Coronavirus disease 2019 (COVID-19)
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## Disclaimer
Summary

Coronavirus disease 2019 (COVID-19) is an infectious acute respiratory disease caused by a novel coronavirus. The World Health Organization (WHO) was informed of cases of pneumonia of unknown microbial etiology associated with Wuhan City, Hubei Province, China on 31 December 2019. The WHO later announced that a novel coronavirus had been detected in samples taken from these patients. Since then, the epidemic has escalated and rapidly spread around the world, with the WHO first declaring a public health emergency of international concern on 30 January 2020, and then formally declaring it a pandemic on 11 March 2020. Clinical trials and investigations to learn more about the virus, its origin, how it affects humans, and its management are ongoing.

Definition

A potentially severe acute respiratory infection caused by the novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] The clinical presentation is generally that of a respiratory infection with a symptom severity ranging from a mild common cold-like illness, to a severe viral pneumonia leading to acute respiratory distress syndrome that is potentially fatal. Characteristic symptoms include fever, cough, and dyspnea, although some patients may be asymptomatic. Complications of severe disease include, but are not limited to, multi-organ failure, septic shock, and venous thromboembolism.
Epidemiology

Adults

- In China, 87% of confirmed cases were ages 30 to 79 years and 3% were ages 80 years or older. Approximately 51% of patients were male.[4]
- In Italy, the median age and prevalence of comorbidities was higher compared with China.[5]
- In the UK, the median age of patients was 73 years and males accounted for 60% of admissions in a prospective observational cohort study of more than 20,000 hospitalized patients.[6]
- In the US, older patients (ages ≥65 years) accounted for 31% of all cases, 45% of hospitalizations, 53% of intensive care unit admissions, and 80% of deaths, with the highest incidence of severe outcomes in patients ages ≥85 years.[7]

Children

- Evidence suggests that children have a lower susceptibility to infection compared with adults, with an odds ratio of 0.56 for being an infected contact compared with adults. Adolescents appear to have similar susceptibility to adults.[8]
- The mean age of children with infection is 6.5 years.[9] Infection rates in children and adolescents vary according to geographic location:[4] [10] [11] [12] [13] [14] [15]
  - China - 2.1% (median age 7 years)
  - Italy - 1.2% (median age 4 to 5 years; higher in males but not statistically significant)
  - Spain - 0.8% (median age 3 years)
  - US - 12.2% (or 2179 cases per 100,000 children in the population) as of 10 December 2020.

- In the UK, a prospective observational cohort study found that children and young adults represented 0.9% of all hospitalized patients at the time. The median age of children admitted to hospital was 4.6 years, 56% were male, 35% were under 12 months of age, and 42% had at least one comorbidity. In terms of ethnicity, 57% were White, 12% were South Asian, and 10% were Black. Age under 1 month, age 10 to 14 years, and Black race were risk factors for admission to critical care.[16]

- In the US, a retrospective cohort study of over 135,000 children found that the mean age of infected children was 8.8 years, and 53% were male. In terms of ethnicity, 59% were White, 15% were Black, 11% were Hispanic, and 3% were Asian. Only 4% of children tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in this population, and clinical manifestations were typically mild.[17]

- Most cases in children are from familial clusters, or children who have a history of close contact with an infected patient. It is rare for children to be the index case in household transmission clusters.[18]

Unlike adults, children do not seem to be at higher risk for severe illness based on age or sex.[19]

Pregnant women

- A meta-analysis of over 2500 pregnant women with confirmed COVID-19 found that 73.9% of women were in the third trimester; 50.8% were from Black, Asian, or minority ethnic groups; 38.2% were obese; and 32.5% had chronic comorbidities.[20]

- In the UK, the estimated incidence of admission to hospital with confirmed SARS-CoV-2 infection in pregnancy is 4.9 per 1000 maternities. Most women were in the second or third trimester. Of these...
patients, 41% were ages 35 years or older, 56% were from Black or other ethnic minority groups, 69% were overweight or obese, and 34% had preexisting comorbidities.[21]

• In the US, 46,731 cases have been reported in pregnant women (as of 14 December 2020), with 8737 hospitalizations and 58 deaths.[22] According to an analysis of approximately 400,000 women ages 15 to 44 years with symptomatic disease, Hispanic and non-Hispanic Black pregnant women appear to be disproportionately affected during pregnancy.[23]

Healthcare workers

• The incidence of infection in healthcare workers ranged from 0% to 49.6% (by polymerase chain reaction), and the prevalence of SARS-CoV-2 seropositivity ranged from 1.6% to 31.6%. The wide ranges are likely related to differences in settings, exposures, rates of community transmission, symptom status, use of infection control measures, and other factors.[24] [25]
• A systematic review and meta-analysis of nearly 130,000 healthcare workers estimated the overall seroprevalence of SARS-CoV-2 antibodies to be 8.7%, with higher seroprevalence reported in North America (12.7%) compared with Europe (8.5%), Africa (8.2%), and Asia (4%). Risk factors for seropositivity included male sex; Black, Asian, or Hispanic ethnicity; working in a COVID-19 unit; patient-facing work; and frontline healthcare work.[26]
• Approximately 14% of the cases reported to the World Health Organization are in healthcare workers (range 2% to 35%).[27]
• The majority of healthcare workers with COVID-19 reported contact in the healthcare setting. In a study of over 9000 cases reported in healthcare workers in the US, 55% had contact only in a healthcare setting, 27% only in a household, 13% only in the community, and 5% in more than one setting.[28]
• The most frequently affected healthcare workers were nurses. Only 5% of healthcare workers developed severe disease and 0.5% died.[29] The incidence of severe or critical disease and mortality in healthcare workers was lower than the incidence of severe or critical disease and mortality in all patients.[30]
• Patient-facing healthcare workers were three times more likely to be admitted to hospital compared with nonpatient-facing workers according to a study in Scotland. In the same study, healthcare workers and their household members accounted for 17% of hospitalizations.[31]
• Analysis of hospitalization data from 13 sites in the US found that 6% of hospitalized adults were healthcare workers, and 36% of these people were in nursing-related roles. Around 90% of hospitalized healthcare workers had at least one underlying condition, the most common conditions being obesity, hypertension, and diabetes.[32]

Resources

Aetiology

Virology

- Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a previously unknown betacoronavirus that was discovered in bronchoalveolar lavage samples taken from clusters of patients who presented with pneumonia of unknown cause in Wuhan City, Hubei Province, China, in December 2019.[35]
- Coronaviruses are a large family of enveloped RNA viruses, some of which cause illness in people (e.g., common cold, severe acute respiratory syndrome [SARS], Middle East respiratory syndrome [MERS]), and others that circulate among mammals and birds. Rarely, animal coronaviruses can spread to humans and subsequently spread between people, as was the case with SARS and MERS.
- SARS-CoV-2 belongs to the Sarbecovirus subgenus of the Coronaviridae family, and is the seventh coronavirus known to infect humans. The virus has been found to be similar to SARS-like coronaviruses from bats, but it is distinct from SARS-CoV and MERS-CoV.[36] [37] The full genome has been determined and published in GenBank. [GenBank](https://www.ncbi.nlm.nih.gov/genbank/)
- A preliminary study suggests that there are two major types (or strains) of the SARS-CoV-2 virus in China, designated L and S. The L type was found to be more prevalent during the early stages of the outbreak in Wuhan City and may be more aggressive (although this is speculative), but its frequency decreased after early January. The relevance of this finding is unknown at this stage and further research is required.[38] Patients in Singapore infected with a SARS-CoV-2 variant with a 382-nucleotide deletion appeared to have a milder course compared with those infected with a wild-type virus.[39]
- A unique variant, known as the cluster 5 variant, has been detected in people in Denmark and is associated with transmission from farmed minks. The clinical implications of this new variant are not yet well understood; however, mutations in the spike protein have been reported. No new human cases of the cluster 5 variant have been reported in Denmark since 20 November 2020, and the variant is no longer circulating in humans. All mink on affected mink farms, and farms within an assigned zone, were culled. Seven other countries have reported SARS-CoV-2 in farmed minks (Lithuania, Greece, Spain, Italy, the Netherlands, Sweden, and the US).[40] [41]
- A new variant of the virus, named VUI-202012/01, was identified in the South East of England in mid-December and includes a mutation in the spike protein. There is currently no evidence to suggest that the strain has any impact on disease severity, antibody response, or vaccine efficacy.[42]
- In a global study of over 12,000 mutations of the SARS-CoV-2 virus, there was no evidence to suggest that any of these variants were associated with increased transmissibility.[43]
Illustration revealing ultrastructural morphology exhibited by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) when viewed with electron microscopically

Centers for Disease Control and Prevention

Origin of virus

- A majority of patients in the initial stages of this outbreak reported a link to the Huanan South China Seafood Market, a live animal or "wet" market, suggesting a zoonotic origin of the virus.[44] [45] [46] An initial assessment of the transmission dynamics in the first 425 confirmed cases found that 55% of cases before 1 January 2020 were linked to the market, whereas only 8.6% of cases after this date were linked to the market. This suggests that person-to-person spread was occurring among close contacts since the middle of December 2019.[46]
- Some studies suggest that SARS-CoV-2 may be a recombinant virus between a bat coronavirus and an origin-unknown coronavirus.[36] [37] [47] [48] Pangolins and minks have been suggested as possible intermediate hosts.[49] [50] [51] [52] However, there is currently no evidence to demonstrate the possible route of transmission from a bat reservoir to human through one or several intermediary animal species.[53] Further research is required to determine the origin of SARS-CoV-2.

Transmission dynamics

- Respiratory transmission is the dominant mode of transmission, with proximity and ventilation being the key determinants of transmission risk.[54] Available evidence suggests that transmission between people occurs primarily through direct, indirect, or close contact with infected people through infected secretions such as saliva and respiratory secretions, or through their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks, or sings.[55]
- Airborne transmission can occur in healthcare settings during aerosol-generating procedures. There are also some outbreak reports that suggest aerosol transmission is possible in the community under certain conditions; however, these reports relate to enclosed indoor crowded spaces with poor ventilation where the infected person may have been breathing heavily (e.g., restaurants, choir
practice, fitness classes). A detailed investigation of these clusters suggests that droplet and fomite transmission could also explain the transmission in these reports.[55] [56]

- Fomite transmission (from direct contact with fomites) may be possible, but there is currently no conclusive evidence for this mode of transmission. In the few cases where fomite transmission has been presumed, respiratory transmission has not been completely excluded.[54] The virus has been found to be more stable on plastic and stainless steel (up to 72 hours) compared with copper (up to 4 hours) and cardboard (up to 24 hours) under experimental conditions, but this does not reflect real-life conditions.[57] In healthcare settings, the virus is widely distributed in the air and on object surfaces in both general wards and intensive care units.[58] However, no virus has been cultured from these samples indicating that the deposition may reflect nonviable viral RNA.[59] [60] [61]

- Fecal-oral transmission (or respiratory transmission through aerosolized feces) may be possible, but there is only limited circumstantial evidence to support this mode of transmission.[54] The pooled detection rate of fecal SARS-CoV-2 RNA in patients with COVID-19 is approximately 51%, with 64% of samples remaining positive for a mean of 12.5 days (up to 33 days maximum) after respiratory samples became negative.[62]

- Transmission via other body fluids (including sexual transmission or bloodborne transmission) has not been reported.[54] While the virus has been detected in blood, cerebrospinal fluid, pericardial fluid, pleural fluid, urine, semen, saliva, ocular tissue, tears, and conjunctival secretions, as well as in the middle ear and mastoid, the presence of virus or viral components does not equate with infectivity.[63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74]

- Vertical transmission occurs rarely and transplacental transmission has been documented. Overall, 6.3% of infants born to mothers with COVID-19 tested positive for SARS-CoV-2 at birth. Transmission was reported in both preterm and full-term infants. There is also evidence for antibodies against SARS-CoV-2 among infants born to mothers with COVID-19 who tested negative for SARS-CoV-2.[75] The rate of infection appears to be no greater when the baby is born vaginally, breastfed, or allowed contact with the mother.[76] Viral fragments have been detected in breast milk; however, no replication-competent virus has been detected, suggesting that transmission via breast milk is unlikely.[77] [78] [79] Vertical transmission is unlikely to occur if correct hygiene precautions are taken.[80]

- Nosocomial transmission was reported in 44% of patients in one systematic review; however, this review was limited to case series conducted early in the outbreak in Wuhan before the institution of appropriate infection prevention and control measures.[81] Hospital-acquired infections (defined as patients diagnosed more than 7 days after hospital admission) account for approximately 17% of infections in the NHS England as of 26 October 2020, and rates have been as high as 25% in some areas.[82] Studies of healthcare workers exposed to index cases (not in the presence of aerosol-generating procedures) found little to no nosocomial transmission when contact and droplet precautions were used.[55] [83]

Transmission dynamics in relation to symptoms

- Symptomatic transmission
  - Transmission appears to be greatest when people are symptomatic, especially around the time of symptom onset.[2] [84] [85] [86] [87] [88] [89] [90]

- Presymptomatic transmission
  - Transmission may occur during the incubation period, usually 1 to 3 days before symptom onset.[2]
• Presymptomatic transmission was reported in 12.6% of cases in China, and 6.4% of cases in Singapore.[91] [92]
• People without symptoms may be presymptomatic, or they may remain persistently asymptomatic.

• Asymptomatic transmission

• Transmission from asymptomatic cases (laboratory-confirmed cases who do not develop symptoms) has been documented.[93] [94] However, evidence is limited, and the World Health Organization states that asymptomatic cases are much less likely to transmit the virus than those who develop symptoms, and asymptomatic cases are not the major driver of the overall epidemic dynamics.[95] [96] Numerous studies have reported no evidence of asymptomatic transmission from carriers of SARS-CoV-2.[97] [98] [99] In a post-lockdown screening study in nearly 10 million residents in Wuhan, there were no positive tests among 1174 close contacts of asymptomatic cases. In addition to this, virus culture was carried out on samples from asymptomatic positive cases and all cultures were negative, indicating that asymptomatic positive cases in the study were not infectious.[100]
• Estimating the prevalence of asymptomatic cases in the population is difficult. A meta-analysis of over 50,000 people found that 15.6% of confirmed cases were asymptomatic at the time of testing, and nearly half developed symptoms later.[101] However, estimates of the proportion of asymptomatic cases vary widely from between 1.2% to 80%, depending on the study population.[102] [103] [104] [105] [106] [107] [108] The overall estimate of the proportion of people who become infected and remain asymptomatic throughout infection was 20%.[109]
• Healthcare workers may play a role in asymptomatic transmission. About 7.6% of healthcare workers who worked in hospital units with infected patients tested positive for SARS-CoV-2 antibodies; however, only 58% of these workers reported prior symptoms.[110] A cross-sectional study of nearly 2800 healthcare workers found that 5.4% of COVID-19-facing asymptomatic healthcare workers tested positive, compared with 0.6% of non-COVID-19-facing asymptomatic healthcare workers.[111]
• Children are more likely to be asymptomatic.[101] The pooled proportion of asymptomatic cases in children was thought to be significant (around 40%).[112] [113] However, a recent study found that the rate of asymptomatic infection in children was 1% compared with 9% in adults.[114]

Superspreading events

• Superspreading events have been reported. These events are associated with explosive growth early in an outbreak and sustained transmission in later stages.[115]
• Reported events include church/religious gatherings, family or social gatherings, weddings, choir practices, overnight youth camps or high school retreats, fitness classes, indoor recreational sporting activities, business conferences, and working in call centers.[54] [116] [117] [118] [119] Widespread transmission has also been reported in long-term care facilities, homeless shelters, prisons, immigration detention centers, and meat and poultry processing facilities, as well as on board cruise ships.[120] [121] [122] [123] [124] [125] [126] [127] [128]
• Limited transmission has been reported in childcare, school, and university settings, and infected cases may transmit the infection to their household members.[129] [130] [131] Outbreaks were uncommon in educational settings during the summer half-term in England.[132]
• Some individuals are supershedders of virus, but the reasons underlying superspreader events are often more complex than just excess virus shedding and can include a variety of behavioral, host, and environmental factors.[133]

Viral transmission factors

• Incubation period
  - The incubation period is estimated to be between 1 and 14 days, with a median of 5 to 6 days.[2] [134] [135] Infectiousness peaks around 1 day before symptom onset and declines within 7 days.[54]
  - The pooled mean incubation period is 9.6 days in children.[136]

• Reproduction number ($R_0$)
  - Reports suggest that the reproduction number, the number of people who acquire the infection from an infected person, is estimated to be 2.2 to 3.3. However, there is very high heterogeneity across studies and the number varies between countries.[46] [137] [138] [139] The Centers for Disease Control and Prevention gives a current best estimate of 2.5 (as of 10 September 2020).[140]
  - The $R_0$ decreases when public health measures (e.g., social distancing) are put in place.[141]

• Serial interval
  - The time between the start of symptoms in the primary patient and the onset of symptoms in the patient being infected in a chain of transmission has been estimated to be approximately 5.45 days (range 4.2 to 6.7 days).[142]

• Secondary attack rate
  - The secondary attack rate is the proportion of people exposed to an index (or primary) case that go on to develop the disease as a result of the exposure.
  - The pooled household secondary attack rate has been estimated to be 16.6%. The rate is higher for symptomatic index cases (18%) compared with asymptomatic cases (0.7%), and adults have a higher susceptibility to infection compared with children. Spouses of the index case are more likely to be infected compared with other household members.[143]
  - The secondary attack rate among all close contacts of an index case ranges from 0.45% to 3.7%.[95] [144] [145]
  - The secondary attack rate increases with the severity of the index case (i.e., 0.3% for asymptomatic cases to 6.2% for severe/critical cases) according to a study of 3410 close contacts of 391 index cases.[95]
  - The secondary attack rate for close contacts of presymptomatic people is approximately 3.3%, with a rate of 16.1% for household contacts, 1.1% for social contacts, and 0% for work contacts.[146]
  - Children ages <5 years had lower secondary attack rates compared with older children, and the risk of infection was higher if the household index case was the mother.[147] The secondary attack rate was 1.2% in children in a childcare setting or school.[148]

• Viral load
• Viral load is highest in the upper respiratory tract (nasopharynx and oropharynx) early in the course of infection (usually peaks in the first week of illness), and then increases in the lower respiratory tract (sputum). Viral load decreases after symptom onset. Patients with severe disease have higher viral loads compared with those with mild disease. Viral load in the upper respiratory tract is comparable in asymptomatic and symptomatic patients; however, most studies demonstrate faster viral clearance among asymptomatic people compared with symptomatic people.[149]

• Viral shedding

  • The mean duration of shedding was 17 days in the upper respiratory tract, 14.6 days in the lower respiratory tract, 17.2 days in stool, and 16.6 days in serum samples. The maximum duration of shedding was 83 days in the upper respiratory tract, 59 days in the lower respiratory tract, 126 days in stool, and 60 days in serum samples. However, no live virus was detected beyond day 9 of symptoms, despite persistently high viral loads. Duration of viral shedding was longer in symptomatic patients compared with asymptomatic patients, and in patients with severe illness compared with those with nonsevere illness.[149]

  • The period of infectiousness is far shorter than the duration of detectable viral shedding. No viable virus has been isolated in patients with mild or moderate disease after 10 days of symptoms, or after 20 days in those with severe or critical disease, despite ongoing viral shedding. Data about the dynamics of viral shedding in people with persistent asymptomatic infection are inconsistent.[54] There is no convincing evidence that duration of viral shedding correlates with duration of infectivity.[150]

  • Factors associated with prolonged viral shedding include male sex, older age, comorbid hypertension, delayed admission to hospital after symptom onset or severe illness on admission, and use of invasive mechanical ventilation or corticosteroids.[151] Immunocompromised patients may shed for at least 2 months.[152]

Pathophysiology

The pathophysiology is not yet fully understood; however, details are emerging.[153]
Angiotensin-converting enzyme-2 (ACE2) receptor

- Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) binds to the ACE2 receptor in humans, which suggests a similar pathogenesis to SARS.[37] [154]
- A unique structural feature of the spike glycoprotein receptor binding domain of SARS-CoV-2 (which is responsible for the entry of the virus into host cells) confers potentially higher binding affinity for ACE2 on host cells compared with SARS-CoV-1.[155] This furin-like cleavage site does not exist in other SARS-like coronaviruses.[156] The binding energy between the SARS-CoV-2 spike protein and ACE2 was highest for humans out of all species tested, suggesting that the SARS-CoV-2 spike protein is uniquely evolved to bind to and infect human cells expressing ACE2.[157]
- Mechanistic evidence from other coronaviruses suggests that SARS-CoV-2 may downregulate ACE2, leading to a toxic overaccumulation of plasma angiotensin-II, which may induce acute respiratory distress syndrome and fulminant myocarditis.[158] [159]
- Based on an analysis of single-cell RNA sequencing datasets derived from major human physiologic systems, the organs considered more vulnerable to SARS-CoV-2 infection due to their ACE2 expression levels include the lungs, heart, esophagus, kidneys, bladder, and ileum.[160] This may explain the extrapulmonary manifestations associated with infection.
• Lower expression of ACE2 in the nasal epithelium of children ages <10 years compared with adults may explain why COVID-19 is less prevalent in children; however, further research on this is required.[161]

Transmembrane protease serine 2 (TMPRSS2)

• SARS-CoV-2 uses host TMPRSS2 for S protein priming and fusion of viral and host cell membranes.[162]
• Higher expression of TMPRSS2 has been noted in the nasal epithelium of Black people compared with Asian people, Latin people, White people, and people of mixed race/ethnicity, which may be a contributing factor to the higher burden of infection among Black people.[163]

Autopsy studies

• Pulmonary: autopsy studies have revealed that patients who died of respiratory failure had evidence of exudative diffuse alveolar damage with massive capillary congestion, often accompanied by microthrombi. Hyaline membrane formation and pneumocyte atypical hyperplasia are common. Pulmonary artery obstruction by thrombotic material at both the macroscopic and microscopic levels has been identified. Patients also had signs of generalized thrombotic microangiopathy. Severe endothelial injury associated with the presence of intracellular virus and disrupted cell membranes has been noted. Other findings include bronchopneumonia, pulmonary embolism, alveolar hemorrhage, and vasculitis. Significant new blood vessel growth through intussusceptive angiogenesis distinguishes the pulmonary pathology of COVID-19 from severe influenza infection.[164] [165] [166] [167] [168] [169] Some patients with severe disease may develop fibrotic lung disease for which lung transplantation may be the only treatment option.[170]
• Neurologic: histopathologic examination of brain specimens showed hypoxic changes but no encephalitis or other specific brain changes due to the virus in one autopsy study. The virus was detected at low levels in brain tissue.[171] Another study found mild neuropathologic changes, with pronounced neuroinflammatory changes in the brainstem being the most common finding.[172]
• Cardiac: SARS-CoV-2 has been frequently detected in the myocardium in autopsy studies.[173] The virus, along with inflammatory changes, has been reported in the cardiac tissue of a child with pediatric inflammatory multisystem syndrome.[174]
• Immunology: evaluation of immune infiltrate has revealed a notable presence of aggregated neutrophils in the lungs and several other organs. Neutrophilic plugs, composed of neutrophils with neutrophil extracellular traps (NETs) or as aggregates of NETs and platelets, were present in the heart, kidney, liver, and brain. NETs may therefore play a role in coagulopathy associated with SARS-CoV-2 infection. The disproportionate presence of aggregate neutrophils and NETs in comparison with the sporadic presence of virus suggests an autonomous maladaptive immune response.[175]
• Other: other novel findings at autopsy include pancreatitis, pericarditis, adrenal microinfarction, secondary disseminated mucormycosis, and brain microglial activation.[176]

Endothelial dysfunction

• There is a hypothesis that COVID-19 is a disease of the endothelium.[177] [178] [179] Endotheliopathy and platelet activation appear to be important features of COVID-19 in hospitalized patients and are likely to be associated with coagulopathy, critical illness, and death.[180]
• Hyperviscosity has been reported in patients. It is known to damage the endothelium, and is a known risk factor for thrombosis. The potential link between hyperviscosity and thrombotic complications warrants further investigation.[181]
Genetic factors

- Genetic factors are thought to play a role. In a case series of four male patients with severe disease, rare putative loss-of-function variants of X-chromosomal TLR7 were identified, and this was associated with impairment of interferon responses.[182]
- A novel susceptibility locus has been detected at a chromosome 3p21.31 gene cluster in patients with respiratory failure, which may confirm the involvement of the ABO blood-group system.[183]

Classification


Mild illness

- Symptomatic patients meeting the case definition for COVID-19 without evidence of hypoxia or pneumonia.
- Common symptoms include fever, cough, fatigue, anorexia, dyspnea, and myalgia. Other nonspecific symptoms include sore throat, nasal congestion, headache, diarrhea, nausea/vomiting, and loss of smell/taste.
- Older people and immunosuppressed people may present with atypical symptoms (e.g., fatigue, reduced alertness, reduced mobility, diarrhea, loss of appetite, delirium, absence of fever).
- Symptoms due to physiologic adaptations of pregnancy or adverse pregnancy events (e.g., dyspnea, fever, gastrointestinal symptoms, fatigue) or other diseases (e.g., malaria) may overlap with COVID-19 symptoms.

Moderate disease

- Adolescent or adult: clinical signs of pneumonia (i.e., fever, cough, dyspnea, fast breathing) but no signs of severe pneumonia, including blood oxygen saturation levels (SpO₂) ≥90% on room air.
- Children: clinical signs of nonsevere pneumonia (i.e., cough or difficulty breathing plus fast breathing and/or chest indrawing) and no signs of severe pneumonia. Fast breathing is defined as:
  - <2 months of age: ≥60 breaths/minute
  - 2-11 months of age: ≥50 breaths/minute
  - 1-5 years of age: ≥40 breaths/minute.
- While the diagnosis can be made on clinical grounds, chest imaging may assist in diagnosis and identify or exclude pulmonary complications.

Severe disease

- Adolescent or adult: clinical signs of pneumonia (i.e., fever, cough, dyspnea, fast breathing) plus one of the following:
  - Respiratory rate >30 breaths/minute
  - Severe respiratory distress
  - SpO₂ <90% on room air.
- Children: clinical signs of pneumonia (i.e., cough or difficulty in breathing) plus at least one of the following:
Coronavirus disease 2019 (COVID-19) Theory

- Central cyanosis or SpO₂ <90%
- Severe respiratory distress (e.g., fast breathing, grunting, very severe chest indrawing)
- General danger signs: inability to breastfeed or drink, lethargy or unconsciousness, or convulsions
- Fast breathing (<2 months: ≥60 breaths per minute; 2-11 months: ≥50 breaths per minute; 1-5 years: ≥40 breaths per minute).

While the diagnosis can be made on clinical grounds, chest imaging may assist in diagnosis and identify or exclude pulmonary complications.

Critical disease

- Presence of acute respiratory distress syndrome (ARDS), sepsis, or septic shock.
- Other complications include acute pulmonary embolism, acute coronary syndrome, acute stroke, and delirium.

National Institutes of Health: clinical classification of COVID-19[3]

Asymptomatic or presymptomatic infection

- People who test positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) using a virologic test but have no symptoms consistent with COVID-19.

Mild illness

- People who have any of various signs and symptoms (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) without shortness of breath, dyspnea, or abnormal chest imaging.

Moderate illness

- People who have evidence of lower respiratory disease by clinical assessment or imaging and an oxygen saturation (SpO₂) ≥94% on room air at sea level.

Severe illness

- People who have respiratory frequency >30 breaths per minute, SpO₂ <94% on room air at sea level, ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO₂/FiO₂) <300 mmHg, or lung infiltrates >50%.

Critical illness

- People who have respiratory failure, septic shock, and/or multiple organ dysfunction.

Persistent symptoms or organ dysfunction after acute COVID-19

- People who experience persistent symptoms and/or organ dysfunction after acute disease. Also known as post-acute COVID-19 syndrome or long COVID. See the Complications section for more information.
Case history

Case history #1

A 61-year-old man presents to the hospital with fever, dry cough, and difficulty breathing. He also reports feeling very tired and unwell. He has a history of hypertension, which is controlled with enalapril. On exam, his pulse is 120 bpm, his temperature is 101.6°F (38.7°C), and his oxygen saturation is 88%. He appears acutely ill. He is admitted to hospital in an isolation room and is started on oxygen, intravenous fluids, and empiric antibiotics. Chest x-ray shows bilateral lung infiltrates, and computed tomography of the chest reveals multiple bilateral lobular and subsegmental areas of ground-glass opacity. A nasopharyngeal swab is sent for real-time reverse transcriptase polymerase chain reaction testing, and the result comes back positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) the next day. The patient develops respiratory distress 7 days after admission and is transferred to the intensive care unit and started on mechanical ventilation.

Case history #2

A 26-year-old woman calls her doctor complaining of a sore throat and a persistent dry cough. She denies having a fever, and has not traveled in the last 14 days or knowingly been in contact with a confirmed case of COVID-19. She is advised to stay at home and self-isolate and to call her doctor if her symptoms get worse.

Other presentations

See the Diagnosis section for more information on other presentations.
Approach

Early recognition and rapid diagnosis are essential to prevent transmission and provide supportive care in a timely manner.

Have a high index of clinical suspicion for COVID-19 in all patients who present with fever and/or acute respiratory illness; however, be aware that some patients may not present with signs or symptoms of a febrile respiratory illness.

COVID-19 care pathways should be established at local, regional, and national levels for people with suspected or confirmed COVID-19. Screen patients at the first point of contact within the health system based on case definitions and an assessment of symptoms, and enter suspected or confirmed cases into the pathway.[2] Suspected cases should remain in the pathway until proven negative.

Immediately isolate all suspected and confirmed cases and implement local infection prevention and control procedures. Triage patients with a standardized triage tool and evaluate the patient to assess the severity of disease.

COVID-19 is a notifiable disease.

Best Practice has published a separate topic on the management of coexisting conditions in the context of COVID-19. [BMJ Best Practice: Management of coexisting conditions in the context of COVID-19] (https://bestpractice.bmj.com/topics/en-us/3000190#important-update)

Key recommendations

- Isolate all suspected or confirmed cases immediately. Triage patients with a standardized triage tool and evaluate the severity of disease. Follow local infection prevention and control guidelines.[2]
- Have a high index of clinical suspicion in all patients who present with fever and/or acute respiratory illness. People with a history of residence/work/travel in a location with a high risk of transmission or community transmission and contacts of probable and confirmed cases are at higher risk of infection.[184]
- Suspect the diagnosis in patients with a new continuous cough, fever, or altered sense of taste or smell.[389] Patients may also present with symptoms including dyspnea, fatigue, myalgia/arthralgia, sore throat, headache, nasal congestion or rhinorrhea, sputum production, chest tightness, or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea).[390]
- Order a real-time reverse transcription polymerase chain reaction (RT-PCR) to confirm the diagnosis. Upper and lower respiratory specimens are preferred. Serologic testing may be useful in some settings.[391] Results should be interpreted in the context of the pretest probability of disease.
- Be on high alert for children and adolescents with acute gastrointestinal symptoms and signs of cardiac inflammation. Evidence so far suggests a milder or asymptomatic course of disease in children.[392] However, a rare multisystem inflammatory condition with some features similar to those of Kawasaki disease and toxic shock syndrome has been temporally associated with COVID-19 in children and adolescents.[393]
- Order the following laboratory investigations in hospitalized patients: complete blood count, comprehensive metabolic panel, arterial blood gas, blood glucose level, coagulation screen, inflammatory markers, cardiac biomarkers, serum creatine kinase, and blood and sputum cultures for other pathogens. Pulse oximetry may reveal low oxygen saturation.
Coronavirus disease 2019 (COVID-19) Diagnosis

• Prioritize a chest x-ray in patients who are seriously ill with suspected pneumonia. Consider a computed tomography scan of the chest if chest x-ray is uncertain or normal.[394] Consult local guidelines.
• Report all suspected or confirmed cases to your local health authorities. COVID-19 is a notifiable disease.
• For full details and guidance see information below.

**History**

Take a detailed history to ascertain the level of risk for COVID-19 and assess the possibility of other causes, including a travel history and an assessment of risk factors.

Suspect the diagnosis in:[184]

• People residing or working in an area with a high risk of transmission (e.g., closed residential settings, humanitarian setting), people residing in or traveling to an area with community transmission, and people working in a health setting (including within health facilities and households) at any time within the 14 days prior to symptom onset
• People who have had contact with a probable or confirmed case. A contact is a person who has experienced any one of the following exposures during the 2 days before and the 14 days after the onset of symptoms of a probable or confirmed case:
  • Face-to-face contact with a probable or confirmed case within 3 feet (1 meter) and for at least 15 minutes
  • Direct physical contact with a probable or confirmed case
  • Direct care for a patient with probable or confirmed COVID-19 without using recommended personal protective equipment
  • Other situations as indicated by local risk assessments.

The Centers for Disease Control and Prevention defines a close contact as someone who has been within 6 feet (2 meters) of an infected person for at least 15 minutes over a 24-hour period, beginning 2 days before symptom onset (or 2 days before testing in asymptomatic patients).[185]

**Clinical presentation in adults**

Approximately 15% of patients present with the symptom triad of fever, cough, and dyspnea, and 90% present with more than one symptom.[45] Some patients may be minimally symptomatic or asymptomatic, while others may present with severe pneumonia or complications such as acute respiratory syndrome, septic shock, acute myocardial infarction, venous thromboembolism, or multi-organ failure.

The most common symptoms are:

• Fever
• Cough
• Dyspnea
• Altered sense of taste/smell.

Less common symptoms include:

• Myalgia or arthralgia
• Fatigue
Coronavirus disease 2019 (COVID-19)

Diagnosis

- Sputum production
- Chest tightness
- Gastrointestinal symptoms
- Sore throat
- Headache
- Dizziness
- Neurologic symptoms
- Ocular symptoms
- Cutaneous symptoms
- Rhinorrhea/nasal congestion
- Chest pain
- Hemoptysis.

Signs and symptoms of febrile respiratory illness may not possess the necessary sensitivity for early diagnostic suspicion.[395] A Cochrane review found that at least half of patients had a cough, sore throat, fever, myalgia/arthritis, fatigue, or headache. The presence of fever, myalgia/arthritis, fatigue, and headache substantially increased the likelihood of COVID-19 when present. Cough and sore throat were common in people without COVID-19, so these symptoms alone were less helpful for diagnosis. No single symptom or sign included in the review could accurately diagnose COVID-19 and the authors concluded that neither the absence or presence of signs or symptoms are accurate enough to rule in or rule out disease.[390] Nonrespiratory symptoms may appear before the onset of fever and lower respiratory tract symptoms.[396]

The clinical presentation has varied slightly across geographic locations. Initial impressions from the US note that the clinical presentation may be broader than that observed in China and Italy, with chest pain, headaches, altered mental status, and gastrointestinal symptoms all observed on initial presentation. Severe hepatic and renal dysfunction that spares the lungs has also been observed.[397] Data from the first hospitalized patients in New York found that while the most common presenting symptoms were fever, cough, dyspnea, and myalgia, gastrointestinal symptoms appeared to be more common than in China.[398]

Severity

- 80% of adults present with mild to moderate illness
- 14% of adults present with severe illness
- 5% of adults present with critical illness
- 1% of adults present with asymptomatic illness.[4]

The most prevalent symptoms in patients with mild to moderate illness, according to one European study, are headache, loss of smell, nasal congestion, cough, asthenia, myalgia, rhinorrhea, gustatory dysfunction, and sore throat. Fever was reported less commonly. The mean duration of symptoms was 11.5 days. The presentation varied according to age, with younger patients generally having ear, nose, and throat complaints, and older patients generally having fever, fatigue, and loss of appetite.[399] More common symptoms in patients with severe disease include fever, dyspnea, and anorexia.[138]

Pregnant women

- The clinical characteristics in pregnant women are similar to those reported for nonpregnant adults.[400] The most common symptoms in pregnant women are fever and cough. However,
pregnant women are less likely to report fever and myalgia compared with nonpregnant women of reproductive age.[401]

- It is important to note that symptoms such as fever, dyspnea, gastrointestinal symptoms, and fatigue may overlap with symptoms due to physiologic adaptations of pregnancy or adverse pregnancy events.[2]

Atypical presentations

- Atypical presentations may occur, especially in older patients and patients who are immunocompromised (e.g., falls, delirium/confusion, functional decline, reduced mobility, syncope, persistent hiccups, absence of fever). Older patients and those with comorbidities may present with mild symptoms, but have a high risk of deterioration.[2]
- There have been case reports of parotitis (possibly related to intraparotid lymphadenitis), oral vesiculobullous lesions, retinal lesions, and androgenetic alopecia in patients with COVID-19; however, it is unknown whether these findings are associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection as yet.[402] [403] [404] [405]

Coinfections

- The pooled prevalence of coinfection with viruses and atypical bacteria in SARS-CoV-2-positive patients was 11.6% (16.8% in studies that tested 100% of patients for copathogens).[406]
- Bacterial coinfections have been reported in 7% of hospitalized patients, and 14% of patients in intensive care units. The most common bacteria were Mycoplasma pneumoniae, Pseudomonas aeruginosa, Haemophilus influenzae, and Klebsiella pneumoniae. Coinfections with fungal pathogens and viruses (e.g., respiratory syncytial virus, influenza A) were less commonly reported.[407]
- Coinfections are more common in critically ill patients.[408]
- Coinfections may be associated with protracted respiratory symptoms, prolonged intensive care stay, morbidity, and mortality if not detected and treated early.[409]
- Patients with influenza coinfection showed similar clinical characteristics to patients with COVID-19 only.[410] [411]

Clinical presentation in children

Signs and symptoms may be similar to other common viral respiratory infections and other childhood illnesses, so a high index of suspicion for COVID-19 is required in children.

Severity

- 33% of children present with mild illness
- 51% of children present with moderate illness
- 7% of children present with severe illness
- 5% of children present with critical illness
- 20% of children present with asymptomatic illness.[412]

Evidence so far suggests a milder, or asymptomatic, course of disease in about 95% of children, but with possible evidence of radiologic lung changes in both categories. Symptoms commonly reported include fever, cough, sore throat, nasal congestion, and rhinorrhea. Fever, cough, and dyspnea are less common in children compared with adults. Children may present with gastrointestinal symptoms more commonly than adults, particularly newborns and infants, and these may be the only symptom.[392] Febrile seizures
have been reported rarely.[11] The clinical manifestations in children under 5 years of age appear to be milder compared with those of influenza A infection.[413]

Severe disease has been reported rarely in children.[392] [414] In a cross-sectional study of 48 critically ill infants and children in the US, the clinical course and hospital outcomes were better compared with adults. Similar to adults, 80% of critically ill children had preexisting comorbidities, most commonly immune suppression/cancer, cardiac disease, obesity, and diabetes.[415] [416] It is worth noting that critical disease has been reported more frequently in children under 1 year of age compared with children older than 1 year of age, and vomiting is more common in this age group.[412] There is increasing concern that a related inflammatory syndrome is emerging in children with severe disease. See the Complications section for more information.

Neonates

- Respiratory tract symptoms and fever are the most common symptoms in neonates.[417] Although illness is usually mild, severe illness, including cases of late-onset neonatal sepsis and encephalitis, has been reported. Severe illness is slightly more common in neonates compared with older children. Infants may present with irritability, crying, feeding difficulties, silent hypoxia, and neurologic symptoms.[392] [418] [419] [420]

Coinfections

- Coinfections may be more common in children.[421] Coinfection was documented in 6% of children in US and Italian studies, with the most common pathogens being respiratory syncytial virus, rhinoviruses, Epstein-Barr virus, enteroviruses, influenza A, non-SARS coronaviruses, and Streptococcus pneumoniae.[11] [218]

Physical exam

Perform a physical exam. Avoid use of a stethoscope if possible due to risk of viral contamination. Patients may be febrile (with or without chills/rigors) and have obvious cough and/or difficulty breathing. Auscultation of the chest may reveal inspiratory crackles, rales, and/or bronchial breathing in patients with pneumonia or respiratory distress. Patients with respiratory distress may have tachycardia, tachypnea, or cyanosis accompanying hypoxia. Bradycardia has been noted in a small cohort of patients with mild to moderate disease.[422]

Pulse oximetry

Pulse oximetry may reveal low oxygen saturation (SpO₂ <90%). Clinicians should be aware that patients with COVID-19 can develop "silent hypoxia": their oxygen saturations can drop to low levels and precipitate acute respiratory failure without the presence of obvious symptoms of respiratory distress. Only a small proportion of patients have other organ dysfunction, meaning that after the initial phase of acute deterioration, traditional methods of recognizing further deterioration (e.g., National Early Warning Score 2 [NEWS2] scores) may not help predict those patients who go on to develop respiratory failure.[423]

While NEWS2 is still recommended for use in patients with COVID-19, the UK Royal College of Physicians now advises that any increase in oxygen requirements in these patients should trigger an escalation call to a competent clinical decision maker, and prompt an initial increase in observations to at least hourly until a clinical review happens.[424]
Initial laboratory investigations

Order the following laboratory investigations in all patients with severe illness:

- ABG
- CBC
- Comprehensive metabolic panel
- Blood glucose level
- Coagulation screen
- Inflammatory markers (e.g., serum C-reactive protein, erythrocyte sedimentation rate, interleukin-6, lactate dehydrogenase, procalcitonin, amyloid A, and ferritin)
- Cardiac biomarkers
- Serum creatine kinase and myoglobin.

