Healthcare System Management During the COVID-19 Pandemic

Lessons From Managing the Pandemic in Israel

by

Yaron Niv and Dana Arad

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Preface

Health System Management During the COVID-19 Pandemic offers a comprehensive, multidisciplinary examination of the challenges the pandemic posed to health systems in Israel and around the world.

The book sets out the scientific and clinical foundations of the pandemic: the biology of the virus, its clinical manifestations, the emergence of variants, and the development of drug therapies. It then traces the successive waves of illness in Israel, the clinical and demographic differences between them, trends in hospitalization and mortality, the evolution of medical care, and the impact of the vaccination campaign. Mortality analyses, cohort studies from Israel and abroad, and comparisons between hospitals make it possible to examine the factors that shaped treatment outcomes and the changes that took place over the course of the pandemic.

The chapters address a wide range of medical issues specific to the care of COVID-19 patients — respiratory support among them — as well as the complications of treatment. Particular attention is given to populations at risk, including pregnant women, oncology patients, and the elderly.

Alongside the clinical dimension, the book examines how the health system conducted itself in a time of crisis: hospital preparedness, the functioning of the health funds and community-based care, the dialogue with the public, lockdown and isolation policy, staff training, the redeployment of roles, and the struggle with workforce shortages and professional burnout.

A central section of the book is devoted to risk management, quality, and patient safety under emergency conditions. It discusses mechanisms of reporting, oversight, and learning; ethical questions; equity in the allocation of resources; patients' rights; and the involvement of families. Drawing on the experience accumulated in Israel and elsewhere, the authors propose models for risk management and operating principles for strengthening organizational, professional, and systemic resilience.

The book closes with insights and recommendations for future policy, among them strengthening emergency preparedness, developing and training the workforce, safeguarding continuity of care, and improving mechanisms of learning and oversight. In doing so, it seeks to draw applicable lessons from the pandemic and to provide a professional basis for preparing the health system for future crises.

About the Authors

Prof. Yaron Niv is a professor of internal medicine and a specialist in gastroenterology, with extensive experience in leading quality systems, patient safety, and risk management in the health care system. He established the quality and patient safety division at Rabin Medical Center and directed it for nine years, and subsequently served as Senior Deputy Director General for Quality and Patient Safety at the Ministry of Health, where he led national policy in these fields.

During the COVID-19 pandemic, Prof. Niv took part in shaping the Ministry of Health's policy for managing the pandemic and headed a team responsible for quality of care and for the risks associated with the disease and with vaccination, in hospitals and in the community. He was also appointed by the Director General of the Ministry of Health to chair an audit and quality committee that reviewed the care of COVID-19 patients hospitalized in Israel.

Dr. Dana Arad is a nurse holding a bachelor's degree in nursing, a master's degree in nursing with a clinical specialization in intensive care, and a doctorate in health systems administration. She is a specialist in policy and administration, with broad clinical and managerial experience in the Israel Defense Forces, in hospitals, at the Ministry of Health, at Clalit Health Services, and at the Academic College of Tel Aviv-Yaffo.

As Director of the Patient Safety Division at the Ministry of Health, Dr. Arad led national policy and projects to improve the quality and safety of care, to strengthen patient involvement, and to advance patients' partnership in the care process. During the COVID-19

pandemic, she established and implemented a national training program for the care of ventilated patients, led investigations and risk surveys of COVID-19 care processes and vaccine administration, and coordinated the committee on COVID-19 vaccine safety.

Acknowledgements

This book is the product of a collective effort. It could not have been written without the many people who lived through the events described in these pages, who recorded them as they unfolded, and who were willing to revisit them afterwards with candor and with a readiness to learn.

Our first and deepest debt is to the contributing authors. Physicians, nurses, dietitians, physiotherapists, epidemiologists, risk managers and hospital administrators agreed to set down in writing what they had done, what had worked, and — no less important — what had not. Writing about one's own practice during a crisis demands a rare kind of professional courage. Each of them found the time to do so while continuing to carry a full clinical and managerial load. Their chapters are the substance of this book.

