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Review Article

COVID-19: An Overview of Etiology, Clinical Manifestations and Management Strategies

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Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), continues to be clinically important despite the transition from the acute pandemic phase. This review summarizes the etiology and virology of SARS-CoV-2, epidemiology, transmission, pathophysiology, clinical manifestations, diagnostic approaches, prevention, and contemporary management. SARS-CoV-2 is an enveloped, positive-sense, single-stranded RNA virus. Infection ranges from asymptomatic or mild respiratory illness to pneumonia, hypoxemic respiratory failure, acute respiratory distress syndrome, thrombo-inflammatory complications, and post-COVID-19 condition. Diagnosis relies primarily on nucleic-acid amplification tests and antigen-detection tests, interpreted in the clinical context. Prevention includes vaccination, ventilation, respiratory hygiene, and appropriate infection-control measures. Management should be based on disease severity and individual risk: supportive care is central for most mild cases, selected high-risk patients may benefit from early antiviral treatment, and severe disease may require oxygen therapy, systemic corticosteroids, and selected immunomodulatory treatment. Pharmacists contribute through medication review, assessment of drug interactions, adherence support, vaccination services, pharmacovigilance, and patient education. As variants and clinical recommendations continue to evolve, healthcare professionals should consult current national and international guidance. This review highlights key clinical and pharmaceutical considerations for the prevention and management of COVID-19.

Keywords: COVID-19, SARS-CoV-2, Antiviral therapy, Vaccination, Long COVID, Clinical pharmacist

INTRODUCTION

The global healthcare landscape was radically altered in late 2019 following the identification of a novel respiratory pathogen, subsequently designated as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in Wuhan, China. Acknowledging its rapid international transmission and severe clinical impact, the World Health Organization (WHO) officially declared COVID-19 a global pandemic on March 11, 2020. This unprecedented health crisis demanded rapid advancements in molecular diagnostics, accelerated vaccine manufacturing pipelines, and the discovery of novel small-molecule antivirals. Over time, the clinical focus has shifted from crisis-driven emergency responses toward structural surveillance, focused immunization of vulnerable demographics, early pharmacological interventions, and specialized management of chronic post-COVID-19 sequelae. Contemporary review articles must differentiate outdated early-pandemic emergency interventions from current evidence-based clinical protocols. Organizations like the WHO regularly revise their living guidelines for clinical management and therapeutics. Adhering to updated frameworks, such as the mid-2025 updates, is essential to avoid relying on obsolete clinical models. This review provides a comprehensive, pharmacy-centric exploration of COVID-19 etiology, transmission dynamics, clinical presentation, diagnostics, and modern therapeutic options.

2. Etiology and Virology

Classified taxonomically within the Coronaviridae family and the Betacoronavirus genus, SARS-CoV-2 possesses an enveloped structure containing a positive-sense, single-stranded RNA genome comprising

approximately 30 kilobases. This genetic material codes for structural components, non-structural replication factors, and various accessory proteins. The structural integrity and infectivity of the virion rely on four core structural proteins: Spike (S), Envelope (E), Membrane (M), and Nucleocapsid (N). Host cell attachment is driven by the surface spike glycoprotein; specifically, the receptor-binding domain (RBD) within the S1 subunit binds to the host cell surface receptor, angiotensin-converting enzyme 2 (ACE2). Subsequent viral entry and membrane fusion are facilitated by the S2 subunit following proteolytic cleavage by host cell proteases like transmembrane protease serine 2 (TMPRSS2). Genetic mutations within the spike gene drive the emergence of novel variants characterized by altered transmissibility rates and heightened immune evasion. Genomic surveillance tracking has documented the transition from early variants of concern (such as Alpha, Beta, Gamma, and Delta) to the current dominance of Omicron sublineages, highlighting the need for continuous genomic monitoring.

3. Epidemiology

The epidemiological profile of COVID-19 has changed considerably due to widespread population immunity acquired through global vaccination campaigns and natural exposures. Modern surveillance data relies less on mass community testing and focuses instead on severe clinical outcomes, including hospital admission rates, intensive care utilization, and mortality statistics. The risk of developing severe clinical phenotypes is strongly correlated with advanced age and specific host comorbidities. Conditions that consistently predict poor clinical outcomes include chronic cardiovascular disorders, diabetes mellitus, severe chronic kidney disease, obstructive pulmonary conditions, profound obesity, and primary or secondary immunocompromised states. Consequently, clinical risk profiling must be highly individualized and guided by updated epidemiological assessments.

