

# The COVID-19 Pandemic: An Epidemiologic, Public Health, and Clinical Brief

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On December 29, 2019, health authorities in China reported 27 cases of an unusual pneumonia, respiratory failure, and death linked to attendance at a live animal market in Wuhan.<sup>1,2</sup> On January 7, 2020, Chinese scientists confirmed a novel coronavirus, 2019-nCoV, as the causative agent.<sup>3</sup> Studies revealed >80% genetic homology of 2019-nCoV with coronaviruses of bats, presumably the original host; pangolins, suggesting this animal sold at the market as an intermediate host; and another human coronavirus, SARS-CoV, the cause of severe acute respiratory syndrome (SARS).<sup>3,4</sup> All evidence indicates that SARS-CoV-2 is of animal and not laboratory origin.<sup>5</sup> The World Health Organization (WHO) later named the novel virus SARS-CoV-2 and the related disease coronavirus disease 2019 (COVID-19).<sup>2,3</sup> SARS-CoV-2 spread quickly through communities in China and other countries (Fig. 1). On January 20, 2020, the first case was recognized in the United State when a 35-year-old man presented to

an urgent care clinic in Snohomish, Washington.<sup>6,7</sup> On January 30, 2020, WHO declared the outbreak a Public Health Emergency of International Concern. On March 11, 2020, WHO designated COVID-19 a pandemic. Almost all countries are implementing public health measures to prevent SARS-CoV-2 transmission and are marshaling clinical care for patients with COVID-19. This review highlights key features of SARS-CoV-2 infection, the epidemiology and clinical course of COVID-19, and interventions to stop the growing COVID-19 pandemic.

## EPIDEMIOLOGY

By March 11, 2020, 105 countries had reported 118,319 confirmed COVID-19 cases and 4292 deaths.<sup>2</sup> Outside China, large epidemics emerged in South Korea, Iran, and Italy. By March 14, 2020, approximately one in four COVID-19 cases and deaths were in Europe. The

Abbreviations: ACE2, angiotensin-converting enzyme 2; CDC, Centers for Disease Control and Prevention; COVID-19, coronavirus disease 2019; CT, computed tomography; FDA, US Food and Drug Administration; IL-6, interleukin-6; RT-PCR, reverse transcription polymerase chain reaction; SARS, severe acute respiratory syndrome; WHO, World Health Organization.

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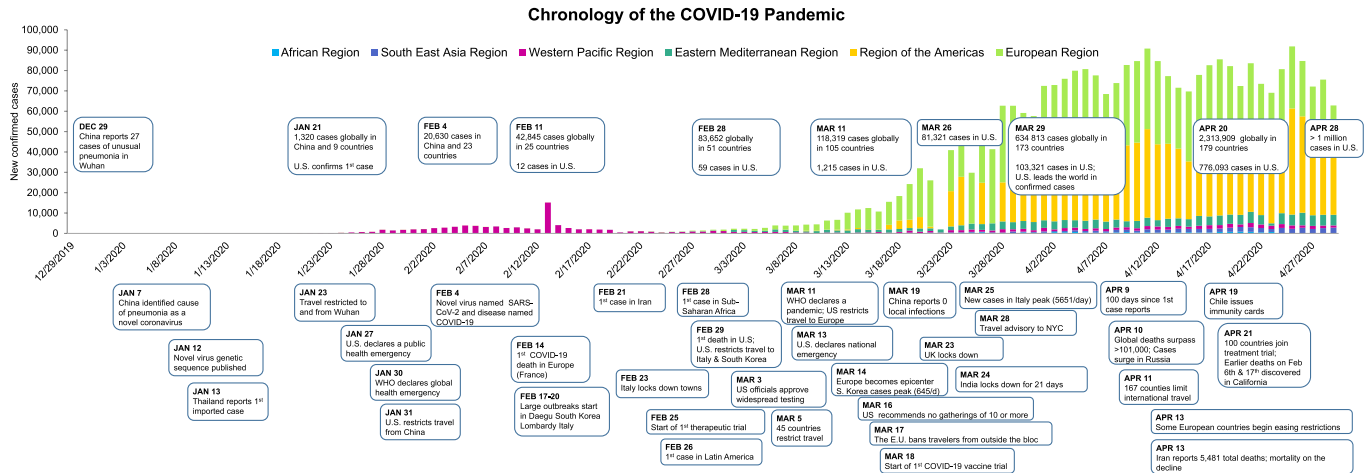


FIG 1 Chronology of the COVID-19 pandemic.