We are grateful to the directors and senior management of the medical centers whose experience is documented here, and to the heads of the internal medicine departments, intensive care units, emergency departments, geriatric services, infection prevention units and laboratories who opened their institutions to inquiry. The willingness to share difficulties as openly as achievements is the precondition for any genuine organizational learning, and it was granted to us generously.

Our thanks go to colleagues at the Ministry of Health, in the health funds and in the community services, whose data, guidance documents and institutional memory made it possible to place local experience within a national frame. We are indebted, too, to the professional societies and advisory committees whose deliberations

shaped clinical policy in real time under conditions of profound uncertainty.

We wish to acknowledge the staff who worked through the waves of the pandemic: those who staffed the wards in full protective equipment for hours at a time, those who reorganized entire departments within days, those who carried the burden of communicating with families who could not be at the bedside, and those who continued to care for patients whose illnesses had nothing to do with the virus and who risked being forgotten. Much of what is written here is, in the end, an account of their work.

We remember the patients and the families. Those who recovered, those who live with the long-term consequences of the disease, and those who did not survive. This book is written in the hope that careful examination of what happened will spare others some measure of the same loss.

We thank the reviewers who read the manuscript in draft and returned it improved, the language and production editors whose care is visible on every page, and the publishing team for their patience with a project whose scope grew as the subject itself continued to develop.

Finally, we thank our families. The hours devoted to this book were taken from them, and they gave those hours without complaint.

Responsibility for the views expressed, and for any errors that remain, is ours alone.

Prof. Yaron Niv
Dr. Dana Arad
October 2026

Chapter 1
Introduction

The COVID-19 pandemic, which erupted in December 2019 in the city of Wuhan, China, and was declared a global pandemic by the World Health Organization in March 2020, rapidly became one of the most significant public health events of our era. The SARS-CoV-2 virus — with its high transmissibility and sophisticated immune evasion mechanisms — confronted healthcare systems worldwide with unprecedented challenges: recurring waves of severe illness, resource shortages, the need to develop treatment protocols under conditions of absolute uncertainty, and the task of stabilizing entire populations in the face of a disease capable of suddenly deteriorating into life-threatening respiratory failure.

Israel, owing to its diverse population structure, accessible public healthcare system, and national biomedical data capabilities, emerged as a unique research arena. It was among the first countries in the world to carry out mass vaccination with mRNA vaccines, effectively becoming a "natural experiment" that provided the entire world with critical data on vaccine efficacy and the dynamics of successive pandemic waves. From early waves contained through lockdowns, to a threatening third wave driven by the Alpha variant, to the Omicron wave that receded in the wake of widespread vaccination — each wave imparted new lessons, and at times overturned paradigms that had seemed firmly established only shortly before.

This book reflects the collective effort of dozens of leading professionals from the forefront of Israeli medicine: internists, intensive care unit physicians, infectious disease specialists,

geriatricians, obstetricians, dietitians, hospital administrators, and family physicians — all of whom worked in the field throughout every wave of the pandemic. The chapters bring together unique clinical experience accumulated during difficult hours, alongside systematic analysis of data collected in real time. Together, they paint a broad and in-depth picture of the pandemic: from the biological mechanism of the virus, through the management of patients in emergency rooms, coronavirus wards, and intensive care units, to the unique challenges the pandemic posed for specific populations such as the elderly, pregnant women, and those suffering from "long COVID."

The chapters cover a wide range of topics. A comprehensive description of the virus and its infection mechanism is accompanied by epidemiological analysis of the pandemic waves in Israel and international comparisons of large clinical cohorts. Mortality issues — by age, wave, and medical institution — are examined in depth with attention to the importance of case-mix Adjustment, since blind comparisons between institutions can be misleading. Findings from controlled clinical trials on drug therapies — from dexamethasone to tocilizumab and remdesivir — are critically summarized and integrated with Israeli clinical experience. The chapters address the treatment of acute respiratory failure through mechanical ventilation and ECMO, pulmonary rehabilitation, and lung transplantation in patients who recovered from severe disease — a field Israel entered with great intensity. There is also attention to the management of geriatric institutions and the elderly — the population most severely affected — to issues of pregnancy and childbirth during the pandemic, to the nutritional challenges of hospitalized patients, and to the prolonged burden of "long COVID" on individuals and the healthcare system.