The most common laboratory abnormalities are lymphopenia, leukocytosis, leukopenia, thrombocytopenia, hypoalbuminemia, elevated cardiac biomarkers, elevated inflammatory markers, elevated D-dimer, and abnormal liver and renal function. Laboratory abnormalities – in particular, lymphopenia, leukocyte abnormalities, and other markers of systemic inflammation – are less common in children. Most patients (62%) with asymptomatic disease present with normal laboratory parameters. Of those with laboratory abnormalities, leukopenia, lymphopenia, elevated lactate dehydrogenase, and elevated C-reactive protein were the most common findings.

Collect blood and sputum specimens for culture in patients with severe or critical disease to rule out other causes of lower respiratory tract infection and sepsis, especially patients with an atypical epidemiologic history. Specimens should be collected prior to starting empiric antimicrobials if possible.

Molecular testing

Molecular testing is required to confirm the diagnosis. Order a nucleic acid amplification test, such as real-time reverse-transcription polymerase chain reaction (RT-PCR), for SARS-CoV-2 in patients with suspected infection whenever possible (see the Criteria section). Tests should be performed according to guidance issued by local health authorities and adhere to appropriate biosafety practices.

Who to test

- Base decisions about who to test on clinical and epidemiologic factors.
- In the UK, testing is recommended in:
  - People in the community with symptoms of new continuous cough, high temperature, or altered sense of smell/taste
  - People requiring hospital admission and who have clinical or radiologic evidence of pneumonia, or acute respiratory distress syndrome, or influenza-like illness, or altered sense of smell/taste in isolation or in combination with any other symptoms.
- In the US, testing is recommended in:
  - People with symptoms, even if they are mild
  - People who are asymptomatic and have been in close contact (less than 6 feet [2 meters] for a total of 15 minutes or more over a 24-hour period) with a person with documented infection...
• People who are asymptomatic and have not been in close contact with a person with documented infection only if required by a healthcare provider or public health official.

• The American Academy of Pediatrics recommends testing children with symptoms consistent with COVID-19, children in close contact with an individual with probable or confirmed infection, and children scheduled for an invasive medical procedure. The decision to test does not differ by the age of the child. Testing is not recommended for other illnesses that lack shared symptoms (e.g., urinary tract infection, cellulitis), or for children exposed to close contacts of infected individuals unless those contacts go on to test positive themselves.[433]

• Consult local health authorities for guidance as testing priorities depend on local recommendations and available resources.

Specimens

• The optimal specimen for testing depends on the clinical presentation and the time since symptom onset. The World Health Organization (WHO) recommends the following.[391]

  • Upper respiratory specimens: recommended for early-stage infections, especially asymptomatic or mild cases. Nasopharyngeal swabs yield a more reliable result than oropharyngeal swabs; combined nasopharyngeal and oropharyngeal swabs further improve reliability.

  • Lower respiratory specimens: recommended for later-stage infections, or patients in whom there is a strong suspicion for infection and their upper respiratory tract specimen test was negative. Suitable specimens are sputum and/or endotracheal aspirate or bronchoalveolar lavage in patients with more severe respiratory disease. However, consider the high risk of aerosol transmission when collecting lower respiratory specimens – an induced sputum specimen is not recommended as it may increase the risk of aerosol transmission.

  • Other respiratory specimens: studies on combined oropharyngeal and nares/nasal swabs, mid-turbinate or lower nasal or nares swabs, or tongue swabs have been conducted; however, further assessment and validation is required. Oral fluid collection may be suitable in some circumstances (e.g., young children, older patients with dementia). There is emerging evidence that saliva may be a reliable specimen for diagnosis.[434] [435] [436] [437] However, the WHO does not currently recommend the use of saliva as the sole specimen type for routine clinical diagnostics.

  • Fecal specimens: consider when upper or lower respiratory specimens are negative and the clinical suspicion for infection remains (may be used from the second week after symptom onset).

  • Recommended specimen types may differ between countries. For example, in the US, the Centers for Disease Control and Prevention (CDC) recommends the following upper respiratory specimens: nasopharyngeal or oropharyngeal swab; nasal mid-turbinate swab; anterior nares swab; or nasopharyngeal/nasal wash/aspirate. Recommended lower respiratory tract specimens include: sputum, bronchoalveolar lavage, tracheal aspirate, pleural fluid, and lung biopsy.[438]

  • Collect specimens under appropriate infection prevention and control procedures.

Test result

• A positive RT-PCR result confirms SARS-CoV-2 infection. If the result is negative, and there is still a clinical suspicion of infection (e.g., an epidemiologic link, typical x-ray findings, absence of
another etiology), resample the patient and repeat the test. A positive result confirms infection. If the second test is negative, consider serologic testing (see below).[391]

- Genomic sequencing is not routinely recommended, but may be useful to investigate the dynamics of an outbreak, including changes in the size of an epidemic over time, its spatiotemporal spread, and testing hypotheses about transmission routes.[391]

Complications of nasal swab testing

- Complications associated with nasal swab testing are not well characterized. Adverse effects may include epistaxis, nasal discomfort, headache, ear discomfort, and rhinorrhea.[439]
- A case of iatrogenic cerebrospinal fluid leak has been reported after nasal testing for COVID-19 in a woman with an undiagnosed skull base defect at the fovea ethmoidalis.[440]

Testing for other infections

- Collect nasopharyngeal swabs for testing to rule out infection with other respiratory pathogens (e.g., influenza, atypical pathogens) when clinically indicated according to local guidance. Depending on local epidemiology and clinical symptoms, test for other potential causes including malaria, dengue fever, and typhoid fever as appropriate. It is important to note that coinfections can occur, and a positive test for a non-COVID-19 pathogen does not rule out COVID-19.[2] [441]
- When SARS-CoV-2 and influenza viruses are cocirculating, test for both viruses in all hospitalized patients with acute respiratory illness, and only test for influenza virus in outpatients with acute respiratory illness if the results will change clinical management of the patient.[3]

Limitations of molecular testing

Interpret RT-PCR test results with caution.

- The evidence for the use of RT-PCR in the diagnosis of COVID-19 is still emerging, and uncertainties about its efficacy and accuracy remain. Estimates of diagnostic accuracy need to be interpreted with caution in the absence of a definitive reference standard to diagnose or rule out COVID-19. Also, more evidence is needed about the efficacy of testing outside of hospital settings and in asymptomatic or mild cases.[442]
- Few studies have attempted to culture live SARS-CoV-2 virus from human samples. This is an issue because viral culture is regarded as a gold standard test against which any diagnostic index test for viruses must be measured and calibrated, to understand the predictive properties of that test.[443] Prospective routine testing of reference and viral culture specimens is necessary to establish the usefulness and reliability of RT-PCR to diagnose COVID-19, and its relation to patients factors such as date of onset of symptoms and copy threshold, in order to help predict infectivity.[444]
- As there is no clear-cut “gold standard” for COVID-19 testing, evaluating test results can be challenging. Clinical adjudication may be the best available ‘gold standard’ based on repeat swabs, history, clinical presentation, and chest imaging.[445]

It is not clear whether a positive result always indicates the presence of infectious virus.

- RT-PCR detects viral RNA, but it is not fully understood how that represents infectious virus. Complete live viruses are necessary for transmission, not the fragments identified by PCR.[446] This could ultimately lead to restrictions for people who do not present an infection risk. Because
inactivated RNA degrades slowly over time, it may still be detected many weeks after the patient is no longer infectious.[443]

• One study found that only 28.9% of positive RT-PCR SARS-CoV-2 samples demonstrated viral growth when incubated on Vero cells. There was no growth in samples with a RT-PCR cycle threshold >24, or when the symptom onset to test time was >8 days. Therefore, infectivity of patients with a cycle threshold >24 and duration of symptoms >8 days may be low.[447] Another study found that patients with a cycle threshold of 34 or above do not excrete infectious virus.[448] A systematic review found that cycle threshold values were significantly lower and log copies higher in specimens that produce live virus culture. Those with high cycle threshold are unlikely to have infectious potential.[446]

• [Centre for Evidence-Based Medicine: are you infectious if you have a positive PCR test result for COVID-19?] (https://www.cebm.net/covid-19/infectious-positive-pcr-test-result-covid-19/)

Interpreting test results depends on the accuracy of the test itself, and the pre- and post-test probabilities of disease. The accuracy of the result depends on various factors including the site and quality of sampling, stage of disease, degree of viral multiplication or clearance, and disease prevalence.[445]

• Sensitivity and specificity: the pooled sensitivity has been estimated to be 87.8%, with the specificity estimated to be in the range of 87.7% to 100%.[442]

• Pretest probability: the pretest probability estimate should be made using knowledge of local rates of infection from national and regional data, as well as the patient’s symptoms, potential exposure to cases, a previous medical history of COVID-19 or the presence of antibodies, and the likelihood of an alternative diagnosis.[445] When the pretest probability is low, positive results should be interpreted with caution, and ideally a second specimen tested for confirmation.[449]

• Post-test probability: the lower the prevalence of disease in a given population, the lower the post-test probability.[450] For example, if a test with a specificity of 99% is used to test a high-risk symptomatic population where the likelihood of infection is 50%, the positive predictive value is 99%. This means that for every 100 people with a positive test result, 99 people will have SARS-CoV-2 infection but 1 person without infection will have a false-positive result. Conversely, in a low-risk asymptomatic population where the likelihood of infection is low (e.g., 0.05%), the positive predictive value is around 4.3%. This means that for every 100 people with a positive test result, 4 to 5 people will have SARS-CoV-2 infection, but 95 to 96 people without infection will have a false-positive result.[451]

• [BMJ Practice Pointer: interpreting a covid-19 tests result] (https://www.bmj.com/content/369/bmj.m1808)

False-positive results

• False-positive results can be caused by a laboratory error or a cross-reaction with antibodies formed by current and past exposure to seasonal human coronavirus infections (e.g., common cold).[452] False-positive results are more likely when the prevalence of SARS-COV-2 is moderate to low.[453]

• There is a lack of data on the rate of false-positive tests. However, preliminary estimates in the UK are in the range of 0.8% to 4%.[454] This rate could translate into a significant proportion of daily false-positive results due to the current low prevalence of the virus in the UK population, adversely affecting the positive predictive value of the test.[449]

• Examples of the potential consequences of false-positive test results include:[449]

  • Unnecessarily postponing or canceling elective procedures or treatments
• Potential exposure to infection following a wrong pathway in hospital settings during urgent hospital admissions
• Financial losses due to self-isolation, income losses, and canceled travel
• Psychological damage due to misdiagnosis including fear of infecting others or stigmatization
• Increased depression or domestic violence due to lockdown and isolation
• Overestimating the incidence and extent of asymptomatic infection in the population.

False-negative results

• False-negative rates of between 2% and 29% have been reported. A systematic review found that the false-negative rate varied across studies from 1.8% to 58% (median 11%); however, there was substantial and largely unexplained heterogeneity across studies.
• The probability of a false-negative result in an infected person decreases from 100% on day 1 of infection to 67% on day 4. The median false-negative rate drops to 38% on the day of symptom onset, decreases to 20% on day 8, and then starts to increase again from day 9.
• Examples of the potential consequences of false-negative test results include:
  • Patients may be moved into non-COVID-19 wards leading to spread of hospital-acquired infection
  • Caregivers could spread infection to vulnerable dependents
  • Healthcare workers risk spreading the infection to multiple vulnerable individuals.

Serologic testing

Serology cannot be used as a standalone diagnostic test for acute SARS-CoV-2 infections. However, it may be useful in various settings (e.g., negative molecular testing, diagnosing patients with late presentation or prolonged symptoms, serosurveillance studies).

The WHO recommends collecting a paired serum sample, one specimen in the acute phase and one in the convalescent phase 2 to 4 weeks later, in patients where infection is strongly suspected and the RT-PCR result is negative.

• Seroconversion or a rise in antibody titers in paired sera help to confirm whether the infection is recent and/or acute. If the initial sample tests positive, this could be due to a past infection that is not related to the current illness.
• Seroconversion may be faster and more robust in patients with severe disease compared with those with mild disease or asymptomatic infection.

The CDC recommends serologic testing as a method to support the diagnosis of acute infection in patients who present late (i.e., 9 to 14 days after symptom onset) in addition to other viral detection methods (e.g., RT-PCR, antigen detection tests), or patients who present with late complications (e.g., pediatric inflammatory multisystem syndrome in children).

• Assays with Food and Drug Administration emergency-use authorization are preferred. There is no advantage of assays whether they test for immunoglobulin G (IgG), IgM and IgG, or total antibody.
• The test’s positive predictive value should be optimized by choosing tests with high specificity (e.g., >99.5%) and testing people or populations with a high pretest probability of having antibodies, or
using an orthogonal testing algorithm. Results should be interpreted in the context of the expected predictive values (positive and negative).

The Infectious Diseases Society of America recommends serologic testing in the following circumstances:[459]

- Evaluation of patients with a high clinical suspicion for infection when molecular diagnostic testing is negative and at least 2 weeks have passed since symptom onset
- Evaluation of pediatric inflammatory multisystem syndrome in children
- Serosurveillance studies.

Antibody responses to SARS-CoV-2 typically occur during the first 1 to 3 weeks of illness, with the seroconversion time of IgG antibodies often being earlier than that of IgM antibodies.[460] [461]

A Cochrane review found that antibody tests for IgG/IgM only detected 30% of people with COVID-19 when the test was performed 1 week after the onset of symptoms, but accuracy increased in week 2 with 70% detected and week 3 with over 90% detected. Data beyond 3 weeks were limited. Tests gave false-positive results in 2% of patients without COVID-19. The review found that the sensitivity of antibody tests is too low in the first week since symptom onset to have a primary role in the diagnosis of COVID-19, but tests are likely to have a useful role in detecting previous infection if used 15 or more days after symptom onset (although there were very little data beyond 35 days).[462]

**Limitations of serologic testing**

The evidence for the use of antibody tests in the diagnosis of COVID-19 is still emerging, and uncertainties about their efficacy and accuracy remain. Estimates of diagnostic accuracy need to be interpreted with caution in the absence of a definitive reference standard to diagnose or rule out COVID-19. More evidence is needed about the efficacy of testing outside of hospital settings and in asymptomatic or mild cases. The estimated sensitivity of antibody tests ranged from 18.4% to 96.1% (the lowest reported sensitivity was from a point-of-care test, although a sensitivity <50% was reported for one laboratory test), and specificity ranged from 88.9% to 100%.[442]

Understanding of the antibody response to SARS-CoV-2 is still emerging; therefore, antibody detection tests must be used with caution, and not used to determine acute infections.[391]

- Results do not indicate the presence or absence of current or previous infection with certainty as IgM and IgG antibodies may take 1 to 3 weeks to develop after infection.[458] A reliable diagnosis is often only possible in the recovery phase when opportunities for management or interruption of transmission have passed.[391]
- The duration of the persistence of antibodies produced in response to SARS-CoV-2 is still under investigation.[391] Some people may not develop detectable antibodies after infection, and in those who do, antibody levels may wane over time to undetectable levels.[458] The presence of antibodies that bind to SARS-CoV-2 does not guarantee that they are neutralizing antibodies, or that they offer protective immunity.[391]
- Some tests may exhibit cross-reactivity with other coronaviruses, such as those that cause the common cold, which can result in false-positive results.[458]
- Tests should not be used to determine the immune status of an individual, or to make decisions about grouping people residing in or being admitted to congregate settings (e.g., schools, dormitories, correctional facilities) or people returning to their workplace.[458]
Rapid diagnostic tests

Antibody detection

- While rapid antibody detection kits have been approved for the qualitative detection of SARS-CoV-2 IgG/IgM antibodies in serum, plasma, or whole blood, the WHO does not recommend the use of these tests outside of research settings as they have not been validated as yet.[463]
- Evidence is particularly weak for point-of-care serologic tests. A meta-analysis found that the overall sensitivity of chemiluminescent immunoassays (CLIA) for IgG or IgM was approximately 98%, and the sensitivity of enzyme-linked immunosorbent assays (ELISA) was 84%; however, lateral flow immunoassays (LFA), which have been developed as point-of-care tests, had the lowest sensitivity at 66%. Test sensitivity was highest 3 or more weeks after onset of symptoms. Available evidence does not support the use of existing point-of-care serologic tests.[464]

Antigen detection

- Antigen testing relies on direct detection of SARS-CoV-2 viral proteins in nasal swabs and other respiratory specimens using a lateral flow immunoassay. Results are usually available in less than 30 minutes. While antigen tests are substantially less sensitive than RT-PCR, they offer the possibility of rapid, inexpensive, and early detection of the most infectious cases in appropriate settings. If used, testing should occur within the first 5 to 7 days following the onset of symptoms.[465]
- The WHO recommends antigen testing only in certain scenarios where RT-PCR is unavailable or where prolonged turnaround times preclude clinical utility, provided that the test meets the minimum performance requirements of ≥80% sensitivity and ≥97% specificity compared with a RT-PCR reference assay.[465]
- The Food and Drug Administration has warned that false positive results can occur with antigen tests, including when users do not follow the instructions for use, and that the number of false positive tests increases as disease prevalence decreases.[466]
- Laboratory-based (nonrapid) antigen tests are also available in some countries.

Chest imaging

All imaging procedures should be performed according to local infection prevention and control procedures to prevent transmission. Chest imaging is considered safe in pregnant women.[467]

Order a chest x-ray in all patients with suspected pneumonia. Unilateral lung infiltrates are found in 25% of patients, and bilateral lung infiltrates are found in 75% of patients.[44] [45] [468] Although chest x-ray appears to have a lower sensitivity compared with chest CT, it has the advantages of being less resource-intensive, associated with lower radiation doses, easier to repeat sequentially, and portable.[469]

Consider ordering a CT scan of the chest. CT imaging is the primary imaging modality in some countries, such as China. It may be helpful in making the diagnosis, guiding individual patient management decisions, aiding the diagnosis of complications, or giving clues to an alternative diagnosis. However, it is not diagnostic for COVID-19 and local guidance should be consulted on whether to perform a CT scan.

The British Society of Thoracic Imaging (BSTI) recommends CT imaging in patients with clinically suspected COVID-19 who are seriously ill if chest x-ray is uncertain or normal. Without the suspicion of COVID-19, the radiology is nonspecific and could represent many other disease processes. The BSTI in
collaboration with NHS England have produced a radiology decision support tool to help clinicians decide whether or not chest imaging should be ordered.[394]


Some institutions in the UK recommend a more pragmatic approach for patients with high clinical suspicion of COVID-19, with chest CT recommended only after two indeterminate or normal chest x-rays in combination with a negative RT-PCR test.[470]

The American College of Radiology recommends reserving CT for hospitalized, symptomatic patients with specific clinical indications for CT, and emphasizes that a normal chest CT does not mean that a patient does not have COVID-19 and that an abnormal chest CT is not specific for COVID-19 diagnosis.[471]

Abnormal chest CT findings have been reported in up to 97% of COVID-19 patients in one meta-analysis of 50,466 hospitalized patients.[472] Evidence of pneumonia on CT may precede a positive RT-PCR result for SARS-CoV-2 in some patients.[473] CT imaging abnormalities may be present in asymptomatic patients. The pooled estimate of the rate of positive chest CT findings in asymptomatic cases was 62%, while it was 90% in those who developed symptoms.[474] Some patients may present with a normal chest finding despite a positive RT-PCR.[475] Also, results of RT-PCR testing may be false-negative, so patients with typical CT findings should have repeat RT-PCR testing to confirm the diagnosis.[476]

Typical features

- The most common findings are ground-glass opacity, either in isolation or coexisting with other findings such as consolidation, interlobular septal thickening, or crazy-paving pattern. The most common distribution pattern is bilateral, peripheral/subpleural, posterior distribution of the opacities, with a lower lobe predominance. Extensive/multilobar involvement with consolidations is more common in older patients and those with severe disease.[477]
- Ground-glass opacity has the highest diagnostic performance for COVID-19 pneumonia, followed by ground-glass opacity plus consolidation, and consolidation only.[478] The simultaneous presence of ground-glass opacity and other features of viral pneumonia had optimum performance in the detection of COVID-19 (sensitivity 90% and specificity 89%).[479]
- CT scan generally shows an increase in the size, number, and density of ground-glass opacities in the early follow-up period, with a progression to mixed areas of ground-glass opacities, consolidations, and crazy paving peaking at day 10 to 11, before gradually resolving or persisting as patchy fibrosis.[477]
- A small comparative study found that patients with COVID-19 are more likely to have bilateral involvement with multiple mottling and ground-glass opacity compared with other types of pneumonia.[480]
- Children frequently have normal or mild CT chest findings. The most common signs in children are patchy ground-glass opacity and, less frequently, nonspecific patchy shadows, areas of consolidation, and a halo sign. Abnormalities are more common in the lower lobes and are predominantly unilateral. Pleural effusion is rare. Children may have signs of pneumonia on chest imaging despite having minimal or no symptoms.[481]

Atypical features

- Pulmonary vascular enlargement, interlobular or intralobular septal thickening, adjacent pleural thickening, air bronchograms, subpleural lines, crazy-paving pattern, bronchus distortion,
bronchiectasis, vacuolar retraction sign, and halo sign are atypical features. Pleural effusion, pericardial effusion, cavitation, pneumothorax, and mediastinal lymphadenopathy have also been reported rarely.[477]

The WHO recommends chest imaging in the following scenarios:[469]

- Symptomatic patients with suspected COVID-19 when RT-PCR is not available, RT-PCR test results are delayed, or initial RT-PCR testing is negative but there is a high clinical suspicion for COVID-19 (for diagnosis)
- Patients with suspected or confirmed COVID-19 who are not currently hospitalized and have mild symptoms (to decide on hospital admission versus home discharge)
- Patients with suspected or confirmed COVID-19 who are not currently hospitalized and have moderate to severe symptoms (to help decide on regular ward admission versus intensive care unit admission)
- Patients with suspected or confirmed COVID-19 who are currently hospitalized and have moderate to severe symptoms (to inform therapeutic management).

**Emerging tests**

**Reverse transcription loop-mediated isothermal amplification**

- Reverse transcription loop-mediated isothermal amplification (RT-LAMP) assays are an emerging test to detect SARS-CoV-2 viral RNA. While assays are simple and quick, there is less evidence for their use. Assays for SARS-CoV-2 have been developed and are being evaluated.[482] [483] [484]

**Lung ultrasound**

- Lung ultrasound is used as a diagnostic tool in some centers as an alternative to chest x-ray and chest CT. Although there is only very low-certainty evidence supporting its diagnostic accuracy, it might be helpful as a supplemental or alternate imaging modality.[469] It has the advantages of portability, bedside evaluation, reduced healthcare worker exposure, easier sterilization process, absence of ionizing radiation exposure, and repeatability during follow-up. It may also be more readily available in resource-limited settings. However, it also has some limitations (e.g., it is unable to discern chronicity of a lesion) and other imaging modalities may be required. B-lines are the prominent pattern in patients with COVID-19, occurring with a pooled frequency of 97%. Pleural line abnormalities are also common, with a pooled frequency of 70%. While these findings are not specific for COVID-19, they increase the likelihood of disease in the context of a characteristic clinical presentation. Other findings include consolidations, pleural thickening, and pleural effusion.[485] May be used in pregnant women and children.[486] [487]


**Viral isolation**

- Viral isolation is not recommended as a routine diagnostic procedure. All procedures involving viral isolation in cell culture require trained staff and biosafety level 3 (BSL-3) facilities.[391]
History and exam

Key diagnostic factors

fever (common)
- Reported in approximately 77% of patients.[138] In one case series, only 44% of patients had a fever on presentation, but it developed in 89% of patients after hospitalization.[488] The course may be prolonged and intermittent, and some patients may have chills/rigors. In children, fever may be absent or brief and rapidly resolving.[489]

cough (common)
- Reported in approximately 68% of patients.[138] The cough is usually dry; however, a productive cough has been reported in some patients.

dyspnea (common)
- Reported in approximately 38% of patients.[138] Median time from onset of symptoms to development of dyspnea is 5 to 8 days.[44] [45] [490] It is less common in children, but the most common sign in neonates.[392] May last weeks after initial onset of symptoms. Wheeze has been reported in 17% of patients.[491]

altered sense of smell/taste (common)
- Olfactory dysfunction (anosmia/hyposmia) has been reported in approximately 41% of patients, and gustatory dysfunction (ageusia/dysgeusia) has been reported in approximately 35% of patients.[138] Prevalence appears to be higher in European studies.[492] May be an early symptom before the onset of other symptoms, or may be the only symptom in patients with mild to moderate illness.[493] Complete resolution or improvement in symptoms was reported in 89% of patients 4 weeks after onset.[494] Many drugs are associated with taste and smell changes (e.g., antibiotics, ACE inhibitors) and should be considered in the differential diagnosis.[495]

Other diagnostic factors

fatigue (common)
- Reported in approximately 30% of patients.[138] Patients may also report malaise. Fatigue and exhaustion may be extreme and protracted, even in patients with mild disease.

myalgia or arthralgia (common)
- Reported in approximately 17% (myalgia) and 11% (arthralgia) of patients.[491] Arthritis has been reported rarely.[496]

sputum production/expectoration (common)
- Reported in approximately 18% of patients.[138]

chest tightness (common)
- Reported in approximately 22.9% of patients.[426]

gastrointestinal symptoms (common)
• Reported in 20% of patients. The weighted pooled prevalence of specific symptoms is as follows: loss of appetite 22.3%; diarrhea 2.4%; nausea/vomiting 9%; and abdominal pain 6.2%. Gastrointestinal symptoms appear to be more prevalent outside of China, although this may be due to increased awareness and reporting of these symptoms as the pandemic progressed.[497] Gastrointestinal symptoms are not associated with an increased likelihood for testing positive for COVID-19; however, anorexia and diarrhea, when combined with loss of smell/taste and fever, were 99% specific for COVID-19 infection in one prospective case-control study.[498] The presence of diarrhea may be a predictor of progression to severe disease.[499] Children may present with gastrointestinal symptoms more commonly than adults, particularly newborns and infants, and these may be the only symptom.[382] Hematochezia has been reported.[500]

sore throat (common)
• Reported in approximately 16% of patients.[138] Usually presents early in the clinical course.

headache (common)
• Reported in approximately 16% of patients.[138]

dizziness (common)
• Reported in approximately 11% of patients.[491]

neurologic symptoms (common)
• Confusion has been reported in approximately 11% of patients.[491] Prevalence of confusion/delirium and agitation is high (65% and 69%, respectively) in patients in the intensive care unit.[501] Delirium is associated with an increased risk of mortality, and rapid onset may indicate clinical deterioration.[502] The pooled prevalence of anxiety, depression, and insomnia is 15.2%, 16%, and 23.9%, respectively.[503] Altered mental status was as common in younger hospitalized patients (<60 years) as it was in older patients in one study.[504][505]

ocular symptoms (common)
• Reported in 11.6% of patients. The most common ocular symptoms include ocular pain (31.2%), discharge (19.2%), redness (10.8%), and follicular conjunctivitis (7.7%).[506] Most symptoms are mild and last for 4 to 14 days with no complications. Prodromal symptoms occur in 12.5% of patients.[507] Mild ocular symptoms (e.g., conjunctival discharge, eye rubbing, conjunctival congestion) were reported in 22.7% of children in one cross-sectional study. Children with systemic symptoms were more likely to develop ocular symptoms.[508]

rhinorrhea/nasal congestion (uncommon)
• Rhinorrhea has been reported in approximately 8% of patients, and nasal congestion has been reported in approximately 5% of patients.[491]

chest pain (uncommon)
• Reported in approximately 7% of patients.[491] May indicate pneumonia.

cutaneous symptoms (uncommon)
• The pooled prevalence of overall cutaneous lesions is 5.7%. The most common symptoms are a viral exanthem-like presentation (4.2%), maculopapular rash (3.8%), and vesiculobullous lesions (1.7%). Other manifestations include urticaria, chilblain-like lesions, livedo reticularis, and finger/toe gangrene.[509] In the UK COVID Symptom Study, 17% of respondents reported rash as the first
symptom of disease, and 21% of respondents reported rash as the only clinical sign.[510] It is unclear whether skin lesions are from viral infection, systemic consequences of the infection, or drugs the patient may be on. Further data is required to better understand cutaneous involvement.


### hemoptysis (uncommon)
- Reported in approximately 2% of patients.[491] May be a symptom of pulmonary embolism.[511]

### bronchial breath sounds (uncommon)
- May indicate pneumonia.

### tachypnea (uncommon)
- May be present in patients with acute respiratory distress.

### tachycardia (uncommon)
- May be present in patients with acute respiratory distress.

### cyanosis (uncommon)
- May be present in patients with acute respiratory distress.

### crackles/rales on auscultation (uncommon)
- May be present in patients with acute respiratory distress.

### Risk factors

#### Strong

### residence/work/travel in location with high risk of transmission
- People residing or working in an area with a high risk of transmission (e.g., closed residential settings, humanitarian setting), people residing in or traveling to an area with community transmission, and people working in a health setting (including within health facilities and households) at any time within the 14 days prior to symptom onset are at higher risk of infection.[184]

### contact with probable or confirmed case
- The World Health Organization defines a contact as a person who has experienced any one of the following exposures during the 2 days before and the 14 days after the onset of symptoms of a probable or confirmed case: face-to-face contact with a probable or confirmed case within 3 feet (1 meter) and for at least 15 minutes; direct physical contact with a probable or confirmed case; direct care for a patient with probable or confirmed COVID-19 without using recommended personal protective equipment; or other situations as indicated by local risk assessments.[184]

- The Centers for Disease Control and Prevention has redefined what it considers to be a close contact in October 2020. A close contact is now defined as someone who has been within 6 feet (2 meters) of an infected person for at least 15 minutes over a 24-hour period, beginning 2 days before symptom onset (or 2 days before testing in asymptomatic patients). In the previous definition, the 15-minute exposure window was continuous.[185] The change was triggered by one study of a correctional facility officer who tested positive after having multiple brief encounters with six positive prisoners totaling over 17 minutes during an 8-hour shift, despite the officer wearing a mask and goggles.[186]
older age

- Older age is a risk factor for infection.[187] Data from a cross-sectional study in the UK indicate that people aged 40 to 64 years are at greatest risk of infection, followed by patients 75 years and older, and then people aged 65 to 74 years.[188] The risk of severe illness in adults increases with age, with older people (ages 65 years and older) at highest risk.[189] [190] The highest mortality rate has been observed in patients 80 years and older.[191] In the US, patients ≥65 years accounted for 31% of all cases, 53% of intensive care unit admissions, and 80% of deaths, with the highest incidence of severe outcomes in patients ages ≥85 years.[7] While age is an independent risk factor, the risk in older people is also partly related to the likelihood that older adults are more likely to have comorbidities.

residence in a long-term care facility

- Widespread transmission has been reported in long-term care facilities.[120] People who live in a nursing home or long-term care facility are at higher risk for severe illness.[190] Care home residents represent approximately one third of the total number of deaths in England and Wales; other countries have reported a similar experience. This is likely due to shortages in personal protective equipment, a vulnerable population, and a lack of testing.[192] More than one third of care homes in England have had cases.[193] A study across four nursing homes in the UK found that 26% of residents died over a 2-month period, with all-cause mortality increasing by 203% compared with previous years. Approximately 40% of residents tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and of these, 43% were asymptomatic and 18% had atypical symptoms.[194]

male sex

- Male sex is a risk factor for severe disease, intensive care admission, and mortality.[195] Data from a cross-sectional study in the UK found that the adjusted odds of a positive test were greater in males (18.4%) compared with females (13.3%).[188] It has been hypothesized that this may be due to the presence of androgens, a lower level of SARS-CoV-2 antibodies compared with females, or women mounting a stronger immune response compared with men; however, further research is required.[196] [197] [198] The higher prevalence of alcohol consumption and smoking may also contribute to the higher prevalence of infection among men.[199]

ethnicity

- People from Black, Asian, and minority ethnic (BAME) groups are at a higher risk of infection and worse outcomes, including an increased risk of intensive care unit admission and mortality, compared with White people.[200] [201]
- Data from a cross-sectional study in the UK found that South Asian and Black patients had 1.93 and 1.47 the odds of suspected infection, respectively.[202] The average age of patients from ethnic minorities was significantly lower than that of White patients.[203] Ethnic minorities in the UK (including South Asian, East Asian, Black, and other ethnic minorities) admitted to hospital were more likely to be admitted to intensive care and require invasive mechanical ventilation compared with White patients, despite similar disease severity at admission and being younger with fewer comorbidities.[204]
- Age-adjusted data from the US Centers for Disease Control and Prevention (as of 5 December 2020) show that Hispanic or Latino people, non-Hispanic American Indian or Alaska Native people, and non-Hispanic Black people have approximately 3.8, 3.7, and 3.3 times the rate of hospitalizations of non-Hispanic White people, respectively.[205] However, cohort studies in the US have found no difference in outcomes between non-Hispanic Black and Hispanic patients compared with White patients after adjusting for sociodemographic factors, and comorbidities (e.g., age, sex, insurance).[206] [207] In a
large national registry of COVID-19 hospitalizations, Black and Hispanic patients accounted for over 50% of hospitalizations. After adjusting for sociodemographic and clinical characteristics, mortality and major cardiovascular or cerebrovascular adverse events did not differ by ethnicity. This indicates that Black and Hispanic patients may have an increased risk of mortality and morbidity due to their disproportionate representation among hospitalizations.[208] In a study of over 10,000 deceased patients in the US, 35% of Hispanic and 30% of non-White decedents were ages <65 years, compared with 13% of White, non-Hispanic decedents.[209] An analysis of over 114,000 COVID-19–associated deaths in the US found that 51.3% of decedents were non-Hispanic White, 24.2% were Hispanic or Latino, and 18.7% were non-Hispanic Black.[210]

- Racial disparities in outcomes may be partially attributed to higher rates of comorbidities in certain ethnic groups.[211]

**presence of comorbidities**

- People with comorbidities are at higher risk for severe illness and mortality.[212] The more comorbidities a person has, the greater their risk for severe illness.[213] In the US, approximately 91% of hospitalized patients had at least one reported underlying medical condition.[205] The most prevalent comorbidities in adults with COVID-19 are hypertension, diabetes, chronic respiratory disease, cardiovascular disease, and other chronic diseases such as cancer.[214] In a prospective observational cohort study of more than 20,000 hospitalized patients in the UK, the most common comorbidities were chronic cardiac disease (31%), uncomplicated diabetes (21%), nonasthmatic chronic pulmonary disease (18%), and chronic kidney disease (16%).[6] Similarly, in the US the most common comorbidities were cardiovascular disease (32%), diabetes (30%), and chronic lung disease (18%). Hospitalizations were six times higher and deaths were 12 times higher in patients with comorbidities compared with those without.[215] It has been estimated that approximately 56% of adults in the US are at risk for requiring hospitalization from COVID-19 because of the presence of at least one comorbidity. These underlying conditions are associated with modifiable risk factors, which, if improved through lifestyle changes, may improve a person’s risk status.[216]

- Among 345 pediatric cases with information on underlying conditions, 23% had at least one underlying condition, most commonly chronic lung disease, cardiovascular disease, or immunosuppression.[217] Approximately 39% of hospitalized children had an underlying condition in another study. The most prevalent comorbidities were asthma, neurologic disorders, diabetes, obesity, cardiovascular disease, and malignancy/hematologic conditions.[218] Children with comorbidities have a relative risk ratio of 1.79 for severe disease, and a relative risk ratio of 2.81 for mortality, compared with children without comorbidities.[219]

- Around 32% of young adults (ages 18-25 years) in the US had underlying conditions that put them at risk for severe disease including heart conditions, diabetes, asthma, immune conditions, liver conditions, and obesity. Smoking (including e-cigarette use) in the past 30 days also increased the risk. The rate of young adults at risk for severe disease decreased to 16% when considering nonsmokers only.[220]

**cardiovascular diseases**

- People with serious heart conditions (e.g., heart failure, coronary artery disease, cardiomyopathies) are at increased risk of severe illness.[213] Arrhythmias, coronary artery disease, and cardiovascular disease are significantly associated with intensive care unit admission. Heart failure, arrhythmias, coronary artery disease, and cardiovascular disease are also significantly associated with an increased risk of mortality.[221]
**hypertension**

- People with hypertension may be at increased risk of severe illness.\[213\] Hypertension has been associated with increased poor composite outcome, including mortality, severe disease, acute respiratory distress syndrome, need for intensive care admission, and disease progression.\[222\] Patients with hypertension have a 2.98-fold higher risk of severe disease, and a 2.88-fold higher risk of fatality compared with patients without hypertension.\[223\]

**obesity**

- People with obesity (≥30 kg/m²) or severe obesity (≥40 kg/m²) are at increased risk of severe illness, and people who are overweight (25-30 kg/m²) may be at increased risk of severe illness; however, evidence is limited for the latter group.\[213\] Obesity is associated with an increased risk for infection, higher risk of hospitalization, progression to severe or critical disease, need for invasive mechanical ventilation, and higher risk of in-hospital mortality.\[224\] \[225\] \[226\] Obesity plays a significant role in the risk of death from COVID-19, particularly in males and younger people (<60 years of age).\[227\] Obese patients are also at higher risk for venous thromboembolism and dialysis.\[228\] Increased body mass index is a significant risk factor for severe disease in pregnant women.\[229\] Obesity was the most common comorbidity in children, and was significantly associated with mechanical ventilation in children 2 years and older in a single-center retrospective study in New York.\[230\]

**diabetes**

- People with type 2 diabetes are at increased risk of severe illness. People with type 1 diabetes or gestational diabetes may also be at increased risk of severe illness; however, evidence is limited for these patient groups.\[213\] The pooled prevalence of diabetes in COVID-19 patients is approximately 15%.\[231\] Diabetes is associated with an increased risk of disease progression, intensive care admission, acute respiratory distress syndrome, mechanical ventilation, and mortality.\[232\] \[233\] The risk of intensive care admission and mortality is significantly higher in patients with diabetes compared with those without diabetes (pooled risk ratio of 1.88 and 1.61, respectively).\[231\] One third of all deaths in hospitalized patients in England occur in patients with diabetes. People with type 1 diabetes have 3.50 times the odds of dying in hospital with COVID-19, while people with type 2 diabetes have 2.03 times the odds.\[234\] An analysis of more than 19,000 patients admitted to critical care over the entire first wave of disease in England found that type 2 diabetes is associated with a 20% increase in mortality in patients with severe disease, independent of age, sex, ethnicity, obesity, or other major comorbidity.\[235\] Risk factors for poor prognosis and higher mortality in patients with type 1 or type 2 diabetes include older age, male sex, non-White ethnicity, socioeconomic deprivation, renal impairment, history of stroke or heart failure, higher glycosylated hemoglobin (HbA1c) levels, higher body mass index, elevated C-reactive protein, diabetic ketoacidosis, and insulin use.\[236\] \[237\] \[238\] However, HbA1c levels were not associated with mortality in a large US cohort of hospitalized patients with diabetes and COVID-19, while insulin treatment and obesity were strong and independent risk factors for in-hospital mortality.\[239\] Hyperglycemia is also an independent risk factor for poor prognosis in hospitalized patients with or without known diabetes.\[240\] \[241\] Patients with newly diagnosed diabetes have a higher risk of all-cause mortality compared with patients with known diabetes, hyperglycemia, or normal glucose.\[242\] The poor prognosis in these patients is likely due to the syndromic nature of diabetes, with factors such as hyperglycemia, older age, and the presence of comorbidities (e.g., obesity, hypertension, cardiovascular disease) all contributing to the increased risk.\[243\] Metformin was significantly associated with reduced mortality in women with obesity or type 2 diabetes who were admitted to hospital for COVID-19 in a large retrospective cohort analysis; however, further research is required.\[244\]
chronic respiratory disease