4. Transmission Routes

The primary mode of SARS-CoV-2 transmission is the inhalation of respiratory particles generated when an infected individual breathes, talks, coughs, or sneezes. The virus spreads most efficiently in poorly ventilated, crowded indoor spaces where aerosols can remain suspended. While transmission via contaminated surfaces (fomites) is biologically plausible, it represents a minor route compared to direct aerosol inhalation. Environmental factors like indoor air exchange rates, spatial proximity, and exposure duration heavily influence transmission dynamics. Additionally, the incubation periods and viral shedding patterns vary across different evolutionary lineages, meaning early-pandemic historical metrics may not accurately reflect current strains.

5. Pathophysiology

Following initial exposure, SARS-CoV-2 targets epithelial cells expressing high levels of ACE2 within the human respiratory tract. Proteolytic activation allows the viral envelope to fuse with the host membrane, releasing viral RNA into the cytoplasm to initiate replication. In most individuals, local immune activation successfully limits viral replication, leading to mild, self-limiting symptoms. However, a subset of patients experiences a dysregulated hyper-inflammatory response characterized by massive cytokine release, endothelial damage, microvascular thrombosis, and diffuse alveolar damage. Severe cases often progress to severe hypoxemic respiratory failure and acute respiratory distress syndrome (ARDS). This systemic endothelial injury can also cause multi-organ damage and thromboembolic complications. While abnormal inflammatory biomarkers (such as C-reactive protein, D-dimer, and ferritin) indicate severe disease, they must be interpreted alongside the patient's full clinical presentation rather than as isolated triggers for aggressive therapy.

6. Clinical Manifestations

The clinical presentation of COVID-19 ranges from asymptomatic infections to critical, life-threatening multi-organ failure. Mild cases typically present with upper respiratory tract symptoms, including fever, persistent dry cough, pharyngitis, generalized fatigue, cephalalgia, and myalgia. Sensory changes, such as anosmia and ageusia, are notably less common with recent variants than with early-pandemic strains. Progression to moderate disease is characterized by clinical or radiological signs of lower respiratory tract involvement, though normal systemic oxygenation is maintained. Severe COVID-19 is defined by significant respiratory distress, tachypnea, and severe hypoxemia requiring supplemental oxygen. Critical

cases present with rapidly progressing respiratory failure, septic shock, and multi-organ dysfunction syndrome (MODS). Beyond the acute phase, post-COVID-19 condition (commonly known as Long COVID) is characterized by persistent, unexplained symptoms—such as chronic fatigue, dyspnea, and cognitive impairment—that last for months after the initial infection and require multidisciplinary care.

7. Diagnostic Approaches

Selecting the appropriate diagnostic method depends on the clinical setting and the time elapsed since symptom onset. Nucleic acid amplification tests (NAATs), particularly real-time reverse transcription-polymerase chain reaction (RT-PCR), remain the gold standard for definitive diagnosis due to their high analytical sensitivity. Rapid antigen detection tests offer faster turnaround times but have lower sensitivity, meaning they can yield false-negative results during early infections or periods of low viral shedding. Consequently, negative antigen tests should be confirmed with molecular testing if clinical suspicion remains high. Serological antibody testing is not suitable for diagnosing acute infections because of delays in seroconversion; instead, it is primarily used for epidemiological surveillance and retrospective immune assessments. Imaging modalities, such as chest radiography and computed tomography (CT), can reveal characteristic bilateral ground-glass opacities, but they should supplement, not replace, definitive microbiological testing.

8. Preventive Strategies

Effective prevention requires a combination of widespread immunization, enhanced indoor ventilation, and targeted infection control measures. Modern vaccination regimens focus on administering updated formulations tailored to circulating variants, with scheduling prioritised by age and risk profile. Individuals should consult current national immunization guidelines rather than historical vaccine protocols. During seasonal spikes in respiratory viruses, public health measures—such as staying home when sick, using high-efficiency particulate air (HEPA) filtration systems, and wearing well-fitting respirators (N95/KN95) in crowded spaces—help reduce community transmission.