Unique chapters are dedicated to the practical management of hospitals during an emergency: interviews with medical center directors from across the country reveal the managerial doctrine born under pressure — converting parking garages into COVID wards, mobilizing emergency personnel, building protocols in the midst of intensive care, and withstanding repeated waves without losing routine medical activity. Here, one of the book's central lessons is illustrated: sound management is itself a life-saving factor, no less than any pharmaceutical treatment.

Finally, the two closing chapters review risk management and quality of medical care throughout the pandemic waves, and consolidate focused insights and recommendations for managing future emergency events. The data speak for themselves: Israel's mortality rate dropped from 1.97% in the first wave to 0.12% in the Omicron wave — a decline of more than 90% — a testament to the cumulative improvement in knowledge, protocols, equipment, and vaccine coverage.

Yet the book does not content itself solely with describing successes — it also speaks frankly about what did not work: delayed intubation in the second wave that led to a sharp rise in mortality; gaps in information transfer between care settings; problems arising in supply chains; and the underrepresentation of risk managers in pandemic governance.

The book is dedicated to the members of the medical staff who worked under conditions no one had anticipated, and to the patients who fought for their lives. It is intended to serve as a milestone for future generations of healthcare professionals, policymakers, and researchers — so that the hard-won experience accumulated will not be forgotten, and so that we may be better prepared for the challenges that lie ahead.

Chapter 2
General Overview of the Pandemic

Abstract

The COVID-19 pandemic is one of the most severe pandemics of the 21st century. The SARS-CoV-2 virus (Severe Acute Respiratory Syndrome Coronavirus 2) is a single-stranded RNA virus of the Coronaviridae family, first identified in December 2019 as the causative agent of an epidemic pneumonia in Wuhan, the capital of Hubei Province, China. The World Health Organization declared a global pandemic on March 11, 2020. By the end of November 2020, over 55 million infections and over one million deaths had been recorded worldwide.

Viral entry into epithelial cells is mediated primarily by binding of the Receptor Binding Domain (RBD) of the Spike protein to Angiotensin-Converting Enzyme 2 (ACE2) on the cell surface. ACE2 is a carboxypeptidase-type enzyme expressed at high levels in the lungs, kidneys, heart, intestines, and testes. Transmission occurs via droplets expelled during coughing, sneezing, and speaking at ranges of up to 2 meters, or via aerosol — small airborne particles that remain suspended in the air, particularly in enclosed spaces and during aerosol-generating procedures. The virus is also shed in gastrointestinal secretions (diarrhea in 10–20% of patients).

Prevention measures are the first step in containing the pandemic: social distancing and avoidance of large gatherings — especially in enclosed spaces without air exchange — use of masks (surgical for the general public, N95 for medical staff), strict hand hygiene (soap and water or alcohol-based sanitizers), maintaining "bubbles" (limiting

contact to fixed groups within family and workplace settings), and protecting high-risk populations — the elderly, the immune-compromised, pregnant women, and patients with chronic underlying conditions. Natural herd immunity will only be achievable once more than 60% of the population has been infected and/or vaccinated.

A considerable proportion of those infected are entirely asymptomatic; many are "pre-symptomatic" and will go on to develop symptoms after the incubation period. Common symptoms include fever, severe dry cough, fatigue and weakness, sore throat, headache, shortness of breath, muscle and joint pain, loss of taste and smell (highly characteristic), diarrhea and nausea (10–20%), and conjunctivitis. Rhinorrhea (runny nose) appears in only a minority of cases.

RT-PCR testing is the gold standard for diagnosis, using material obtained by swabbing the nasal/pharyngeal mucosa. The PCR cycle threshold (Ct) value also serves as an estimate of viral load. Chest CT has high sensitivity and demonstrates segmental pulmonary involvement correlating with disease severity. Typical laboratory findings include leukocytosis or leukopenia, lymphopenia, elevated liver enzymes, thrombocytopenia, and elevated LDH. Inflammatory markers: elevated CRP, low procalcitonin (distinguishing from bacterial infection), elevated ferritin and D-dimer, and elevated troponin (in myocarditis).