- There is no clear evidence that people with asthma or chronic obstructive pulmonary disease (COPD) are at higher risk of infection.[245] [246] However, people with COPD (including emphysema and chronic bronchitis) are at increased risk of severe illness.[213] COPD is associated with a 5-fold increased risk of severe illness.[247] People with moderate to severe asthma may be at increased risk of severe illness; however, evidence is limited.[213] A meta-analysis found that asthma is not associated with severe disease, worse prognosis, or a higher risk of intubation or mechanical ventilation. Patients with asthma had a lower risk of death compared with nonasthmatic patients.[248] People with other chronic lung diseases (e.g., cystic fibrosis, idiopathic pulmonary fibrosis) may be at increased risk of severe illness; however, the evidence is limited.[213] There are no data on whether pediatric respiratory diseases (including childhood asthma) are risk factors for infection or severity.[249]

chronic kidney disease

- People with chronic kidney disease may be at higher risk of infection. Data from a cross-sectional study in the UK found that the adjusted odds of a positive test were greater in patients with chronic kidney disease (32.9%) compared with those without (14.4%).[188] People with chronic kidney disease are also at increased risk of severe illness.[213] The prevalence of preexisting chronic kidney disease in COVID-19 patients was 5.2% (2.3% for end-stage kidney disease), and is an independent risk factor for developing acute kidney injury as a complication.[250]

malignancy

- People with cancer are at a higher risk of infection, likely due to immunosuppressive treatments and/or recurrent hospital visits.[251] The overall pooled prevalence of cancer in hospitalized patients is approximately 2.6%, with a lower incidence in China compared with Western countries.[252] People with cancer are also at increased risk of severe illness.[213] Patients with cancer are 76% more likely to get severe disease compared with those without cancer.[253] They also have an increased risk of worse clinical outcomes including intensive care unit admission and all-cause mortality (particularly those with metastatic disease, hemato logic cancer, or lung cancer), and appear to deteriorate more quickly compared with patients without cancer.[254] [255] The odds ratio of intensive care admission rates and mortality rates between cancer and noncancer groups was 2.88 and 2.25, respectively.[256] The pooled in-hospital mortality risk in patients with cancer is 14.1%.[252] Risk factors for mortality in patients with cancer include male sex, older age, presence of one or more comorbidities, hypertension, COPD, and the presence of complications (e.g., acute respiratory distress syndrome, acute renal failure). Patients with hematologic malignancies have an increased risk of mortality compared with those with solid tumors. Recent anticancer treatments are not significantly associated with an increased mortality rate.[257] While active chemotherapy or chemotherapy within the last 30 days increased the risk of death, targeted therapies, immunotherapy, surgery, and radiation therapy did not appear to increase the risk for severe disease or death.[258] [259] Children with cancer may be no more vulnerable to infection compared with children without cancer. Limited data show that the overall morbidity in pediatric patients with cancer is low, with only 5% requiring hospitalization for symptoms.[260]

sickle cell disease

- People with sickle cell disease are at increased risk of severe illness.[213] Among 178 patients with sickle cell disease and COVID-19 in the US (mean patient age <40 years), 69% were hospitalized,
11% were admitted to intensive care, and 7% died.[261] Infection can cause acute chest syndrome in patients with sickle cell disease.[262] [263]

**solid organ transplant**

- People with an immunocompromised state from solid organ transplant are at increased risk of severe illness.[213] Solid organ transplant recipients are at higher risk of hospitalization, intensive care unit admission, and mortality. However, the increased rate of hospitalization may reflect a preferred management strategy of closer inpatient monitoring in these patients rather than being an indicator of disease severity. Overall mortality in solid organ transplant recipients was 20%.[264] Hospitalization and mortality rates in liver transplant recipients are disproportionately high compared with nontransplant patients regardless of age or time after transplant. Older age and diabetes are significant risk factors for death among these patients.[265]

**smoking**

- People who are current or former smokers are at increased risk of severe illness.[213] Current smokers have an increased risk of severe or critical disease. Patients with any smoking history have a significantly increased risk of severe or critical disease, in-hospital mortality, disease progression, and need for mechanical ventilation.[266] Smokers have double the mortality risk compared with nonsmokers.[267] This may be due to increased airway expression of the angiotensin-converting enzyme-2 receptor in smokers.[268] The World Health Organization has reviewed the available evidence and concluded that smoking is associated with increased severity of disease and death in hospitalized patients.[269]

**cerebrovascular disease**

- People with cerebrovascular disease may be at increased risk of severe illness; however, evidence is limited.[213] The pooled prevalence of preexisting cerebrovascular disease in COVID-19 patients is 3%. [270] Patients with a history of cerebrovascular disease are more likely to progress to adverse outcomes compared with patients without a history of cerebrovascular disease.[271] Patients with preexisting cerebrovascular disease have 2.67-fold higher odds of poor outcomes including intensive care admission, mechanical ventilation, and mortality.[272]

**dementia**

- Dementia is associated with increased risk of infection and increased mortality.[273] People with dementia are also at increased risk of severe illness; however, evidence is limited.[213] The incidence of dementia in COVID-19 patients is approximately 9%.[274] In the UK, over one quarter of people who died with COVID-19 from March to June 2020 had dementia. Dementia and Alzheimer disease was the most common main preexisting health condition in deaths involving COVID-19 between March and June 2020.[275]

**chronic liver disease**

- People with chronic liver disease, especially cirrhosis, may be at increased risk of severe illness; however, evidence is limited.[213] The prevalence of chronic liver disease in COVID-19 patients is approximately 3%. The presence of chronic liver disease is associated with more severe disease and overall mortality.[276] The 30-day mortality rate is higher in patients with cirrhosis, with the main causes of death being respiratory complications and sudden worsening of liver function leading to end-stage liver disease.[277]
metabolic dysfunction-associated fatty liver disease

- People with metabolic dysfunction-associated fatty liver disease (MAFLD; also called nonalcoholic fatty liver disease) are at increased risk of severe illness, with a pooled odds ratio of 2.93.[278] Severity of COVID-19 has been associated with younger age (<60 years) and intermediate or high fibrosis-4 (FIB-4) scores in patients with MAFLD.[279] [280]

surgery

- Surgical mortality and complications are higher in patients with COVID-19 compared with patients without COVID-19.[281] A retrospective study of 34 patients in China who underwent elective surgeries during the incubation period of COVID-19 found that all patients developed pneumonia after surgery. Approximately 44% of these patients required admission to the intensive care unit, and 20% died.[282] Postoperative pulmonary complications occur in half of patients with perioperative SARS-CoV-2 infection, and are associated with higher mortality, particularly in men and those ages 70 years and over.[283]

pregnancy

- Pregnant women are at increased risk of severe illness.[213] According to an analysis of approximately 400,000 women ages 15 to 44 years with symptomatic disease, pregnant women were more likely to be hospitalized, to be admitted to the intensive care unit, to receive invasive mechanical ventilation or extracorporeal membrane oxygenation, and to die compared with nonpregnant women.[23]

immunosuppression

- People who are immunocompromised (e.g., blood or bone marrow transplant, immune deficiencies, prolonged use of corticosteroids or other immunosuppressant medications) may be at increased risk of severe illness; however, evidence is limited.[213] Patients with inflammatory bowel disease who were on long-term biologics did not have a higher risk of poor outcomes; however, recent corticosteroid use, thiopurine use, or combination therapy may be related to an increased risk of severe disease and worse outcomes.[284] [285] Glucocorticoid exposure of ≥10 mg/day (prednisone) has been associated with a higher odds of hospitalization in patients with rheumatologic disease.[286] Patients treated with cyclosporine/tacrolimus also had an increased risk of hospitalization; however, it was not clear whether the increased risk is related to the drug itself, the underlying condition for which the patient is treated, or other factors.[287] Also see HIV infection and autoimmune disease, below.

autoimmune disease

- Autoimmune disease is associated with an increased risk of infection. However, clinical outcomes were not considerably worse when compared with people without autoimmune disease. Use of corticosteroids increased the risk of infection and severe outcomes, and use of combination disease-modifying antirheumatic drugs (DMARDs) increased the risk of severe outcomes. DMARD monotherapy, particularly tumor necrosis factor inhibitors, reduced the risk of severe disease and mortality. Other factors associated with severe disease in this population include older age and the presence of comorbidities.[288] In patients with multiple sclerosis, neurologic disability, age, and obesity were risk factors for severe disease.[289] In patients with inflammatory bowel disease, infection risk is comparable to the general population, and patient outcomes (hospitalization, intensive care unit admission, and mortality) are worse in ulcerative colitis and patients on corticosteroids or aminosalicylates. Outcomes are better in patients on biologic agents.[290]
**Coronavirus disease 2019 (COVID-19)**

**Diagnosis**

**vitamin D deficiency**

- Limited evidence supports an association between vitamin D deficiency and the risk of infection and worse outcomes. Observational and retrospective studies have found an association between vitamin D deficiency and a higher risk for infection.[291] [292] [293] [294] [295] A population-based study in Israel found that patients who tested positive for COVID-19 had significantly lower plasma vitamin D levels compared with those who tested negative. Univariate analysis demonstrated an association between low plasma vitamin D level and increased likelihood of hospitalization. The study concluded that low plasma vitamin D level appears to be an independent risk factor for COVID-19 infection and for hospitalization.[296] A meta-analysis found that vitamin D deficiency increased the risk of hospitalization and mortality, and patients with severe disease were more likely to have vitamin D deficiency compared with patients with mild disease.[297] A cross-sectional study in 235 hospitalized patients in Iran found that patients who had sufficient serum vitamin D levels at admission, defined as serum 25(OH)D level ≥30 nanograms/mL, had significantly lower blood levels of C-reactive protein and a higher total blood lymphocyte count compared with those with insufficient vitamin D levels, suggesting that sufficient vitamin D levels improved immune function in these patients. Severe disease was less prevalent in patients with adequate vitamin D levels, and among those ages 40 years and over who died approximately 90% had insufficient vitamin D levels.[298]

**air pollution**

- Evidence suggests that there may be an association between long-term exposure to ambient air pollution and COVID-19.[299] [300] The highest numbers of cases were recorded in the most polluted regions of Italy, with patients presenting with more severe disease requiring intensive care. The mortality was 2-fold higher in polluted regions compared with other regions.[301] One study found that of deaths from COVID-19 across 66 administrative regions in Italy, Spain, France, and Germany, 78% of deaths occurred in just five regions, and these regions were the most polluted in terms of nitrogen dioxide levels.[302] A preprint study from Harvard University found that people who live in US regions with high levels of air pollution were more likely to die from COVID-19 than those who live in less polluted areas. The researchers found that an increase of 1 microgram/m³ in fine particulate matter is associated with an 8% increase in the COVID-19 death rate.[303]

**climate and latitude**

- Distribution of community outbreaks along restricted latitude, temperature, and humidity measurements are consistent with the behavior of a seasonal respiratory virus.[304] Evidence suggests that cold and dry conditions may increase transmission, and warm and humid conditions may reduce the rate of infections; however, evidence is not yet sufficient to prove causation.[305] [306] However, there is other evidence that suggests ambient temperature has no significant impact on transmission, especially during the pandemic stage of an emerging pathogen.[307] [308] [309] Further research is required on how weather conditions influence transmission as colder temperatures have been associated with increased transmission of other coronaviruses. Higher latitude may also be associated with an increased risk of cases and deaths in some countries.[310] A positive correlation has been found between lower death rates and a country’s proximity to the equator, suggesting a correlation between sunlight exposure (and vitamin D levels) and reduced mortality.[311]

**residence in urban or deprived areas**

- Data from a cross-sectional study in the UK found that the adjusted odds of a positive test were greater in people living in urban areas (26.2%) compared with people living in rural areas (5.6%), and
ACE inhibitor/angiotensin-II receptor antagonist use

- There was originally concern that people on these drugs may be at increased risk of infection or more severe disease due to upregulation of angiotensin-converting enzyme-2 (ACE2) receptor expression.[312] However, high-certainty evidence suggests that use of these drugs is not associated with severe disease, and moderate-certainty evidence suggests that there is no association between the use of these medications and a positive SARS-CoV-2 test result among symptomatic patients.[313][314] Despite this reassuring evidence, another meta-analysis found that the use of angiotensin-II receptor antagonists, and not ACE inhibitors, may augment the risk of SARS-CoV-2 infection in adults <60 years of age.[315] A prospective cohort study of over 19,000 patients in England found that these drugs were associated with a significantly reduced risk of COVID-19, and were not associated with an increased risk of intensive care. However, variations between ethnic groups raise the possibility of ethnic-specific effects.[316] The UK National Institute for Health and Care Excellence states that conclusion cannot be drawn on whether these drugs increase or decrease the risk of developing COVID-19 or severe disease based on the current available evidence.[317] Professional societies recommend that patients who are already on these drugs continue to take them.[318][319][320]

dyslipidemia

- Dyslipidemia appears to be associated with an increased risk of severe disease; however, evidence is limited.[321][322]

statin use

- There is concern that people on these drugs may be at increased risk of infection or more severe disease as statins have been shown to increase the expression of ACE2 in laboratory animals, and may promote the activation of the inflammatory pathway in acute respiratory distress syndrome leading to more severe disease.[312] A meta-analysis of four retrospective studies suggests a reduced risk for fatal or severe disease among statin users.[323] An observational cohort study found that recent statin exposure was not associated with an increased or decreased risk of severe infection or all-cause mortality.[324] Further research into the potential therapeutic or detrimental effects of statins is required.[325]

proton-pump inhibitor use

- Proton-pump inhibitors (PPIs) are known to increase the risk of infections due to hypochlorhydria. There is evidence of an independent, dose-response relationship between the use of antisecretory medications and COVID-19 positivity. People taking PPIs had significantly increased odds for reporting a positive COVID-19 test when compared with those not taking PPIs. People taking H2 antagonists were not at elevated risk.[326] Patients taking PPIs may also be at increased risk of secondary infections, severe clinical outcomes, and death.[327][328] Current or regular users of PPIs were more likely to have severe outcomes compared with non-PPI users. Also, current PPI users were more likely to be hospitalized for longer compared with non-PPI users, although this was not statistically significant. Past use of PPIs is not associated with increased susceptibility to infection or severe outcomes.[329]
HIV infection

• It is still unclear whether HIV infection influences infection and disease course. A retrospective cohort study found that people with HIV in the UK appear to be at increased risk of mortality. However, the largest cohort study of HIV-positive patients with COVID-19 so far found that although crude mortality is higher in HIV-positive patients when compared with HIV-negative patients, propensity-matched analyses revealed no difference in outcomes, showing that this high mortality is driven by the higher burden of risk factors for severe disease in HIV-positive patients. Males affected by antiretroviral therapy-related complications may be at greater risk of severe disease. Another cohort study found that HIV-positive patients receiving tenofovir disoproxil/emtricitabine had a lower risk for COVID-19 and related hospitalization than those receiving other antiretroviral therapies.

thalassemia

• People with thalassemia may be at increased risk of severe illness; however, evidence is limited.

Down syndrome

• People with Down syndrome may be at increased risk for hospitalization and death, possibly due to the presence of immune dysfunction, congenital heart disease, and pulmonary pathology. A cohort study in the UK found a 4-fold increased risk for hospitalization and a 10-fold increased risk for COVID-19-related death in people with Down syndrome.

children with certain underlying conditions

• Children may be at increased risk of severe illness if they have certain conditions (e.g., obesity, diabetes, asthma and chronic lung disease, immunosuppression, sickle cell disease, chronic kidney disease); are medically complex; have serious genetic, neurologic, or metabolic disorders; or have congenital heart disease. However, evidence is limited.

blood groups A and B

• Blood groups A and B have been associated with an increase in the risk of infection compared with non-A and non-B blood groups. Blood group A may also be associated with an increased risk of mortality. There is no evidence for an association between blood group AB and the risk of infection. Blood group O appears to be protective against infection. People who are Rh-positive were more vulnerable to infection compared with those who were Rh-negative. A genome-wide association study found that patients with blood group A are at 45% increased risk of respiratory failure compared with other blood groups. It also found a protective effect in blood group O. Two chromosomal loci were associated with respiratory failure, and one of these coincided with the ABO blood group locus.

gut dysbiosis

• There is some emerging evidence that gut microbiota dysfunction may be implicated in the pathogenesis of COVID-19, although this is yet to be confirmed. Patients appear to have a depletion of beneficial commensals and an overgrowth of opportunistic pathogens during hospitalisation. Gut microbiome configuration has been associated with disease severity.
Investigations

1st test to order

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>real-time reverse transcription polymerase chain reaction (RT-PCR)</td>
<td>positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viral RNA; may be positive for influenza A and B viruses and other respiratory pathogens</td>
</tr>
</tbody>
</table>

• Order a RT-PCR for SARS-CoV-2 in patients with suspected infection whenever possible (see the Criteria section).[391]
• Base decisions about who to test on clinical and epidemiologic factors.[391] Consult local health authorities for guidance as testing priorities depend on local recommendations and available resources.
• In the UK, testing is recommended in: (1) people in the community with symptoms of new continuous cough, high temperature, or altered sense of smell/taste; (2) people requiring hospital admission and who have clinical or radiologic evidence of pneumonia, or acute respiratory distress syndrome, or influenza-like illness, or altered sense of smell/taste in isolation or in combination with any other symptoms.[389] [431]
• In the US, testing is recommended in: (1) people with symptoms, even if they are mild; (2) people who are asymptomatic and have been in close contact (less than 6 feet [2 meters] for a total of 15 minutes or more over a 24-hour period) with a person with documented infection; (3) people who are asymptomatic and have not been in close contact for at least 15 minutes with a person with documented infection only if required by a healthcare provider or public health official.[432]
• The American Academy of Pediatrics recommends testing children with symptoms consistent with COVID-19, children in close contact with an individual with probable or confirmed infection, and children scheduled for an invasive medical procedure. The decision to test does not differ by the age of the child. Testing is not recommended for other illnesses that lack shared symptoms (e.g., urinary tract infection, cellulitis), or for children exposed to close contacts of infected individuals unless those contacts go on to test positive themselves.[433]
• The optimal specimen for testing depends on the clinical presentation and the time since symptom onset. The World Health Organization recommends upper respiratory specimens (nasopharyngeal and/or oropharyngeal swabs) for early-stage infections, especially asymptomatic or mild cases, and lower respiratory specimens (sputum and/or endotracheal aspirate or bronchoalveolar lavage in patients with more severe respiratory disease) for later-stage infections or patients in whom there is a strong suspicion for infection and their upper respiratory tract specimen test was negative. Other specimens (e.g., nasal mid-turbinate swab, anterior nares swab, nasopharyngeal/nasal wash/aspirate, saliva, fecal) may be recommended in some circumstances; consult local guidance.[431] [438]
• A positive RT-PCR result confirms SARS-CoV-2 infection (in the context of the limitations associated with RT-PCR testing). If the result is negative, and there is still a clinical suspicion of infection (e.g., an epidemiologic link, typical x-ray findings, absence of another etiology), resample the patient and repeat the test. A positive result confirms infection. If the second test is negative, consider serologic testing (see below).[391]
### Diagnosis

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
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<tbody>
<tr>
<td>• The pooled sensitivity has been estimated to be 87.8%, with the specificity estimated to be in the range of 87.7% to 100%.[442]</td>
<td></td>
</tr>
<tr>
<td>• Interpret test results with caution. Evidence for the use of RT-PCR in the diagnosis of COVID-19 is still emerging, and uncertainties about its efficacy and accuracy remain.[442] It is not fully understood whether a positive result always represents infectious virus, especially at high cycle thresholds.[443] [446] [447] [448] Interpreting the result depends on the accuracy of the test itself, and the pre- and post-test probabilities of disease.[445] When the pretest probability is low, positive results should be interpreted with caution, and ideally a second specimen tested for confirmation.[449] The lower the prevalence of disease in a given population, the lower the post-test probability.[450] False-positive results can be caused by a laboratory error or a cross-reaction with antibodies formed by current and past exposure to seasonal human coronavirus infections (e.g., common cold), and are more likely when the prevalence of disease is moderate to low.[452] [453] Preliminary estimates of the false-positive rate in the UK are in the range of 0.8% to 4%.[454] False-negative rates of between 2% and 29% have been reported.[445] A systematic review found that the false-negative rate varied across studies from 1.8% to 58% (median 11%); however, there was substantial and largely unexplained heterogeneity across studies.[512]</td>
<td></td>
</tr>
<tr>
<td>• Also collect nasopharyngeal swabs to rule out influenza and other respiratory infections according to local guidance. It is important to note that coinfections can occur, and a positive test for a non-COVID-19 pathogen does not rule out COVID-19.[2] [441] When SARS-CoV-2 and influenza viruses are cocirculating, test for both viruses in all hospitalized patients with acute respiratory illness, and only test for influenza virus in outpatients with acute respiratory illness if the results will change clinical management of the patient.[3] Single-test multiplex assays to diagnose infection caused by influenza A, influenza B, and SARS-CoV-2 are available in some countries.</td>
<td></td>
</tr>
<tr>
<td>pulse oximetry</td>
<td>may show low oxygen saturation (SpO₂ &lt;90%)</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Recommended in patients with respiratory distress and cyanosis.</td>
<td></td>
</tr>
<tr>
<td>• Clinicians should be aware that patients with COVID-19 can develop &quot;silent hypoxia&quot;: their oxygen saturations can drop to low levels and precipitate acute respiratory failure without the presence of obvious symptoms of respiratory distress. Only a small proportion of patients have other organ dysfunction, meaning that after the initial phase of acute deterioration, traditional methods of recognizing further deterioration (e.g., National Early Warning Score 2 [NEWS2] scores) may not help predict those patients who go on to develop respiratory failure.[423]</td>
<td></td>
</tr>
<tr>
<td>ABG</td>
<td>may show low partial oxygen pressure</td>
</tr>
<tr>
<td>• Order in patients with severe illness as indicated to detect hypercarbia or acidosis.</td>
<td></td>
</tr>
<tr>
<td>• Recommended in patients with respiratory distress and cyanosis who have low oxygen saturation (SpO₂ &lt;90%).</td>
<td></td>
</tr>
<tr>
<td>CBC</td>
<td>lymphopenia; leukocytosis; leukopenia; thrombocytopenia; decreased eosinophils; decreased hemoglobin</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Lymphopenia, leukocytosis, thrombocytopenia, decreased eosinophils, decreased hemoglobin, and high neutrophil-to-lymphocyte ratio are significantly associated with severe disease, and</td>
<td></td>
</tr>
</tbody>
</table>
**Test** | **Result**
--- | ---
may be useful for predicting disease progression. Severe cases are more likely to present with lymphopenia and thrombocytopenia, but not leukopenia.[513]
| elevated liver enzymes; elevated total bilirubin; renal impairment; hypoalbuminemia; electrolyte derangements
- Elevated red blood cell distribution width (at admission and increasing during hospitalization) has been associated with a significantly increased risk of mortality in hospitalized patients.[514]
- Absolute counts of major lymphocyte subsets, particularly CD4+ and CD8+ T-cell counts, are significantly decreased in patients with severe disease.[515]
- Late-phase thrombocytopenia (i.e., occurring 3 weeks or more after symptom onset) has been reported but is uncommon.[516]
comprehensive metabolic panel

| Order in patients with severe illness.
| Elevated liver enzymes, total bilirubin, creatinine, and blood urea nitrogen, and hypoalbuminemia are significantly associated with severe disease, and may be useful for predicting disease progression.[513]
| Hypokalemia has been reported in 54% of patients.[517] Hypocalcemia has been reported in 63% of patients.[518] Other electrolyte derangements may be present.
| elevated liver enzymes; elevated total bilirubin; renal impairment; hypoalbuminemia; electrolyte derangements
- Order in patients with severe illness.
- High fasting blood glucose level on admission independently predicts poor prognosis.[519]
- Hypoglycemia has also been associated with increased mortality in a retrospective cohort study.[520]
| variable
blood glucose level

| Order in patients with severe illness.
| Elevated D-dimer, elevated fibrinogen (and fibrin degradation product), and prolonged prothrombin time are significantly associated with severe disease, and may be useful for predicting disease progression.[513] [521]
| The risk of severe disease and mortality is 2-fold and 4-fold higher, respectively, in patients with elevated D-dimer levels.[522] Patients with very high D-dimer levels have an increased risk of thrombosis.[523] [524]
| elevated D-dimer; prolonged prothrombin time; elevated fibrinogen
coagulation screen

| Order in patients with severe illness.
| Elevated serum troponin I and creatine kinase-myocardial band (CK-MB) are significantly associated with severe disease, and may be useful for predicting disease progression.[513]
| Other cardiac biomarkers (e.g., brain natriuretic peptide, cardiac troponin T) may also be elevated and are associated with severe disease and worse outcomes.[525] [526]
| CK-MB has been found to be elevated in mild disease in children. The significance of this is unknown.[429]
| may be elevated
cardiac biomarkers

| Order in patients with severe illness.
| Elevated C-reactive protein is significantly associated with severe disease, and may be useful for predicting disease progression.[513]
| may be elevated
serum C-reactive protein

| Order in patients with severe illness.
| may be elevated
serum erythrocyte sedimentation rate
### Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>serum lactate dehydrogenase</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Commonly elevated in patients with COVID-19.[427]</td>
<td></td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Elevated serum lactate dehydrogenase is significantly associated with severe disease, and may be useful for predicting disease progression.[513]</td>
<td></td>
</tr>
<tr>
<td><strong>serum interleukin-6 level</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Elevated interleukin-6 level is significantly associated with severe disease, and may be useful for predicting disease progression.[513]</td>
<td></td>
</tr>
<tr>
<td>• Less likely to be elevated in children.[527]</td>
<td></td>
</tr>
<tr>
<td><strong>serum procalcitonin</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Elevated serum procalcitonin is significantly associated with severe disease, and may be useful for predicting disease progression.[513]</td>
<td></td>
</tr>
<tr>
<td>• Elevated serum procalcitonin may be more common in children.[421]</td>
<td></td>
</tr>
<tr>
<td>• May be elevated in patients with secondary bacterial infection.[44][45]</td>
<td></td>
</tr>
<tr>
<td>• There is insufficient evidence to recommend routine procalcitonin testing to guide decisions about the use of antibiotics.[528]</td>
<td></td>
</tr>
<tr>
<td>• However, it may be helpful in limiting overuse of antibiotics in patients with COVID-19-related pneumonia.[529]</td>
<td></td>
</tr>
<tr>
<td><strong>serum ferritin level</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Elevated ferritin is significantly associated with severe disease, and may be useful for predicting disease progression.[530]</td>
<td></td>
</tr>
<tr>
<td>• May indicate development of cytokine release syndrome.[531]</td>
<td></td>
</tr>
<tr>
<td><strong>serum amyloid A level</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Levels increase in severe disease; therefore, it may be useful as a biomarker for predicting disease progression.[532]</td>
<td></td>
</tr>
<tr>
<td><strong>serum creatine kinase and myoglobin</strong></td>
<td>may be elevated</td>
</tr>
<tr>
<td>• Order in patients with severe illness.</td>
<td></td>
</tr>
<tr>
<td>• Elevated serum creatine kinase and myoglobin are significantly associated with severe disease, and may be useful for predicting disease progression.[513]</td>
<td></td>
</tr>
<tr>
<td><strong>blood and sputum cultures</strong></td>
<td>negative for bacterial infection</td>
</tr>
<tr>
<td>• Collect blood and sputum specimens for culture in patients with severe or critical disease to rule out other causes of lower respiratory tract infection and sepsis, especially patients with an atypical epidemiologic history.[2]</td>
<td></td>
</tr>
<tr>
<td>• Testing is most useful when there is concern for multidrug-resistant pathogens.[529]</td>
<td></td>
</tr>
<tr>
<td>• Specimens should be collected prior to starting empiric antimicrobials if possible.</td>
<td></td>
</tr>
<tr>
<td><strong>chest x-ray</strong></td>
<td>unilateral or bilateral lung infiltrates</td>
</tr>
<tr>
<td>• Order in all patients with suspected pneumonia.</td>
<td></td>
</tr>
<tr>
<td>• Unilateral lung infiltrates are found in 25% of patients, and bilateral lung infiltrates are found in 75% of patients.[44][45][468]</td>
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<tr>
<td>Test</td>
<td>Result</td>
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</tr>
<tr>
<td>Although chest x-ray appears to have a lower sensitivity compared with chest CT, it has the advantages of being less resource-intensive, associated with lower radiation doses, easier to repeat sequentially, and portable.</td>
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</tr>
</tbody>
</table>
Other tests to consider

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>computed tomography (CT) chest</td>
<td>ground-glass opacity in isolation or coexisting with other findings (e.g., consolidation, interlobular septal thickening, crazy-paving pattern); bilateral, peripheral/subpleural, posterior distribution with a lower lobe predominance</td>
</tr>
<tr>
<td>• Consider a CT scan of the chest. Consult local guidance on whether to perform a CT scan. The British Society of Thoracic Imaging (BSTI) recommends CT imaging in patients with clinically suspected COVID-19 who are seriously ill if chest x-ray is uncertain or normal. [BSTI: radiology decision tool for suspected COVID-19] (<a href="https://www.bsti.org.uk/media/resources/files/NHSE_BSTI_APPROVED_Radiology_on_CoVid19_v6_modified1__Read-Only.pdf">https://www.bsti.org.uk/media/resources/files/NHSE_BSTI_APPROVED_Radiology_on_CoVid19_v6_modified1__Read-Only.pdf</a>) Some institutions in the UK recommend a more pragmatic approach for patients with high clinical suspicion of COVID-19, with chest CT recommended only after two indeterminate or normal chest x-rays in combination with a negative RT-PCR test.[470] The American College of Radiology recommends reserving CT for hospitalized, symptomatic patients with specific clinical indications for CT, and emphasizes that a normal chest CT does not mean that a patient does not have COVID-19 and that an abnormal chest CT is not specific for COVID-19 diagnosis.[471] • Abnormal chest CT findings have been reported in up to 97% of hospitalized patients.[472] Evidence of pneumonia on CT may precede a positive RT-PCR result for SARS-CoV-2 in some patients.[473] CT imaging abnormalities may be present in asymptomatic patients. The pooled estimate of the rate of positive chest CT findings in asymptomatic cases was 62%, while it was 90% in those who developed symptoms.[474] Some patients may present with a normal chest finding despite a positive RT-PCR.[475] Also, results of RT-PCR testing may be false-negative, so patients with typical CT findings should have repeat RT-PCR testing to confirm the diagnosis.[476] • The most common findings are ground-glass opacity, either in isolation or coexisting with other findings such as consolidation, interlobular septal thickening, or crazy-paving pattern. The most common distribution pattern is bilateral, peripheral/subpleural, posterior distribution of the opacities, with a lower lobe predominance. Extensive/multilobar involvement with consolidations is more common in older patients and those with severe disease. Pulmonary vascular enlargement, interlobular or intralobular septal thickening, adjacent pleural thickening, air bronchograms, subpleural lines, crazy-paving pattern, bronchus distortion, bronchiectasis, vascular retraction sign, and halo sign are atypical features. Pleural effusion, pericardial effusion, cavitation, pneumothorax, and mediastinal lymphadenopathy have also been reported rarely.[477] Ground-glass opacity has the highest diagnostic performance for COVID-19 pneumonia, followed by ground-glass opacity plus consolidation, and consolidation only.[533] • Children frequently have normal or mild CT chest findings. The most common signs in children are patchy ground-glass opacity and, less frequently, nonspecific patchy shadows, areas of consolidation, and a halo sign. Abnormalities are more common in the lower lobes and are predominantly unilateral. Pleural effusion is rare.[481] • CT scan generally shows an increase in the size, number, and density of ground-glass opacities in the early follow-up period, with a progression to mixed areas of ground-glass opacities, consolidations, and crazy paving peaking at day 10 to 11, before gradually resolving or persisting as patchy fibrosis.[477]</td>
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</tbody>
</table>
## Diagnosis

<table>
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<tr>
<th>Test</th>
<th>Result</th>
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<tbody>
<tr>
<td>• The positive predictive value was low (1.5% to 30.7%) in low-prevalence regions, and the negative predictive value ranged from 95.4% to 99.8% in one meta-analysis. Pooled sensitivity and specificity were 94% to 96% and 37%, respectively. The simultaneous presence of ground-glass opacity and other features of viral pneumonia had optimum performance in the detection of COVID-19 (sensitivity 90% and specificity 89%).</td>
<td></td>
</tr>
<tr>
<td>• In a cohort of over 1000 patients in a hyperendemic area in China, chest CT had a higher sensitivity for diagnosis of COVID-19 compared with initial RT-PCR from swab samples (88% versus 59%). Improvement of abnormal CT findings also preceded change from RT-PCR positivity to negativity in this cohort during recovery. The sensitivity of chest CT was 97% in patients who ultimately had positive RT-PCR results. However, in this setting, 75% of patients with negative RT-PCR results also had positive chest CT findings. Of these patients, 48% were considered highly likely cases, while 33% were considered probable cases.</td>
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</tbody>
</table>

Transverse CT scans from a 32-year-old man, showing ground-glass opacity and consolidation of lower lobe of right lung near the pleura on day 1 after symptom onset (top panel), and bilateral ground-glass opacity and consolidation on day 7 after symptom onset. Xu XW et al. BMJ. 2020;368:m606

serology
- Cannot be used as a standalone diagnostic for acute infections; however, may be useful in various settings (e.g, negative molecular testing, diagnosing patients with late presentation or prolonged symptoms, serosurveillance studies). [391] [457]
- [BMJ practice pointer: testing for SARS-CoV-2 antibodies] (https://www.bmj.com/content/370/bmj.m3325) positive for SARS-CoV-2 virus antibodies; seroconversion or a rise in antibody titers in paired sera
## Diagnosis

### Test | Result
--- | ---
• The World Health Organization (WHO) recommends collecting a paired serum sample, one specimen in the acute phase and one in the convalescent phase 2 to 4 weeks later, in patients where infection is strongly suspected and the RT-PCR result is negative. Seroconversion or a rise in antibody titers in paired sera help to confirm whether the infection is recent and/or acute. If the initial sample tests positive, this could be due to a past infection that is not related to the current illness. Seroconversion may be faster and more robust in patients with severe disease compared with those with mild disease or asymptomatic infection.[391]  
• The Centers for Disease Control and Prevention recommends serologic testing as a method to support the diagnosis of acute infection in patients who present late (i.e., 9 to 14 days after symptom onset) in addition to other viral detection methods (e.g., RT-PCR, antigen detection tests), or patients who present with late complications (e.g., pediatric inflammatory multisystem syndrome in children).[458]  
• The Infectious Diseases Society of America recommends serologic testing in the following circumstances: evaluation of patients with a high clinical suspicion for infection when molecular diagnostic testing is negative and at least 2 weeks have passed since symptom onset; evaluation of pediatric inflammatory multisystem syndrome in children; and serosurveillance studies.[459]  
• Antibody responses to SARS-CoV-2 typically occur during the first 1 to 3 weeks of illness, with the seroconversion time of IgG antibodies often being earlier than that of IgM antibodies.[460] [461]  
• The estimated sensitivity of antibody tests ranged from 18.4% to 96.1% (the lowest reported sensitivity was from a point-of-care test, although a sensitivity <50% was reported for one laboratory test), and specificity ranged from 88.9% to 100%. Estimates of diagnostic accuracy need to be interpreted with caution in the absence of a definitive reference standard to diagnose or rule out COVID-19.[442]  
• Limitations of testing: serologic testing cannot be used to determine acute infection; results do not indicate the presence or absence of current or previous infection with certainty; reliable diagnosis is often only possible in the recovery phase when opportunities for management or interruption of transmission have passed; cross-reactivity with other coronaviruses, which can result in false-positive results.[391] [458]  
• While rapid antibody detection kits have been approved for the qualitative detection of SARS-CoV-2 IgG/IgM antibodies in serum, plasma, or whole blood, the WHO does not recommend the use of these tests outside of research settings as they have not been validated as yet.[463]

### antigen test

• Rapid diagnostic test. Relies on direct detection of SARS-CoV-2 viral proteins in nasal swabs and other respiratory specimens using a lateral flow immunoassay. Results are usually available in less than 30 minutes. While antigen tests are substantially less sensitive than RT-PCR, they offer the possibility of rapid, inexpensive, and early detection of the most infectious cases in appropriate settings. If used, testing should occur within the first 5 to 7 days following the onset of symptoms. The World Health Organization recommends antigen testing only in certain scenarios where RT-PCR is unavailable or where prolonged turnaround times preclude clinical utility, provided that the test meets the minimum performance requirements of ≥80% positive for SARS-CoV-2 virus antigen.
### Diagnosis

#### Test

<table>
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<th>Test</th>
<th>Result</th>
</tr>
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</table>
| sensitivity and ≥97% specificity compared with a RT-PCR reference assay.[465]  
- The Food and Drug Administration has warned that false positive results can occur with antigen tests, including when users do not follow the instructions for use, and that the number of false positive tests increases as disease prevalence decreases.[466]  
- Rapid, lateral flow antigen tests for home use are available over-the-counter in some countries.[537]  
- Laboratory-based (nonrapid) antigen tests are also available in some countries. | |

#### Emerging tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
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| reverse transcription loop-mediated isothermal amplification (RT-LAMP)  
- A similar process to RT-PCR, but uses constant temperatures and produces more viral DNA compared with RT-PCR. While simple and quick, it is a newer technology and there is less evidence for its use. Assays for SARS-CoV-2 have been developed and are being evaluated.[482] [483] [484]  
- An at-home test kit that provides rapid results within 30 minutes has been approved in the US under an emergency-use authorization for self-testing at home that provides rapid results.[538] | positive for SARS-CoV-2 viral RNA |
| lung ultrasound  
- Lung ultrasound is used as a diagnostic tool in some centers as an alternative to chest x-ray and chest CT. Although there is only very low-certainty evidence supporting its diagnostic accuracy, it might be helpful as a supplemental or alternate imaging modality.[469]  
- Has the advantages of portability, bedside evaluation, reduced healthcare worker exposure, easier sterilization process, absence of ionizing radiation exposure, and repeatability during follow-up. It may also be more readily available in resource-limited settings. However, it also has some limitations (e.g., it is unable to discern chronicity of a lesion) and other imaging modalities may be required.  
- B-lines are the prominent pattern in patients with COVID-19, occurring with a pooled frequency of 97%. Pleural line abnormalities are also common with a pooled frequency of 70%. While these findings are not specific for COVID-19, they increase the likelihood of disease in the context of a characteristic clinical presentation. Other findings include consolidations, pleural thickening, and pleural effusion.[485]  
- May be used in pregnant women and children.[486] [487]  
- [BSTI: lung ultrasound (LUS) for COVID-19 patients in critical care areas](https://www.bsti.org.uk/media/resources/files/Lung_US_print_out_and_scoring_proforma.pdf) | B-lines; pleural line abnormalities |
<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
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| Community-acquired pneumonia      | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset.  
  • Differentiating COVID-19 from community-acquired bacterial pneumonia is not usually possible from signs and symptoms. However, patients with bacterial pneumonia are more likely to have rapid development of symptoms and purulent sputum. They are less likely to have myalgia, anosmia, or pleuritic pain.[539] [540] | • Blood or sputum culture or molecular testing: positive for causative organism.  
  • RT-PCR: negative for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viral RNA (coinfections are possible).  
  • CT chest: centrilobular nodules, mucoid impactions.[541]                                                                                                                                                                            |
| Influenza infection               | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset.  
  • Differentiating COVID-19 from community-acquired respiratory tract infections is not possible from signs and symptoms.  
  • Incubation period is shorter.[542] Symptoms typically peak during the first 3 to 7 days of illness with influenza, compared with week 2 or 3 of illness with COVID-19.[543]  
  • More common in children.[543] Children with COVID-19 tend to be older, and are more likely to have comorbidities, fever, gastrointestinal symptoms, headache, and chest pain compared with those with influenza.[544]  
  • Rhinorrhea, sore throat, and dyspnea are more common.[542] New-onset smell and/or taste disorders                                                                                                                                 | • Only testing can distinguish between influenza infection and COVID-19 and identify coinfection. When SARS-CoV-2 and influenza viruses are cocirculating, test for both viruses in all hospitalized patients with acute respiratory illness, and only test for influenza virus in outpatients with acute respiratory illness if the results will change clinical management of the patient.[3]  
  • RT-PCR: positive for influenza A or B viral RNA; negative for SARS-CoV-2 viral RNA (coinfections are possible).  
  • Chest x-ray: less likely to be abnormal.[542]  
  • CT chest: there is emerging evidence that CT can be used for differentiating between influenza and COVID-19. COVID-19 patients are more likely to have rounded or linear opacities, crazy-paving sign, vascular enlargement, and interlobular septal opacity. |
<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
</table>
| Common cold                             | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset.  
• Differentiating COVID-19 from community-acquired respiratory tract infections is not possible from signs and symptoms. | • RT-PCR; positive for causative organism; negative for SARS-CoV-2 viral RNA (coinfections are possible). |
| Other viral or bacterial respiratory infections | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset.  
• Differentiating COVID-19 from community-acquired respiratory tract infections is not possible from signs and symptoms.  
• Adenovirus and *Mycoplasma* should be considered in clusters of pneumonia patients, especially in closed settings such as military camps and schools. | • Blood or sputum culture of molecular testing: positive for causative organism.  
• RT-PCR: negative for SARS-CoV-2 viral RNA (coinfections are possible). |
| Aspiration pneumonia                    | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset. | • RT-PCR: negative for SARS-CoV-2 viral RNA (coinfections are possible).  
• CT chest: difficult to distinguish on CT; however, anterior lung involvement |
<table>
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<tr>
<th>Condition</th>
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<th>Differentiating tests</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• Differentiating COVID-19 from aspiration pneumonia is not usually possible from signs and symptoms.</td>
<td>may be more suggestive of COVID-19 pneumonia. [549]</td>
</tr>
</tbody>
</table>
| Pneumocystis jirovecii pneumonia         | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case of COVID-19 in the 14 days prior to symptom onset. | • Sputum culture: positive for *Pneumocystis*.  
• RT-PCR: negative for SARS-CoV-2 viral RNA (coinfections are possible).  
• CT chest: ground-glass opacity is usually more diffusely distributed with a tendency to spare the subpleural regions. [541] |
| Middle East respiratory syndrome (MERS)  | • Travel history to the Middle East or contact with a confirmed case of MERS.                    | • Reverse-transcriptase polymerase chain reaction (RT-PCR): positive for MERS-CoV viral RNA. |
| Severe acute respiratory syndrome (SARS) | • There have been no cases of SARS reported since 2004.                                          | • RT-PCR: positive for severe acute respiratory syndrome coronavirus (SARS-CoV) viral RNA. |
| Avian influenza A (H7N9) virus infection | • May be difficult to differentiate based on epidemiologic history as avian influenza H7N9 is endemic in China.  
• Close contact with infected birds (e.g., farmer or visitor to a live market in endemic areas), or living in an area when avian influenza is endemic. | • RT-PCR: positive for H7-specific viral RNA.                                             |
| Avian influenza A (H5N1) virus infection | • Lack of residence in/travel history to an area with ongoing transmission, or lack of close contact with a suspected/confirmed case | • RT-PCR: positive for H5N1 viral RNA.                                                   |
Coronavirus disease 2019 (COVID-19)  

Diagnosis

<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
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<tbody>
<tr>
<td></td>
<td>of COVID-19 in the 14 days prior to symptom onset.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Close contact with infected birds (e.g., farmer or visitor to a live market in endemic areas), or living in an area when avian influenza is endemic.</td>
<td></td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>• Consider diagnosis in endemic areas, especially in patients who are immunocompromised.</td>
<td>• Chest x-ray: fibronodular opacities in upper lobes with or without cavitation; atypical pattern includes opacities in middle or lower lobes, or hilar or paratracheal lymphadenopathy, and/or pleural effusion.</td>
</tr>
<tr>
<td></td>
<td>• History of symptoms is usually longer.</td>
<td>• Sputum acid-fast bacilli smear and sputum culture: positive.</td>
</tr>
<tr>
<td></td>
<td>• Presence of night sweats and weight loss may help to differentiate.</td>
<td>• Molecular testing: positive for Mycoplasma tuberculosis.</td>
</tr>
<tr>
<td>Febrile neutropenia</td>
<td>• Suspect neutropenic sepsis in patients with a history of recent systemic anticancer treatment who present with fever (with or without respiratory symptoms) as this can be rapid and life-threatening.[550]</td>
<td>• CBC: neutropenia.</td>
</tr>
<tr>
<td></td>
<td>• Symptoms of COVID-19 and neutropenic sepsis may be difficult to differentiate at initial presentation.</td>
<td>• RT-PCR: negative for SARS-CoV-2 viral RNA.</td>
</tr>
</tbody>
</table>

Criteria

Case definitions

Various case definitions are available:

Screening

Management of contacts

Definition

- The World Health Organization defines a contact as a person who has experienced any one of the following exposures during the 2 days before and the 14 days after the onset of symptoms of a probable or confirmed case:[551]

  - Face-to-face contact with a probable or confirmed case within 3 feet (1 meter) and for more than 15 minutes
  - Direct physical contact with a probable or confirmed case
  - Direct care for a patient with probable or confirmed COVID-19 without using recommended personal protective equipment
  - Other situations as indicated by local risk assessments.