9. Management And Therapeutics

9.1 Non-Severe Disease

The majority of patients presenting with mild infections require supportive care, including oral hydration, adequate rest, and over-the-counter antipyretics or analgesics for symptom relief. However, individuals identified as having a high risk for clinical progression must be evaluated immediately for early outpatient antiviral therapy.

9.2 Antiviral Therapy

For high-risk outpatients with non-severe disease, oral nirmatrelvir/ritonavir or intravenous remdesivir are preferred options to prevent hospitalization, provided they are started early in the disease course. Oral molnupiravir serves as an alternative when preferred agents are contraindicated or unavailable, though its use is restricted to specific clinical scenarios. Notably, ritonavir-boosted regimens require comprehensive medication reconciliation due to their potent inhibition of the cytochrome P450 3A (CYP3A) pathway, which can lead to severe drug-drug interactions.

9.3 Severe and Critical Disease

Hospitalized patients with severe or critical presentations require supplemental oxygen therapy alongside respiratory support. Systemic corticosteroids, such as dexamethasone, significantly improve outcomes in patients requiring supplemental oxygen but are contraindicated in non-severe cases where oxygen is not needed. In cases of rapid respiratory decline and high systemic inflammation, targeted immunomodulators—such as interleukin-6 (IL-6) receptor antagonists or Janus kinase (JAK) inhibitors—may be added based on specific eligibility criteria.

9.4 Anticoagulation

Given the high risk of thromboembolism associated with COVID-19, hospitalized patients should receive standard pharmacological thromboprophylaxis. However, escalating to therapeutic-dose anticoagulation should be done cautiously, balancing the patient's individual thrombotic risk against their potential bleeding risk, rather than introducing it routinely.

9.5 Advanced Respiratory Support

Patients who develop progressive hypoxemia require a step-up approach to respiratory support, moving

from low-flow supplemental oxygen to high-flow nasal oxygen (HFNO), non-invasive ventilation (NIV), or invasive mechanical ventilation. Awake prone positioning can improve oxygenation in selected patients receiving non-invasive oxygen therapy, and critical care management should follow established ARDS and sepsis protocols.

10. The Pharmacist's Role In COVID-19 Management

• Conducting rigorous medication reconciliation to identify and mitigate severe drug-drug interactions, particularly with ritonavir-based antiviral regimens. • Providing comprehensive patient counseling on correct medication adherence, identifying adverse drug reactions, and recognizing red-flag symptoms that require urgent medical attention. • Managing immunization clinics, ensuring cold-chain storage compliance, maintaining accurate documentation, and addressing vaccine hesitancy. • Participating in national pharmacovigilance programs by identifying and reporting suspected adverse drug reactions to regulatory bodies. • Enforcing antimicrobial stewardship principles to prevent the inappropriate use of empirical antibiotics in cases of purely viral respiratory infections. • Educating the public on evidence-based infection prevention methods to counter health-related misinformation. • Utilizing telepharmacy platforms to ensure continuity of care for isolated patients while minimizing community exposure risks. • Collaborating with physicians to adjust medication dosages based on renal or hepatic impairment and to optimize the management of underlying comorbidities.

11. Management Of Post-COVID-19 Conditions

Post-COVID-19 condition, or Long COVID, presents a complex clinical challenge, causing persistent physical, cognitive, and psychological symptoms that last well beyond the acute infection. The most common symptoms include chronic fatigue, exertional dyspnea, and cognitive dysfunction ('brain fog'). Clinical evaluation must systematically rule out alternative diagnoses, medication side effects, or physical deconditioning. Management focuses on symptom relief and individualized rehabilitation programs. Pharmacists support this process by performing medication reviews to minimize polypharmacy, ensuring adherence to supportive therapies, and referring patients to specialists if symptoms worsen.

12. Clinical Considerations For Special Populations

Vulnerable groups, including geriatric populations and individuals with advanced chronic organ failures, require specialized clinical protocols. Patients with severe renal or hepatic impairment need precise dose adjustments or alternative selections for antiviral therapies. Immunocompromised individuals may experience prolonged viral replication, necessitating personalized treatment plans. Managing COVID-19 during pregnancy or lactation requires a careful assessment of product-specific safety profiles, while pediatric cases must be treated using age- and weight-stratified protocols. Due to the evolving nature of clinical evidence, practitioners must consult updated guidelines rather than relying on static treatment algorithms.