US epidemic accelerated, with cases doubling every 6 to 7 days.<sup>7</sup> By March 29, 2020, more than 100,000 persons had COVID-19 in the United States, the largest burden of COVID-19 globally.<sup>2,7</sup> As of April 29, 2020, the COVID-19 pandemic has grown to more than 3 million confirmed cases and more than 206,000 deaths in 179 countries. The United States now has more than 1 million cases (33%) and more than 50,000 deaths (25%).<sup>2,7</sup> The potential is high for large COVID-19 epidemics in Brazil, Russia, India, and many African countries.

SARS-CoV-2 is transmitted directly through inhalation or mucosal surface exposure to an infected person’s respiratory droplets or indirectly when touching the face after contact with contaminated objects.<sup>2,4,7</sup> SARS-CoV-2 can remain viable on environmental surfaces for up to 72 hours.<sup>8</sup> SARS-CoV-2 is highly infectious with an R0 of approximately 2.2 to 3.0, meaning each infected person will infect about two to three other persons.<sup>7</sup> Large COVID-19 outbreaks have occurred in health care facilities, households, cruise ships, religious services (e.g., funerals), and other large gatherings.<sup>1,2,7</sup> Individuals can transmit SARS-CoV-2 before, during, and after symptomatic disease. As many as half of individuals with SARS-CoV-2 infection have no symptoms.<sup>7</sup>

## CLINICAL PRESENTATION

Similar to SARS-CoV, SARS-CoV-2 binds to angiotensin-converting enzyme 2 (ACE2) receptors for entry via endocytosis into alveolar epithelial cells, as well as other cells with ACE2 receptors in the heart, gastrointestinal

tract, and kidneys.<sup>2,4</sup> COVID-19 results from SARS-CoV-2 replication, causing early cell death (i.e., apoptosis) and provoking a storm of proinflammatory cytokines (e.g., interleukin-6 [IL-6]) disrupting alveolar walls with resulting fluid accumulation in alveoli.<sup>4</sup>

The incubation period from infection to onset of COVID-19 disease is typically 5 to 7 days (range 1-14 days).<sup>1,2,7</sup> The most common symptoms of COVID-19 are fever and non-productive cough (Table 1).<sup>1,4,7,9</sup> The Centers for Disease Control and Prevention (CDC) recently added anosmia and ageusia, the loss of smell and taste, as COVID-19 symptoms.<sup>7</sup> Laboratory findings are remarkable for a normal leukocyte count, lymphopenia, and elevated C-reactive protein.<sup>1,6,8</sup> Most hospitalized patients with COVID-19 have a bilateral ground-glass appearance on chest computed tomography (CT) scan consistent with viral pneumonia.

Today, reverse transcription polymerase chain reaction (RT-PCR) is the COVID-19 diagnostic test.<sup>2,7</sup> RT-PCR sensitivity is highest for testing bronchial alveolar lavage fluid (93%) and declines for sputum (72%) and nasal swab (63%) specimens.<sup>10</sup> COVID-19 diagnosis might require repeat testing.<sup>2,7</sup> Serological tests to detect SARS-CoV-2 IgM and IgG antibodies are available. However, because of test sensitivity and other quality concerns, the US Food and Drug Administration (FDA; <https://www.fda.gov>) advises current serological tests are best used for surveillance and research, and not as the sole basis for COVID-19 diagnosis.

COVID-19 is commonly a mild disease. Of the first 72,314 COVID-19 disease reported in China, 81% had no or mild pneumonia, 21% had severe dyspnea and

radiological evidence of pulmonary disease, and 5% progressed to SARS.<sup>1</sup> Individuals can be ill for a week or longer before experiencing severe symptoms.