- The Centers for Disease Control and Prevention (CDC) defines a close contact as someone who has been within 6 feet (2 meters) of an infected person for at least 15 minutes over a 24-hour period, beginning 2 days before symptom onset (or 2 days before testing in asymptomatic patients).[185]

  - Consult local guidance as definitions of a contact may vary depending on local public health advice.

Quarantine periods

- Contacts should remain in quarantine and monitor their health for up to 14 days from the last day of possible contact with the infected person.

- In the UK, Public Health England recommends a 10-day quarantine (or self-isolation) period after a potential exposure (it was reduced from 14 days to 10 days on 14 December 2020).[552]

- The CDC has shortened the minimum quarantine time after a potential exposure from 14 days to 7-10 days. Quarantine can end after day 7 if the patient tests negative and no symptoms have been reported during the quarantine period. Quarantine can end after day 10 without testing and if no symptoms have been reported during the quarantine period. Additional criteria (e.g., symptom monitoring, mask wearing) should continue until day 14 in both cases.[553]

  - Consult local guidance for recommended quarantine locations and timeframes as recommendations vary depending on local public health advice.

Screening of travelers

Exit and entry screening may be recommended in countries where borders are still open, particularly when repatriating nationals from affected areas. Travelers returning from affected areas should self-monitor for symptoms for 14 days and follow local protocols of the receiving country. Some countries may require travelers to enter mandatory quarantine in a designated location (e.g., a hotel). Travelers who develop symptoms are advised to contact their local healthcare provider, preferably by phone.[554] One study of 566 repatriated Japanese nationals from Wuhan City found that symptom-based screening performed poorly and missed presymptomatic and asymptomatic cases. This highlights the need for testing and follow-up.[555]

Drive-through screening centers

Drive-through screening centers have been set up in some countries for safer and more efficient screening. The testee does not leave their car throughout the entire process, which includes registration and questionnaire, exam, specimen collection, and instructions on what to do after. This method has the advantage of increased testing capacity and prevention of cross-infection between testees in the waiting space.[556]
Temperature screening

There is little scientific evidence to support temperature screening with thermal cameras or temperature screening products as a reliable method for the detection of COVID-19 or any other febrile illness, especially if used as the main method of testing.[557]

Noncontact infrared thermometers generally have reasonable sensitivity and specificity for detecting fever; however, their performance varies in different settings. Environmental factors (e.g., absolute temperature, variation in temperature, relative humidity) play an important role in the accuracy of the result. False negatives may be seen in people wearing make-up on the target area or who are significantly perspiring. False positives may be seen in people who are pregnant, menstruating, or on hormone replacement therapy, or those who have recently consumed alcohol or hot beverages, or done strenuous physical activity. Also, fever is not present in asymptomatic or presymptomatic people, and may not be present in symptomatic people, which means infected individuals could be missed.[558]

While the forehead is the most feasible site for scanning, it is thought to be more prone to physiologic and environmental variations, and the wrist may be a better option as it may give more stable measurements under different circumstances.[559]

Noncontact infrared thermometers demonstrated variable accuracy levels across populations and had a low sensitivity for temperatures >99.5°F (>37.5°C) in adults compared with temporal artery thermometers. Therefore, they may not be the most accurate device for the mass screening of fever during a pandemic.[560]
Management predominantly depends on disease severity, and focuses on the following principles: isolation at a suitable location; infection prevention and control measures; symptom management; optimized supportive care; and organ support in severe or critical illness.

Best Practice has published a separate topic on the management of coexisting conditions in the context of COVID-19. [BMJ Best Practice: Management of coexisting conditions in the context of COVID-19](https://bestpractice.bmj.com/topics/en-us/3000190#important-update)

### Key recommendations

- Consider whether the patient can be managed at home. Generally, patients with asymptomatic or mild disease can be managed at home or in a community facility.[2]
- Admit patients with moderate or severe disease to an appropriate healthcare facility. Assess adults for frailty on admission. Patients with critical disease require intensive care; involve the critical care team in discussions about admission to critical care when necessary. Monitor patients closely for signs of disease progression.[2] [573]
- Provide symptom relief as necessary. This may include treatments for fever, cough, breathlessness, anxiety, delirium, or agitation.[2] [574]
- Start supportive care according to the clinical presentation. This might include oxygen therapy, intravenous fluids, venous thromboembolism prophylaxis, high-flow nasal oxygen, noninvasive or invasive mechanical ventilation, or extracorporeal membrane oxygenation. Sepsis and septic shock should be managed according to local protocols.[2]
- Consider empiric antibiotics if there is clinical suspicion of bacterial infection. Antibiotics may be required in patients with moderate, severe, or critical disease. Give within 1 hour of initial assessment for patients with suspected sepsis or if the patient meets high-risk criteria. Base the regimen on the clinical diagnosis, local epidemiology and susceptibility data, and local treatment guidelines.[2] [528]
- Consider systemic corticosteroid therapy for 7 to 10 days in adults with severe or critical disease. Moderate-quality evidence suggests that systemic corticosteroids probably reduce 28-day mortality in patients with severe and critical disease, and probably reduce the need for invasive ventilation.[3] [573] [575]
- Assess whether the patient requires any rehabilitation or follow-up after discharge. Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms.[2]
- For full details and guidance see information below.

### Location of care

The decision about location of care depends on various factors including clinical presentation, disease severity, need for supportive care, presence of risk factors for severe disease, and conditions at home (including the presence of vulnerable people). Make the decision on a case-by-case basis using the following general principles.[2]

- Mild disease: manage in a healthcare facility, in a community facility, or at home. Home isolation can be considered in most patients, including asymptomatic patients.
• Moderate disease: manage in a healthcare facility, in a community facility, or at home. Home isolation can be considered in low-risk patients (i.e., patients who are not at high risk of deterioration).
• Severe disease: manage in an appropriate healthcare facility.
• Critical disease: manage in an intensive/critical care unit.

The location of care will also depend on guidance from local health authorities and available resources. Forced quarantine orders are being used in some countries.

The strongest risk factors for hospital admission are older age (odds ratio of >2 for all age groups older than 44 years, and odds ratio of 37.9 for people ages 75 years and over), heart failure, male sex, chronic kidney disease, and increased body mass index (BMI). The median time from onset of symptoms to hospital admission is around 7 days.[44] [490]

Approximately 8.6% of patients with COVID-19 who were discharged from an emergency department returned within 72 hours. Nearly 5% of patients were admitted to hospital within 72 hours of the initial visit, and 8.2% were admitted within 7 days. Risk factors associated with an increased rate of return admission included older age, abnormal chest x-ray, fever, and hypoxia on presentation.[577]

Children are less likely to require hospitalization, but if admitted, generally only require supportive care.[19] [217] Risk factors for intensive care admission in children include age <1 month, male sex, preexisting medical conditions, and presence of lower respiratory tract infection signs or symptoms at presentation.[578] The majority of children who require ventilation have underlying comorbidities, most commonly cardiac disease.[416] Children with COVID-19 are reported to have similar hospitalization rates, intensive care admission rates, and mechanical ventilator use compared with those with seasonal influenza.[544]

Overall, 19% of hospitalized patients require noninvasive ventilation, 17% require intensive care, 9% require invasive ventilation, and 2% require extracorporeal membrane oxygenation.[491] The rate of intensive care admission varies between studies; however, a meta-analysis of nearly 25,000 patients found that the admission rate was 32%, and the pooled prevalence of mortality in patients in the intensive care unit was 39%.[579] The most common reasons for intensive care unit admission are hypoxic respiratory failure leading to mechanical ventilation and hypotension.[580] Patients admitted to intensive care units were older, were predominantly male, and had a median length of stay of 23 days (range 12 to 32 days).[581] The strongest risk factors for critical illness are oxygen saturation <88%; elevated serum troponin, C-reactive protein, and D-dimer; and, to a lesser extent, older age, BMI >40, heart failure, and male sex.[576]

Management of mild COVID-19

Patients with suspected or confirmed mild disease (i.e., symptomatic patients meeting the case definition for COVID-19 without evidence of hypoxia or pneumonia) and asymptomatic patients should be isolated to contain virus transmission.[2]

Location of care

• Manage patients in a healthcare facility, in a community facility, or at home. Home isolation can be considered in most patients, with telemedicine or remote visits as appropriate.[2] [3] This decision requires careful clinical judgment and should be informed by an assessment of the patient’s home environment to ensure that: infection prevention and control measures and other requirements
can be met (e.g., basic hygiene, adequate ventilation); the caregiver is able to provide care and recognize when the patient may be deteriorating; the caregiver has adequate support (e.g., food, supplies, psychological support); the support of a trained health worker is available in the community.[551]

Isolation period

- Discontinue transmission-based precautions (including isolation) and release patients from the care pathway: 10 days after positive test (asymptomatic patients); 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms (symptomatic patients).[2]
- The Centers for Disease Control and Prevention (CDC) recommends discontinuing home isolation once at least 10 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing home isolation once at least 10 days have passed since the date of a positive test. Alternatively, it recommends at least two negative reverse-transcription polymerase chain reaction (RT-PCR) tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used.[582] If the patient is hospitalized, the CDC guidance for discontinuing isolation is the same as for moderate disease (see below).
- Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the self-isolation period is 10 days in patients with milder disease who are managed in the community.[583]

Infection prevention and control

- For patients in home isolation, advise patients and household members to follow appropriate infection prevention and control measures:

Symptom management

- Fever and pain: acetaminophen or ibuprofen are recommended.[2] [574] There is no evidence at present of severe adverse events in COVID-19 patients taking nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, or of effects as a result of the use of NSAIDs on acute healthcare utilization, long-term survival, or quality of life in patients with COVID-19.[2] [574] [584] [585] [586] [587] [588] [589] Ibuprofen should only be taken at the lowest effective dose for the shortest period needed to control symptoms.
- Cough: advise patients to avoid lying on their back as this makes coughing ineffective. Use simple measures (e.g., a teaspoon of honey in patients ages 1 year and older) to help cough.[574] A meta-analysis found that honey is superior to usual care (e.g., antitussives) for the improvement of upper respiratory tract infection symptoms, particularly cough frequency and severity.[590]
Management

• Olfactory dysfunction: consider treatment (e.g., olfactory training) if olfactory dysfunction persists beyond 2 weeks. Often it improves spontaneously and does not require specific treatment. There is no evidence to support the use of treatments in patients with COVID-19.[591]

Supportive care

• Advise patients about adequate nutrition and appropriate rehydration. Too much fluid can worsen oxygenation.[2]
• Advise patients to improve air circulation by opening a window or door (fans can spread infection and should not be used).[2] [574]
• Provide basic mental health and psychosocial support for all patients, and manage any symptoms of insomnia, depression, or anxiety as appropriate.[2]

Monitor

• Closely monitor patients with risk factors for severe illness, and counsel patients about signs and symptoms of deterioration or complications that require prompt urgent care (e.g., difficulty breathing, chest pain).[2] [3]

Management of moderate COVID-19

Patients with suspected or confirmed moderate disease (i.e., clinical signs of pneumonia but no signs of severe pneumonia) should be isolated to contain virus transmission.[2]

Location of care

• Manage patients in a healthcare facility, in a community facility, or at home. Home isolation, with telemedicine or remote visits as appropriate, can be considered in low-risk patients. Manage patients at high risk of deterioration in a healthcare facility.[2] [3]

Isolation period

• Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms.[2]
• The CDC recommends discontinuing isolation once at least 10 days (not severely immunocompromised) or 20 days (severely immunocompromised) have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing home isolation once at least 10 days (not severely immunocompromised) or 20 days (severely immunocompromised) have passed since the date of a positive test. Alternatively, it recommends at least two negative RT-PCR tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients.[592] If the patient is isolated at home, the CDC guidance for discontinuing isolation is the same as for mild disease (see above).
• Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients, and 10 days in patients with milder disease who are managed in the community.[583]

Infection prevention and control
• Implement local infection prevention and control procedures when managing patients with COVID-19. For patients in home isolation, advise patients and household members to follow appropriate infection prevention and control measures (see above).

Symptom management and supportive care

• Manage symptoms and provide supportive care as appropriate (see above).

Antibiotics

• Consider empiric antibiotics if there is clinical suspicion of bacterial infection. Antibiotics may also be considered in older people (particularly those in long-term care facilities) and children <5 years of age to provide empiric antibiotic treatment for possible pneumonia.

Monitor

• Closely monitor patients for signs or symptoms of disease progression.
• If the patient is being managed at home, counsel them about signs and symptoms of deterioration or complications that require prompt urgent care (e.g., difficulty breathing, chest pain). There is no evidence to support the use of pulse oximeters in the home setting.
• If the patient is being managed in hospital, monitor patients closely for signs of clinical deterioration using medical early warning scores (e.g., National Early Warning Score 2 [NEWS2]), and respond immediately with appropriate supportive care interventions.

Corticosteroids

• The WHO does not recommend corticosteroids in patients with nonsevere disease as they may increase the risk of mortality in these patients. In the UK, NHS England supports these guidelines, and does not recommend the use of corticosteroids in patients with nonsevere COVID-19.

Management of severe COVID-19

Patients with suspected or confirmed severe disease are at risk of rapid clinical deterioration.

• Severe disease in adults is defined as having clinical signs of pneumonia plus at least one of the following:
  • Respiratory rate >30 breaths/minute
  • Severe respiratory distress
  • SpO₂ <90% on room air

• Severe disease in children is defined as having clinical signs of pneumonia plus at least one of the following:
  • Central cyanosis or SpO₂ <90%
  • Severe respiratory distress
  • General danger signs: inability to breastfeed or drink, lethargy or unconsciousness, or convulsions
  • Fast breathing (<2 months: ≥60 breaths per minute; 2-11 months: ≥50 breaths per minute; 1-5 years: ≥40 breaths per minute).
Location of care

- Manage patients in an appropriate healthcare facility under the guidance of a specialist team.[2]
- Assess all adults for frailty on admission to hospital, irrespective of age and COVID-19 status, using the Clinical Frailty Scale (CFS). [Clinical frailty scale](https://www.nice.org.uk/guidance/ng159/resources/clinical-frailty-scale-pdf-8712262765) A large observational study found that disease outcomes were better predicted by frailty than either age or comorbidity; frailty (CFS score 5-8) was associated with earlier death and longer duration of hospital stay, and these outcomes worsened with increasing frailty after adjustment for age and comorbidity.[594]
- Involve critical care teams in discussions about admission to critical care for patients where:
  - The CFS score suggests the person is less frail (e.g., CFS <5), they are likely to benefit from critical care organ support, and the patient wants critical care treatment; or
  - The CFS score suggests the person is more frail (e.g., CFS ≥5), there is uncertainty regarding the benefit of critical care organ support, and critical care advice is needed to help the decision about treatment.
- Take into account the impact of underlying pathologies, comorbidities, and severity of acute illness.[573]

Isolation period

- Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms.[2]
- The CDC recommends discontinuing isolation once at least 20 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing isolation once at least 20 days have passed since the date of a positive test. Alternatively, it recommends at least two negative RT-PCR tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients.[592]
- Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients.[583]

Infection prevention and control

- Implement local infection prevention and control procedures when managing patients with COVID-19.

Oxygen

- Start supplemental oxygen therapy immediately in any patient with emergency signs (i.e., obstructed or absent breathing, severe respiratory distress, central cyanosis, shock, coma and/or convulsions), or any patient without emergency signs and SpO₂ <90%.[2] [3] There is no evidence of benefit for oxygen therapy in patients with COVID-19 in the absence of hypoxemia.[595]
- Target SpO₂ to ≥94% during resuscitation in adults and children with emergency signs who require emergency airway management and oxygen therapy. Once the patient is stable, a target SpO₂ >90% in children and nonpregnant adults, and ≥92% to 95% in pregnant women is recommended.
Nasal prongs or a nasal cannula are preferred in young children. Some guidelines recommend that SpO₂ should be maintained no higher than 96%. Some centers may recommend different SpO₂ targets in order to support prioritization of oxygen flow for the most severely ill patients in hospital. NHS England recommends a target of 92% to 95% (or 90% to 94% if clinically appropriate), for example. Consider positioning techniques (e.g., high supported sitting, prone position), and airway clearance management to assist with secretion clearance in adults. Oxygen delivery can be increased by using a nonrebreathing mask and prone positioning. Consider a trial of awake prone positioning to improve oxygenation in patients with persistent hypoxemia despite increasing supplemental oxygen requirements in whom endotracheal intubation is not otherwise indicated. Early self-proning of awake, nonintubated patients has been shown to improve oxygen saturation and may delay or reduce the need for intensive care. Monitor patients closely for signs of progressive acute hypoxemic respiratory failure. Patients who continue to deteriorate despite standard oxygen therapy require advanced oxygen/ventilatory support.

Symptom management and supportive care

- Fluids and electrolytes: use cautious fluid management in adults and children without tissue hypoperfusion and fluid responsiveness as aggressive fluid resuscitation may worsen oxygenation. Correct any electrolyte or metabolic abnormalities, such as hyperglycemia or metabolic acidosis, according to local protocols.
- Fever and pain: acetaminophen or ibuprofen are recommended. There is no evidence at present of severe adverse events in COVID-19 patients taking nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, or of effects as a result of the use of NSAIDs on acute healthcare utilization, long-term survival, or quality of life in patients with COVID-19.
- Ibuprofen should only be taken at the lowest effective dose for the shortest period needed to control symptoms.
- Cough: advise patients to avoid lying on their back as this makes coughing ineffective. Use simple measures (e.g., a teaspoon of honey in patients ages 1 year and older) to help cough. Short-term use of a cough suppressant may be considered in select patients (e.g., if the cough is distressing to the patient) provided there are no contraindications. A meta-analysis found that honey is superior to usual care (e.g., antitussives) for the improvement of upper respiratory tract infection symptoms, particularly cough frequency and severity.
- Breathlessness: keep the room cool, and encourage relaxation, breathing techniques, and changing body positions. Identify and treat any reversible causes of breathlessness (e.g., pulmonary edema). Consider a trial of oxygen, if available. Consider an opioid and benzodiazepine combination in patients with moderate to severe breathlessness or patients who are distressed.
- Anxiety, delirium, and agitation: identify and treat any underlying or reversible causes (e.g., offer reassurance, treat hypoxia, correct metabolic or endocrine abnormalities, address coinfections, minimize use of drugs that may cause or worsen delirium, treat substance withdrawal, maintain normal sleep cycles, treat pain or breathlessness). Consider a benzodiazepine for the management of anxiety or agitation that does not respond to other measures. Consider haloperidol or a phenothiazine for the management of delirium. Low doses of haloperidol (or another suitable antipsychotic) can also be considered for agitation. Nonpharmacologic interventions are the mainstay for the management of delirium when possible, and prevention is key.
• Mouth care: an important part of overall patient care in hospitalized patients who are ventilated or nonventilated and those undergoing step-down or end-of-life care.[606]
• Provide basic mental health and psychosocial support for all patients, and manage any symptoms of insomnia or depression as appropriate.[2]

Venous thromboembolism prophylaxis

• Assess the risk of bleeding as soon as possible after admission, or by the time of the first consultant review, using a suitable risk assessment tool.[607]
• Start venous thromboembolism (VTE) prophylaxis in acutely ill hospitalized adults and adolescents with COVID-19 as per the standard of care for other hospitalized patients without COVID-19, provided there are no contraindications. A COVID-19 diagnosis should not influence a pediatrician’s recommendations about VTE prophylaxis in hospitalized children. Pregnant women should be managed by a specialist.[2] [3] [608] [609] Start as soon as possible and within 14 hours of admission, and continue for the duration of the hospital stay or 7 days, whichever is longer.[607]
• Low molecular weight heparin or fondaparinux are preferred over unfractionated heparin in order to reduce patient contact.[2] The National Institute for Health and Care Excellence in the UK recommends low molecular weight heparin first-line, with fondaparinux or unfractionated heparin reserved for patients who cannot have low molecular weight heparin.[607] Unfractionated heparin is contraindicated in patients with severe thrombocytopenia. Fondaparinux is recommended in patients with a history of heparin-induced thrombocytopenia. Direct oral anticoagulants are not recommended. Mechanical thromboprophylaxis (e.g., intermittent pneumatic compression devices) is recommended if anticoagulation is contraindicated or not available.[2] [609] [610]
• The optimal dose is unknown. Standard prophylaxis doses are recommended over intermediate- or full treatment-dose regimens.[607] [609] Some clinicians are using intermediate- or full treatment-dose regimens rather than prophylactic doses as they are worried about undetected thrombi; however, this may lead to major bleeding events.[611] There are insufficient data to recommend increased anticoagulant doses for VTE prophylaxis in COVID-19 patients outside the setting of a clinical trial.[3] However, some guidelines recommend that escalated doses can be considered in critically ill patients.[608] [612] The National Institute for Health and Care Excellence in the UK only recommends considering intermediate doses in patients who are having advanced respiratory support, and the decision should be based on multidisciplinary or senior opinion, or locally agreed protocols. Reassess VTE and bleeding risks daily in these patients.[607] There was a slight tendency toward a reduction in the mortality rate among mechanically ventilated patients with COVID-19 receiving full treatment-dose anticoagulation.[613] Dose adjustments may be required in patients with extremes of body weight or renal impairment.[607]
• For patients who are already on an anticoagulant for another condition, continue the patient’s current therapeutic dose unless contraindicated by a change in clinical circumstances. Consider switching to low molecular weight heparin if the patient’s clinical condition is deteriorating and the patient is not currently on low molecular weight heparin.[607]
• Monitor patients for signs and symptoms suggestive of thromboembolism and proceed with appropriate diagnostic and management pathways if clinically suspected.[2] If the patient’s clinical condition changes, assess the risk of VTE, reassess the bleeding risk, and review VTE prophylaxis.[607]
• Routine post-discharge VTE prophylaxis is not generally recommended, except in certain high-risk patients.[3] [608] [609] Ensure patients who require VTE prophylaxis after discharge are able to use it correctly or have arrangements made for someone to help them.[607]
• There is currently insufficient evidence to determine the risks and benefits of prophylactic anticoagulation in hospitalized patients with COVID-19. A retrospective analysis of over 4000 patients found that anticoagulation was associated with lower mortality and intubation among hospitalized COVID-19 patients. Therapeutic anticoagulation was associated with lower mortality compared with prophylactic anticoagulation, but the difference was not statistically significant. Clinicians should rely on pre-COVID-19 evidence-based principles of anticoagulation management combined with rational approaches to address clinical challenges.

Antimicrobials

• Consider empiric antibiotics if there is clinical suspicion of bacterial infection. Give within 1 hour of initial assessment for patients with suspected sepsis or if the patient meets high-risk criteria (or within 4 hours of establishing a diagnosis of pneumonia); do not wait for microbiology results. Base the regimen on the clinical diagnosis (e.g., community-acquired pneumonia, hospital-acquired pneumonia, sepsis), local epidemiology and susceptibility data, and local treatment guidelines.

• Some guidelines recommend empiric antibiotics for bacterial pathogens in all patients with community-acquired pneumonia without confirmed COVID-19. It is likely that the bacterial pathogens in patients with COVID-19 and pneumonia are the same as in previous patients with community-acquired pneumonia, and therefore empiric antimicrobial recommendations should be the same. However, the National Institute for Health and Care Excellence in the UK recommends that it is reasonable not to start empiric antimicrobials if you are confident that the clinical features are typical for COVID-19. There is insufficient evidence to recommend empiric broad-spectrum antimicrobials in the absence of another indication.

• Some patients may require continued antibiotic therapy once COVID-19 has been confirmed depending on the clinical circumstances (e.g., clinical or microbiologic evidence of bacterial infection regardless of severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2] test results, SARS-CoV-2 test result is positive but clinical features are not typical for COVID-19). In these circumstances, review antibiotic choice based on microbiology results and switch to a narrower-spectrum antibiotic if appropriate, review intravenous antibiotic use within 48 hours and consider switching to oral therapy, and give for a total of 5 days unless there is a clear indication to continue.

• Reassess antibiotic use daily. De-escalate empiric therapy on the basis of microbiology results and clinical judgment. Regularly review the possibility of switching from intravenous to oral therapy. Duration of treatment should be as short as possible (e.g., 5 to 7 days). Antibiotic stewardship programs should be in place.

• Treat laboratory-confirmed coinfections (e.g., malaria, tuberculosis, influenza) as appropriate according to local protocols. The treatment of influenza is the same in all patients regardless of SARS-CoV-2 coinfection. Start empiric treatment with oseltamivir in hospitalized patients who are suspected of having either or both infections as soon as possible without waiting for influenza test results. Antiviral therapy can be stopped once influenza has been ruled out.

Corticosteroids

• The WHO strongly recommends systemic corticosteroid therapy (low-dose intravenous or oral dexamethasone or hydrocortisone) for 7 to 10 days in adults with severe or critical disease. This recommendation is based on two meta-analyses that pooled data from eight randomized trials (over 7000 patients), including the UK RECOVERY trial. Moderate-quality evidence suggests that systemic corticosteroids probably reduce 28-day mortality in patients with severe and critical
Coronavirus disease 2019 (COVID-19) management. They also probably reduce the need for invasive ventilation. There is no evidence directly comparing dexamethasone and hydrocortisone. The harms of treatment in this context are considered to be minor. It is unclear whether these recommendations can be applied to children or those who are immunocompromised. The WHO does not recommend corticosteroids in patients with nonsevere disease as they may increase the risk of mortality in these patients.[575] [616] [617] [618]

- In the UK, the National Institute for Health and Care Excellence recommends dexamethasone or hydrocortisone in patients with severe or critical COVID-19 (in line with WHO guidance). The marketing authorizations cover this indication in the UK.[573] [NICE: COVID-19 prescribing brief – corticosteroids] (https://www.nice.org.uk/guidance/ng159/resources/covid19-prescribing-briefing-corticosteroids-pdf-8839913581)
- In Europe, the European Medicines Agency has endorsed the use of dexamethasone for patients with severe disease who require oxygen therapy or mechanical ventilation.[619]
- In the US, the National Institutes of Health guidelines panel recommends dexamethasone, either alone or in combination with remdesivir (see the Emerging section for information on remdesivir), in hospitalized patients who require supplemental oxygen. The panel recommends against using dexamethasone in patients who do not require supplemental oxygen. Alternative corticosteroids may be used in situations where dexamethasone is not available.[3] The Infectious Diseases Society of America supports the use of dexamethasone in hospitalized patients with severe disease.[620]

Monitor

- Monitor patients for adverse effects (e.g., hyperglycemia, secondary infections, psychiatric effects, reactivation of latent infections) and assess for drug-drug interactions.[3] Follow local policies on gastroprotection during corticosteroid treatment. Clinically significant interactions between remdesivir and corticosteroids are unlikely; however, lopinavir/ritonavir may increase hydrocortisone concentrations.[573]

Discharge and rehabilitation

- Routinely assess older patients for mobility, functional swallow, cognitive impairment, and mental health concerns, and based on that assessment determine whether the patient is ready for discharge, and whether the patient has any rehabilitation and follow-up requirements.[2]

Palliative care

- Palliative care interventions should be made accessible at each institution that provides care for patients with COVID-19. Identify whether the patient has an advance care plan and respect the patient’s priorities and preferences when formulating the patient’s care plan.[2] Follow local palliative care guidelines.

Management of critical COVID-19

Patients with critical disease (i.e., presence of acute respiratory distress syndrome, sepsis, or septic shock) should be admitted or transferred to an intensive/critical care unit.[2]

Location of care
• Manage patients in an intensive/critical care unit under the guidance of a specialist team.[2]
• Discuss the risks, benefits, and potential outcomes of treatment options with patients and their families, and allow them to express preferences about their management. Take their wishes and expectations into account when considering the ceiling of treatment. Use decision support tools if available. Put treatment escalation plans in place, and discuss any existing advance care plans or advance decisions to refuse treatment with patients who have preexisting advanced comorbidities.[574]

Isolation period

• Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms.[2]
• The CDC recommends discontinuing isolation once at least 20 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing isolation once at least 20 days have passed since the date of a positive test. Alternatively, it recommends at least two negative RT-PCR tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients.[592]
• Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients.[583]

Infection prevention and control

• Implement local infection prevention and control procedures when managing patients with COVID-19.

High-flow nasal oxygen or noninvasive ventilation

• Consider a trial of high-flow nasal oxygen (HFNO) or noninvasive ventilation (e.g., continuous positive airway pressure [CPAP] or bilevel positive airway pressure [BiPAP]) in selected patients with mild acute respiratory distress syndrome (ARDS).[2]
• Airborne precautions are recommended for these interventions (including bubble CPAP) due to uncertainty about the potential for aerosolization.[2] Novel methods to protect clinicians without access to standard personal protective equipment during aerosol-generating procedures have been suggested.[621] [622] [623] [624]
• Patients with hypercapnia, hemodynamic instability, multi-organ failure, or abnormal mental status should generally not receive HFNO, although emerging data suggests that it may be safe in patients with mild to moderate and nonworsening hypercapnia. Patients with hypoxemic respiratory failure and hemodynamic instability, multi-organ failure, or abnormal mental status should not receive these treatments in place of other options such as invasive ventilation.[2]
• There is ongoing debate about the optimal mode of respiratory support before mechanical ventilation.[625] NHS England recommends CPAP as the preferred form of noninvasive ventilation in patients with hypoxemic (type 1) respiratory failure. It doesn't advocate the use of HFNO based on a lack of efficacy, oxygen use (HFNO can place a strain on oxygen supplies with the risk of site supply failure), and infection spread.[626] Other guidelines recommend HFNO over noninvasive
ventilation, unless HFNO is not available.[3] [596] Despite the trend to avoid HFNO, it has been shown to have a similar risk of aerosol generation to standard oxygen masks.[627]

- Early CPAP may provide a bridge to invasive mechanical ventilation. Reserve the use of BiPAP for patients with hypercapnic acute on chronic ventilatory failure (type 2 respiratory failure).[626]
- Indirect and low-certainty evidence suggests that noninvasive ventilation probably reduces mortality in patients with COVID-19, similar to mechanical ventilation, but may increase the risk of viral transmission.[628] [629]
- Monitor patients closely for acute deterioration. If patients do not improve after a short trial of these interventions they require urgent endotracheal intubation.[2] [596]
- More detailed guidance on the management of ARDS in COVID-19 is beyond the scope of this topic; consult a specialist for further guidance.

Mechanical ventilation

- Consider endotracheal intubation and invasive mechanical ventilation in patients who are acutely deteriorating despite advanced oxygen/noninvasive ventilatory support measures.[2] [3]
- Two-thirds of patients who required critical care in the UK had mechanical ventilation within 24 hours of admission.[630] In New York, 33% of hospitalized patients developed respiratory failure leading to mechanical ventilation. These patients were more likely to be male, have obesity, and have elevated inflammatory markers and liver function tests.[398] Patients spent an average of 18 days on a ventilator (range 9-28 days).[631] Patients who required invasive mechanical ventilation had an 36% to 88% mortality rate in studies.[632] [633] [634]
- Endotracheal intubation should be performed by an experienced provider using airborne precautions.[2] Intubation by video laryngoscopy is recommended if possible.[3] Young children, or adults who are obese or pregnant, may desaturate quickly during intubation and therefore require preoxygenation with 100% FiO₂ for 5 minutes.[2]
- Mechanically ventilated patients with ARDS should receive a lung-protective, low tidal volume/low inspiratory pressure ventilation strategy (lower targets are recommended in children). A higher positive end-expiratory pressure (PEEP) strategy is preferred over a lower PEEP strategy in moderate to severe ARDS. However, individualization of PEEP, where the patient is monitored for beneficial or harmful effects and driving pressure during titration with consideration of the risks and benefits of PEEP titration, is recommended.[2] [3] [596] NHS England recommends a low PEEP strategy in patients with normal compliance where recruitment may not be required.[635]
- Although some patients with COVID-19 pneumonia meet the criteria for ARDS, there is some discussion about whether COVID-19 pneumonia is its own specific disease with atypical phenotypes. Anecdotal evidence suggests that the main characteristic of the atypical presentation is the dissociation between well-preserved lung mechanics and the severity of hypoxemia.[636] [637] [638] [639] [640] [641] However, this approach has been criticized.[642] [643] It has been argued that an evidence-based approach extrapolating data from ARDS not related to COVID-19 is the most reasonable approach for intensive care of COVID-19 patients.[644] As a consequence of this, some clinicians have warned that protocol-driven ventilator use may be causing lung injury in some patients, and that ventilator settings should be based on physiologic findings rather than using standard protocols. High PEEP may have a detrimental effect on patients with normal compliance.[636] PEEP should always be carefully titrated.[598]
- Consider prone ventilation in patients with severe ARDS for 12 to 16 hours per day. Pregnant women in the third trimester may benefit from being placed in the lateral decubitus position. Caution is required in children.[2] [3] [596] Longer durations may be feasible in some patients.[645] A small cohort study of 12 patients in Wuhan City, China, with COVID-19-related ARDS suggests that
spending periods of time in the prone position may improve lung recruitability.[646] Two small case series found that many people tolerate the prone position while awake, breathing spontaneously, or receiving noninvasive ventilation. In the patients who tolerated it, improvement in oxygenation and a decrease in respiratory rate occurred.[647] [648]

- Lung recruitment maneuvers are suggested, but staircase recruitment maneuvers are not recommended.[3] [596]
- More detailed guidance on the management of ARDS in COVID-19, including sedation and the use of neuromuscular blockade during ventilation, is beyond the scope of this topic; consult a specialist for further guidance.

Inhaled pulmonary vasodilator

- Consider a trial of an inhaled pulmonary vasodilator in adults who have severe ARDS and hypoxemia despite optimizing ventilation. Taper off if there is no rapid improvement in oxygenation.[3] [596]

Extracorporeal membrane oxygenation

- Consider ECMO according to availability and expertise if the above methods fail.[2] [596] [649] [650] ECMO is not suitable for all patients, and only those who meet certain inclusion criteria may be considered for ECMO.[651]
- There is insufficient evidence to recommend either for or against the routine use of ECMO.[3]
- The estimated 60-day survival rate of ECMO-rescued patients with COVID-19 (31%) was similar to that of previous studies of ECMO for severe ARDS.[652] An international cohort study of 1035 patients found that both the estimated mortality 90 days after ECMO initiation and mortality in those who achieved a final outcome of death or discharge were <40%, consistent with previously reported survival rates in acute hypoxemic respiratory failure.[653]
- Single-access, dual-stage venovenous ECMO with early extubation appears to be safe and effective in patients with COVID-19 respiratory failure.[654]

Management of septic shock/sepsis

- The management of sepsis and septic shock in patients with COVID-19 is beyond the scope of this topic. See the Complications section.

