

COVID-19: Epidemiology, Virology, Transmission, and Prevention

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ABSTRACT

Coronavirus disease-2019 (COVID-19) is a major global human threat caused by severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). Following the first pneumonia case in China in December 2019, humanity faced a dreadful infection in a short period when the World Health Organization declared a pandemic on March 11, 2020. This review aims to look at the epidemiology of COVID-19, the virological characteristics of SARS-CoV-2, and the methods of transmission and prevention.

Keywords: COVID-19, SARS-CoV-2, pandemic, infectious disease and microbiology

Introduction

Epidemiology

Severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) is a coronavirus strain that causes severe and potentially fatal respiratory symptoms (1). In March 2020, the World Health Organization (WHO) declared coronavirus disease-2019 (COVID-19) as the first coronavirus-initiated pandemic. Since then, Turkey has reported approximately 16 million total cases and 101.000 deaths. The WHO has received reports of nearly 620 million confirmed cases of COVID-19, including 6 million deaths (2).

SARS-CoV-2 infection can result in five outcomes (3):

- Asymptomatic infection
- Mild-to-moderate cases
- Severe cases
- Critical cases
- Death

The typical symptoms, such as fever, dry cough, myalgia, fatigue, dyspnea, normal/decreased leukocyte/lymphocyte counts, and radiographic evidence, can vary depending on the severity of the disease (4). The global case fatality rate has been reported to be around 1.2% late. Individuals with underlying medical conditions have a higher mortality rate. Hypertension, obesity, diabetes, cardiovascular disease, and kidney disease are all considered to be risk factors for death. Mortality rises from 0.9% in healthy people to 6% in hypertensive patients, 7.3% in diabetics, and 10.5% in people with cardiovascular diseases (5,6).

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Virology

SARS-CoV-2 is a member of the family *Coronaviridae*, subfamily *Orthocoronavirinae*.

Coronaviruses are positive-stranded RNA viruses with an envelope that primarily infect the respiratory system (7). SARS-CoV-2 is a beta-coronavirus in the same subgenus, according to full-genome sequencing and phylogenetic analysis. SARS-CoV-2 has a zoonotic origin, beginning in bats and spreading to other species before reaching humans (8).

Structure proteins include spike, membrane, envelope and nucleocapsid proteins. The virion's nucleocapsid is composed of genomic RNA and phosphorylated nucleocapsid (N) protein, which is buried within phospholipid bilayers and protected by the spike glycoprotein trimmer (S). Among the S proteins, the membrane (M) protein hemagglutinin-esterase (HE) and the envelope (E) protein are located. (9). These proteins, which are required for the assembly of new viral particles, are encoded by one-third of the viral genome (10,11,12).

SARS-CoV-2 interacts with the angiotensin-converting enzyme-2 (ACE-2) binding site on host cells, which is abundant in the heart, lungs, kidney, and gastrointestinal tract. When the SARS-CoV-2 "S protein" binds to ACE-2 receptors, the infection is activated and clinical symptoms develop based on the location of the entry receptor in organs (1,13,14,15,16). The high affinity of SARS-CoV-2 for ACE-2 receptors explains its efficient spread and transmission from person to person that has been reported thus far. Men and individuals with diabetes mellitus or cardiovascular disease who may have higher levels of circulating ACE-2 had higher hospitalization and mortality rates (15,17).

The rapid spread of the SARS-CoV-2 (D614G variant), suggested that virus adaptation could occur between March and May 2020 (18). SARS-CoV-2 variants currently include (19,20):

- Alpha (B.1.1.7) variant
- Beta (B.1.351) variant
- Gamma (P.1) variant
- Delta (B.1.617.2) variant
- Omicron (B.1.1.529) variant

A new strain of the virus, VUI 202012/01 or B.1.1.7 (WHO Alpha variant), was discovered in the United Kingdom (UK) in September 2020. It is distinguished by multiple S-protein mutations as well as mutations in other regions of the genome. A mutation (N501Y) affects the cell receptor's binding site. The Alpha variant differs from the Wuhan strain by 29 nucleotides (21). Soon after the Alpha lineage emerged, different viral

lineage, B.1.617.2 (Delta variant), swept through India and became dominant globally (22). The Delta variant was 40%-60% more transmissible than the B.1.1.7 Alpha variant, and the risk of hospitalization was higher in unvaccinated individuals (23).

A rise in the number of COVID-19 cases with S gene target failure (SGTF) was observed in South Africa in November 2021. The WHO identified this variant as one of concerns, naming it the B.1.1.529 Omicron variant, based on its mutational profile and extremely rapid spread. In December 2021, this variety spread quickly over the globe, leading to a record-high number of confirmed illnesses (24). Dominant sublineages of the Omicron variant were defined as BA.1, BA.2, BA.3, BA.4, and BA.5. These sublineages have been linked to local increases in SARS-CoV-2 infections.