The risk for severe COVID-19 disease is highest for men, older adults, and patients with certain comorbidities. In the United States, 80% of reported COVID-19–related deaths are among people aged ≥65 years.<sup>7,9,11</sup> Deaths are rare among persons <24 years of age.<sup>1,7,11</sup> In the United States, most hospitalized patients with COVID-19 have

comorbid conditions, including obesity, hypertension, diabetes, and cardiovascular disease<sup>7,11</sup> (Table 2). Although listed by the CDC as a comorbid condition associated with severe COVID-19, chronic liver disease, including cirrhosis, has not been a common comorbidity associated with hospitalization in the United States (Table 2). The high prevalence of comorbid conditions can explain, in part, African Americans' increased risk for hospitalization with COVID-19 disease.<sup>5</sup> Variable comorbidity prevalence contributes to differences in national COVID mortality. Globally, crude fatality rates for COVID-19 range from 0.2% in Singapore, to 2.0% to 3.0% in South Korea and Germany, to 4.3% for the United States, and to 10% to 13% in Spain, Italy, and the United Kingdom.<sup>2,5</sup>

**TABLE 1. CLINICAL FEATURES OF COVID-19 IN WUHAN AND MULTIPLE OTHER LOCATIONS IN CHINA**

Clinical Features	Wuhan, China	Multiple Locations, China
Number of patients	10,999	3,062
Symptoms		
Fever	89%	80%
Cough	68%	63%
Expectoration	34%	42%
Dyspnea	19%	34%
Fatigue/Myalgia	38%	46%
Headache	14%	15%
Nausea/Vomiting	5%	10%
Diarrhea	4%	13%
Laboratory results		
Leukocytes in normal range	94%	70%
Lymphopenia	83%	57%
Increased C-reactive protein	61%	74%
Alanine aminotransferase above upper limit of normal	21%	29%
Imaging		
Abnormal chest CT	86%	89%
Bilateral infiltrates (ground glass)	56%	76%
Acute respiratory distress syndrome	6%	20%
Mortality	1.4%	6%

Data are from Guna et al.<sup>1</sup> and Centers for Disease Control and Prevention.<sup>7</sup>

The search for effective therapies and a vaccine is occurring at a remarkable pace, with at least 29 studies of therapeutic agents and 5 studies of candidate vaccines registered on ClinicalTrials.org (<https://www.clinicaltrials.gov>). On May 1, 2020, the FDA granted Emergency Use Authorization of remdesivir, a broad-spectrum antiviral nucleotide prodrug for treatment of severe COVID-19. Studies of monoclonal antibodies against IL-6 and hyperimmune immunoglobulin are in progress. Following reports of serious cardiac arrhythmias, the FDA cautioned clinicians of prescribing hydroxychloroquine or chloroquine for treatment of COVID-19. A safe and effective vaccine, if successfully developed, probably will not be available for 12 to 18 months.

**PREVENTION**

In the absence of a vaccine, prevention is composed of a combination of nonpharmacological interventions

**TABLE 2. COMORBIDITIES AMONG PERSONS WITH COVID-19 DISEASE, UNITED STATES**

Condition	United States*			New York City
	Not Hospitalized	Hospitalized	Intensive Care	Hospitalized
Patients	5143	1037	457	5700
One or more condition	27%	71%	78%	88%
Obesity				42%
Hypertension				57%
Diabetes mellitus	6%	24%	32%	34%
Cardiovascular disease	5%	23%	29%	18%
Chronic renal disease	1%	9%	12%	0.6%
Chronic liver disease	1%	1%	2%	9%
Immunocompromised	3%	6%	9%	2%
Mortality				21%
Total				21%
1 Comorbidity				88%

\*Based on data from the CDC for all 50 states and territories. Otherwise, data are Richardson et al.<sup>11</sup>

**TABLE 3. PREVENTION MEASURES TO REDUCE RISKS FOR COVID-19, PRIORITY POPULATIONS FOR TESTING, AND INFORMATION RESOURCES**