Symptom management and supportive care

- Consider fluid and electrolyte management, antimicrobial treatment, VTE prophylaxis, and symptom management as appropriate (see above).
- As with severe disease, guidelines recommend low molecular weight heparin as the preferred option for VTE prophylaxis. However, unfractionated heparin is preferred over fondaparinux in critically ill patients if low molecular weight heparin cannot be used.[609] Some guidelines recommend that escalated doses can be considered in critically ill patients.[607] [608] [612]

Corticosteroids

- Consider systemic corticosteroids for the management of critically ill patients (see above). In the US, the National Institutes of Health recommends dexamethasone, either alone or in combination with remdesivir, in hospitalized patients who require high-flow oxygen, noninvasive ventilation, mechanical ventilation, or ECMO.[3]

Discharge and rehabilitation
• Routinely assess intensive care patients for mobility, functional swallow, cognitive impairment, and mental health concerns, and based on that assessment determine whether the patient is ready for discharge, and whether the patient has any rehabilitation and follow-up requirements.[2]

Palliative care

• Palliative care interventions should be made accessible at each institution that provides care for patients with COVID-19. Identify whether the patient has an advance care plan and respect the patient’s priorities and preferences when formulating the patient’s care plan.[2] Follow local palliative care guidelines.

Management of pregnant women

Pregnant women should be managed by a multidisciplinary team, including obstetric, perinatal, neonatal, and intensive care specialists, as well as midwifery and mental health and psychosocial support. A woman-centered, respectful, skilled approach to care is recommended.[2] In women with severe or critical disease, the multidisciplinary team should be organized as soon as possible after maternal hypoxemia occurs in order to assess fetal maturity, disease progression, and the best options for delivery.[655]

There are limited data available on the management of pregnant women with COVID-19; however, pregnant women can generally be treated with the same supportive therapies detailed above, taking into account the physiologic changes that occur with pregnancy.[2]

The prevalence of asymptomatic SARS-CoV-2-positive pregnant women admitted for delivery appears to be low (<3% in a cohort in Connecticut, and 0.43% in a cohort in California).[656] [657] Screening women and their delivery partners before admission may not be helpful. More than 15% of asymptomatic maternity patients tested positive for SARS-CoV-2 infection despite having been screened negative using a telemedicine screening tool in one small observational study in New York. In addition to this, 58% of their asymptomatic support persons tested positive despite being screened negative.[658] Another study in a New York obstetric population found that 88% of women who tested positive for SARS-CoV-2 at admission were asymptomatic at presentation.[659]

Location of care

• Manage pregnant women in a healthcare facility, in a community facility, or at home. Women with suspected or confirmed mild disease may not require acute care in a hospital unless there is concern for rapid deterioration or an inability to return to hospital promptly.[2] Follow local infection prevention and control procedures as for nonpregnant people.
• Consider home care in women with asymptomatic or mild illness, provided the patient has no signs of potentially severe illness (e.g., breathlessness, hemoptysis, new chest pain/pressure, anorexia, dehydration, confusion), no comorbidities, and no obstetric issues; the patient is able to care for herself; and monitoring and follow-up is possible. Otherwise, manage pregnant women in a hospital setting with appropriate maternal and fetal monitoring whenever possible.[467] [660] [661]
• Postpone routine prenatal or postpartum health visits for women who are in home isolation and reschedule them after the isolation period is completed. Delivery of counseling and care should be conducted via telemedicine whenever possible. Counsel women about healthy diet, mobility and exercise, intake of micronutrients, smoking, and alcohol and substance use. Advise women to seek urgent care if they develop any worsening of illness or danger signs, or danger signs of pregnancy.[2]
• The American College of Obstetricians and Gynecologists has published an algorithm to help decide whether hospital admission or home care is more appropriate. [ACOG: outpatient assessment and management for pregnant women with suspected or confirmed novel coronavirus (COVID-19)] (https://www.acog.org/-/media/project/acog/acogorg/files/pdfs/clinical-guidance/practice-advisory/covid-19-algorithm.pdf?la=en&hash=2D9E7F62C97F8231561616FFDCA3B1A6)

Prenatal corticosteroids

• Consider prenatal corticosteroids for fetal lung maturation in women who are at risk of preterm birth (24 to 37 weeks' gestation). Caution is advised because corticosteroids could potentially worsen the maternal clinical condition, and the decision should be made in conjunction with the multidisciplinary team.[467] [661] [662] The WHO recommends prenatal corticosteroids only when there is no clinical evidence of maternal infection and adequate childbirth and newborn care is available, and in women with mild COVID-19 after assessing the risks and benefits.[2]
• There is no evidence that corticosteroids in the doses prescribed for fetal lung maturation cause any harm in the context of COVID-19, but there is also no evidence of safety. The unknown effect on maternal outcome should be weighed against the neonatal benefit, particularly at later preterm gestations.[663]

Treatments

• Most clinical trials to date have excluded pregnant women. However, potentially effective treatments should not be withheld from pregnant women due to theoretical concerns about the safety of these therapeutic agents in pregnancy. Decisions should be made with a shared decision-making process between the patient and the clinical team.[3]
• There is no convincing evidence that systemic corticosteroids increase the incidence of congenital abnormalities. The benefits of corticosteroids in pregnant or breastfeeding women with severe or critical disease are thought to outweigh the risks.[573]

VTE prophylaxis

• The National Institutes of Health recommends prophylactic dose anticoagulation in pregnant women who are hospitalized with severe disease, provided there are no contraindications to its use. Anticoagulation during labor and delivery requires specialized care and planning, and should be managed in a similar way to pregnant women with other conditions that require anticoagulation. VTE prophylaxis after discharge is not recommended.[3]
• The Royal College of Obstetricians and Gynaecologists (RCOG) has also published guidance on the prevention of VTE in pregnant women.[663]

Labor and delivery

• Implement local infection prevention and control measures during labor and delivery. A negative pressure isolation room is recommended if available. Screen birth partners for COVID-19 infection using the standard case definition.[2]
• Individualize mode of birth based on obstetric indications and the woman’s preferences. Vaginal delivery is preferred in women with confirmed infection to avoid unnecessary surgical complications. Induction of labor, interventions to accelerate labor and delivery, and cesarean delivery are generally only recommended when medically justified based on maternal and fetal condition. COVID-19 positive status alone is not an indication for cesarean section.[2] [467] [661] Avoid using birthing pools in patients with suspected or confirmed infection.[663]
• Delayed umbilical cord clamping (not earlier than 1 minute after birth) is recommended for improved maternal and infant health and nutrition outcomes. The risk of transmission via blood is thought to be minimal, and there is no evidence that delayed cord clamping increases the risk of viral transmission from the mother to the newborn.[2]

• Consider babies born to mothers with suspected or confirmed infection to be a person under investigation and isolate them from healthy newborns. Test them for infection 24 hours after birth, and, if negative, again 48 hours after birth.[664]

Newborn care

• Experts are divided on separating mother and baby after delivery; make decisions on a case-by-case basis using shared-decision making.

• A retrospective cohort analysis, the largest series to date, found no clinical evidence of vertical transmission in 101 newborns born to mothers with suspected or confirmed SARS-CoV-2 infection, despite most newborns rooming-in and direct breastfeeding practices. This suggests that separation may not be warranted and breastfeeding appears to be safe.[665]

• The WHO recommends that mothers and infants should remain together unless the mother is too sick to care for her baby. Breastfeeding should be encouraged while applying appropriate infection prevention and control measures (e.g., performing hand hygiene before and after contact with the baby, wearing a mask while breastfeeding).[2] The WHO advises that the benefits of breastfeeding outweigh the potential risks for transmission.[666] Mother-to-infant transmission appears to be rare during rooming-in, provided that adequate droplet and contact precautions are taken.[667]

• The CDC recommends that temporary separation of a newborn from a mother with confirmed or suspected COVID-19 may be considered after weighing the risks and benefits as current evidence suggests the risk of a neonate acquiring infection from its mother is low; healthcare providers should respect maternal autonomy in the medical decision-making process. If separation is not undertaken, measures to minimize the risk of transmission should be implemented.[668] A mother with confirmed infection should be counseled to take all possible precautions to avoid transmission to the infant during breastfeeding (e.g., hand hygiene, wearing a cloth face covering). Expressed milk should be fed to the newborn by a healthy caregiver.[669]

• The RCOG recommends that mothers with confirmed infection and healthy babies are kept together in the immediate postpartum period. It is recommended that the risks and benefits are discussed with neonatologists and families in order to individualize care in babies who may be more susceptible to infection. The RCOG advises that the benefits of breastfeeding outweigh any potential risks of transmission of the virus through breast milk, and recommends appropriate preventive precautions to limit transmission to the baby.[663]

• The American Academy of Pediatrics (AAP) recommends that temporary separation is the safest option, but acknowledges there are situations where this is not possible or the mother chooses to room-in. The AAP supports breastfeeding as the best choice for feeding. Breast milk can be expressed after appropriate hygiene measures and fed by an uninfected caregiver. If the mother chooses to breastfeed the infant themselves, appropriate prevention measures are recommended. After discharge, advise mothers with COVID-19 to practice prevention measures (e.g., distance, hand hygiene, respiratory hygiene/mask) for newborn care until either: they are afebrile for 72 hours without use of antipyretics and at least 10 days have passed since symptoms first appeared; or they have at least two consecutive negative SARS-CoV-2 tests from specimens collected ≥24 hours apart. This may require the support of an uninfected caregiver. A newborn with documented infection requires close outpatient follow-up after discharge for 14 days after birth.[664]
Management of people living with HIV

Recommendations for the triage, management, and treatment of COVID-19 in people with HIV are the same as those for the general population. Continue antiretroviral therapy and prophylaxis for opportunistic infections whenever possible, including patients who require hospitalization. Consult with a HIV specialist before adjusting or switching antiretroviral medications, and pay attention to potential drug-drug interactions and overlapping toxicities with COVID-19 treatments.[3]

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.
## Acute

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Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.
### Acute

#### mild COVID-19

1st **consider home isolation**

- Patients with suspected or confirmed mild disease (i.e., symptomatic patients meeting the case definition for COVID-19 without evidence of hypoxia or pneumonia) and asymptomatic patients should be isolated to contain virus transmission.[2]

- Manage patients in a healthcare facility, in a community facility, or at home. Home isolation can be considered in most patients, with telemedicine or remote visits as appropriate.[2] [3] This decision requires careful clinical judgment and should be informed by an assessment of the patient’s home environment to ensure that: infection prevention and control measures and other requirements can be met (e.g., basic hygiene, adequate ventilation); the caregiver is able to provide care and recognize when the patient may be deteriorating; the caregiver has adequate support (e.g., food, supplies, psychological support); the support of a trained health worker is available in the community.[551] The location of care will depend on guidance from local health authorities and available resources.

- Pregnant women with suspected or confirmed mild disease may not require acute care in a hospital unless there is concern for rapid deterioration or an inability to return to hospital promptly.[2]

- Advise patients and household members to follow appropriate infection prevention and control measures:

- Discontinue transmission-based precautions (including isolation) and release patients from the care pathway: 10 days after positive test (asymptomatic patients); 10 days after
Coronavirus disease 2019 (COVID-19) Management

Acute symptom onset plus at least 3 days without fever and respiratory symptoms (symptomatic patients).[2] The Centers for Disease Control and Prevention (CDC) recommends discontinuing home isolation once at least 10 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing home isolation once at least 10 days have passed since the date of a positive test. Alternatively, it recommends at least two negative reverse-transcription polymerase chain reaction (RT-PCR) tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used.[582] If the patient is hospitalized, CDC guidance for discontinuing isolation is the same as for moderate disease (see below). Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 10 days in patients with milder disease who are managed in the community.[583]

**plus monitoring**

Treatment recommended for ALL patients in selected patient group

- Closely monitor patients with risk factors for severe illness and counsel patients about signs and symptoms of deterioration or complications that require prompt urgent care (e.g., difficulty breathing, chest pain).[2] [3]

**plus symptom management and supportive care**

Treatment recommended for ALL patients in selected patient group

- Advise patients to avoid lying on their back as this makes coughing ineffective. Use simple measures (e.g., a teaspoon of honey in patients ages 1 year and older) to help cough.[574] A meta-analysis found that honey is superior to usual care (e.g., antitussives) for the improvement of upper respiratory tract infection symptoms, particularly cough frequency and severity.[590]

- Advise patients about adequate nutrition and appropriate rehydration. Too much fluid can worsen oxygenation.[2]
### Acute

- Advise patients to improve air circulation by opening a window or door (fans can spread infection and should not be used).[^574]

- Provide basic mental health and psychosocial support for all patients, and manage any symptoms of insomnia, depression, or anxiety as appropriate.[2]

- Consider treatment for olfactory dysfunction (e.g., olfactory training) if it persists beyond 2 weeks. There is no evidence to support the use of these treatments in patients with COVID-19.[591]

<table>
<thead>
<tr>
<th>adjunct</th>
<th>antipyretic/analgesic</th>
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<tbody>
<tr>
<td>Treatment recommended for SOME patients in selected patient group</td>
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</table>

**Primary options**

- **acetaminophen:** children: 10-15 mg/kg orally every 4-6 hours when required, maximum 75 mg/kg/day; adults: 325-1000 mg orally (immediate-release) every 4-6 hours when required, maximum 4000 mg/day

**OR**

- **ibuprofen:** children 6 months to 11 years of age: 5-10 mg/kg orally every 6-8 hours when required, maximum 40 mg/kg/day; children ≥12 years of age and adults: 200-400 mg orally every 4-6 hours when required, maximum 2400 mg/day

- Acetaminophen or ibuprofen are recommended.[2][^574] There is no evidence at present of severe adverse events in COVID-19 patients taking nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, or of effects as a result of the use of NSAIDs on acute healthcare utilization, long-term survival, or quality of life in patients with COVID-19.[584][585][586][587][588][589]

- Ibuprofen should only be taken at the lowest effective dose for the shortest period needed to control symptoms. It is not recommended in pregnant women (especially in the third trimester) or children <6 months of age (age cut-offs vary by country).

### adjunct experimental therapies

- Treatment recommended for SOME patients in selected patient group
## Acute

- Consider appropriate experimental or emerging therapies.
- Antiviral therapies will have a greater effect early in the course of the disease, whereas immunosuppressive/anti-inflammatory therapies are likely to have a greater effect later in the course of the disease. [3]
- See the Emerging section for more information.

## moderate COVID-19

### 1st consider home isolation or hospital admission

- Patients with suspected or confirmed moderate disease (i.e., clinical signs of pneumonia but no signs of severe pneumonia) should be isolated to contain virus transmission. [2]
- Manage patients in a healthcare facility, in a community facility, or at home. Home isolation, with telemedicine or remote visits as appropriate, can be considered in low-risk patients. Manage patients at high risk of deterioration and pregnant women in a healthcare facility. [2] [3]
- Implement local infection prevention and control procedures when managing patients with COVID-19. For patients in home isolation, advise patients and household members to follow appropriate infection prevention and control measures:
- Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms. [2] The Centers for Disease Control and Prevention (CDC) recommends discontinuing isolation once at least 10 days (not severely immunocompromised) or 20 days (severely immunocompromised) have passed.
MANAGEMENT

Acute

since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing isolation once at least 10 days (not severely immunocompromised) or 20 days (severely immunocompromised) have passed since the date of a positive test. Alternatively, it recommends at least two negative reverse-transcription polymerase chain reaction (RT-PCR) tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients.[592] If the patient is isolated at home, CDC guidance for discontinuing isolation is the same as for mild disease (see above). Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients, and 10 days in patients with milder disease who are managed in the community.[583]

plus monitoring

Treatment recommended for ALL patients in selected patient group

» Closely monitor patients for signs or symptoms of disease progression. If the patient is being managed at home, counsel them about signs and symptoms of deterioration or complications that require prompt urgent care (e.g., difficulty breathing, chest pain). If the patient is being managed in hospital, monitor patients closely for signs of clinical deterioration using medical early warning scores (e.g., National Early Warning Score 2 [NEWS2]), and respond immediately with appropriate supportive care interventions.[2]

plus symptom management and supportive care

Treatment recommended for ALL patients in selected patient group

» Advise patients to avoid lying on their back as this makes coughing ineffective. Use simple measures (e.g., a teaspoon of honey in patients ages 1 year and older) to help cough.[574] A meta-analysis found that honey is superior to usual care (e.g., antitussives) for the improvement of upper respiratory tract infection symptoms, particularly cough frequency and severity.[590]
**Acute**

» Advise patients about adequate nutrition and appropriate rehydration. Too much fluid can worsen oxygenation.[2]

» Advise patients to improve air circulation by opening a window or door (fans can spread infection and should not be used).[574]

» Provide basic mental health and psychosocial support for all patients, and manage any symptoms of insomnia, depression, or anxiety as appropriate.[2]

» Consider treatment for olfactory dysfunction (e.g., olfactory training) if it persists beyond 2 weeks. There is no evidence to support the use of these treatments in patients with COVID-19.[591]

<table>
<thead>
<tr>
<th>adjunct</th>
<th>antibiotics</th>
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<tbody>
<tr>
<td>Treatment recommended for SOME patients in selected patient group</td>
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<tr>
<td>» Consider empiric antibiotics if there is clinical suspicion of bacterial infection.[2] [3] Antibiotics may also be considered in older people (particularly those in long-term care facilities) and children &lt;5 years of age to provide empiric antibiotic treatment for possible pneumonia. The regimen should be based on the clinical diagnosis, local epidemiology and susceptibility data, and local treatment guidelines.[2]</td>
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<tr>
<th>adjunct</th>
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<tr>
<td><strong>Primary options</strong></td>
<td></td>
</tr>
<tr>
<td>» <strong>acetaminophen</strong>: children: 10-15 mg/kg orally every 4-6 hours when required, maximum 75 mg/kg/day; adults: 325-1000 mg orally (immediate-release) every 4-6 hours when required, maximum 4000 mg/day</td>
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**OR**

| » **ibuprofen**: children 6 months to 11 years of age: 5-10 mg/kg orally every 6-8 hours when required, maximum 40 mg/kg/day; children ≥12 years of age and adults: 200-400 mg orally every 4-6 hours when required, maximum 2400 mg/day |

» Acetaminophen or ibuprofen are recommended.[2] [574] There is no evidence at present of severe adverse events in COVID-19 patients taking nonsteroidal anti-inflammatory
| Acute |  
|---|---|
| drugs (NSAIDs) such as ibuprofen, or of effects as a result of the use of NSAIDs on acute healthcare utilization, long-term survival, or quality of life in patients with COVID-19.[584][585][586][587][588][589]  
  » Ibuprofen should only be taken at the lowest effective dose for the shortest period needed to control symptoms. It is not recommended in pregnant women (especially in the third trimester) or children <6 months of age (age cut-offs vary by country).  
| adjunct experimental therapies | Treatment recommended for SOME patients in selected patient group  
  » Consider appropriate experimental or emerging therapies.  
  » Antiviral therapies will have a greater effect early in the course of the disease, whereas immunosuppressive/anti-inflammatory therapies are likely to have a greater effect later in the course of the disease.[3]  
  » See the Emerging section for more information.  
| severe COVID-19  
1st hospital admission |  
  » Patients with suspected or confirmed severe disease are at risk of rapid clinical deterioration and should be admitted to an appropriate healthcare facility under the guidance of a specialist team. Severe disease in adults is defined as having clinical signs of pneumonia plus at least one of the following: respiratory rate >30 breaths/minute, severe respiratory distress, or SpO₂ <90% on room air. Severe disease in children is defined as having clinical signs of pneumonia plus at least one of the following: central cyanosis or SpO₂ <90%, severe respiratory distress, general danger signs (inability to breastfeed or drink, lethargy or unconsciousness, or convulsions), or fast breathing (<2 months: ≥60 breaths per minute; 2-11 months: ≥50 breaths per minute; 1-5 years: ≥40 breaths per minute).[2]  
  » Assess all adults for frailty on admission to hospital, irrespective of age and COVID-19 status, using the Clinical Frailty Scale (CFS). [Clinical frailty scale](https://www.nice.org.uk/guidance/ng159/resources/clinical-frailty-scale-pdf-8712262765) Involve critical care teams in discussions about admission to critical
Acute care.[573] A large observational study found that disease outcomes were better predicted by frailty than either age or comorbidity; frailty (CFS score 5-8) was associated with earlier death and longer duration of hospital stay, and these outcomes worsened with increasing frailty after adjustment for age and comorbidity.[594]

» Implement local infection prevention and control procedures when managing patients with COVID-19.

» Pregnant women should be managed by a multidisciplinary team, including obstetric, perinatal, neonatal, and intensive care specialists, as well as midwifery and mental health and psychosocial support. A woman-centered, respectful, skilled approach to care is recommended.[2] The multidisciplinary team should be organized as soon as possible after maternal hypoxemia occurs in order to assess fetal maturity, disease progression, and the best options for delivery.[655]

» Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms.[2] The Centers for Disease Control and Prevention (CDC) recommends discontinuing isolation once at least 20 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing isolation once at least 20 days have passed since the date of a positive test. Alternatively, it recommends at least two negative reverse-transcription polymerase chain reaction (RT-PCR) tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients.[592] Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients.[583]

plus consider oxygen therapy

Treatment recommended for ALL patients in selected patient group

» Start supplemental oxygen therapy immediately in any patient with emergency signs (i.e., obstructed or absent breathing, severe respiratory distress, central cyanosis, shock,
Acute coma and/or convulsions), or any patient without emergency signs and SpO₂ <90%. [2] [3]

- Target SpO₂ to ≥94% during resuscitation in adults and children with emergency signs who require emergency airway management and oxygen therapy. Once the patient is stable, a target SpO₂ >90% in children and nonpregnant adults, and ≥92% to 95% in pregnant women, is recommended. Nasal prongs or a nasal cannula are preferred in young children. [2] Some guidelines recommend that SpO₂ should be maintained no higher than 96%. [596]

- Some centers may recommend different SpO₂ targets in order to support prioritization of oxygen flow for the most severely ill patients in hospital. NHS England recommends a target of 92% to 95% (or 90% to 94% if clinically appropriate), for example. [597]

- Consider positioning techniques (e.g., high supported sitting, prone position), and airway clearance management to assist with secretion clearance in adults. [2] Oxygen delivery can be increased by using a nonrebreathing mask and prone positioning. [598] Consider a trial of awake prone positioning to improve oxygenation in patients with persistent hypoxemia despite increasing supplemental oxygen requirements in whom endotracheal intubation is not otherwise indicated. [3] Early self-proning of awake, nonintubated patients has been shown to improve oxygen saturation and may delay or reduce the need for intensive care. [599] [600] [601] [602] [603]

- Monitor patients closely for signs of progressive acute hypoxemic respiratory failure. [2] [3]

**plus** symptom management and supportive care

Treatment recommended for ALL patients in selected patient group

- Fluids and electrolytes: use cautious fluid management in adults and children without tissue hypoperfusion and fluid responsiveness as aggressive fluid resuscitation may worsen oxygenation. [2] Correct any electrolyte or metabolic abnormalities, such as hyperglycemia or metabolic acidosis, according to local protocols. [604]

- Cough: advise patients to avoid lying on their back as this makes coughing ineffective. Use simple measures (e.g., a teaspoon of honey in
Coronavirus disease 2019 (COVID-19)

Management

Acute patients ages 1 year and older) to help cough. Short-term use of a cough suppressant may be considered in select patients (e.g., if the cough is distressing to the patient) provided there are no contraindications. A meta-analysis found that honey is superior to usual care (e.g., antitussives) for the improvement of upper respiratory tract infection symptoms, particularly cough frequency and severity.

» Breathlessness: keep the room cool, and encourage relaxation, breathing techniques, and changing body positions. Identify and treat any reversible causes of breathlessness (e.g., pulmonary edema). Consider a trial of oxygen, if available. Consider an opioid and benzodiazepine combination in patients with moderate to severe breathlessness or patients who are distressed.

» Anxiety, delirium, and agitation: identify and treat any underlying or reversible causes (e.g., offer reassurance, treat hypoxia, correct metabolic or endocrine abnormalities, address coinfections, minimize use of drugs that may cause or worsen delirium, treat substance withdrawal, maintain normal sleep cycles, treat pain or breathlessness). Consider a benzodiazepine for the management of anxiety or agitation that does not respond to other measures. Consider haloperidol or a phenothiazine for the management of delirium. Low doses of haloperidol (or another suitable antipsychotic) can also be considered for agitation. Nonpharmacologic interventions are the mainstay for the management of delirium when possible, and prevention is key.

» Mouth care: an important part of overall patient care in hospitalized patients who are ventilated or nonventilated and those undergoing step-down or end-of-life care.

» Mental health symptoms: provide basic mental health and psychosocial support for all patients, and manage any symptoms of insomnia or depression as appropriate.

plus venous thromboembolism prophylaxis

Treatment recommended for ALL patients in selected patient group

Primary options

» enoxaparin: consult specialist for guidance on dose
**Acute**

OR

» **dalteparin**: consult specialist for guidance on dose

**Secondary options**

» **fondaparinux**: consult specialist for guidance on dose

OR

» **heparin**: consult specialist for guidance on dose

» Assess the risk of bleeding as soon as possible after admission, or by the time of the first consultant review, using a suitable risk assessment tool.[607]

» Start venous thromboembolism (VTE) prophylaxis in acutely ill hospitalized adults and adolescents with COVID-19 as per the standard of care for other hospitalized patients without COVID-19, provided there are no contraindications. A COVID-19 diagnosis should not influence a pediatrician’s recommendations about VTE prophylaxis in hospitalized children. Pregnant women should be managed by a specialist.[2] [3] [608] [609] Start as soon as possible and within 14 hours of admission, and continue for the duration of the hospital stay or 7 days, whichever is longer.[607]

» Low molecular weight heparin or fondaparinux are preferred over unfractionated heparin in order to reduce patient contact.[2] The National Institute for Health and Care Excellence in the UK recommends low molecular weight heparin first-line, with fondaparinux or unfractionated heparin reserved for patients who cannot have low molecular weight heparin.[607] Unfractionated heparin is contraindicated in patients with severe thrombocytopenia. Fondaparinux is recommended in patients with a history of heparin-induced thrombocytopenia. Direct oral anticoagulants are not recommended. Mechanical thromboprophylaxis (e.g., intermittent pneumatic compression devices) is recommended if anticoagulation is contraindicated or not available.[2] [609] [610]

» The optimal dose is unknown. Standard prophylaxis doses are recommended over intermediate- or full treatment-dose regimens,[607] [609] Some clinicians are using intermediate- or full treatment-dose regimens...
Coronavirus disease 2019 (COVID-19) Management

Acute rather than prophylactic doses as they are worried about undetected thrombi; however, this may lead to major bleeding events.[611] There are insufficient data to recommend increased anticoagulant doses for VTE prophylaxis in COVID-19 patients outside the setting of a clinical trial.[3] However, some guidelines recommend that escalated doses can be considered in critically ill patients.[608] The National Institute for Health and Care Excellence in the UK only recommends considering intermediate doses in patients who are having advanced respiratory support, and the decision should be based on multidisciplinary or senior opinion, or locally agreed protocols. Reassess VTE and bleeding risks daily in these patients.[607] There was a slight tendency toward a reduction in the mortality rate among mechanically ventilated patients with COVID-19 receiving full treatment-dose anticoagulation.[670] Dose adjustments may be required in patients with extremes of body weight or renal impairment.[607]

» For patients who are already on an anticoagulant for another condition, continue the patient’s current therapeutic dose unless contraindicated by a change in clinical circumstances. Consider switching to low molecular weight heparin as the preferred option for venous thromboembolism prophylaxis if the patient’s clinical condition is deteriorating and the patient is not currently on low molecular weight heparin.[607]

» Monitor patients for signs and symptoms suggestive of thromboembolism and proceed with appropriate diagnostic and management pathways if clinically suspected.[2] If the patient’s clinical condition changes, assess the risk of VTE, reassess the bleeding risk, and review VTE prophylaxis.[607]

» Routine post-discharge VTE prophylaxis is not generally recommended, except in certain high-risk patients.[3] [608] [609] Ensure patients who require VTE prophylaxis after discharge are able to use it correctly or have arrangements made for someone to help them.[607]

» There is currently insufficient evidence to determine the risks and benefits of prophylactic anticoagulation in hospitalized patients with COVID-19.[614] A retrospective analysis of over 4000 patients found that anticoagulation was associated with lower mortality and intubation among hospitalized COVID-19 patients. Therapeutic anticoagulation was associated
### Acute

<table>
<thead>
<tr>
<th>Management</th>
<th>with lower mortality compared with prophylactic anticoagulation, but the difference was not statistically significant.[615] Clinicians should rely on pre-COVID-19 evidence-based principles of anticoagulation management combined with rational approaches to address clinical challenges.[608]</th>
</tr>
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<tbody>
<tr>
<td>plus monitoring</td>
<td>Treatment recommended for ALL patients in selected patient group</td>
</tr>
<tr>
<td>» Monitor patients closely for signs of clinical deterioration, and respond immediately with appropriate supportive care interventions.[2]</td>
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<tr>
<td>adjunct antibiotics</td>
<td>Treatment recommended for SOME patients in selected patient group</td>
</tr>
<tr>
<td>» Consider empiric antibiotics if there is clinical suspicion of bacterial infection. Give within 1 hour of initial assessment for patients with suspected sepsis or if the patient meets high-risk criteria (or within 4 hours of establishing a diagnosis of pneumonia); do not wait for microbiology results. Base the regimen on the clinical diagnosis (e.g., community-acquired pneumonia, hospital-acquired pneumonia, sepsis), local epidemiology and susceptibility data, and local treatment guidelines.[2] [3] [528]</td>
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<tr>
<td>» Some guidelines recommend empiric antibiotics for bacterial pathogens in all patients with community-acquired pneumonia without confirmed COVID-19. It is likely that the bacterial pathogens in patients with COVID-19 and pneumonia are the same as in previous patients with community-acquired pneumonia, and therefore empiric antimicrobial recommendations should be the same.[529] However, the National Institute for Health and Care Excellence in the UK recommends that it is reasonable not to start empiric antimicrobials if you are confident that the clinical features are typical for COVID-19.[528] There is insufficient evidence to recommend empiric broad-spectrum antimicrobials in the absence of another indication.[3]</td>
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<tr>
<td>» Some patients may require continued antibiotic therapy once COVID-19 has been confirmed depending on the clinical circumstances (e.g., clinical or microbiologic evidence of bacterial infection regardless of severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2] test results, SARS-CoV-2 test result is positive but clinical features are not typical for COVID-19).</td>
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</table>
**Coronavirus disease 2019 (COVID-19) Management**

### Acute

In these circumstances, review antibiotic choice based on microbiology results and switch to a narrower-spectrum antibiotic if appropriate, review intravenous antibiotic use within 48 hours and consider switching to oral therapy, and give for a total of 5 days unless there is a clear indication to continue.[528]

» Reassess antibiotic use daily. De-escalate empiric therapy on the basis of microbiology results and clinical judgment. Regularly review the possibility of switching from intravenous to oral therapy. Duration of treatment should be as short as possible (e.g., 5 to 7 days). Antibiotic stewardship programs should be in place.[2]

<table>
<thead>
<tr>
<th>adjunct corticosteroid</th>
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<td>Treatment recommended for SOME patients in selected patient group</td>
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</table>

#### Primary options

» **dexamethasone**: adults: 6 mg orally/intravenously once daily for 7-10 days

OR

» **hydrocortisone**: adults: 50 mg orally/intravenously every 8 hours for 7-10 days

#### Secondary options

» **prednisone**: adults: 40 mg/day orally given in 1-2 divided doses for 7-10 days

OR

» **methylprednisolone**: adults: 32 mg/day orally/intravenously given in 1-2 divided doses for 7-10 days

» The World Health Organization (WHO) strongly recommends systemic corticosteroid therapy (low-dose intravenous or oral dexamethasone or hydrocortisone) for 7 to 10 days in adults with severe COVID-19. This recommendation is based on two meta-analyses that pooled data from eight randomized trials (over 7000 patients), including the UK RECOVERY trial. Moderate-quality evidence suggests that systemic corticosteroids probably reduce 28-day mortality in patients with severe and critical COVID-19. They also probably reduce the need for invasive ventilation. There is no evidence directly comparing dexamethasone and hydrocortisone. The harms of treatment in this context are considered to be minor.
### Acute

is unclear whether these recommendations can be applied to children or those who are immunocompromised.[575] [616] [617] [618]

» [BMJ rapid recommendations: a living WHO guideline on drugs for COVID-19] (https://www.bmj.com/content/370/bmj.m3379)

» In the UK, the National Institute for Health and Care Excellence recommends dexamethasone or hydrocortisone in patients with severe COVID-19 (in line with WHO guidance). The marketing authorizations cover this indication in the UK.[573]


» In Europe, the European Medicines Agency has endorsed the use of dexamethasone for patients with severe disease who require oxygen therapy or mechanical ventilation.[619]

» In the US, the National Institutes of Health guidelines panel recommends dexamethasone, either alone or in combination with remdesivir (see the Emerging section for information on remdesivir), in hospitalized patients who require supplemental oxygen. The panel recommends against using dexamethasone in patients who do not require supplemental oxygen. Alternative corticosteroids may be used in situations where dexamethasone is not available.[3] The Infectious Diseases Society of America supports the use of dexamethasone in hospitalized patients with severe disease.[620]

» Monitor patients for adverse effects (e.g., hyperglycemia, secondary infections, psychiatric effects, reactivation of latent infections) and assess for drug-drug interactions.[3] Follow local policies on gastroprotection during corticosteroid treatment. Clinically significant interactions between remdesivir and corticosteroids are unlikely; however, lopinavir/ritonavir may increase hydrocortisone concentrations.[573]

» Treatment should stop if the person is discharged from hospital before the 10-day course is completed.[573]

<table>
<thead>
<tr>
<th>adjunct</th>
<th>treatment of coinfections</th>
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</table>
Acute

» Treat laboratory-confirmed coinfections (e.g., malaria, tuberculosis, influenza) as appropriate according to local protocols.[2] The treatment of influenza is the same in all patients regardless of SARS-CoV-2 coinfection. Start empiric treatment with oseltamivir in hospitalized patients who are suspected of having either or both infections as soon as possible without waiting for influenza test results. Antiviral therapy can be stopped once influenza has been ruled out.[3]

adjunct antipyretic/analgesic

Treatment recommended for SOME patients in selected patient group

Primary options

» acetaminophen: children: 10-15 mg/kg orally every 4-6 hours when required, maximum 75 mg/kg/day; adults: 325-1000 mg orally (immediate-release) every 4-6 hours when required, maximum 4000 mg/day

OR

» ibuprofen: children 6 months to 11 years of age: 5-10 mg/kg orally every 6-8 hours when required, maximum 40 mg/kg/day; children ≥12 years of age and adults: 200-400 mg orally every 4-6 hours when required, maximum 2400 mg/day

» Acetaminophen or ibuprofen are recommended.[2][596] There is no evidence at present of severe adverse events in COVID-19 patients taking nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, or of effects as a result of the use of NSAIDs on acute healthcare utilization, long-term survival, or quality of life in patients with COVID-19.[584][585][586][587][588][589]

» Ibuprofen should only be taken at the lowest effective dose for the shortest period needed to control symptoms. It is not recommended in pregnant women (especially in the third trimester) or children <6 months of age (age cut-offs vary by country).

adjunct experimental therapies

Treatment recommended for SOME patients in selected patient group

» Consider appropriate experimental or emerging therapies.

» Antiviral therapies will have a greater effect early in the course of the disease, whereas...
**Acute**

- **immunosuppressive/anti-inflammatory therapies** are likely to have a greater effect later in the course of the disease.[3]

  » See the Emerging section for more information.

**adjunct plan for discharge and rehabilitation**

Treatment recommended for SOME patients in selected patient group

» Routinely assess older patients for mobility, functional swallow, cognitive impairment, and mental health concerns, and based on that assessment determine whether the patient is ready for discharge, and whether the patient has any rehabilitation and follow-up requirements.[2]

**adjunct palliative care**

Treatment recommended for SOME patients in selected patient group

» Palliative care interventions should be made accessible at each institution that provides care for patients with COVID-19. Identify whether the patient has an advance care plan and respect the patient’s priorities and preferences when formulating the patient’s care plan.[2] Follow local palliative care guidelines.

**critical COVID-19**

**1st intensive/critical care unit admission**

» Patients with critical disease (i.e., presence of acute respiratory distress syndrome, sepsis, or septic shock) should be admitted or transferred to an intensive/critical care unit under the guidance of a specialist team.[2]

» Discuss the risks, benefits, and potential outcomes of treatment options with patients and their families, and allow them to express preferences about their management. Take their wishes and expectations into account when considering the ceiling of treatment. Use decision support tools if available. Put treatment escalation plans in place, and discuss any existing advance care plans or advance decisions to refuse treatment with patients who have preexisting advanced comorbidities.[574]

» Implement local infection prevention and control procedures when managing patients with COVID-19.

» Pregnant women should be managed by a multidisciplinary team, including obstetric, perinatal, neonatal, and intensive care
specialists, as well as midwifery and mental health and psychosocial support. A woman-centered, respectful, skilled approach to care is recommended. The multidisciplinary team should be organized as soon as possible after maternal hypoxemia occurs in order to assess fetal maturity, disease progression, and the best options for delivery.

Discontinue transmission-based precautions (including isolation) and release patients from the care pathway 10 days after symptom onset plus at least 3 days without fever and respiratory symptoms. The Centers for Disease Control and Prevention (CDC) recommends discontinuing isolation once at least 20 days have passed since symptoms first appeared, and at least 24 hours have passed since last fever without the use of antipyretics, and symptoms have improved, if a symptom-based strategy is used. In asymptomatic people, the CDC recommends discontinuing isolation once at least 20 days have passed since the date of a positive test. Alternatively, it recommends at least two negative reverse-transcription polymerase chain reaction (RT-PCR) tests on respiratory specimens collected 24 hours apart before ending isolation if a test-based strategy is used. A symptom-based strategy is preferred in these patients. Guidance on when to stop isolation depends on local recommendations and may differ between countries. For example, in the UK the isolation period is 14 days from a positive test in hospitalized patients.

plus symptom management and supportive care

Treatment recommended for ALL patients in selected patient group

Consider fluid and electrolyte management, antimicrobial treatment, venous thromboembolism prophylaxis, and symptom management as appropriate. See Severe COVID-19 above for more detailed information.

As with severe disease, guidelines recommend low molecular weight heparin as the preferred option for venous thromboembolism prophylaxis. However, unfractionated heparin is preferred over fondaparinux in critically ill patients if low molecular weight heparin as the preferred option for venous thromboembolism prophylaxis cannot be used. Some guidelines recommend that escalated doses can be considered in critically ill patients. The National Institute for Health and Care Excellence in the UK recommends considering intermediate
doses in patients who are having advanced respiratory support, and the decision should be based on multidisciplinary or senior opinion, or locally agreed protocols. Reassess venous thromboembolism and bleeding risks daily in these patients. There was a slight tendency toward a reduction in the mortality rate among mechanically ventilated patients with COVID-19 receiving full treatment-dose anticoagulation. Dose adjustments may be required in patients with extremes of body weight or renal impairment.

Follow local guidelines for the management of pain, sedation, and delirium. Implement standard interventions to prevent complications associated with critical illness. Consider high-flow nasal oxygen or noninvasive ventilation

Treatment recommended for ALL patients in selected patient group

Consider a trial of high-flow nasal oxygen (HFNO) or noninvasive ventilation (e.g., continuous positive airway pressure [CPAP] or bilevel positive airway pressure [BiPAP]) in selected patients with mild acute respiratory distress syndrome.

Airborne precautions are recommended for these interventions (including bubble CPAP) due to uncertainty about the potential for aerosolization. Patients with hypercapnia, hemodynamic instability, multi-organ failure, or abnormal mental status should generally not receive HFNO, although emerging data suggest that it may be safe in patients with mild to moderate and nonworsening hypercapnia. Patients with hypoxemic respiratory failure and hemodynamic instability, multi-organ failure, or abnormal mental status should not receive these treatments in place of other options such as invasive ventilation.