13. Drug Safety And Pharmaceutical Stewardship

The clinical management of COVID-19 highlights the importance of rational prescribing principles. Antibacterial agents should not be prescribed routinely unless a bacterial co-infection is highly suspected. Similarly, systemic corticosteroids provide clear benefits in severe cases requiring respiratory support but can be harmful if used prematurely in mild, non-severe cases. Pharmacists can prevent medication errors by conducting structured medication reconciliations and clinical reviews, with particular attention paid to avoiding polypharmacy in older patients with multiple comorbidities.

14. FUTURE CLINICAL PERSPECTIVES

The long-term management of COVID-19 will rely on sustained genomic surveillance, the development of next-generation variant-proof vaccines, and the introduction of broad-spectrum small-molecule antivirals. Research must also focus on understanding the mechanisms driving post-COVID-19 syndromes and securing equitable global access to essential therapeutics and diagnostics. Because clinical evidence changes rapidly, healthcare systems should adopt dynamic 'living guidelines' over rigid historical treatment protocols to ensure high standards of patient care.

CONCLUSION

Despite transitioning from an emergency pandemic to an endemic phase, COVID-19 remains a highly significant infectious disease. SARS-CoV-2 presents with a broad clinical spectrum, ranging from mild upper respiratory symptoms to critical respiratory failure and systemic thrombo-inflammatory complications. Modern clinical management centers on early risk stratification, timely outpatient antiviral therapy for high-risk individuals, and structured oxygenation, corticosteroid therapy, and immunomodulation for hospitalized patients. Pharmacists remain vital to the healthcare infrastructure, contributing through medication safety initiatives, vaccination services, clinical pharmacovigilance, and antimicrobial stewardship. Ultimately, clinical decisions must always align with the most recent guidelines from national and international health organizations.

Tables

Table 1: Structural Proteins of SARS-CoV-2 and Their Clinical Relevance.

Protein Type	Primary Biological Function	Pharmacological & Clinical Relevance
Spike (S)	Facilitates cellular attachment and host membrane fusion.	Primary target for neutralizing antibodies and vaccine antigen designs.
Envelope (E)	Regulates intracellular virion assembly and budding.	Essential structural component driving viral replication cycles.
Membrane (M)	Dictates structural morphology and virion assembly.	Provides structural scaffolding to maintain viral envelope integrity.
Nucleocapsid (N)	Binds to viral RNA and stabilizes the genetic core.	Common diagnostic biomarker utilized in rapid antigen immunoassay kits.

Table 2: Clinical Categories, Presentations, and Core Therapeutic Principles.

Clinical Category	Key Clinical Presentation	Core Therapeutic Principles
Asymptomatic / Mild	No objective signs of pneumonia; minor upper respiratory symptoms.	Symptomatic relief, routine monitoring, and proactive clinical risk screening.
Moderate	Evidence of lower respiratory infection without systemic hypoxemia.	Continuous clinical observation and assessment for risk of progression.
Severe	Severe respiratory distress alongside systemic hypoxemia ($SpO_2 < 90\%$).	Immediate hospitalization, supplemental oxygen therapy, and guideline-driven pharmacology.
Critical	Acute respiratory failure, septic shock, or acute multi-organ dysfunction.	Intensive care admission, mechanical organ support, and advanced immunomodulation.

Table 3: Management Strategies by Clinical Setting.

Clinical Setting	Recommended Interventions	Key Clinical Considerations & Sources
Non-severe, Low Risk	Routine symptomatic control and supportive care.	Continuous home monitoring for signs of worsening; WHO guidance.
Non-severe, High Risk	Nirmatrelvir/ritonavir or IV remdesivir.	Must be initiated early; perform strict drug interaction checks.
Severe / Critical	Supplemental oxygen and systemic corticosteroids.	Reserve immunomodulators for cases with high systemic inflammation.
Respiratory Failure	Advanced mechanical ventilation and prone positioning.	Follow standard lung-protective ventilation and sepsis protocols.

Declarations

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Ethical Approval

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Data Availability

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