Prevention measures to reduce risks for COVID-19	<ul style="list-style-type: none"> <li>• Practice good hygiene                             <ul style="list-style-type: none"> <li>○ Wash hands often for &gt;20 seconds with soap and water or 60% alcohol sanitizer</li> <li>○ Avoid touching eyes, nose, and mouth with unwashed hands</li> <li>○ Sneeze or cough into a tissue or inside of the elbow</li> <li>○ Disinfect surfaces and used items frequently with soap and water and Environmental Protection Agency–registered household disinfectants or bleach solution (4 teaspoons [20 mL] bleach per quart [1 L] water)</li> </ul> </li> <li>• Limit close social contact                             <ul style="list-style-type: none"> <li>○ Learn signs and symptoms of COVID-19, and follow local disease trends</li> <li>○ Stay home as much as possible, particularly persons who are ill, older (&gt;65 years) adults, and those at risk for severe COVID-19</li> <li>○ Persons who are ill, call a health care provider</li> <li>○ Consider 2-week supply of medications, food, and other essentials</li> <li>○ When out in public, keep social distance of at least 6 feet and wear a cloth face cover</li> <li>○ Avoid gatherings of &gt;10 persons</li> <li>○ Work or attend school from home</li> <li>○ Avoid unnecessary travel</li> <li>○ Avoid visits to nursing homes or long-term retirement facilities</li> </ul> </li> <li>• Protect patients and health care workers                             <ul style="list-style-type: none"> <li>○ Reduce facility risks: screen for COVID-19 symptoms on entry; reduce visits; practice telemedicine</li> <li>○ Isolate symptomatic patients as soon as possible</li> <li>○ Protect health care personnel with recommended infection-control procedures</li> </ul> </li> </ul>
Recommended testing in consultation with health care provider	<ul style="list-style-type: none"> <li>• Hospitalized patients</li> <li>• Persons with symptoms of COVID-19                             <ul style="list-style-type: none"> <li>○ Health care facility workers</li> <li>○ Patients in long-term care facilities</li> <li>○ Patients &gt;65 years of age</li> <li>○ Patients with underlying conditions with symptoms</li> <li>○ First responders</li> </ul> </li> <li>• Critical infrastructure workers and others with symptoms</li> <li>• Health care facility workers and first responders</li> <li>• Persons mildly ill in communities with high numbers of COVID-19 hospitalizations</li> </ul>
Good information resources	<p>Centers for Disease Control and Prevention: <a href="https://www.cdc.gov/coronavirus/2019-ncov/index.html">https://www.cdc.gov/coronavirus/2019-ncov/index.html</a></p> <p>World Health Organization: <a href="https://www.who.int/emergencies/diseases/novel-coronavirus-2019">https://www.who.int/emergencies/diseases/novel-coronavirus-2019</a></p> <p>Infectious Disease Society of America: <a href="https://www.idsociety.org/public-health/COVID-19-Resource-Center/">https://www.idsociety.org/public-health/COVID-19-Resource-Center/</a></p> <p>American Association for the Study of Liver Diseases: <a href="https://www.aasld.org/about-aasld/covid-19-resources">https://www.aasld.org/about-aasld/covid-19-resources</a></p> <p>European Association for the Study of the Liver: <a href="https://easl.eu/covid-19-and-the-liver/">https://easl.eu/covid-19-and-the-liver/</a></p> <p>European Centre for Disease Control and Prevention: <a href="https://www.ecdc.europa.eu/en/covid-19-pandemic">https://www.ecdc.europa.eu/en/covid-19-pandemic</a></p> <p>The Society for Healthcare Epidemiology of America: <a href="https://www.shea-online.org/">https://www.shea-online.org/</a></p>

for suppression of transmission to  $R_0 < 1$  and mitigation of the number of patients with COVID-19 who require intensive care and mechanical respiratory support.<sup>12</sup> Interventions include improved personal hygiene promotions, symptomatic screening and laboratory testing for case detection, contact tracing, household quarantine of those with transmission risks, and social distancing (Table 3). The United States and most other countries have implemented extensive travel restrictions, workplace and school closures, and cancellation of sporting and other large public events. China, South Korea, and Taiwan successfully curbed large COVID-19 epidemics with prompt scale-up of testing, contact tracing, and quarantine.<sup>2,4,7</sup> In the United States, although testing rates are low, models suggest prevention measures are reducing transmission and future deaths.<sup>13</sup> The US government recently recommended increased COVID-19 surveillance, testing, and

contact tracing with modified social distancing measures to sustain SARS-CoV-2 prevention while opening up education and commerce.<sup>14</sup>

## SUMMARY

SARS-CoV-2 is a new human pathogen, readily spread via respiratory droplets and the cause of the growing COVID-19 pandemic. Men, older adults (>65 years old), and persons with comorbidities are at risk for severe COVID-19 and death. Countries have successfully suppressed transmission and mitigated needs for intensive care with robust case/contact detection (testing), isolation of infected/exposed persons, and social distancing. To stop the COVID-19 pandemic, the challenge is for all countries to scale up and sustain prevention measures while awaiting the arrival of effective vaccines and therapies.

## CORRESPONDENCE

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