There is ongoing debate about the optimal mode of respiratory support before mechanical ventilation. NHS England recommends CPAP as the preferred form of noninvasive ventilation in patients with hypoxemic (type 1) respiratory failure. It doesn't advocate the use of HFNO based on a lack of efficacy, oxygen use (HFNO can place a strain on oxygen supplies with the risk of site supply failure), and infection spread. Other guidelines recommend...
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HFNO over noninvasive ventilation, unless HFNO is not available.[3] [596] Despite the trend to avoid HFNO, it has been shown to have a similar risk of aerosol generation to standard oxygen masks.[627]

» Early CPAP may provide a bridge to invasive mechanical ventilation. Reserve the use of BiPAP for patients with hypercapnic acute on chronic ventilatory failure (type 2 respiratory failure).[626]

» Monitor patients closely for acute deterioration. If patients do not improve after a short trial of these interventions, they require urgent endotracheal intubation.[2] [596]

**plus** consider invasive mechanical ventilation

Treatment recommended for ALL patients in selected patient group

» Consider endotracheal intubation and mechanical ventilation in patients who are acutely deteriorating despite advanced oxygen/noninvasive ventilatory support measures.[2] [3]

» Endotracheal intubation should be performed by an experienced provider using airborne precautions.[2] Intubation by video laryngoscopy is recommended if possible.[3] Young children, or adults who are obese or pregnant, may desaturate quickly during intubation and therefore require preoxygenation with 100% fraction of inspired oxygen (FiO₂) for 5 minutes.[2]

» Mechanically ventilated patients with acute respiratory distress syndrome (ARDS) should receive a lung-protective, low tidal volume/low inspiratory pressure ventilation strategy (lower targets are recommended in children). A higher positive end-expiratory pressure (PEEP) strategy is preferred over a lower PEEP strategy in moderate to severe ARDS. However, individualization of PEEP, where the patient is monitored for beneficial or harmful effects and driving pressure during titration with consideration of the risks and benefits of PEEP titration, is recommended.[2] [3] [596] NHS England recommends a low PEEP strategy in patients with normal compliance where recruitment may not be required.[635]

» Although some patients with COVID-19 pneumonia meet the criteria for ARDS, there is some discussion about whether COVID-19 pneumonia is its own specific disease with atypical phenotypes. Anecdotal evidence
suggests that the main characteristic of the atypical presentation is the dissociation between well-preserved lung mechanics and the severity of hypoxemia. However, this approach has been criticized. It has been argued that an evidence-based approach extrapolating data from ARDS not related to COVID-19 is the most reasonable approach for intensive care of COVID-19 patients. As a consequence of this, some clinicians have warned that protocol-driven ventilator use may be causing lung injury in some patients, and that ventilator settings should be based on physiologic findings rather than using standard protocols. High PEEP may have a detrimental effect on patients with normal compliance. PEEP should always be carefully titrated.

Consider prone ventilation in patients with severe ARDS for 12 to 16 hours per day. Pregnant women in the third trimester may benefit from being placed in the lateral decubitus position. Caution is required in children. Longer durations may be feasible in some patients.

Lung recruitment maneuvers are suggested, but staircase recruitment maneuvers are not recommended.

adjunct inhaled pulmonary vasodilator

Treatment recommended for SOME patients in selected patient group

Consider a trial of an inhaled pulmonary vasodilator in adults who have severe acute respiratory distress syndrome and hypoxemia despite optimizing ventilation. Taper off if there is no rapid improvement in oxygenation.

extracorporeal membrane oxygenation

Treatment recommended for SOME patients in selected patient group

Consider extracorporeal membrane oxygenation (ECMO) according to availability and expertise if the above methods fail. ECMO is not suitable for all patients, and only those who meet certain inclusion criteria may be considered for ECMO.

There is insufficient evidence to recommend either for or against the routine use of ECMO.

The estimated 60-day survival rate of ECMO-rescued patients with COVID-19 (31%) was
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similar to that of previous studies of ECMO for severe ARDS.[652]

» An international cohort study of 1035 patients found that both the estimated mortality 90 days after ECMO initiation and mortality in those who achieved a final outcome of death or discharge were <40%, consistent with previously reported survival rates in acute hypoxemic respiratory failure.[653]

» Single-access, dual-stage venovenous ECMO with early extubation appears to be safe and effective in patients with COVID-19 respiratory failure.[654]

adjunct management of sepsis/septic shock

Treatment recommended for SOME patients in selected patient group

» The management of sepsis and septic shock in patients with COVID-19 is beyond the scope of this topic. See the Complications section.

adjunct corticosteroid

Treatment recommended for SOME patients in selected patient group

Primary options

» dexamethasone: adults: 6 mg orally/intravenously once daily for 7-10 days

OR

» hydrocortisone: adults: 50 mg orally/intravenously every 8 hours for 7-10 days


Secondary options

» prednisone: adults: 40 mg/day orally given in 1-2 divided doses for 7-10 days

OR

» methylprednisolone: adults: 32 mg/day orally/intravenously given in 1-2 divided doses for 7-10 days

» The World Health Organization (WHO) strongly recommends systemic corticosteroid therapy (low-dose intravenous or oral dexamethasone...
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or hydrocortisone) for 7 to 10 days in adults with critical COVID-19. This recommendation is based on two meta-analyses that pooled data from eight randomized trials (over 7000 patients), including the UK RECOVERY trial. Moderate-quality evidence suggests that systemic corticosteroids probably reduce 28-day mortality in patients with severe and critical COVID-19. They also probably reduce the need for invasive ventilation. There is no evidence directly comparing dexamethasone and hydrocortisone. The harms of treatment in this context are considered to be minor. It is unclear whether these recommendations can be applied to children or those who are immunocompromised.[57] [61] [62] [63]

» [BMJ rapid recommendations: a living WHO guideline on drugs for COVID-19](https://www.bmj.com/content/370/bmj.m3379)

» In the UK, the National Institute for Health and Care Excellence recommends dexamethasone or hydrocortisone in patients with critical COVID-19 (in line with WHO guidance). The marketing authorizations cover this indication in the UK.[573]


» In Europe, the European Medicines Agency has endorsed the use of dexamethasone for patients with severe disease who require oxygen therapy or mechanical ventilation.[619]

» In the US, the National Institutes of Health guidelines panel recommends using dexamethasone, either alone or in combination with remdesivir (see the Emerging section for information on remdesivir), in hospitalized patients who require high-flow oxygen, noninvasive ventilation, mechanical ventilation, or extracorporeal membrane oxygenation. Alternative corticosteroids may be used in situations where dexamethasone is not available.[3] The Infectious Diseases Society of America supports the use of dexamethasone in hospitalized patients with severe disease.[620]

» Monitor patients for adverse effects (e.g., hyperglycemia, secondary infections, psychiatric effects, reactivation of latent infections) and assess for drug-drug interactions.[3] Follow local policies on gastroprotection during corticosteroid treatment. Clinically significant interactions
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between remdesivir and corticosteroids are unlikely; however, lopinavir/ritonavir may increase hydrocortisone concentrations.\[573\]

> Treatment should stop if the person is discharged from hospital before the 10-day course is completed.\[573\]

**adjunct** treatment of coinfections

Treatment recommended for SOME patients in selected patient group

> Treat laboratory-confirmed coinfections (e.g., malaria, tuberculosis, influenza) as appropriate according to local protocols.\[2\] The treatment of influenza is the same in all patients regardless of SARS-CoV-2 coinfection. Start empiric treatment with oseltamivir in hospitalized patients who are suspected of having either or both infections as soon as possible without waiting for influenza test results. Antiviral therapy can be stopped once influenza has been ruled out.\[3\]

**adjunct** experimental therapies

Treatment recommended for SOME patients in selected patient group

> Consider appropriate experimental or emerging therapies.

> Antiviral therapies will have a greater effect early in the course of the disease, whereas immunosuppressive/anti-inflammatory therapies are likely to have a greater effect later in the course of the disease.\[3\]

> See the Emerging section for more information.

**adjunct** plan for discharge and rehabilitation

Treatment recommended for SOME patients in selected patient group

> Routinely assess intensive care patients for mobility, functional swallow, cognitive impairment, and mental health concerns, and based on that assessment determine whether the patient is ready for discharge, and whether the patient has any rehabilitation and follow-up requirements.\[2\]

**adjunct** palliative care

Treatment recommended for SOME patients in selected patient group

> Palliative care interventions should be made accessible at each institution that provides care for patients with COVID-19. Identify whether the patient has an advance care plan and respect
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<td>the patient’s priorities and preferences when formulating the patient’s care plan. [2] Follow local palliative care guidelines.</td>
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Introduction

Various treatments for COVID-19 are in clinical trials around the world. [Global coronavirus COVID-19 clinical trial tracker] (https://www.covid-trials.org/) There are several treatments being used off-label on a compassionate-use basis, or as part of a clinical trial. [WHO: off-label use of medicines for COVID-19] (https://www.who.int/news-room/commentaries/detail/off-label-use-of-medicines-for-covid-19) It is important to note that there may be serious adverse effects associated with these drugs, and that these adverse effects may overlap with the clinical manifestations of COVID-19. These drugs may also increase the risk of death in an older patient or a patient with an underlying health condition (e.g., drugs that prolong the QT interval may increase the risk of cardiac death).[617] Drug-drug interactions with the patient's existing medication(s), and drug-disease interactions (e.g., impact of inflammation on drug metabolism in COVID-19 patients), must also be considered.[622] International trials to identify treatments that may be beneficial, such as the World Health Organization’s (WHO) Solidarity trial (the world’s largest randomized controlled trial on COVID-19 therapeutics across 30 countries), and the UK’s randomized evaluation of COVID-19 therapy (RECOVERY) trial, are ongoing. [WHO: “Solidarity” clinical trial for COVID-19 treatments] (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov/solidarity-clinical-trial-for-covid-19-treatments) [RECOVERY trial] (https://www.recoverytrial.net/)

Remdesivir

Remdesivir is a broad-spectrum investigational antiviral agent. There are conflicting recommendations across international guidelines about the use of remdesivir, so it is important that you check local guidance and protocols. The WHO recommends against the use of remdesivir in hospitalized patients in addition to standard care, regardless of disease severity. This is a weak or conditional recommendation.[575] [618] The recommendation is based on a systematic review and network meta-analysis of four randomized trials with 7333 hospitalized patients, and included the NIAID-ACTT-1 trial (on which the original US approval of remdesivir was based) and the WHO Solidarity trial. There is currently no evidence that remdesivir improves patient outcomes such as time to clinical improvement, the need for mechanical ventilation, or mortality. However, the meta-analysis did not prove that remdesivir has no benefit.[618] The WHO Solidarity trial found that remdesivir appears to have little or no effect on hospitalized patients, as indicated by overall mortality, initiation of ventilation, and duration of hospital stay.[673] In the US, the National Institutes of Health guidelines panel recommends remdesivir, either alone or in combination with dexamethasone, in hospitalized patients who require supplemental oxygen. The panel also recommends remdesivir, in combination with dexamethasone, in hospitalized patients who require high-flow oxygen, noninvasive ventilation, mechanical ventilation, or extracorporeal membrane oxygenation (ECMO). The panel does not recommend either for or against remdesivir for the treatment of patients with moderate or mild disease as there are insufficient data; however, it does recognize that there may be situations in which a clinician judges that remdesivir is an appropriate treatment for a hospitalized patient with moderate disease (e.g., a person who is at a particularly high risk for clinical deterioration). The recommended treatment course is 5 days or until hospital discharge, whichever comes first. Some experts recommend a 10-day course in patients who have not shown clinical improvement after 5 days.[3] The Infectious Diseases Society of America recommends remdesivir (5 days in patients on oxygen and 10 days in patients on mechanical ventilation or ECMO) over no antiviral treatment in hospitalized patients with severe disease based on moderate-certainty evidence. The panel recommends against the routine use of remdesivir in hospitalized patients who do not require oxygen and have an oxygen saturation >94% on room air, based on very low-certainty evidence.[620] The American College of Physicians recommends the use of remdesivir in hospitalized patients with moderate disease. This recommendation is based on low-certainty evidence that suggests remdesivir may slightly reduce mortality and serious adverse events, reduce time to clinical improvement and recovery, and reduce the need for invasive mechanical ventilation or ECMO compared with standard of care.[674] [675] In the UK and Europe, remdesivir is conditionally approved in adolescents ≥12 years of age and adults with pneumonia who require supplemental oxygen (usually classified as severe disease).[676] However, the European Medicines Agency is reviewing the data from the WHO to see whether any changes are needed to the European marketing authorization, and has recommended a change to the marketing authorization to clarify it should only be used in patients on low- or high-flow oxygen or other noninvasive ventilation at start of treatment.[677] [678] The Food and Drug Administration (FDA) has approved remdesivir for the treatment of COVID-19 in hospitalized children (≥12 years of age and ≥40 kg) and adults. The approval...
Monoclonal antibodies

SARS-CoV-2 monoclonal antibodies have the potential to be used for prophylaxis and treatment of COVID-19. These antibodies bind to the SARS-CoV-2 surface spike protein receptor binding domain, which blocks the binding of the virus to the angiotensin-converting enzyme-2 (ACE2) host cell surface receptor. The combination of casirivimab and imdevimab (formerly known as REGN-COV2) has been issued an emergency-use authorization by the FDA for the treatment of mild to moderate disease in children and adults. The authorization covers patients with positive results of direct SARS-CoV-2 viral testing who are 12 years of age and older weighing at least 40 kg, and who are at high risk for progressing to severe disease and/or hospitalization. This includes patients who are 65 years of age or older, or who have certain chronic medical conditions. The authorization was based on a randomized, double-blind, placebo-controlled trial in nonhospitalized adults with mild to moderate symptoms. The trial found that the monoclonal antibody combination reduced COVID-19-related hospitalization or emergency department visits in patients at high risk for disease progression within 28 days after treatment, when compared with placebo. The study is yet to be published. Casirivimab/imdevimab is not authorized for use in hospitalized patients or those who require oxygen as it has not shown benefit in these patients. Further enrollment of patients requiring high-flow oxygen or mechanical ventilation has been placed on hold due to a potential safety signal and an unfavorable risk/benefit profile at this time. However, enrollment of hospitalized patients requiring either no or low-flow oxygen is being continued. The UK RECOVERY trial is investigating whether adding casirivimab/imdevimab to usual standard of care (versus standard care alone) has any impact on all-cause 28-day mortality. The National Institutes of Health guidelines panel states that there are insufficient data to recommend either for or against the use of casirivimab/imdevimab for the treatment of outpatients with mild to moderate COVID-19, and that it should not be considered the standard of care. Patients at higher risk for disease progression should be prioritized for treatment, and patients who are hospitalized should not receive casirivimab/imdevimab outside of a clinical trial. The treatment must be administered as an intravenous infusion. The combination of LY-CoV016 and LY-CoV555 (bamlanivimab) is currently undergoing a randomized, placebo-controlled phase 2 trial in patients with mild to moderate disease. Interim results showed that the combination reduced viral load at day 11, severity of symptoms, and hospitalizations. The FDA has issued an emergency-use authorization for bamlanivimab for the treatment of mild to moderate disease in children and adults. The authorization covers patients with positive results of direct SARS-CoV-2 viral testing who are 12 years of age and older weighing at least 40 kg, and who are at high risk for progressing to severe disease and/or hospitalization. This includes patients who are 65 years of age or older, or who have certain chronic medical conditions. Another trial that was investigating the efficacy of bamlanivimab in hospitalized patients has been stopped based on trial data that suggests bamlanivimab is unlikely to help hospitalized patients recover from advanced disease. Other studies of bamlanivimab in recently diagnosed mild to moderate disease, recently diagnosed disease in the ambulatory setting, and prevention of disease in residents and staff at long-term care facilities remain ongoing. The National Institutes of Health guidelines panel states that there are insufficient data to recommend either for or against the use of bamlanivimab for the treatment of outpatients with mild to moderate COVID-19, and that it should not be considered the standard of care. Patients at higher risk for disease progression should be prioritized for treatment, and patients who are hospitalized should not receive bamlanivimab outside of a clinical trial. The Infectious Diseases Society of America recommends against the routine use of bamlanivimab in ambulatory patients; however, it states that bamlanivimab may be a reasonable treatment option in patients at increased risk. The combination AZD7442 (AZD8895 and AZD1061) is currently in phase 2 trials and is set to advance to phase 3 trials. This combination of long-acting antibodies derived from convalescent
patients has been engineered to extend the half-life of the antibodies and increase protection to 6 to 12 months after administration.\[688\]

**Convalescent plasma**

Clinical trials to determine the safety and efficacy of convalescent plasma that contains antibodies to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in patients with COVID-19 are ongoing. In the US, the FDA has issued an emergency-use authorization for convalescent plasma for the treatment of COVID-19 in hospitalized patients.\[689\] This follows publication of a preprint (not peer reviewed) of an open-label, multicenter, expanded access program study of over 35,000 patients that found convalescent plasma lowered 7-day mortality by 9% in hospitalized patients when given within 3 days of diagnosis, and by 12% when given 4 or more days later.\[690\] A meta-analysis and systematic review with a total of 5444 patients found that the use of convalescent plasma reduced mortality, increased viral clearance, and resulted in clinical improvement in patients with COVID-19; however, the evidence is of low quality and further randomized controlled trials are required.\[691\] An open-label, randomized controlled trial in hospitalized patients with moderate disease found that convalescent plasma was not associated with a reduction in progression to severe disease or all-cause mortality.\[692\] The authors of a Cochrane review were uncertain as to whether convalescent plasma is beneficial for hospitalized patients with COVID-19. The currently available evidence on the safety and efficacy of convalescent plasma for the treatment of hospitalized patients is of low or very low certainty.\[693\] The National Institutes of Health guidelines panel says that there is currently insufficient evidence to recommend either for or against the use of convalescent plasma for the treatment of COVID-19.\[3\] The Infectious Diseases Society of America recommends convalescent plasma only in the context of a clinical trial.\[620\] The UK RECOVERY trial is currently investigating whether convalescent plasma is effective in the treatment of COVID-19.

**Baricitinib**

Baricitinib, an oral Janus kinase inhibitor, may prevent the dysregulated production of proinflammatory cytokines observed in patients with severe/critical COVID-19. The FDA has issued an emergency-use authorization for baricitinib in combination with remdesivir for the treatment of suspected or confirmed COVID-19 in hospitalized adults and children ages 2 years and older who require supplemental oxygen, invasive mechanical ventilation, or extracorporeal membrane oxygenation.\[694\] The authorization is based on a randomized, double-blind, placebo-controlled trial that found baricitinib plus remdesivir was shown to reduce time to recovery (defined as either being discharged from the hospital, or being hospitalized but not requiring supplemental oxygen and no longer requiring ongoing medical care) within 29 days after initiating treatment compared with patients who received placebo plus remdesivir. The median time to recovery was 7 days for baricitinib plus remdesivir and 8 days for placebo plus remdesivir.\[695\] The National Institutes of Health guidelines panel states that there are insufficient data to recommend either for or against the use of baricitinib in combination with remdesivir for the treatment of hospitalized patients in cases where corticosteroids can be used instead. In rare cases where corticosteroids cannot be used, the panel recommends baricitinib in combination with remdesivir for the treatment of hospitalized, nonintubated patients who require oxygen supplementation. The panel recommends against the use of baricitinib without remdesivir. There is insufficient data to recommend either for or against the use of baricitinib in combination with corticosteroids.\[3\]

**Hydroxychloroquine/chloroquine**

Hydroxychloroquine and chloroquine are oral drugs that are indicated for the prophylaxis and treatment of malaria, as well as the treatment of some autoimmune conditions. Both drugs show in vitro activity against SARS-CoV-2; however, hydroxychloroquine has been used more commonly in trials due to its better adverse-effect profile.\[696\] \[697\] Initial data from clinical trials of hydroxychloroquine seemed promising.\[698\] \[699\] \[700\] However, a living systematic review of current evidence (as of 21 September) concludes that there is low-strength evidence from trials and cohort studies that hydroxychloroquine has no positive effect on all-cause mortality or the need for mechanical ventilation. Trials show low strength of evidence for no positive effect on intubation or death and discharge from the hospital, whereas evidence from cohort studies about these outcomes remains insufficient. Data are insufficiently strong to support a treatment benefit of hydroxychloroquine for other outcomes (e.g., intensive care unit admission, symptom resolution). In trials where hydroxychloroquine is initiated in the outpatient setting, there is low strength of evidence that it reduces hospitalization; however, there is insufficient evidence from cohort studies.\[701\] \[702\] A preprint
meta-analysis found that early use of hydroxychloroquine in nonhospitalized patients reduced the risk of infection, hospitalization, and death (grouped together into a composite outcome—a limitation of the study) by 24%, with no serious adverse cardiac events reported.[703] A systematic review of 43 mainly retrospective or prospective observational preprint studies also found it is effective when used early in the outpatient setting.[704] Hydroxychloroquine is in trials for the prevention of COVID-19 (mainly in healthcare workers). A randomized, double-blind, placebo-controlled trial with 132 healthcare workers found that there was no significant difference in infection rates in participants receiving daily hydroxychloroquine for 8 weeks compared with placebo, and mild adverse effects were more common in the hydroxychloroquine arm. However, this trial was terminated early and may have been underpowered to detect a clinically important difference.[705] Post-exposure prophylaxis with hydroxychloroquine has not been shown to be effective in other trials.[706] [707] The WHO and the National Institutes of Health have prematurely discontinued their clinical trials of hydroxychloroquine citing a lack of efficacy. The WHO Solidarity trial found that hydroxychloroquine appears to have little or no effect on hospitalized patients, as indicated by overall mortality, initiation of ventilation, and duration of hospital stay.[708] Results from the UK RECOVERY trial found that hydroxychloroquine does not reduce the risk of death at 28 days compared with usual care.[709] The WHO strongly recommends against the use of hydroxychloroquine or chloroquine, regardless of disease severity, based on low- to moderate-certainty evidence.[575] [618] The National Institutes of Health guidelines panel recommends against the use of hydroxychloroquine or chloroquine for the treatment of COVID-19 in hospitalized patients. The panel recommends against the use of both drugs in nonhospitalized patients except in the context of a clinical trial.[3] The Infectious Diseases Society of America strongly recommends against the use of hydroxychloroquine or chloroquine (with or without azithromycin) for the treatment of COVID-19 in hospitalized patients based on moderate-quality evidence.[620] The FDA has revoked its emergency-use authorization for hydroxychloroquine and chloroquine as it believes the potential benefits no longer outweigh the known and potential risks.[609] If used, hydroxychloroquine and chloroquine should be used with caution in patients with preexisting cardiovascular disease due to the risk of arrhythmias, and a baseline echocardiogram is recommended before treatment, particularly in patients who are critically ill.[710] [711] Caution is recommended when using these drugs with other drugs that prolong the QT interval (e.g., azithromycin) due to an increased risk of QT interval prolongation and/or ventricular tachycardia (including Torsades de Pointes).[712] [713] [714] A phase 1 trial of inhaled liposomal hydroxychloroquine has been approved.[715]

**Lopinavir/ritonavir**

An oral antiretroviral protease inhibitor currently approved for the treatment of HIV infection. Results from the UK RECOVERY trial found that there is no beneficial effect of lopinavir/ritonavir in hospitalized patients with COVID-19. There was no significant difference in 28-day mortality, risk of progression to mechanical ventilation or death, or duration of hospital stay between the two treatment arms (lopinavir/ritonavir versus usual care alone).[716] The WHO Solidarity trial found that lopinavir/ritonavir appears to have little or no effect on hospitalized patients, as indicated by overall mortality, initiation of ventilation, and duration of hospital stay.[708] A systematic review and meta-analysis found that lopinavir/ritonavir had no significant advantage in efficacy over standard care, no antivirals, or other antiviral treatments.[717] The WHO strongly recommends against the use of lopinavir/ritonavir, regardless of disease severity, based on low- to moderate-certainty evidence.[575] [618] The National Institutes of Health guidelines panel recommends against the use of lopinavir/ritonavir for the treatment of COVID-19 except in the context of a clinical trial.[3] The Infectious Diseases Society of America recommends against the use of lopinavir/ritonavir based on moderate-certainty evidence.[620] Lopinavir/ritonavir causes QT interval prolongation and may increase the risk of bradycardia, especially in older, critically ill patients.[718]

**Intravenous immune globulin**

Intravenous immune globulin (IVIG) is being trialed in some patients with COVID-19.[45] [719] A retrospective study of 58 patients with severe COVID-19 found that IVIG, when used as an adjuvant treatment within 48 hours of admission, may reduce the use of mechanical ventilation, reduce hospital/ intensive care unit stay, and reduce 28-day mortality; however, this study had several limitations.[720] There is currently insufficient evidence to recommend IVIG for the treatment of COVID-19.[721] The National Institutes of Health guidelines panel recommends against the use of non-SARS-CoV-2-specific IVIG for the treatment of COVID-19 except in the context of a clinical trial.[3]
Interleukin-6 (IL-6) inhibitors

IL-6 inhibitors (e.g., tocilizumab, siltuximab) are being trialed in COVID-19 patients for the treatment of virus-induced cytokine release syndrome. These drugs are already approved in some countries for other indications. A living systematic review and meta-analysis found that (as of 8 October 2020) there is moderate-certainty evidence that tocilizumab reduces the risk of mechanical ventilation in hospitalized patients. Low-certainty evidence from cohort studies suggests an association between tocilizumab and lower mortality.[722] The randomized controlled phase 3 EMPACTA trial found that tocilizumab reduced the need for mechanical ventilation in hospitalized patients compared with placebo, although there was no statistical difference in mortality between the two arms.[723] However, the randomized controlled phase 3 COVACTA trial failed to meet its primary end point of clinical status, and found that tocilizumab did not improve mortality.[724] Full results of both trials are yet to be published. Other randomized trials also give conflicting results.[725] The National Institutes of Health guidelines panel recommends against the use of IL-6 inhibitors for the treatment of COVID-19 except in the context of a clinical trial.[3] The Infectious Diseases Society of America recommends against the routine use of tocilizumab in hospitalized patients based on low-certainty evidence.[620] In the UK, patients are eligible for tocilizumab if they are admitted to the intensive care unit with severe pneumonia requiring respiratory support, and infection is confirmed by microbiological testing or where a multidisciplinary team has a high level of confidence that the clinical and radiologic features suggest that COVID-19 is the most likely diagnosis. In addition to this, the patient must not meet specific exclusion criteria for treatment.[729] The UK RECOVERY trial is currently investigating whether tocilizumab is effective in the treatment of COVID-19.

Anakinra

Anakinra, an interleukin-1 inhibitor, is being trialed in COVID-19 patients for the treatment of virus-induced cytokine release syndrome. It is already approved in some countries for other indications. Addition of high-dose intravenous anakinra to noninvasive ventilation and standard care (which included hydroxychloroquine and lopinavir/ritonavir) in COVID-19 patients with moderate to severe acute respiratory distress syndrome and hyperinflammation was associated with a higher survival rate at 21 days in a small retrospective study.[730] A small prospective cohort study found that anakinra significantly reduced the need for invasive mechanical ventilation and mortality in patients with severe disease.[731] A small retrospective case series found that anakinra could be beneficial in patients with cytokine release syndrome when initiated early after the onset of acute hypoxic respiratory failure.[732] A phase 3 trial comparing anakinra with optimized standard of care in hospitalized patients has been suspended due to excess mortality in the intervention arm.[733] The National Institutes of Health guidelines panel states that there is currently insufficient evidence to recommend either for or against the use of anakinra for the treatment of COVID-19.[3] The National Institute for Health and Care Excellence in the UK states that there is no evidence available to determine whether anakinra is effective, safe, or cost-effective for treating adults and children with secondary hemophagocytic lymphohistiocytosis triggered by SARS-CoV-2 or a similar coronavirus.[734]

Antigranulocyte–macrophage colony-stimulating factor (GM-CSF) monoclonal antibodies

Mavrilimumab was associated with improved clinical outcomes compared with standard care in nonmechanically ventilated patients with severe disease and systemic hyperinflammation in a single-center prospective cohort study.[735] Lenzilumab was associated with a reduction in the relative risk of progression to invasive mechanical ventilation and/or death in high-risk COVID-19 patients with severe pneumonia compared with a matched control cohort of patients who received standard care alone in a small study of 39 patients.[736] [737]

Tumor necrosis factor (TNF)-alpha inhibitors

A trial has been launched in the UK to investigate whether adalimumab is effective for treating patients in the community, including care homes. The trial will test two dose levels of adalimumab, and patients will be followed up for 4 months. The trial comes after a recent study reported that TNF inhibitors were associated with a decreased odds of hospitalization in people with rheumatic disease and COVID-19.[738]

Stem cell therapy
Stem cell therapy is being investigated to treat patients with COVID-19 in clinical trials. It is thought that mesenchymal stem cells can reduce the pathologic changes that occur in the lungs, and inhibit the cell-mediated immune inflammatory response.[739] Remestemcel-L (ex vivo cultured adult human mesenchymal stem cells from the bone marrow of healthy adult donors) is currently in phase 3 trials for the treatment of moderate to severe acute respiratory distress syndrome in COVID-19 patients, and has been granted fast-track designation by the FDA for this indication.[740] The National Institutes of Health guidelines panel recommends against the use of mesenchymal stem cells for the treatment of COVID-19 except in the context of a clinical trial.[3] Adipose-derived mesenchymal stem cells have been approved by the FDA for the treatment of severe COVID-19.

**Granulocyte colony-stimulating factor (G-CSF)**

Recombinant G-CSF plus usual care did not accelerate clinical improvement compared with usual care alone according to preliminary findings from a randomized clinical trial in patients with lymphopenia and no comorbidities. Larger studies are needed to determine whether G-CSF, which increases peripheral blood leukocyte and lymphocyte cell counts, is beneficial in COVID-19 patients.[741]

**Bacille Calmette-Guerin (BCG) vaccine**

The BCG vaccine is being trialed in some countries for the prevention of COVID-19, including in healthcare workers. There is some evidence that BCG vaccination prevents other respiratory tract infections in children and older people mediated by induction of innate immune memory.[742] However, there is no evidence to support its use in COVID-19, and the WHO does not recommend it for the prevention of COVID-19.[743]

**Bemcentinib**

An experimental small molecule that inhibits AXL kinase. Bemcentinib has previously demonstrated a role in the treatment of cancer, but has also been reported to have antiviral activity in preclinical models, including activity against SARS-CoV-2. It was the first candidate to be selected as part of the UK’s Accelerating COVID-19 Research and Development (ACCORD) study.[744] The study has stopped recruiting new patients into the trial due to the reduction of new COVID-19 cases in the UK. Patients already recruited will continue on treatment as per the study protocol.

**Angiotensin-II receptor antagonists**

Angiotensin-II receptor antagonists such as losartan are being investigated as a potential treatment because it is thought that the angiotensin-converting enzyme-2 (ACE2) receptor is the main binding site for the virus.[745] [746] [747] However, some experts believe that these drugs may worsen COVID-19 due to overexpression of ACE2 in people taking these drugs.

**Angiotensin-II receptor agonists**

C21, a first-in-class oral low molecular weight angiotensin-II receptor agonist, demonstrated efficacy in a randomized, double-blind, placebo-controlled phase 2 trial. C21 reduced the risk of needing oxygen or mechanical ventilation in hospitalized patients compared with placebo.[748] [749]

**Interferons**

A randomized, placebo-controlled, phase 2 study found that nebulized interferon beta-1a was associated with a higher odds of clinical improvement and more rapid recovery.[750] The WHO Solidarity trial found that interferon beta-1a appears to have little or no effect on hospitalized patients, as indicated by overall mortality, initiation of ventilation, and duration of hospital stay.[708] Triple therapy with interferon beta-1b, lopinavir/ritonavir, and ribavirin has been tested in hospitalized COVID-19 patients in a small open-label randomized phase 2 trial. Patients who received triple therapy had a significantly shorter median time to a negative nasopharyngeal swab result compared with the control group (lopinavir/ritonavir only). Patients had mild to moderate disease at the time of enrolment.[751] A phase 2 trial found that peginterferon lambda reduced viral load and increased the number of participants with a negative nasopharyngeal swab at day 7 in outpatients with mild to moderate disease compared with placebo.[752] [753] Clinical trials of inhaled
remdesivir, and remdesivir plus interferon beta-1a, have started. The National Institutes of Health guidelines panel recommends against the use of interferons for the treatment of severe or critically ill patients, except in the context of a clinical trial.

**Antibiotics**

The PRINCIPLE trial in the UK is currently evaluating three treatment strategies in older people (people ages over 65 years, or people ages over 50 years with an underlying health condition): usual care alone; usual care plus azithromycin; and usual care plus doxycycline. The UK RECOVERY trial found that azithromycin showed no significant clinical benefit (i.e., length of hospital stay, need for invasive mechanical ventilation, 28-day mortality) in hospitalized patients compared with usual standard care alone. The UK Medicines and Healthcare products Regulatory Agency recommends that azithromycin should not be used in the management of confirmed or suspected COVID-19 in hospitalized patients unless there are additional indications for which its use remains appropriate.

**Ivermectin**

Ivermectin, a broad-spectrum antiparasitic agent, has been shown to be effective against SARS-CoV-2 in vitro. It is unclear whether the doses necessary to achieve antiviral activity against SARS-CoV-2 are attainable in humans. Numerous registered clinical studies of ivermectin, either alone or in combination with other drugs (e.g., doxycycline, hydroxychloroquine), are ongoing in many countries for the treatment or prevention of COVID-19. Further research in randomized controlled trials is necessary. A systematic review and meta-analysis found that adding ivermectin to usual care led to significant clinical improvement and a significant reduction in all-cause mortality compared with usual care; however, the quality of evidence was very low. The National Institutes of Health guidelines panel recommends against the use of ivermectin for the treatment of COVID-19 except in the context of a clinical trial.

**Favipiravir**

A meta-analysis found that there was significant clinical and radiologic improvement following treatment with favipiravir compared with standard of care.

**Colchicine**

Colchicine, an anti-inflammatory agent that is used for the management of gout and other inflammatory conditions, is being tested in various clinical trials. The UK RECOVERY trial is currently investigating whether colchicine is effective in the treatment of COVID-19. The main outcome the trial will assess is mortality after 28 days. Other outcomes include the impact on hospital stay and the need for ventilation.

**Aspirin**

Although it is not currently recommended, aspirin may be effective for the prevention of blood clots in patients with COVID-19. The UK RECOVERY trial is currently investigating whether aspirin plus usual standard of care reduces mortality at 28 days, length of hospital stay, or the need for ventilation in hospitalized patients with COVID-19 compared with standard of care alone.

**Vitamin C**

Vitamin C supplementation has shown promise in the treatment of viral infections. High-dose intravenous vitamin C is being trialed in some centers for the treatment of severe COVID-19. There is no evidence to support or refute the use of vitamin C in the treatment of patients with COVID-19; however, a substantial number of trials are ongoing. A pilot randomized controlled trial found high-dose intravenous vitamin C may show potential benefit in improving oxygenation and reducing mortality in critically ill patients; however, the trial was underpowered. The National Institutes of Health guidelines panel states that there is insufficient data to recommend either for or against vitamin C for the treatment of COVID-19 in noncritically ill or critically ill patients.

**Vitamin D**

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Vitamin D supplementation has been associated with a reduced risk of acute respiratory infections such as influenza.[767] [768] [769] [770] Vitamin D is being trialed in patients with COVID-19.[771] [772] However, there is no evidence to recommend vitamin D for the prophylaxis or treatment of COVID-19 as yet.[773] A pilot randomized controlled trial found that high-dose calcifediol, a vitamin D3 analog, significantly reduced the need for intensive care unit treatment in hospitalized patients, and may improve clinical outcomes.[774] The UK National Institute for Health and Care Excellence recommends vitamin D supplementation in adults (including pregnant and breastfeeding women), young people, and children over 4 years of age between October and early March (and at other times of the year if at risk of vitamin D deficiency) to maintain bone and muscle health. However, it does not recommend supplementation to solely prevent or treat COVID-19, except as part of a clinical trial.[775] The National Institutes of Health guidelines panel states that there is insufficient data to recommend either for or against vitamin D.[3]

Probiotics

There is emerging evidence that gut dysbiosis may have a role in the pathogenesis of COVID-19.[335] [336] [337] Probiotics may represent a complementary approach for the prevention or treatment of mucosal damage or inflammation through the modulation of gut microbiota; however, further research is required.[776]

Traditional Chinese medicine

Traditional Chinese medicine is being used in patients with COVID-19 in China according to local guidelines and as part of clinical trials.[777] A meta-analysis found that Chinese medicine combined with conventional treatment significantly improved clinical efficacy compared with conventional treatment alone; however, high-quality, multiple-center, large-sample randomized controlled trials are needed.[778]

Fluvoxamine

A selective serotonin-reuptake inhibitor with a strong affinity for the sigma-1 receptor. Sigma-1 agonism is a potential mechanism for immune modulation. Previous studies have shown that fluvoxamine reduces the damaging aspects of the inflammatory response during sepsis. A double-blind, randomized, preliminary trial of fluvoxamine versus placebo in adult outpatients with symptomatic COVID-19 found that patients treated with fluvoxamine had a lower likelihood of deterioration over 15 days. However, the study was limited by sample size and short follow-up duration.[779]

Hyperbaric oxygen

Preliminary evidence suggests that hyperbaric oxygen treatment has been successfully used to treat deteriorating, severely hypoxemic patients with severe COVID-19.[780] [781] Clinical trials are currently recruiting.[782] [783]

Nitric oxide

Studies indicate that nitric oxide may help to reduce respiratory tract infection by inactivating viruses and inhibiting their replication in epithelial cells.[784] The FDA has approved an investigational drug application for inhaled nitric oxide to be studied in a phase 3 study of up to 500 patients with COVID-19. Other studies are currently recruiting.

Aviptadil

A synthetic form of vasoactive intestinal peptide (also known as RLF-100) has been granted an expanded access protocol (which makes the treatment available to patients who have exhausted approved therapies and who are not eligible for the current clinical trial of aviptadil) and fast-track designation by the FDA for the treatment of respiratory failure in patients with COVID-19. Intravenous and inhaled formulations are currently in phase 2 and 3 clinical trials in the US.[785] [786] The manufacturer has requested emergency-use authorization from the FDA for the treatment of patients with critical disease and respiratory failure who have exhausted approved therapies, based on the results of a small case-control study.[787]

Icatibant
A selective bradykinin B2 receptor antagonist. A small exploratory case-control study of 9 people found an association between the administration of icatibant and improved oxygenation, suggesting that administration in the early stages of disease when patients are hypoxic may be beneficial. Treatment strategies that target the kallikrein-kinin system require further investigation in randomized trials for patients with COVID-19.[788]

**Tradipitant**

A neurokinin 1 antagonist that is being trialed for the treatment of neurogenic inflammation of the lung secondary to SARS-CoV-2 infection. Interim analysis of the ODYSSEY study found that hospitalized patients improved sooner when treated with tradipitant compared with placebo. The trial is ongoing.[789] [790]

### Primary prevention

**Infection prevention and control for healthcare professionals**

- Always consult local infection prevention and control protocols; only basic principles are detailed here.
- Immediately isolate all suspected or confirmed cases in an area that is separate from other patients. Place patients in adequately ventilated single rooms if possible. When single rooms are not available, place all cases together in the same room and ensure there is at least 3 feet (1 meter) between patients.[338]
- Implement standard precautions at all times:[338]
  - Practice hand and respiratory hygiene
  - Give patients a medical mask to wear
  - Wear appropriate personal protective equipment
  - Practice safe waste management and environmental cleaning.
- Implement additional contact and droplet precautions before entering a room where cases are admitted:[338]
  - Wear a medical mask, gloves, an appropriate gown, and eye/facial protection (e.g., goggles or a face shield)
  - Use single-use or disposable equipment.
- Implement airborne precautions when performing aerosol-generating procedures, including placing patients in a negative pressure room.[338]
  - Some countries and organizations recommend airborne precautions for any situation involving the care of a COVID-19 patient.
- All specimens collected for laboratory investigations should be regarded as potentially infectious.[338]
- Appropriate personal protective equipment gives healthcare workers a high level of protection against COVID-19. A cross-sectional study of 420 healthcare workers deployed to Wuhan with appropriate personal protective equipment tested negative for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) on molecular and serologic testing when they returned home, despite all participants having direct contact with COVID-19 patients and performing at least one aerosol-generating procedure.[339] Standard surgical masks are as effective as respirator masks for preventing infection of healthcare workers in outbreaks of viral respiratory illnesses such as influenza, but it is unknown whether this applies to COVID-19.[340]
- Detailed infection prevention and control guidance is available:
  - [WHO: infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed](https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC-2020.4)
Coronavirus disease 2019 (COVID-19) 

Management

Telehealth for primary care physicians

- It is important that primary care physicians avoid in-person assessment of patients with suspected COVID-19 in primary care when possible to avoid infection.[341] Most patients can be managed remotely by telephone or video consultations. Algorithms for dealing with these patients are available:

  - [BMJ: covid-19 – a remote assessment in primary care](https://www.bmj.com/content/368/bmj.m1182)

General prevention measures for the general public

- People should be advised to:[342] [343]

  - Wash hands often with soap and water for at least 20 seconds or an alcohol-based hand sanitizer (that contains at least 60% alcohol), especially after being in a public place, blowing their nose, or coughing/sneezing. Avoid touching the eyes, nose, and mouth with unwashed hands
  - Avoid close contact with people (i.e., maintain a distance of at least 3 feet [1 meter]) including shaking hands, particularly those who are sick, have a fever, or are coughing or sneezing. Avoid going to crowded places. It is important to note that recommended distances differ between countries (for example, 6 feet [2 meters] is recommended in the US and UK) and you should consult local guidance. However, there is no evidence to support a distance of 6 feet (2 meters)[344]
  - Practice respiratory hygiene (i.e., cover mouth and nose when coughing or sneezing, discard tissue immediately in a closed bin, and wash hands)
  - Seek medical care early if they have a fever, cough, and difficulty breathing, and share their previous travel and contact history (travelers or suspected/confirmed cases) with their healthcare provider
  - Stay at home and self-isolate if they are sick, even with mild symptoms, until they recover (except to get medical care)
  - Clean and disinfect frequently touched surfaces daily (e.g., light switches, door knobs, countertops, handles, phones).

