested thoroughly for safety. The target for the vaccine, the spike protein, has been identified and vaccine candidates are being generated. This is usually followed by two important steps that are typically needed before bringing a vaccine into clinical trial. First, the vaccine is tested in appropriate animal models to see if it is protective. However, animal models for SARS-CoV-2 might be difficult to develop. The virus does not grow in wild type mice and only induced mild disease in transgenic animals expressing human ACE2 (Bao et al., 2020). Other potential animal models include ferrets and NHPs for which pathogenicity studies are currently ongoing. Even in the absence of an animal model that replicates human disease, it is possible to evaluate the vaccine since serum from vaccinated animals can be tested in *in vitro* neutralization assays; post-challenge safety data should also be collected in these cases, to assed for complications such as the ones seen in cases of SARS-CoV-1 and MERS CoV vaccines. Second, vaccines need to be tested for toxicity in animals, e.g. in rabbits. Usually viral challenge is not part of this process since only the safety of the vaccine itself will be evaluated. This testing, which has to be performed in a manner compliant with GLP (good laboratory practice), typically takes 3-6 months to complete. For some vaccine platforms parts of the safety testing might be skipped if there is already sufficient data available for similar vaccines made in the same production process. Vaccines for human use are produced in processes

that comply with current Good Manufacturing Practice (cGMP) to ensure constant quality and safety of vaccines. This requires dedicated facilities, trained personnel, proper documentation and raw material that was also produced in cGMP quality. These processes have to be designed or amended to fit SARS-CoV-2 vaccines. For many vaccine candidates in the preclinical phase such processes do not exist yet and have to be developed from scratch.

Once sufficient pre-clinical data is available and initial batches of the vaccine have been produced in cGMP quality, clinical trials may be initiated. Typically, clinical development of vaccines starts with small phase I trials to evaluate the safety of vaccine candidates in humans. These are then followed by phase II trials (formulation and doses are established, initial prove of efficacy) and finally by phase III trials in which the efficacy and safety of a vaccine needs to be demonstrated in a larger cohort. However, in an extraordinary situation like the current one this scheme might be compressed and an accelerated regulatory approval pathway might be developed. If efficacy is shown, a vaccine may be licensed by regulatory agencies.

Another important point is that production capacity to produce sufficient amounts of cGMP quality vaccine needs to be available. For vaccines based on existing vaccine platforms, e.g. inactivated or live attenuated vaccines, this can be relatively easily achieved since existing infrastructure can be used (**Table 1**). For vaccines based on novel technologies, e.g. mRNA, this capacity needs to be built and this typically also takes time. While it would be beneficial if even a limited amount of doses would be available to protect health care workers and the most vulnerable segments of the population, the ultimate goal should be to make vaccine available to the global population. This will be challenging. Even for influenza virus vaccines, for which many production facilities exist in high

income as well as low and middle income countries, the demand in the case of a pandemic would by far exceed the production capacity. Finally, it also takes time to distribute vaccines and administer them. To vaccinate a large proportion of the population would likely take weeks. Given that the population is currently completely naïve to SARS-CoV-2, it is highly likely that more than one dose of the vaccine is needed. Prime-boost vaccination regimens are typically used in that case and the two vaccinations are usually spaced 3-4 weeks apart. It is likely that only 1-2 week after the second vaccination protective immunity will be achieved. This therefore adds another 1-2 months to the timeline. Even if shortcuts for several of the steps mentioned above can be found, it is unlikely that a vaccine would be available earlier than 6 months after the initiation of clinical trials. Realistically, SARS- CoV-2 vaccines will not be available for another 12-18 months.

What are potential solutions for these long-time frames in the future? One possibility is to build production capacity, if possible globally distributed, that can be activated in the event of a new emerging viruses. From today's perspective only very few types of viruses are likely to cause respiratory disease that leads to rapid global spread. Surveillance in the animal reservoir paired with virus characterization studies can identify members of virus families that have potential to cause pandemics. Vaccine candidates using these isolates could then be produced, tested in animals to determine mechanisms of protection and tested in humans to establish safety of the vaccines. It is unlikely that exactly the same viruses that are chosen as vaccine candidates will later cause outbreaks. However, if the vaccine candidate is sufficiently closely related, sequences for the vaccines could be quickly switched and the vaccines for the newly emerging viruses could be swiftly produced and moved to late stage clinical trials right away (while large scale production is ramped up globally). In addition,

stockpiled vaccines based on the initial candidates could be deployed, even if slightly mismatched to the strain causing the outbreak (a strategy that is currently used for H5 and H7 avian influenza virus vaccines). This would allow a response within a few weeks and could potentially stop a virus locally before it becomes pandemic. An alternative, but also very challenging solution would be the development of broadly protective vaccines that cover whole virus families or genera. This effort is currently ongoing for influenza viruses (Erbelding et al., 2018) and could potentially also be applied to coronaviruses, or at least betacoronaviruses. Both of these options are costly and require global political will and vision.

Concluding remarks

Considering the deep dive stock markets have taken in recent weeks and given the expected impact of a pandemic on the economy, funding for vaccine production infrastructure that would allow a swift response to emerging viruses looks like a great investment. However, without a pandemic looming such investments have rarely been made in the past, except for H5 and H7 subtype influenza viruses. Now would be the right time to consider investing in vaccines against emerging viruses that can lead to loss of human lives and also burden the global economy. An investment of a few billion dollars would allow us to have sufficient surveillance, appropriate vaccine candidates and infrastructure ready that could churn out vaccines for use in the global population quickly and effectively, potentially stopping an emerging virus in its tracks. In addition, we need well developed emergency plans that allow us to develop, test, produce and distribute vaccines within weeks, not months or years. This would need tight coordination between pharmaceutical companies, governments, regulatory agencies and the WHO as well as novel and out of the box approaches to cGMP

production, release processes, regulatory science and clinical trial design. For SARS-CoV-2, vaccines may come too late to make an impact on the first wave of this pandemic. However, they might be very useful if additional waves occur later in time or in a post- pandemic scenario in which SARS-CoV-2 continues to circulate as a seasonal virus. In addition, lessons learned from handling this outbreak will certainly allow us to be better prepared in the future. The viruses will keep coming.

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