BA.4 and BA.5 were found in South Africa and were predicted to have a replication advantage over BA.2, equivalent to BA.2's advantage over BA.1, based on an examination of the shifting predominance of Omicron sublineages (25). In the UK, where both sublineages are becoming more prevalent, the research found that BA.5 has a bigger projected replication advantage than BA.4 does (26).

Transmission

SARS-CoV-2 is primarily spread through airborne infectious particles and droplets from infected individuals to close contacts (27,28,29,30). The potential for SARS-CoV-2 transmission begins before symptoms and is highest early during COVID-19. Evidence suggests that each primary infected person causes two to three secondary infectious cases on average (6).

SARS-CoV-2 has three distinct transmission routes (31):

1. Directly from one infected individual to another, or indirectly via an intermediate contaminated object,
2. Droplet sprays transmission from person to person,
3. Transmission of aerosolized particles from person to person via the air.

SARS-CoV-2 in aerosols is viable for 3 h (32) and could land in other people's mucus membranes or on surfaces, causing cross-contamination. Potential transmission routes include also environmental cross-contamination and fecal shedding (33,34). The virus appears less stable on copper and cardboard surfaces than on plastic and stainless-steel surfaces, where it was detectable up to 72 h later (33,35,36).

Three to six days following the onset of symptoms is when viral RNA reaches its peak and there is the greatest chance that an infectious virus will be released (37). The median duration

of infectious Omicron virus detection in nasal specimens ranged from three to five days after diagnosis. Transmission after ten days following the onset of symptoms is considered unlikely with it (38,39).

In Taiwan, a study of over 2500 close contacts of 100 patients with COVID-19 found that all 22 secondary cases had their first exposure to the index case within six days of symptom onset. After this period, no infections were diagnosed in the 850 contacts who were exposed (40).

Prevention

The Centers for Disease Control and Prevention took the lead in developing infection prevention and control guidelines for both US and non-US healthcare settings as soon as SARS-CoV-2 had spread and the pandemic had been declared (31). The herd immunity theory and the presumption that virus exposure produced long-term immunity had been the basis of both pandemic control and national measures (41).

Lockdown, social distancing measures, and eventually, the use of face masks were among the non-pharmaceutical interventions (NPIs). The adoption of NPIs during the first wave of the pandemic flattened the curve, extending the period during which cases occurred (42). As a personal preventive measure, the following general measures are recommended to prevent infection:

1. Hand washing and respiratory hygiene: If the hands are not visibly dirty, using a hand sanitizer containing at least 60% alcohol is suggested as an alternative to hand washing (43).

2. Adequate ventilation of indoor spaces: By opening windows/doors, continuously running air conditioning fans, and using portable high-efficiency particulate air filtration systems (44,45).

3. Avoiding close contact with COVID-19 infected individuals: If community transmission levels are high, avoiding crowds and close contact with other people outside the household is also recommended to reduce the risk of exposure (46).

4. Wearing a mask: As part of a comprehensive strategy to reduce SARS-CoV-2 transmission in either outdoor or indoor settings with poor ventilation (47).

Although NPIs reduced viral spread at the population level, infection risk was not reduced equally across populations. In April and May 2020, healthcare and frontline workers were at a particularly high risk of infection (48). During a pandemic, a population's immunity to natural infection improved over time. Initial expectations for SARS-CoV-2 were that population

immunity in regions with significant first waves would significantly lower future transmission (49).

Many countries around the world considered the administration of COVID-19 vaccines a top priority (50). mRNA vaccines are associated with a lower viral load and a shorter duration of illness before Delta transmission (51,52). mRNA vaccines from Pfizer/BioNTech (BNT162b2) and Moderna (CX-024414) have been critical in launching mass vaccination campaigns in the USA and around the world. Both vaccines generated higher titers of anti-SARS-CoV-2 spike (protein-specific) antibodies capable of neutralizing the original circulating SARS-CoV-2 strains as well as subsequent vaccine design variations. Antibodies produced by mRNA vaccines in animal models and humans appear effective in protection from COVID-19. Laboratory tests on PfizerBioNTech vaccines showed that three doses provide a high level of protection against the Omicron variant. Only the booster dose can increase neutralizing antibody titers by a factor of 25 compared with the other two doses (53,54).

A study from Singapore showed that BNT162b2 vaccination was associated with a faster decrease in viral loads among those vaccinated (55). Ad26.COV2.S (Janssen Vaccine) and BNT162b2 were associated with a lower probability of viral culture positivity; this suggests that vaccinated people are shedding less contagious Delta virus (56). Before the spread of Delta, a study in England found that BNT162b2 or AZD1222 (The Oxford-AstraZeneca Vaccine) reduced transmission in a household setting (57).

In conclusion, the most successful strategies for decreasing transmission remain to be the vaccine programs and tests, as well as tracking and isolating the system (58).

Ethics

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: P.I., S.T., Concept: P.I., S.T., Design: P.I., S.T., Data Collection or Processing: P.I., S.T., Analysis or Interpretation: S.T., Literature Search: P.I., S.T., Writing: P.I., S.T.

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