- [BMJ Learning: Covid-19 – handwashing technique and PPE videos](https://www.youtube.com/playlist?list=PLVnZu1tiqPoTtOlGGdCiRjJtS6ep9vSVxE)
- [Centre for Evidence-Based Medicine: what is the evidence to support the 2-metre social distancing rule to reduce COVID-19 transmission?](https://www.cebm.net/covid-19/what-is-the-evidence-to-support-the-2-metre-social-distancing-rule-to-reduce-covid-19-transmission/)

Face masks in community settings

- Recommendations on the use of face masks in community settings vary between countries.[345] It is mandatory to wear a mask in public in certain countries or in certain situations, and masks may be worn in some countries according to local cultural habits. Consult local public health guidance for more information.
Coronavirus disease 2019 (COVID-19) Management

- There is no high-quality or direct scientific evidence to support the widespread use of masks by healthy people in the community setting, and there are risks and benefits that must be considered. Data on effectiveness is based on limited and inconsistent observational and epidemiologic studies.[96] The first randomized controlled trial to investigate the efficacy of masks in the community (in addition to other public health measures such as social distancing) found that the recommendation to wear surgical masks when outside the home among others did not reduce incident SARS-CoV-2 infection compared with no mask recommendation. However, the study did not assess whether masks could decrease disease transmission from mask wearers to others.[346] A Cochrane review found that wearing a mask may make little to no difference in how many people caught influenza-like illnesses; however, this is based on low-certainty evidence, and does not include results of studies from the current COVID-19 pandemic.[347] Evidence for mask effectiveness for respiratory tract infection prevention is stronger in healthcare settings compared with community settings; direct evidence on comparative effectiveness in SARS-CoV-2 infection is lacking.[348]

- Despite the lack of good-quality evidence, the World Health Organization (WHO) advises that in areas of known or suspected community or cluster transmission, people should wear a nonmedical mask in the following circumstances: indoor or outdoor settings where physical distancing cannot be maintained; indoor settings with inadequate ventilation, regardless of whether physical distancing can be maintained; and in situations when physical distancing cannot be maintained and the person has a higher risk of severe complications (e.g., older age, underlying condition). Caregivers and those living with suspected or confirmed cases should wear a medical mask when in the same room, regardless of whether the case has symptoms. Children ages up to 5 years should not wear masks for source control. A risk-based approach is recommended for children ages 6 to 11 years. Special considerations are required for immunocompromised children, or children with certain diseases, developmental disorders, or disabilities. The WHO advises that people should not wear masks during vigorous-intensity physical activity. Use of a mask alone is insufficient to provide adequate protection, and they should be used in conjunction with other infection prevention and control measures such as frequent hand hygiene and social distancing.[96]

- Potential harms and disadvantages of wearing masks include: potential increased risk of self-contamination due to manipulation of face mask and touching face/eyes, or when nonmedical masks are not changed when wet or soiled; headache and/or breathing difficulties; facial skin lesions, irritant dermatitis, or worsening acne; discomfort; difficulty communicating; social and psychological acceptance; false sense of security; poor compliance; waste management issues; and difficulties for patients with chronic respiratory conditions or breathing problems.[96] Masks may also create a humid habitat where the virus can remain active and this may increase viral load in the respiratory tract; deeper breathing caused by wearing a mask may push the virus deeper into the lungs.[349]

- Cloth masks have limited efficacy in preventing viral transmission compared with medical-grade masks.[350] Efficacy depends on the type of material used, the number of layers, the degree of moisture in the mask, and the fitting of the mask on the face. In a study comparing the use of cloth masks to surgical masks in healthcare workers, the rates of all infection outcomes were highest in the cloth mask arm, with the rate of influenza-like illness statistically significantly higher in this group. Moisture retention, reuse of cloth masks, and poor filtration may result in increased risk of infection.[351]

- [BMJ: facemasks for the prevention of infection in healthcare and community settings] (https://www.bmj.com/content/350/bmj.h694)

Alcohol-based hand sanitizers

- The Centers for Disease Control and Prevention has issued a warning about alcohol-based sanitizers containing methanol (which may be labeled as containing ethanol). Methanol poisoning should be considered in patients who present with relevant signs and symptoms (e.g., headache, impaired vision, nausea/vomiting, abdominal pain, loss of coordination, decreased level of consciousness) who report ingestion of hand sanitizer or frequent repeated topical use. Cases of permanent blindness and death have been reported.[352]

- Frequent use of hand sanitizers may result in antimicrobial resistance. Accidental ingestion, especially by children, has been reported.[353]
Coronavirus disease 2019 (COVID-19) Management

- Many countries have implemented travel-related control measures including complete closure of borders, partial travel restrictions, entry or exit screening, and/or quarantine of travelers. Overall, low to very low evidence suggests that travel-related control measures may help to limit the spread of infection across national borders. Cross-border travel restrictions are likely to be more effective than entry and exit screening, and screening is likely to be more effective in combination with other measures (e.g., quarantine, observation).[354]

- Entry/exit screening: people traveling from areas with a high risk of infection may be screened using questionnaires about their travel, contact with ill persons, symptoms of infection, and/or measurement of their temperature. Low-certainty evidence suggests that screening at travel hubs may slightly slow the importation of infected cases; however, the evidence base comes from two mathematical model studies and is limited by their assumptions. Evidence suggests that one-time screening in apparently healthy people may miss between 40% and 100% of people who are infected, although the certainty of this ranges from very low to moderate. In very low-prevalence settings, screening for symptoms or temperature may result in few false negatives and many true negatives, despite low overall accuracy. Repeated screenings may result in more cases being identified eventually and reduced harm from false reassurance.[355] Entry screening at three major US airports found a low yield of laboratory-diagnosed cases (one case per 85,000 travelers) between January and September 2020.[356]

- Quarantine: enforced quarantine is being used to isolate easily identifiable cohorts of people at potential risk of recent exposure. Despite limited evidence, a Cochrane review found quarantine to be important in reducing the number of people infected and deaths, especially when started earlier and when used in combination with other prevention and control measures. However, the current evidence is limited because most studies are based on mathematical modeling studies that make assumptions on important model parameters.[357] The psychosocial effects of enforced quarantine may have long-lasting repercussions.[358] [359]


Social distancing

- Many countries have implemented mandatory social distancing measures in order to reduce and delay transmission (e.g., city lockdowns, stay-at-home orders, curfews, nonessential business closures, bans on gatherings, school and university closures, travel restrictions and bans, remote working, quarantine of exposed people).

- Although the evidence for social distancing for COVID-19 is limited, it is emerging, and the best available evidence appears to support social distancing measures to reduce the transmission and delay spread. The timing and duration of these measures appears to be critical.[360] [361]

- Researchers in Singapore found that social distancing measures (isolation of infected individuals and family quarantine, school closures, and workplace distancing) significantly decreased the number of infections in simulation models.[362]

- Harms must also be considered. Public health policies mostly rely on models and these models often ignore potential harms including excess death and inequalities arising from economic damage, negative health effects, and effects on vulnerable populations.[363] Negative consequences of community-based mass quarantine include psychological distress, food insecurity, economic challenges, diminished healthcare access, heightened communication inequalities, alternative delivery of education, and gender-based violence.[364]

Shielding extremely vulnerable people

- Shielding is a measure used to protect vulnerable people (including children) who are at very high risk of severe illness from COVID-19 because they have an underlying health condition. Shielding involves minimizing all interactions between those who are extremely vulnerable and other people to protect them from coming into contact with the virus.

- Extremely vulnerable groups include:[365]
• Solid organ transplant recipients
• People with specific cancers
• People with severe respiratory conditions (e.g., cystic fibrosis, severe asthma, or severe COPD)
• People with rare diseases that significantly increase the risk of infections (e.g., homozygous sickle cell disease, severe combined immunodeficiency)
• People on immunosuppression therapies sufficient to significantly increase the risk of infection
• People with spleen problems (e.g., prior splenectomy)
• Adults with Down syndrome
• Adults on dialysis or with chronic kidney disease
• Women who are pregnant with significant heart disease (congenital or acquired)
• Other people who have also been classed as clinically extremely vulnerable based on clinical judgment and an assessment of their needs.

• The UK government recommends that from 2 December 2020, clinically extremely vulnerable people are urged to follow specific precautions based on the tiered system of local restrictions:
  
  
  • Consult current guidance for specific recommendations (recommendations may differ between countries).
  
  • Shielding advice for children and young adults is available. Consult current guidance for specific recommendations (recommendations may differ between countries).


Lifestyle modifications

• Lifestyle modifications (e.g., smoking cessation, weight loss) may help to reduce the risk of COVID-19, and may be a useful adjunct to other interventions.[366]

COVID-19 mRNA vaccine BNT162b2 (Pfizer/BioNTech)

• An experimental lipid nanoparticle-formulated, nucleoside-modified, messenger RNA vaccine that encodes the SARS-CoV-2 viral spike glycoprotein.

• Granted emergency authorization for the active immunization to prevent COVID-19 in people ages 16 years and over in the UK, the US, and Canada. These are not full marketing authorizations. A decision by the European Medicines Agency is expected by the end of December 2020.

• The vaccine is administered intramuscularly as a 2-dose series given 21 days apart. People may not be protected until at least 7 days after the second dose. Consult local prescribing information before administering the vaccine.


• Severe allergic reactions have been reported in three healthcare workers in the UK (two reports of anaphylaxis and one report of a possible allergic reaction) after vaccination. The UK-based Medicines and Healthcare products Regulatory Agency (MHRA) recommends that the vaccine should not be
given to anyone with a history of immediate-onset anaphylaxis to a vaccine, drug, or food. Vaccination should only be carried out in facilities where resuscitation measures are available, and a protocol for the management of anaphylaxis must be available. Recipients should be monitored for 15 minutes after vaccination, with a longer observation period when indicated after clinical assessment. A second dose should not be administered to anyone who experienced anaphylaxis after the first dose.[33] [34] There are news reports of another severe allergic reaction after the first dose in a woman in Alaska who had no history of allergies.

- Use caution in pregnant and breastfeeding women as there are no safety and efficacy data available. The American College of Obstetricians and Gynecologists recommends that COVID-19 vaccines should not be withheld from pregnant or breastfeeding women who meet criteria for vaccination based on recommended priority groups. Discuss the risks and benefits with the person before vaccination. Pregnant women who decline vaccination should be supported in their decision.[367] Effects on fertility are unknown. Advise women of childbearing age to avoid pregnancy for at least 2 months after their second dose.

- Use caution in immunocompromised patients as there are no safety and efficacy data available. Vaccination should be delayed in people with moderate to severe acute illness, if possible.

- Authorization was based on results from a phase 3 trial of 43,448 participants.[368]

  - Efficacy: the vaccine is reported to be 95% effective in preventing COVID-19 after 2 doses compared with placebo (saline), in people ages 16 years and older. This is based on an analysis of 170 confirmed cases of COVID-19 with an onset at least 7 days after the second dose among recipients with no evidence of existing or prior SARS-CoV-2 infection (8 cases in the vaccine arm versus 162 cases in the placebo arm). A case was defined as a person with at least one symptom consistent with COVID-19 (i.e., fever, new or increased cough, new or increased shortness of breath, chills, new or increased myalgia, new loss of taste or smell, sore throat, diarrhea, or vomiting) plus a positive reverse transcription polymerase chain reaction (RT-PCR) for SARS-CoV-2 within 4 days before or after symptom onset. Efficacy was only 52% after the first dose. Among 10 cases of severe disease with onset after the first dose, 9 cases occurred in the placebo arm and 1 case occurred in the vaccine arm. This only provides preliminary evidence of vaccine-mediated protection against severe disease.

  - Safety: data on reactogenicity was based on an analysis of a subset of 8183 patients. Local reactions were more common in the vaccine arm (85%), with the most common reaction being mild to moderate pain at the injection site within 7 days after injection (83% of younger patients and 71% of patients older than 55 years reported pain after the first dose). Reported local reactions were similar after the first and second doses. Less than 1% of participants reported severe pain. Systemic reactions were reported in 77% of participants, more often by younger patients and more commonly after the second dose. The most common systemic events after the second dose were fatigue (59% in younger patients; 51% in older patients), headache (52% in younger patients; 39% in older patients), and fever (16% in younger patients; 11% in older patients). Severe systemic events were reported in <2% of recipients after either dose. Other rare adverse events include lymphadenopathy, shoulder injury (related to vaccine administration), paroxysmal ventricular arrhythmia, and right leg paresthesia. Two deaths were reported in the vaccine arm but were considered to be unrelated to the vaccine.

  - Limitations: the trial was not sufficiently powered to detect less common adverse events reliably, and the median follow-up time was only 2 months after the second dose. However, unsolicited, nonserious adverse events were only reported if they occurred within 1 month after the second dose. The trial does not address whether the vaccine prevents transmission, and the duration of protection is yet to be determined. There are no data on children, younger adolescents, pregnant women, or immunocompromised people. Although the trial included people living with HIV, they are not included in this analysis. Only 9% of participants were Black or African
American, and 28% were Hispanic or Latin. The planned 2-year follow-up of participants is unlikely to occur in the context of this trial due to the ethics of following a placebo recipient for 2 years without offering the vaccine.

- All suspected adverse reactions should be reported via the Yellow Card scheme in the UK. [Yellow Card: coronavirus (COVID-19)](https://coronavirus-yellowcard.mhra.gov.uk/) In the US, it is mandatory to report the following to the Vaccine Adverse Event Reporting System (VAERS): all vaccine administration errors, serious adverse events, cases of multisystem inflammatory syndrome, and cases of COVID-19 that result in hospitalization or death.

- Interactions with other vaccines/drugs and interchangeability with other COVID-19 vaccines has not been evaluated.

- Immunization programs vary between countries, but generally prioritize vaccine administration in people who are at highest risk from serious disease or death (e.g., residents and staff in care homes, older people, healthcare workers, and those with underlying health conditions). Consult local guidance.

- As there is limited information on how much the vaccine may reduce transmission in the general population, and how long protection lasts, advise vaccinated people to continue to follow all local public health recommendations.

**Other vaccine candidates**

- Several other vaccine candidates are either approved, undergoing an approval process, or in clinical trials, including mRNA and DNA platform vaccines, adenovirus vector vaccines, spike glycoprotein subunit vaccines, live-attenuated vaccines, inactivated virus vaccines, and intranasal delivery systems.[369] Vaccines have been authorized for use in China and Russia.

  - mRNA-1273: a messenger RNA vaccine that encodes for a full-length prefusion stabilized spike protein of SARS-CoV-2 encapsulated in a lipid nanoparticle. Results from a phase 1 trial indicated that all 45 healthy adults (ages 18-55 years) who were given 2 injections (25, 100, or 250 micrograms) of the vaccine 28 days apart seroconverted by day 15 after the first dose. All dose groups had antibody levels in the top quartile for convalescent serum after the second vaccination. Systemic adverse events occurred more frequently after the second vaccination and occurred in 54% of participants in the 25-microgram group, and 100% of participants in the 100-microgram and 250-microgram groups. Of the cohort of 14 patients who received the highest dose (250 micrograms), 21% of participants experienced one or more severe adverse events following the second dose. One participant in the 25-microgram group was withdrawn due to transient urticaria related to the first vaccination. The study did not include people with underlying conditions.[370] A phase 1 trial in older adults has also been completed.[371] Enough cases have occurred in the phase 3 trial to trigger an interim efficacy analysis; however, the phase 3 study is yet to be published. The FDA and EMA have both received emergency authorization applications from the manufacturer, and these approvals will proceed under an accelerated timeline with a decision expected in the next few weeks. Trials have started in adolescents.

  - AZD1222 (ChAdOx1 nCoV-19): an adenovirus vector vaccine that carries the SARS-CoV-2 spike protein. Preliminary results from animal studies found that a single dose induced a humoral and cellular response in mice and rhesus macaques. However, while viral loads in bronchoalveolar lavage fluid and lung tissues of vaccinated animals were significantly reduced compared with unvaccinated animals, reduction in viral shedding from the nose was not observed.[372] A phase 1/2, single-blind, randomized controlled trial in young healthy volunteers that used the meningococcal conjugate vaccine as a control found that AZD1222 was immunogenic. Local and systemic reactions were more common in the AZD1222 group and no serious adverse events were reported in the 28 days following vaccination.[373] The UK-based phase 3 trial was halted in early September after a vaccine participant experienced an unexplained illness.[374] News reports suggested that the participant developed transverse myelitis, a serious adverse event reported with almost all vaccines. The trial has now resumed in the UK following confirmation by the MHRA that it was safe to do so. The company has not disclosed the nature of the adverse event.[375] Trials have now resumed in all countries,
including the US. A single-blind, randomized, controlled phase 2/3 trial found that the vaccine appears to be better tolerated in adults ages 70 years and older compared with younger adults, and has similar immunogenicity across all age groups after a boost dose.[376] Enough cases have occurred in the phase 3 trials in the UK, Brazil, and South Africa to trigger an interim efficacy analysis. Overall efficacy was 70.4% (the primary outcome was a positive test with at least one qualifying symptom). The efficacy was 62% among people who received two full doses, and 90% among people who received a half dose followed by a full dose. However, the half dose was given inadvertently to a subset of UK participants and therefore additional research is required on the mixed-dose regimen.[377] The MHRA is currently reviewing the authorization application.

• Inactivated SARS-CoV-2 virus (CoronaVac®): contains a more traditional chemically inactivated version of the virus. The vaccine was found to induce immunity in mice, rats, and nonhuman primates. When challenged with the virus, monkeys who were vaccinated with the highest dose of the vaccine did not develop infection, and no virus was recovered from the throat, lung, or rectum.[378] In an interim analysis of two ongoing randomized controlled trials in healthy adults ages 18 to 59 years, a phase 1 trial of 96 participants and a phase 2 trial of 224 participants, the vaccine induced a neutralizing antibody response by 14 days. The studies compared the vaccine with an alum adjuvant. The incidence of adverse effects across all participants within 7 days of injection was 15%, most commonly injection-site reactions and fever.[379] The vaccine has been approved for emergency use in China based on data from a phase 1/2 study that showed that the vaccine elicited a humoral response against SARS-CoV-2. The protective efficacy of the vaccine remains to be determined.[380] No data from the ongoing phase 3 trials have been published as yet.

• NVX-CoV2373: a recombinant SARS-CoV-2 nanoparticle vaccine composed of trimeric, full-length, SARS-CoV-2 spike glycoproteins and Matrix-M1® adjuvant (an adjuvant based on saponin extracted from the *Quillaja saponaria* Molina tree). A phase 1/2 randomized, placebo controlled trial in 131 healthy adults ages 18 to 59 years in Australia found that NVX-CoV2373 elicited immune responses that exceeded levels in COVID-19 convalescent serum at 35 days.[381] A phase 3 trial has started, and it has been granted fast-track designation by the FDA.

• JNJ-78436735 (Ad26.COV2.S): a monovalent vaccine composed of a recombinant, replication-incompetent adenovirus type 26 (Ad26) vector, constructed to encode the SARS-CoV-2 spike protein. The vaccine is currently in phase 3 trials. The trial was paused due to an undisclosed serious adverse event, but has now resumed.[382] The EMA has started a rolling review of the vaccine.

* Results from other vaccine candidates are becoming available; however, a detailed discussion of all vaccine candidates is beyond the scope of this topic.

**Vaccine safety concerns**

• Previous trials of coronavirus vaccines identified cellular immunopathology and antibody-dependent enhancement (ADE) as potential safety issues, so there are concerns over ADE of SARS-CoV-2 due to subsequent exposure to wild-type SARS-CoV-2 post vaccination and prior exposure to other coronaviruses (such as those that cause the common cold).[383] [384]

• There are concerns that the phase 3 trials may not be designed to detect a reduction in any serious outcome such as hospital admissions, use of intensive care, or deaths, or whether the vaccines can interrupt transmission of the virus – two key primary end points in vaccine efficacy trials.[385]

**Pre-exposure or postexposure prophylaxis**

• There are no drugs recommended for pre-exposure prophylaxis or postexposure prophylaxis, except in the context of a clinical trial.[3] See the Emerging section for more information.

**Immunity passports**

• Some governments are discussing or implementing certifications for people who have contracted and recovered from COVID-19 based on antibody tests (sometimes called "immunity passports"). Possession of a passport would allow people to have a greater range of privileges (e.g., work, education, travel). However, the WHO does not support these certifications as there is currently no
Coronavirus disease 2019 (COVID-19) Management

Evidence that people who have recovered from infection and have antibodies are protected from reinfection.[386] Other potential issues include lack of public support for these measures, potential for discrimination of groups of people, testing errors (including cross-reactivity with other human coronaviruses), access to testing, fraud, legal and ethical objections, and people getting infected intentionally in order to obtain a certification.[387]

Smoking cessation


Patient discussions

General prevention measures

- Wash hands often with soap and water for at least 20 seconds or an alcohol-based hand sanitizer (that contains at least 60% alcohol), especially after being in a public place, blowing your nose, or coughing/sneezing. Avoid touching the eyes, nose, and mouth with unwashed hands.

- Avoid close contact with people (i.e., maintain a distance of at least 3 feet [1 meter]) including shaking hands, particularly those who are sick, have a fever, or are coughing or sneezing. It is important to note that recommended distances differ between countries (for example, 6 feet [2 meters] is recommended in the US and UK) and you should consult local guidance.

- Practice respiratory hygiene (i.e., cover mouth and nose when coughing or sneezing, discard tissue immediately in a closed bin, and wash hands).

- Stay at home if you are sick, even with mild symptoms, until you recover (except to get medical care)

- Clean and disinfect frequently touched surfaces daily (e.g., light switches, door knobs, countertops, handles, phones).[342] [343]


Face masks

- Despite the lack of good-quality evidence, the World Health Organization (WHO) advises that in areas of known or suspected community or cluster transmission, people should wear a nonmedical mask in the following circumstances: indoor or outdoor settings where physical distancing cannot be maintained; indoor settings with inadequate ventilation, regardless of whether physical distancing can be maintained; and in situations when physical distancing cannot be maintained and the person has a higher risk of severe complications (e.g., older age, underlying condition). Caregivers and those living with suspected or confirmed cases should wear a medical mask when in the same room, regardless of whether the case has symptoms. Children ages up to 5 years should not wear masks for source control. A risk-based approach is recommended for children ages 6 to 11 years. Special considerations are required for immunocompromised children, or children with certain diseases, developmental disorders, or disabilities. The WHO advises that people should not wear masks during vigorous-intensity physical activity. Use of a mask alone is insufficient to provide adequate protection, and they should be used in conjunction with other infection prevention and control measures such as frequent hand hygiene and social distancing.[96]
Coronavirus disease 2019 (COVID-19)

Management


• [Public Health England: how to make a cloth face covering](https://www.gov.uk/government/publications/how-to-wear-and-make-a-cloth-face-covering)

Travel advice

• Many countries have implemented international travel bans/closed their borders, have issued advice for domestic travel, and are requesting that citizens traveling abroad should come home immediately if they are able to. Some countries are restricting entry to foreign nationals who have been to affected areas in the preceding 14 days, or are enforcing 14-day quarantine periods where the person’s health should be closely monitored (e.g., twice-daily temperature readings).

• Consult local guidance for specific travel restriction recommendations in your country:

  
  
  • [NaTHNac: travel health pro](https://travelhealthpro.org.uk/)
  
  
  
  

Pets

• At this time, there is no evidence that companion animals (including pets and other animals) play a significant role in the spread of COVID-19, and the risk of animals spreading COVID-19 to people is considered to be very low. There is no evidence that the virus can spread to people from the skin or fur of companion animals.[1002]

• A very small number of pets have been reported to be infected with the virus after close contact with people with confirmed COVID-19; however, thousands of pets have been tested in the US with none testing positive. There is evidence that cats and ferrets are highly susceptible to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, while dogs and other livestock have no or low susceptibility. Large cats in captivity (lions, tigers, and a puma) and domestic pet cats have tested positive after contact with symptomatic humans. The virus has been reported in mink on farms, and once the virus is introduced on a farm, can spread between mink, and between mink and other animals on the farm. There is also the possibility that mink may transmit the infection to humans in these environments.[1003] [1004] [1005] [1006] Transmission between cats has also been reported.[1007]

• Advise patients to limit their contact with their pets and other animals, especially while they are symptomatic. Advise people to not let pets interact with people or animals outside the household, and if a member of the household becomes unwell to isolate them from everyone else, including pets.[1008]


Athletes and highly active people
• Advise asymptomatic patients who test positive not to exercise for 2 weeks after their test result, with slow resumption of activity under the guidance of a healthcare team. Advise mildly symptomatic patients who test positive not to exercise until 2 weeks after symptom resolution and only after a thorough cardiac evaluation. If the assessment is normal, slow resumption of activity under the guidance of a healthcare team can be considered with close monitoring for clinical deterioration.[1009]

• Guidance on return to sports after COVID-19 in children is available from the American Academy of Pediatrics:


Resources


Monitoring

Regularly monitor the following in hospitalized patients to facilitate early recognition of deterioration and monitor for complications:[2] [612]

- Vital signs (temperature, respiratory rate, heart rate, blood pressure, oxygen saturation)
- Hematologic and biochemistry parameters
- Coagulation parameters (D-dimer, fibrinogen, platelet count, prothrombin time)
- ECG
- Chest imaging
- Signs and symptoms of venous or arterial thromboembolism.

Medical early warning scores

- Utilize medical early warning scores that facilitate early recognition and escalation of treatment of deteriorating patients (e.g., National Early Warning Score 2 [NEWS2], Pediatric Early Warning Signs [PEWS]) where possible.[2]
- There are no data on the value of using these scores in patients with COVID-19 in the primary care setting.[990]

Pregnant women

- Monitor vital signs three to four times daily and fetal heart rate in pregnant women with confirmed infection who are symptomatic and admitted to hospital. Perform fetal growth ultrasounds and Doppler assessments to monitor for potential intrauterine growth restriction in pregnant women with confirmed infection who are asymptomatic.[661] Perform fetal growth ultrasound 14 days after resolution of symptoms.[663]

Post-discharge follow-up

- Guidelines for the respiratory follow-up of patients with COVID-19 pneumonia have been published. Follow-up algorithms depend on the severity of pneumonia, and may include clinical consultation and review (face-to-face or telephone) by a doctor or nurse, chest imaging, pulmonary function tests, echocardiogram, sputum sampling, walk test, and assessment of oxygen saturation.[991]
- More than half of patients discharged from hospital had lung function and chest imaging abnormalities 12 weeks after symptom onset.[992] Pulmonary function tests may reveal altered diffusion capacity, a restrictive pattern, or an obstructive pattern.[993]

Prognostic scores in development

- Various prognostic and clinical risk scores are being researched or developed for COVID-19; however, further external validation across various populations is needed before their use can be recommended.
  - A-DROP: a modified version of CURB-65 that showed better accuracy of in-hospital death prediction on admission in patients with COVID-19 pneumonia compared with other widely used community-acquired pneumonia scores.[994]
  - APACHE II: an effective clinical tool to predict hospital mortality that performed better than SOFA and CURB-65 scores in patients with COVID-19. A score of 17 or more is an early indicator of death and may help provide guidance to make further clinical decisions.[995]
  - CALL: a risk factor scoring system that scores patients based on four factors: comorbidities, age, lymphocyte count, and lactate dehydrogenase level. One study found that 96% of patients with low CALL scores did not progress to severe disease.[996]
• COVID-GRAM: a web-based calculator that estimates the probability that a patient will develop critical illness and relies on the following 10 variables at admission: chest radiographic abnormality, age, hemoptysis, dyspnea, unconsciousness, number of comorbidities, cancer history, neutrophil-to-lymphocyte ratio, lactate dehydrogenase, and direct bilirubin. Additional validation studies, especially outside of China, are required.[997]

• COVID-19MRS: a rapid, operator-independent clinical tool that was found to objectively predict mortality in one retrospective cohort study.[998]

• 3F: a mortality prediction model based on three clinical features: age, minimum oxygen saturation, and type of patient encounter (i.e., inpatient vs outpatient and telehealth encounters). One study found that the model showed high accuracy when applied to retrospective and prospective data sets of COVID-19 patients.[999]

• 4C: a score developed and validated in a UK prospective cohort study of adults admitted to hospital with COVID-19. The score uses patient demographics, clinical observations, and blood parameters commonly available at the time of hospital admission, and can accurately characterize patients as being at low, intermediate, high, or very high risk of death. The score outperformed other risk stratification tools, showed clinical decision-making utility, and had similar performance to more complex models.[1000]

• QCOVID: a novel clinical risk prediction algorithm to estimate the risk of hospital admission and mortality based on age, ethnicity, deprivation, body mass index, and a range of comorbidities. A population-based cohort study found that the algorithm performed well, showing very high levels of discrimination for deaths and hospital admissions.[1001]
Coronavirus disease 2019 (COVID-19) - Follow up

Complications

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<tr>
<th>Complications</th>
<th>Timeframe</th>
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<tbody>
<tr>
<td>post-intensive care syndrome</td>
<td>variable</td>
<td>high</td>
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Early reports suggest that COVID-19 patients treated in the intensive care unit can present with post-intensive care syndrome, a spectrum of psychiatric, cognitive, and/or physical disability (e.g., muscle weakness, cognitive dysfunction, insomnia, depression, anxiety, post-traumatic stress disorder, delirium, encephalopathy) that affects survivors of critical illness, and persists after the patient has been discharged from the intensive care unit. Weakness affects 33% of patients who receive mechanical ventilation, 50% of patients with sepsis, and <50% of patients who remain in the intensive care unit for more than 1 week. Cognitive dysfunction affects 30% to 80% of patients. The risk can be minimized with medication management, physical rehabilitation, family support, and follow-up clinics.[3] [868]

| venous thromboembolism        | variable  | high |

The pooled incidence of venous thromboembolism, deep vein thrombosis, and pulmonary embolism among hospitalized patients was 17%, 12%, and 7%, respectively.[869] The incidence was higher in patients admitted to the intensive care unit. The pooled incidence was 10% in non-intensive care settings, and 28% in in intensive care settings.[870] COVID-19 patients with thromboembolic events have 1.93 times the odds of dying compared with patients without venous thromboembolism.[871]

Coagulopathy in COVID-19 has a prothrombotic character, which may explain reports of thromboembolic complications.[872] Patients may be predisposed to venous thromboembolism due to the direct effects of COVID-19, or the indirect effects of infection (e.g., severe inflammatory response, critical illness, traditional risk factors).[611] Thrombotic events may be due to cytokine storm, hypoxic injury, endothelial dysfunction, hypercoagulability, and/or increased platelet activity.[873]

The risk factors with the most evidence for being predictive of venous thromboembolism are older age and elevated D-dimer levels.[874] Patients with very high D-dimer levels have the greatest risk of thrombosis and may benefit from active monitoring.[523] [524]

If venous thromboembolism is suspected, perform a computed tomographic angiography or ultrasound of the venous system of the lower extremities.[875]

Treat patients with a thromboembolic event (or who are highly suspected to have thromboembolic disease if imaging is not possible) with therapeutic doses of anticoagulant therapy as per the standard of care for patients without COVID-19. There are currently insufficient data to recommend either for or against using therapeutic doses of antithrombotic or thrombolytic agents for COVID-19. Patients who require extracorporeal membrane oxygenation or continuous renal replacement therapy, or who have thrombosis of catheters or extracorporeal filters, should be treated with antithrombotic therapy as per the standard institutional protocols for those without COVID-19.[3]

Initial parenteral anticoagulation with a low molecular weight heparin or unfractionated heparin is preferred in acutely ill hospitalized patients; however, direct oral anticoagulants may be used provided there is no potential for drug-drug interactions (lead-in therapy with a parenteral anticoagulant is required for dabigatran and edoxaban). Warfarin can be used after overlap with initial parenteral anticoagulation. Parenteral anticoagulation with a low molecular weight heparin or fondaparinux is preferred over unfractionated heparin in critically ill patients. Direct oral anticoagulants are the preferred option in outpatients provided there is no potential for drug-drug interactions, with warfarin considered a suitable alternative. Anticoagulation therapy is recommended for a minimum of 3 months. Thrombolytic therapy is recommended in select patients with pulmonary embolism.[609]

The American Society of Hematology has published draft guideline recommendations on the use of anticoagulation in patients with COVID-19.[876]
Coronavirus disease 2019 (COVID-19) Follow up

Complications | Timeframe | Likelihood
--- | --- | ---
A high incidence (14.7%) of asymptomatic deep vein thrombosis was reported in a cohort of patients with COVID-19 pneumonia.[877] An autopsy study of 12 patients revealed deep vein thrombosis in 58% of patients in whom venous thromboembolism was not suspected before death.[878] These studies highlight the importance of having a high suspicion for venous thromboembolism in patients who have signs of coagulopathy, including elevated D-dimer level.

While these patients are at higher risk of thrombotic events, they may also be at an elevated risk for bleeding. In a small retrospective study, 11% of patients at high risk of venous thromboembolism also had a high risk of bleeding.[879]

Antiphospholipid antibodies and lupus anticoagulant have been detected in a small number of critically ill patients. The presence of these antibodies can rarely lead to thrombotic events in some patients (especially those who are genetically predisposed) that are difficult to differentiate from other causes of multifocal thrombosis. In other patients, antiphospholipid antibodies may be transient and disappear within a few weeks. The significance of this finding is unknown, although it is thought that these antibodies may not be involved in the pathogenesis of venous thromboembolism in patients with severe COVID-19. Anticoagulation should be considered in these patients.[880] [881] [882] [883] [884]

It has been suggested that a new term (e.g., COVID-19-associated pulmonary thrombosis, diffuse pulmonary intravascular coagulopathy, or microvascular COVID-19 lung vessels obstructive thrombo-inflammatory syndrome [MicroCLOTS]) be used rather than the term pulmonary embolism as it has been hypothesized that the pathophysiology is different; local thrombi are formed in the lung vessels due to a local inflammatory process rather than the classical emboli coming from elsewhere in the body.[885] [886] [887] However, this has not become accepted practice.

Cases of arterial thrombosis, cerebral venous thrombosis, and acute limb ischemia secondary to thrombosis have been reported.[888] [889] [890] [891] [892]

cardiovascular complications | variable | high
--- | --- | ---
COVID-19 is associated with a high inflammatory burden that can result in cardiovascular complications with a variety of clinical presentations. Inflammation in the myocardium can result in myocarditis, heart failure, arrhythmias, acute coronary syndrome, rapid deterioration, and sudden death.[893] [894] These complications can occur on presentation or develop as the severity of illness worsens.[895] It is uncertain to what extent acute systolic heart failure is mediated by myocarditis, cytokine storm, small vessel thrombotic complications, microvascular dysfunction, or a variant of stress-induced cardiomyopathy.[896]

Myocardial injury has been reported in 20% of hospitalised patients. Factors associated with the development of myocardial injury include older age, male sex, and the presence of comorbidities.[897] Cardiac injury was associated with higher risk of mortality, intensive care unit admission, mechanical ventilation, and developing coagulopathy.[898]

Cardiovascular complications have been reported in 14.1% of patients during hospitalization, with an overall case fatality rate of 9.6%. Patients with preexisting cardiovascular comorbidities or risk factors are at higher risk for cardiovascular complications and mortality. Complications include arrhythmias or palpitations (18.4%), myocardial injury (10.3%), angina (10.2%), acute myocardial infarction (3.5%), and acute heart failure (2%).[899] Cases of fulminant myocarditis, cardiac tamponade, cor pulmonale, takotsubo syndrome, and pericarditis have also been reported.[900] [901] [902] [903] [904]

Elevated cardiac biomarkers and emerging arrhythmia are associated with the development of severe COVID-19 and the need for intensive care admission.[905]

Prevalence of cardiac disease is high among patients who are severely or critically ill, and these patients usually require intensive care and have a poor prognosis and higher rate of in-hospital mortality. These patients are more likely to require noninvasive or invasive ventilation, and have a higher risk of thromboembolic events and septic shock compared with patients without a history of cardiac disease.[895] [906] [907] [908] [909]
Complications | Timeframe | Likelihood
--- | --- | ---
Perform an ECG and order high-sensitivity troponin I (hs-cTnI) or T (hs-cTnT) and N-terminal pro-brain natriuretic peptide (NT-proBNP) levels in patients with symptoms or signs that suggest acute myocardial injury in order to make a diagnosis. Results should be considered in the clinical context.[910]

Monitor blood pressure, heart rate, and fluid balance, and perform continuous ECG monitoring in all patients with suspected or confirmed acute myocardial injury.[910]

There are limited data to recommend any specific drug treatments for these patients. Management should involve a multidisciplinary team including intensive care specialists, cardiologists, and infectious disease specialists.[896] It is important to consider that drugs such as hydroxychloroquine and azithromycin may prolong the QT interval and lead to arrhythmias.[910] Guidelines for the management of COVID-19-related myocarditis are available.[911]

Infection may have longer-term implications for overall cardiovascular health; however, further research is required.[912] A study of 100 patients who had recently recovered from COVID-19 found that cardiovascular magnetic resonance imaging revealed ongoing myocardial inflammation in 60% of patients, independent of preexisting conditions, severity and overall course of the acute illness, and time from the original diagnosis.[913]

**acute kidney injury** | variable | high
--- | --- | ---
The pooled incidence of acute kidney injury is 10.6%, which is higher than the incidence in hospitalized patients without COVID-19. Patients with acute kidney injury have a significantly increased risk of in-hospital mortality (odds ratio of 11.05). The mortality rate and incidence in patients in China was significantly lower than those in patients outside of China. Risk factors include older age ≥60 years, male sex, and severe infection.[914]

In a small UK cohort, 29% of hospitalized children met the diagnostic criteria for acute kidney injury, with most cases occurring in children admitted to the intensive care unit and in those with pediatric inflammatory multisystem syndrome.[915]

Can develop at any time before or during hospital admission. Causes include hemodynamic changes, hypovolemia, viral infection leading directly to kidney tubular injury, thrombotic vascular processes, glomerular pathology, or rhabdomyolysis.[916] Direct kidney infection has been confirmed in an autopsy study of a single patient.[917]

The European Medicines Agency has started a review of a safety signal to assess reports of acute kidney injury associated with the use of remdesivir in some patients. At this stage, it has not been determined whether there is a causal relationship between remdesivir and acute kidney injury.[680]

Patients should meet criteria for acute kidney injury for diagnosis. [NHS England: acute kidney injury (AKI) algorithm](https://www.england.nhs.uk/akiprogramme/aki-algorithm/) Perform a urinalysis for blood, protein, and glucose to help identify the underlying cause. Imaging is recommended if urinary tract obstruction is suspected.[916]

Stop any drugs that can cause or worsen acute kidney injury, if possible. Aim to achieve optimal fluid status (euvolemia) in all patients. Consider a loop diuretic for treating fluid overload only. Manage hyperkalemia according to local protocols. See local protocols for guidance on renal replacement therapy.[916]

Specialist input may be required in some cases (e.g., uncertainty about cause, abnormal urinalysis results, complex fluid management needs, indications for renal replacement therapy), and some patients may require critical care admission.[916] Continuous renal replacement therapy (CRRT) is recommended in critically ill patients with acute kidney injury who develop indications for renal replacement therapy; prolonged intermittent renal replacement therapy is recommended over hemodialysis if CRRT is not available or possible.[3]
### Complications

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<th>Timeframe</th>
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<tr>
<td>Monitor fluid status daily, as well as serum blood urea nitrogen, creatinine, and electrolytes at least every 48 hours (or more often if clinically indicated). Monitor patients for the development of, or progression to, chronic kidney disease for at least 2 to 3 years after acute kidney injury.[916]</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Medium</td>
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Cases of nephritis and collapsing glomerulopathy have been reported.[918] [919]

### neurologic complications

<table>
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<th>Timeframe</th>
<th>Likelihood</th>
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<tr>
<td>Patients commonly have central or peripheral neurologic complications, possibly due to viral invasion of the central nervous system, inflammatory response, or immune dysregulation.[924]</td>
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</tr>
<tr>
<td>Variable</td>
<td>Medium</td>
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Neurologic manifestations have been reported in 4% to 57% of patients in large retrospective observational studies. Central nervous system manifestations were more common than peripheral nervous system manifestations.[924] However, most studies included minor symptoms such as headache and dizziness, which are classified as symptoms of COVID-19 in this topic rather than complications. Neurologic complications are rare in children.[925] Neurologic complications include acute cerebrovascular disease, impairment of consciousness, ataxia, seizures, corticospinal tract signs, meningoencephalitis, encephalopathy, encephalomyelitis, peripheral demyelinating lesions, peripheral neuropathy, intracerebral hemorrhage, cerebral venous sinus thrombosis, myopathy, myasthenia gravis, Guillain-Barre syndrome and other neuropathies, and abnormal findings on brain magnetic resonance imaging.[924] [926] Patients may present with these manifestations, or they may develop them during the course of the disease. Neurologic complications tend to develop 1 to 2 weeks after the onset of respiratory disease.[927] Acute cerebrovascular disease (including ischemic stroke, hemorrhagic stroke, cerebral venous thrombosis, and transient ischemic attack) has been reported in 0.5% to 5.9% of patients. The most common type was ischemic stroke (0.4% to 4.9%).[924] Stroke is relatively frequent among hospitalized COVID-19 patients relative to other viral respiratory infections, and has a high risk of in-hospital mortality. Risk factors include older age and male sex. Median time from onset of COVID-19 symptoms to stroke was 8 days.[928] [929] Stroke presents later in severe disease, and earlier in mild to moderate disease.[930] Ischemic stroke appears to be more severe and result in worse outcomes (severe disability) in patients with COVID-19, with the median NIH Stroke Scale score being higher among those with COVID-19 compared with those without.[931] Guidelines for the management of acute ischemic stroke in patients with COVID-19 infection have been published.[932] Guillain-Barre syndrome has been reported. Both post-infectious and pre-infectious patterns have been reported.[924] The mean age of patients was 55 years with a male predominance. Most patients had respiratory and/or severe symptoms of COVID-19, although it has also been reported in asymptomatic
Complications | Timeframe | Likelihood
--- | --- | ---
patients. A higher prevalence of the classic sensorimotor form and acute inflammatory demyelinating polyneuropathy have been reported, although rare variants have also been noted.[933]

Patients with preexisting neurologic disorders may develop an exacerbation of their neurologic symptoms and severe COVID-19.[934]

Patients may show cerebral changes on magnetic resonance imaging months after recovery, suggesting that long-term consequences may be possible.[935]

**post-COVID syndrome (long COVID)** | variable | medium

Protracted symptoms following infectious diseases are common in many viral and bacterial infections. The term “long COVID” has been used to describe post-acute COVID-19 symptoms.[936] Some of the symptoms overlap with post-intensive care syndrome (see above).[3]

The National Institute for Health and Care Excellence, the Scottish Intercollegiate Guidelines Network, and the Royal College of General Practitioners in the UK have defined post-COVID syndrome as: signs and symptoms that develop during or following an infection consistent with COVID-19 that continue for more than 12 weeks and are not explained by an alternative diagnosis. The condition usually presents with clusters of symptoms, often overlapping, which may change over time and can affect any system within the body. Many people with post-COVID syndrome can also experience generalized pain, fatigue, persisting high temperature, and psychiatric problems. Post-COVID-19 syndrome may be considered before 12 weeks while the possibility of an alternative underlying disease is also being assessed.[937]

In a study in Italy, nearly 90% of hospitalized patients who recovered from COVID-19 reported persistence of at least one symptom 2 months after discharge. Only 12.6% of patients had no related symptoms, 32% had one or two symptoms, and 55% had three or more symptoms.[868] Another study in the UK found that nearly 75% of patients who are discharged from hospital remain symptomatic at 3 months.[938] Prolonged illness can occur among young adults with no underlying comorbidities. In a survey study of symptomatic adults, 35% had not returned to their usual state of health 2 to 3 weeks after testing. Among those ages 18 to 34 years with no underlying chronic medical conditions, 20% had not returned to their usual state of health.[939] The number of symptoms at follow-up was associated with the symptom load during the acute phase of infection and the number of comorbidities in nonhospitalized patients.[940]

Symptoms vary widely, may relapse and remit, and can occur in those with mild disease only. Common long-term symptoms include persistent cough, low-grade fever, breathlessness, and fatigue. Chest pain, palpitations, myalgia, arthralgia, headaches, vision changes, hearing loss, loss of taste/smell, impaired mobility, numbness in extremities, tremors, memory loss, mood changes, rashes, gastrointestinal symptoms, neurocognitive difficulties, and mental health conditions (e.g., anxiety, depression) have also been reported. Persistent symptoms have been reported in pregnant women.[3][941] The inability to return to normal activities, emotional and mental health outcomes, and financial loss are common.[942]

Blood tests should be ordered selectively and for specific clinical indications after a careful history and examination. Other investigations may include chest x-ray, urine tests, and an electrocardiogram.[3][941] Around 9% of patients had deteriorating chest x-ray appearances at follow-up, which may indicate lung fibrosis. Persistently elevated D-dimer and C-reactive protein have also been reported.[943]

There are no definitive, evidence-based recommendations for the management of post-acute COVID-19 as yet; therefore, patients should be managed pragmatically and symptomatically (e.g., antipyretic for fever, breathing techniques for chronic cough, home pulse oximetry for monitoring breathlessness, pulmonary rehabilitation, staged return to exercise). Many patients recover spontaneously with holistic support, rest, symptomatic treatment, and a gradual increase in activity. Referral to a specialist may be required in patients where there is clinical concern along with respiratory, cardiac, or neurologic symptoms that are new, persistent, or progressive.[941]

There is limited information on the prevalence, duration, and underlying causes. More research is needed to better understand the pathophysiology and clinical course, and to identify suitable management strategies.[3] Long-term symptoms have been reported rarely in children.[944]
## Complications

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<th>Complication</th>
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<tbody>
<tr>
<td><a href="https://www.bmj.com/content/370/bmj.m3489">BMJ webinar: long COVID – how to define it and how to manage it</a></td>
<td>variable</td>
<td>medium</td>
</tr>
<tr>
<td><a href="https://www.bmj.com/content/370/bmj.m3026">BMJ: management of post-acute covid-19 in primary care</a></td>
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### In-hospital cardiac arrest

In-hospital cardiac arrest is common in critically ill patients with COVID-19, and is associated with poor survival, particularly among older patients. Among 5019 critically ill patients with COVID-19, 14% had an in-hospital cardiac arrest. Risk factors included older age, male sex, presence of comorbidities, and admission to a hospital with a smaller number of intensive care unit beds. Approximately 57% of patients received cardiopulmonary resuscitation. The most common rhythms at the time of resuscitation were pulseless electrical activity (49.8%) and asystole (23.8%). Of those who received resuscitation, 12% survived to hospital discharge with most of these patients being younger than 45 years of age.[945]

### Septic shock

Reported in 4% to 8% of patients in case series.[44] [45] [490] [946]

Guidelines for the management of shock in critically ill patients with COVID-19 recommend a conservative fluid strategy (crystalloids preferred over colloids) and a vasoactive agent. Norepinephrine (noradrenaline) is the preferred first-line agent, with vasopressin or epinephrine (adrenaline) considered suitable alternatives. Vasopressin can be added to norepinephrine if target mean arterial pressure cannot be achieved with norepinephrine alone.[3] [596] Dopamine is only recommended as an alternative vasopressor in certain patients (e.g., those with a low risk of bradycardia or tachyarrhythmias). Dobutamine is recommended in patients who show evidence of persistent hypoperfusion despite adequate fluid loading and the use of vasopressors. Low-dose corticosteroid therapy is recommended for refractory shock.[3]

### Disseminated intravascular coagulation

Disseminated intravascular coagulation (DIC) is a manifestation of coagulation failure, and an intermediate link in the development of multi-organ failure. Patients may be at high risk of bleeding/hemorrhage or venous thromboembolism.[947] Reported in 71% of nonsurvivors.[948]

Coagulopathy manifests as elevated fibrinogen, elevated D-dimer, and minimal change in prothrombin time, partial thromboplastin time, and platelet count in the early stages of infection. Increasing interleukin-6 levels correlate with increasing fibrinogen levels. Coagulopathy appears to be related to severity of illness and the resultant thromboinflammation. Monitor D-dimer level closely.[949]

Anticoagulant therapy with a low molecular weight heparin or unfractionated heparin has been associated with a better prognosis in patients with severe COVID-19 who have a sepsis-induced coagulopathy (SIC) score of ≥4 or a markedly elevated D-dimer level.[950] In patients with heparin-induced thrombocytopenia (or a history of it), argatroban or bivalirudin are recommended.[947]

Standard guidance for the management of bleeding manifestations associated with DIC or septic coagulopathy should be followed if bleeding occurs; however, bleeding manifestations without other associated factors is rare.[612] [949]

### Acute respiratory failure

Reported in 8% of patients in case series.[45]

Leading cause of mortality in patients with COVID-19.[817]

Children can quickly progress to respiratory failure.[10]
Cytokine release syndrome may cause ARDS or multiple-organ dysfunction, which may lead to death. Elevated serum proinflammatory cytokines (e.g., tumor necrosis factor alpha, interleukin-2, interleukin-6, interleukin-8, interleukin-10, granulocyte-colony stimulating factor, monocyte chemoattractant protein 1) and inflammatory markers (e.g., C-reactive protein, serum ferritin) have been commonly reported in patients with severe COVID-19. This likely represents a type of virus-induced secondary hemophagocytic lymphohistiocytosis, which may be fatal. Interleukin-6, in particular, has been associated with severe COVID-19 and increased mortality. Cytokine release syndrome has been reported in children, although cases appear to be rare. See the section below on pediatric inflammatory multisystem syndrome.

A rare, but severe condition, reported in children and adolescents approximately 2 to 4 weeks after the onset of COVID-19, likely due to a postinfectious inflammatory process. The syndrome has a strong temporal association with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Also known as PIMS, multisystem inflammatory syndrome in children (MIS-C), pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS), as well as other variations.

The syndrome shares common features with Kawasaki disease and toxic shock syndrome, but case definitions vary. Most patients have fever, as well as features of shock, cardiac involvement (e.g., elevated cardiac markers, congestive heart failure, cardiac dysfunction, myocarditis, coronary artery dilatation or aneurysm, hypotension, pericardial effusion, mitral regurgitation), gastrointestinal symptoms (e.g., abdominal pain, vomiting, diarrhea), and significantly elevated inflammatory markers. Additional clinical and laboratory characteristics including thrombocytopenia, fatigue, headache, myalgia, sore throat, and lymphadenopathy have been suggested to refine the case definition. Muco cutaneous findings may be present, many of which overlap with Kawasaki disease.

Three types of clinical manifestations have been recognized: persistent fever and gastrointestinal symptoms (the most common type); shock with heart dysfunction; and symptoms coincident with the diagnostic criteria for Kawasaki disease.

A systematic review of 35 studies (783 cases) found that the median age of patients was 8.6 years of age, and 55% of patients were male. Comorbidities were reported in 20% of cases, with obesity being the most common. Cardiovascular symptoms (82% of patients were tachycardic and 61% were hypotensive) and gastrointestinal symptoms (71%) were prominent. Rashes were reported in 42% of patients. Respiratory symptoms were infrequent. The proportion of patients with a positive SARS-CoV-2 reverse-transcription polymerase chain reaction (RT-PCR) or serology test result was 59%, and 41% had chest imaging abnormalities. Inflammatory markers were elevated in 83% of patients. Cardiac markers were also elevated in the majority of patients. Approximately 68% of patients required intensive care admission, 63% required inotropic support, and 28% of patients required respiratory support. The mortality rate was 1.5%.
Complications | Timeframe | Likelihood
--- | --- | ---
In a multicenter observational study in the UK, 78 cases were reported across 21 pediatric intensive care units. The median age was 11 years and 67% were male. Children from minority ethnic backgrounds accounted for 78% of cases. Fever, shock, abdominal pain, vomiting, and diarrhea were the common presenting features. Around 36% had evidence of coronary artery abnormalities. In terms of treatment, 46% required invasive ventilation and 83% required vasopressor support.\cite{965}

The most common cardiovascular complications include shock, cardiac arrhythmias, pericardial effusion, and coronary artery dilatation.\cite{966}

Management is mainly supportive and involves a multidisciplinary team (pediatric infectious disease, cardiology, rheumatology, critical care). Patients are commonly managed with intravenous immune globulin, vasopressor support, corticosteroids, immune modulators, anticoagulation, antiplatelet therapy, and respiratory support.\cite{957} \cite{958} A national consensus management pathway from the UK is available.\cite{967} The American College of Rheumatology has published guidelines on the diagnosis and management of MIS-C.\cite{968}

While an association between this syndrome and COVID-19 seems plausible based on current evidence, the association is not definitive and further research is required. It is not clear yet whether this syndrome is Kawasaki disease with SARS-CoV-2 as the triggering agent, or whether this is a different syndrome, although increasing evidence suggests that they are two separate syndromes. The syndrome appears to occur in children who have not manifested the early stages of COVID-19, but appears similar to the later phase of COVID-19 in adults.\cite{969} Immunologically, PIMS appears to be a distinct clinical entity from Kawasaki disease as neutrophilia and raised monocyte counts, features of Kawasaki disease, were not observed in one cohort.\cite{970}

Cases of COVID-19-associated Kawasaki-like multisystem inflammatory disease have been reported in adults.\cite{971}

pregnancy-related complications | variable | low

Pregnancy outcome is usually good, although there are little data on exposure during early pregnancy. Risk factors for severe disease in pregnant women include preexisting comorbidities (e.g., chronic hypertension, diabetes), high maternal age, and high body mass index. Pregnant women are more likely to need intensive care unit admission and invasive ventilation, especially those with a preexisting comorbidity. Preterm birth is more common in pregnant women with COVID-19 compared with pregnant women without the disease. Cesarean delivery occurs in approximately 50% of cases, with the most common indication being severe maternal pneumonia or concern about sudden maternal decompensation. Perinatal deaths are rare, and occur in less than 1% of cases. Maternal morbidity is similar to that of women of reproductive age.\cite{20} \cite{401} Stillbirths have been reported. However, there is no evidence of an increase in stillbirths regionally or nationally during the pandemic in England when compared with the same months in the previous year and despite variable community infection rates in different regions.\cite{972}

Limited low-quality evidence suggests that the risk of infection in neonates is extremely low. Most infections are acquired in the postpartum period, although congenitally acquired infection has been reported. Unlike children who generally have asymptomatic infection, two-thirds of neonatal cases are symptomatic and a significant proportion require intensive care, although the overall prognosis appears to be excellent.\cite{401} \cite{973}

aspergillosis | variable | low

Invasive pulmonary aspergillosis has been reported in critically ill patients with moderate to severe ARDS.\cite{974} \cite{975} \cite{976} A prospective observational study found that one third of mechanically ventilated patients with COVID-19 had putative invasive pulmonary aspergillosis.\cite{977}

Intubation for more than 7 days may be a risk factor. Other potential risk factors include older age, chronic obstructive pulmonary disease, immunosuppression, critical illness, or use of high-dose corticosteroids.
### Complications

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<tr>
<td>Consider aspergillosis in patients who deteriorate despite optimal supportive care or have other suspicious radiologic or clinical features.[635] [978]</td>
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<tr>
<td>Prescribe appropriate antifungal therapy according to local guidelines.[979] Guidance on the diagnosis and management of COVID-19-associated pulmonary aspergillosis has been published.[980]</td>
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</table>

#### pancreatic injury

Mild pancreatic injury (defined as elevated serum amylase or lipase levels) has been reported in 17% of patients in one case series.\[981\] It is unknown whether this is a direct viral effect or due to the harmful immune response that occurs in some patients. Clinical acute pancreatitis has not been reported.\[982\] \[983\] Prior history of pancreatitis does not appear to be a risk factor for pancreatic inflammation in patients with COVID-19.\[984\]

#### autoimmune hemolytic anemia

Warm or cold autoimmune hemolytic anemia (first episode) has been reported in 7 patients after the onset of COVID-19 symptoms and within the timeframe compatible with cytokine release syndrome. Four patients had indolent B lymphoid malignancy. It is unknown whether the hemolytic anemia is related to COVID-19 infection.\[985\]

#### immune thrombocytopenia

Immune thrombocytopenia has been reported rarely. The majority of cases were in patients >50 years of age, with only 7% of cases reported in children. The majority of cases were in patients with moderate to severe COVID-19; however, 7% of cases were in asymptomatic COVID-19 patients. Onset occurred in 20% of cases 3 weeks after the onset of COVID-19 symptoms, with most cases reported after clinical recovery. Severe life-threatening bleeding was uncommon. Treatment involved the use of corticosteroids, intravenous immune globulin, and thrombopoietin-receptor agonists.\[986\]

#### subacute thyroiditis

Cases of subacute thyroiditis have been reported in patients with COVID-19 who require intensive care.\[987\] The first known case of subacute thyroiditis was reported in an 18-year-old woman. Subacute thyroiditis is a thyroid disease of viral or post-viral origin.\[988\]

#### gastrointestinal complications

Critically ill patients may develop gastrointestinal complications; however, it is unclear whether this is a manifestation of critical illness in general, or whether it is specific to COVID-19. One study found that patients with COVID-19 were more likely to develop gastrointestinal complications compared with those without COVID-19, specifically transaminitis, severe ileus, and mesenteric ischemia.\[989\]

### Prognosis

#### Mortality

The leading cause of death is respiratory failure from acute respiratory distress syndrome (ARDS).\[817\] The overall pooled mortality rate from ARDS in COVID-19 patients is 39%; however, this varies significantly between countries (e.g., China 69%, Iran 28%, France 19%, Germany 13%).\[818\]
People <65 years of age have a very small risk of death even in pandemic epicenters, and deaths in people <65 years of age without any underlying conditions is rare.\[819\]

**Infection fatality rate (IFR)**

- Defined as the proportion of deaths among all infected individuals including confirmed cases, undiagnosed cases (e.g., asymptomatic or mildly symptomatic cases), and unreported cases. The IFR gives a more accurate picture of the lethality of a disease compared with the case fatality rate.
- Approximately 10% of the global population may have been infected by October 2020, with an estimated overall IFR of 0.15% to 0.2% (0.03% to 0.04% in those <70 years of age).\[820\]
- The US Centers for Disease Control and Prevention’s current best estimate of the IFR, according to age (as of 10 September 2020):\[140\]
  - 0 to 19 years – 0.003%
  - 20 to 49 years – 0.02%
  - 50 to 69 years – 0.5%
  - ≥70 years – 5.4%.
- Based on these figures, the overall IFR for people <70 years of age is approximately 0.18%.
- The IFR can vary across locations. A meta-analysis reports the point estimate of the IFR to be 0.68% across populations, with high heterogeneity (as of July 2020). The rate varied across locations from 0.17% to 1.7%.\[821\]
- Among people on board the Diamond Princess cruise ship, a unique situation where an accurate assessment of the IFR in a quarantined population can be made, the IFR was 0.85%. However, all deaths occurred in patients >70 years of age, and the rate in a younger, healthier population would be much lower.\[822\]
- These estimates have limitations and are likely to change as more data emerge over the course of the pandemic.

**Seroprevalence studies**

- Estimates of the IFR can be inferred from seroprevalence studies.
  - Worldwide seroprevalence estimates range between 0.37% and 22.1%, with a pooled estimate of 3.38% (based on data from 23 countries as of August 2020).\[823\]
  - UK: seroprevalence was 7.1% in the UK overall according to the first round of results of the UK Biobank COVID-19 antibody study. Previous infection was most common among people who lived in London (10.4%), and least common among those who lived in the south west of England and Scotland (4.4% in both).\[824\]
  - US: less than 10% of people are thought to have detectable severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antibodies based on data from July to September 2020.\[825\]
    - Current seroprevalence estimates for 10 sites in the US are available. [CDC: commercial laboratory seroprevalence survey data] (https://covid.cdc.gov/covid-data-tracker/#serology-surveillance)
  - China: seroprevalence was 3.2% to 3.8% in Wuhan, and decreased in other Chinese cities as the distance to the epicentre increased.\[826\]
- These studies suggest that the prevalence of infections is much higher than the official case counts suggest, and therefore the virus is much less lethal than initially thought.

**Case fatality rate (CFR)**

- Defined as the total number of deaths reported divided by the total number of detected cases reported. CFR is subject to selection bias as more severe/hospitalised cases are likely to be tested.
- The World Health Organization’s current estimate of the global CFR is 2.3% (as of 15 December 2020).\[827\]
  - This is much lower than the reported CFR of severe acute respiratory syndrome
Coronavirus disease 2019 (COVID-19)  
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coronavirus (SARS), which was 10%, and Middle East respiratory syndrome (MERS), which was 37%. [44]

• CFR varies considerably between countries.

  • In China, the overall CFR has been reported to be between 1.4% and 2.3% (0.9% in patients without comorbidities). [4] [828]

• CFR increases with age.

  • In the US, the majority of deaths were in patients ages ≥65 years. The CFR was highest among patients ages ≥85 years (10% to 27%), followed by those ages 65 to 84 years (3% to 11%), then those ages 55 to 64 years (1% to 3%), and finally those ages 20 to 54 years (<1%). [7]
  • In China, the majority of deaths were in patients ages ≥60 years. [4] The CFR was highest among patients ages ≥80 years (13.4%), followed by those ages 60 to 79 years (6.4%), and then those ages <60 years (0.32%). [828]
  • In Italy, the CFR was highest among patients ages ≥80 years (52.5%), followed by those ages 70 to 79 years (35.5%), and then those ages 60 to 69 years (8.5%). [829]
  • Deaths are rare in children. [7] [19] In one study, 70% of deaths occurred in those ages 10 to 20 years, 20% in those ages 1 to 9 years, and 10% in children under 1 year of age. [830]

• CFR increases with the presence of comorbidities.

  • In China, the majority of deaths were in patients who had preexisting underlying health conditions (10.5% for cardiovascular disease, 7.3% for diabetes, 6.3% for chronic respiratory disease, 6% for hypertension, and 5.6% for cancer). [4]

• CFR increases with disease severity.

  • The CFR is highest in patients with critical disease, ranging from 26% to 67% in studies. [4] [831] [832]

Limitations of IFR/CFR

• Estimating the IFR and CFR in the early stages of a pandemic is subject to considerable uncertainties and estimates are likely to change as more data emerges. Rates tend to be high at the start of a pandemic and then trend downwards as more data becomes available. [833]

• There is currently no set case definition of a confirmed case, and case definitions vary. A positive polymerase chain reaction (PCR) result is sometimes the only criterion for a case to be recognized; however, a positive PCR test does not necessarily equal a diagnosis of COVID-19, or mean that a person is infected or infectious. [834] [835]

• The number of deaths reported on a particular day may not accurately reflect the number of deaths from the previous day due to delays associated with reporting deaths. This makes it difficult to know whether deaths are falling over time in the short term. [836]

• Patients who die “with” COVID-19 and patients who die “from” COVID-19 may be counted towards the death toll in some countries. For example, in Italy only 12% of death certificates reported direct causality from COVID-19, while 88% of patients who died had at least one comorbidity. [833] [837]

Mortality rate by country

• The number of deaths (per 100,000 population) for different countries varies: [838]

  • South Korea – 0.7
  • Japan – 1.2
  • Australia – 3.3
  • Germany – 11.3
  • Canada – 24.6
  • France – 46.6
  • Sweden – 57.4
Prognostic factors

Prognostic factors that have been associated with increased risk of severe disease and mortality include:[839]

- Increasing age
- Male sex
- Smoking
- Presence of comorbidities (e.g., hypertension, diabetes, cardiovascular or cerebrovascular disease, arrhythmias, COPD, dementia, malignancy)
- Dyspnea
- Tachypnea
- Hypoxemia
- Respiratory failure
- Hypotension
- TachyCARDIA
- Lymphopenia
- Leukocytosis
- Neutrophilia
- Thrombocytopenia
- Hypoalbuminemia
- Liver, kidney impairment, or cardiac injury
- Elevated inflammatory markers (C-reactive protein, procalcitonin, erythrocyte sedimentation rate)
- Elevated lactate dehydrogenase
- Elevated creatine kinase
- Elevated cardiac markers
- Elevated D-dimer
- Elevated interleukin-6
- Consolidative infiltrate or pleural effusion on chest imaging
- High sequential organ failure assessment (SOFA) score.

The most common underlying diseases in deceased patients were hypertension, diabetes, and cardiovascular diseases.[840]

A ratio of arterial partial pressure of oxygen to fraction of inspired oxygen ($\text{PaO}_2/\text{FiO}_2$) $\leq$ 200 mmHg and respiratory failure at admission are also independently associated with an increased risk of in-hospital mortality.[841] Almost half of patients who received invasive mechanical ventilation died. The mortality rate was higher in older patients >80 years (84%) compared with younger patients $\leq$ 40 years (48%).[842]

Hospital readmission

Approximately 9% of over 106,000 patients were readmitted to the same hospital within 2 months of discharge from the initial hospitalization. Multiple readmissions occurred in 1.6% of patients. The median time from discharge to the first readmission was 8 days. Less than 0.1% of patients died during readmission. Risk factors for readmission include:[843]
Follow up

• Age ≥65 years
• Presence of chronic conditions (COPD, heart failure, diabetes, chronic kidney disease, obesity)
• Hospitalization within the 3 months preceding the first COVID-19 hospitalization
• Discharge to a skilled nursing facility or with home health care.

Reinfection

There is limited information about reinfection. Recurrent RT-PCR positivity in patients 1 to 60 days after recovery ranges between 7% to 23% in studies, with an estimated pooled rate of 12%. Patients with longer initial illness and younger age were more likely to experience recurrent RT-PCR positivity, while those with severe disease, diabetes, and a low lymphocyte count were less likely. It is currently unclear whether this is due to reinfection, persistent viral shedding, or whether the test result was a false-negative at the time of discharge.

Studies have repeatedly reported positive RT-PCR tests for up to 90 days after initial infection; therefore, it is most likely that these cases are actually protracted initial infections. It is important to note that although persistent viral shedding has been reported for up to 90 days after the onset of infection, replication-competent virus has not been identified 10 to 20 days after the onset of symptoms (depending on disease severity).

True cases of reinfection (defined as two episodes of infection at least 3 months apart by virus strains with different genomic sequences) have been reported in Hong Kong, India, Ecuador, and Belgium. Two possible cases of reinfection have also been reported in the US; however, while different genomic variants were responsible for the two episodes in both men, the infections occurred less than 2 months apart.

Immunity

The immune response, including duration of immunity, is not yet fully understood. However, there is evidence that suggests that infection with SARS-CoV-2 is likely to confer protective immunity against reinfection. Emerging studies suggest that the majority of people develop a strong and broad T-cell response with both CD4+ and CD8+ T cells, and some have a memory phenotype. A preprint study found that spike immunoglobulin G (IgG) was relatively stable over 6 months, spike-specific memory B cells were more abundant at 6 months than at 1 month, and CD4+ and CD8+ T cells declined with a half-life of 3 to 5 months in adults (mostly with mild disease) who recovered from COVID-19. Another preprint study in over 12,000 healthcare workers found that prior SARS-CoV-2 infection that generated antibody responses offered protection from reinfection for most people in the 6 months following infection. This bodes well for potential longer-term immunity.

The immune response to SARS-CoV-2 involves both cell-mediated immunity and antibody production. Adaptive immunity to SARS-CoV-2 is thought to occur within the first 7 to 10 days of infection. A robust memory B-cell and plasmablast response is detected early in infection, with secretion of IgA and IgM antibodies by day 5 to 7, and IgG by day 7 to 10 from the onset of symptoms. IgA and IgM titers decline after approximately 28 days, and IgG titers peak at approximately 49 days. T cells are simultaneously activated in the first week of infection and SARS-CoV-2-specific memory CD4+ and CD8+ T cells peak within 2 weeks, but remain detectable for ≥100 days. Antibody and T-cell responses differ among individuals, and depend on disease severity. A preprint study has found that T-cell response is likely to be present in most adults 6 months after primary infection.

While there have been concerns about early declining IgG neutralizing antibodies during convalescence, this is not thought to be an issue, because antibody levels always decline after the acute phase of an infection, and it is the levels of antibody titer after an infection that is important as this represents the generation of long-lived plasma cells to protect against subsequent infection. Antibodies have been found to be relatively stable for at least 5 months.

Analysis of a large cohort of convalescent serum donors in New York City suggests that 99.5% of patients with confirmed mild disease seroconvert 4 weeks after illness. IgG antibodies developed over a period of
7 to 50 days from symptom onset, and 5 to 49 days from symptom resolution. This suggests that people with mild disease may have the ability to develop immunity.[863] However, among patients who recovered from mild disease in China, neutralizing antibody titers varied substantially.[864] There are data to suggest that asymptomatic people may have a weaker immune response to infection; however, this is yet to be confirmed.[865]

Testing of blood samples taken before the COVID-19 pandemic have shown that some people already have immune cells that recognize SARS-CoV-2. Studies have reported T-cell reactivity against SARS-CoV-2 in 20% to 50% of people with no known exposure to the virus.[866] Approximately 5% of uninfected adults and 62% of uninfected children aged 6 to 16 years had antibodies that recognize SARS-CoV-2 in one study.[867] This may be a consequence of true immune memory derived in part from previous infection with common cold coronaviruses, or from other unknown animal coronaviruses. However, further research into whether there is preexisting immunity to SARS-CoV-2 in the human population is required.
## Diagnostic guidelines

### International

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<tr>
<td><strong>Diagnostic testing for SARS-CoV-2: interim guidance</strong> (<a href="https://www.who.int/publications/i/item/diagnostic-testing-for-sars-cov-2">https://www.who.int/publications/i/item/diagnostic-testing-for-sars-cov-2</a>) [391]</td>
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<td><strong>Prevention, identification and management of health worker infection in the context of COVID-19</strong> (<a href="https://www.who.int/publications/i/item/10665-336265">https://www.who.int/publications/i/item/10665-336265</a>) [27]</td>
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Last published: 2020 |
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| **A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia** ([link](https://mmrjournal.biomedcentral.com/articles/10.1186/s40779-020-0233-6)) [571] | Published by: Zhongnan Hospital of Wuhan University Novel Coronavirus Management and Research Team; Evidence-Based Medicine Chapter of China International Exchange and Promotive Association for Medical and Health Care  
Last published: 2020 |
| **Diagnosis and clinical management of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection** ([link](https://www.tandfonline.com/doi/full/10.1080/22221751.2020.1735265)) [572] | Published by: Peking Union Medical College Hospital  
Last published: 2020 |
## Treatment guidelines

### International

**Coronavirus disease 2019 (COVID-19) treatment guidelines** (https://covid19treatmentguidelines.nih.gov/)  
**Published by:** National Institutes of Health  
**Last published:** 2020

**Published by:** Centers for Disease Control and Prevention  
**Last published:** 2020

**Published by:** Centers for Disease Control and Prevention  
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**Published by:** Centers for Disease Control and Prevention  
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**Last published:** 2020

**Infectious Diseases Society of America guidelines on the treatment and management of patients with COVID-19** (https://www.idsociety.org/practice-guideline/alphabetical-guidelines/)  
**Published by:** Infectious Diseases Society of America  
**Last published:** 2020

**Diagnosis and management of COVID-19 disease** (https://www.thoracic.org/covid/covid19-clinician-resources.php)  
**Published by:** American Thoracic Society  
**Last published:** 2020
## International

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<td>Thromboembolism and anticoagulant therapy during the COVID-19 pandemic: interim clinical guidance from the Anticoagulation Forum</td>
<td>Anticoagulation Forum</td>
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<td>Evaluation and management considerations for neonates at risk for COVID-19</td>
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<td>Clinical guidance</td>
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<td>Caring for children and youth with special health care needs during the COVID-19 pandemic</td>
<td>American Academy of Pediatrics</td>
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## International

### Country & technical guidance - coronavirus disease (COVID-19)  

**Published by:** World Health Organization  
**Last published:** 2020

### Clinical management of COVID-19: interim guidance  

**Published by:** World Health Organization  
**Last published:** 2020

### Therapeutics and COVID-19: living guideline  
(https://www.who.int/publications/i/item/therapeutics-and-covid-19-living-guideline)  [575]

**Published by:** World Health Organization  
**Last published:** 2020

### Home care for patients with suspected or confirmed COVID-19 and management of their contacts: interim guidance  

**Published by:** World Health Organization  
**Last published:** 2020

### Criteria for releasing COVID-19 patients from isolation: scientific brief  
(https://www.who.int/publications/i/item/criteria-for-releasing-covid-19-patients-from-isolation)  [797]

**Published by:** World Health Organization  
**Last published:** 2020

### Mask use in the context of COVID-19: interim guidance  

**Published by:** World Health Organization  
**Last published:** 2020

### Rapid advice guidelines for management of children with COVID-19  
(http://atm.amegroups.com/article/view/43612/html)  [798]

**Published by:** International multidisciplinary working group  
**Last published:** 2020

### COVID-19 guidance and the latest research in the Americas  
(https://covid19-evidence.paho.org/)  [799]

**Published by:** Pan American Health Organization  
**Last published:** 2020

### ISTH interim guidance on recognition and management of coagulopathy in COVID-19  

**Published by:** International Society of Thrombosis and Haemostasis  
**Last published:** 2020

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## International

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<td>Community palliative, end of life and bereavement care in the COVID-19 pandemic</td>
<td><a href="https://elearning.rcgp.org.uk/mod/page/view.php?id=10537">https://elearning.rcgp.org.uk/mod/page/view.php?id=10537</a></td>
<td>Royal College of General Practitioners; Association for Palliative Medicine</td>
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<td>Chinese Center for Disease Control and Prevention</td>
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## International


**Published by:** Zhongnan Hospital of Wuhan University Novel Coronavirus Management and Research Team; Evidence-Based Medicine Chapter of China International Exchange and Promotive Association for Medical and Health Care  
**Last published:** 2020


**Published by:** National Health Commission of the People's Republic of China; National Administration of Traditional Chinese Medicine of the People's Republic of China  
**Last published:** 2020


**Published by:** Peking Union Medical College Hospital  
**Last published:** 2020


**Published by:** Ministry of Health Singapore  
**Last published:** 2020


**Published by:** National Institute of Infectious Diseases Japan  
**Last published:** 2020


**Published by:** Japanese Association for Infectious Diseases  
**Last published:** 2020


**Published by:** Working Group for the Prevention and Control of Neonatal SARS-CoV-2 Infection in the Perinatal Period of the Editorial Committee of Chinese Journal of Contemporary Pediatrics  
**Last published:** 2020


**Published by:** Department of Health Australia  
**Last published:** 2020
### Online resources


5. BMJ Best Practice: Management of coexisting conditions in the context of COVID-19 (https://bestpractice.bmj.com/topics/en-us/3000190#important-update) (external link)


10. UK Department of Health and Social Care: monthly results for REACT-1 studies (https://www.gov.uk/government/collections/monthly-results-for-react-1-studies) (external link)


| 15. | BMJ: covid-19 in primary care (UK)  | (external link) |
| 18. | WHO: coronavirus disease (COVID-19) advice for the public  | (external link) |
| 19. | Centre for Evidence-Based Medicine: what is the evidence to support the 2-metre social distancing rule to reduce COVID-19 transmission?  | (external link) |
| 20. | BMJ: facemasks for the prevention of infection in healthcare and community settings  | (external link) |
| 22. | Public Health England: guidance on shielding and protecting people who are clinically extremely vulnerable from COVID-19  | (external link) |
| 23. | Royal College of Paediatrics and Child Health: COVID-19 – guidance on clinically extremely vulnerable children and young people  | (external link) |
| 24. | MHRA: information for healthcare professionals on Pfizer/BioNTech COVID-19 vaccine  | (external link) |
| 25. | FDA: interim clinical considerations for use of Pfizer/BioNTech COVID-19 vaccine  | (external link) |
| 28. | Centre for Evidence-Based Medicine: are you infectious if you have a positive PCR test result for COVID-19?  | (external link) |
29. BMJ Practice Pointer: interpreting a covid-19 tests result (https://www.bmj.com/content/369/bmj.m1808) (external link)

30. BMJ practice pointer: testing for SARS-CoV-2 antibodies (https://www.bmj.com/content/370/bmj.m3325) (external link)


40. Clinical frailty scale (https://www.nice.org.uk/guidance/ng159/resources/clinical-frailty-scale-pdf-8712262765) (external link)


43. BMJ rapid recommendations: a living WHO guideline on drugs for COVID-19 (https://www.bmj.com/content/370/bmj.m3379) (external link)


47. RECOVERY trial (https://www.recoverytrial.net/) (external link)


50. BMJ webinar: long COVID – how to define it and how to manage it (https://www.bmj.com/content/370/bmj.m3489) (external link)

51. BMJ: management of post-acute covid-19 in primary care (https://www.bmj.com/content/370/bmj.m3026) (external link)


57. NaTHNac: travel health pro (https://travelhealthpro.org.uk/) (external link)

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<td>NHS UK: your COVID recovery (<a href="https://www.yourcovidrecovery.nhs.uk">https://www.yourcovidrecovery.nhs.uk</a>) (external link)</td>
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98. **Chen F, Fu D, Yang Q, et al.** Low transmission risk of 9 asymptomatic carriers tested positive for both SARS-CoV-2 nucleic acid and serum IgG. J Infect. 2020 Sep;81(3):452-82. Full text


Coronavirus disease 2019 (COVID-19)

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Figure 1: Number of COVID-19 cases reported weekly by WHO Region, and global deaths, as of 13 December 2020

World Health Organization
Figure 2: Illustration revealing ultrastructural morphology exhibited by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) when viewed with electron microscopically

Centers for Disease Control and Prevention
Figure 3: Virus replication cycle

BMJ. 2020;371:m3862
Figure 4: Transverse CT scans from a 32-year-old man, showing ground-glass opacity and consolidation of lower lobe of right lung near the pleura on day 1 after symptom onset (top panel), and bilateral ground-glass opacity and consolidation on day 7 after symptom onset

Xu XW et al. BMJ. 2020;368:m606
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BMJ accepts no responsibility for misinterpretation of numbers which comply with this stated numerical separator standard.

This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

Figure 1 – BMJ Best Practice Numeral Style
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