Treatment is primarily supportive, aimed at preventing respiratory failure. Anticoagulation is recommended from an early stage, particularly when D-dimer is elevated fourfold or more above normal. Benefit has been found from antiviral agents (remdesivir, lopinavir/ritonavir) and from immunomodulation with tocilizumab

(anti-IL-6R antibody), anti-IL-17 antibodies, canakinumab (anti-IL-1β), and mesenchymal stromal cells.

One of the unique and dangerous features of COVID-19 is the sudden and unpredictable deterioration that can follow a mild initial phase. Among hospitalized patients, 10–20% are transferred to intensive care, 3–10% require intubation, and 2–5% of symptomatic patients die. Risk factors for severe disease include advanced age, hypertension, type 2 diabetes, heart failure, chronic lung disease, renal failure, immunosuppression (chemotherapy or biological agents), pregnancy, and severe obesity.

Keywords: *coronavirus pandemic, epidemic, COVID-19, SARS-CoV-2, emergency medicine*

A. Genetic and Molecular Structure of SARS-CoV-2 (Figure 1)

SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) is a single-stranded RNA virus of the Coronaviridae family, biologically related to the causative agents of earlier epidemics — SARS-CoV (2003) and MERS-CoV (2012).[1] The virus was first identified in December 2019 as the cause of an epidemic pneumonia in Wuhan, the capital of Hubei Province, China. After spreading rapidly worldwide, the World Health Organization declared a global pandemic on March 11, 2020. By the end of November 2020, over 55 million infections and more than one million deaths had been recorded globally.[2] [3]

The biological origin of the virus is most likely bats and pangolins (scaly anteaters), with transmission to humans occurring via an intermediate host. The viral genome comprises 29,900 nucleotides (approximately 30 kilobases) encoding 9,860 amino acids across 15 different genes.[14]

Viral Proteins

Viral proteins are divided into two main groups:

- Functional proteins — such as the Replicase complex, responsible for viral replication within the host cell.
- Structural proteins — responsible for receptor binding and cell entry: the Spike (S) protein, Nucleocapsid (N), Membrane (M), and Envelope (E).[1]

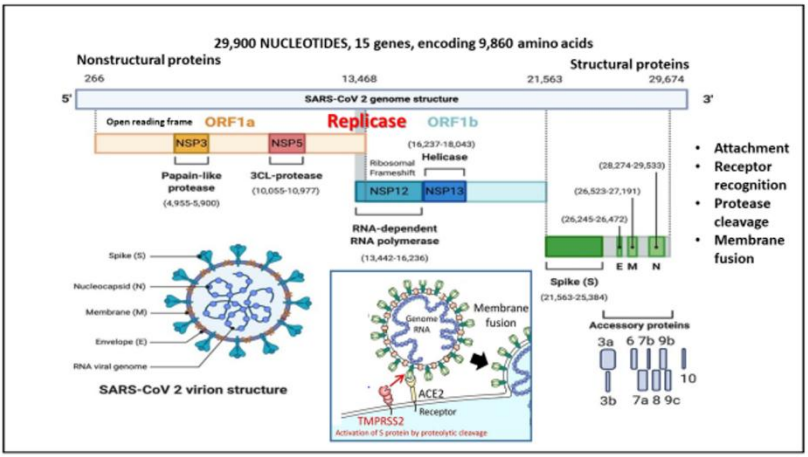


Figure 1. Structure of the SARS-CoV-2 virus

B. Mechanism of Cell Entry — The Spike Protein and ACE2

Viral entry into the host cell is mediated primarily by binding of the Receptor Binding Domain (RBD) of the Spike protein to Angiotensin-Converting Enzyme 2 (ACE2) on the cell surface.[5] ACE2 is a carboxypeptidase-type enzyme expressed at high levels in the human body in the lungs, kidneys, heart, intestines, and testes.[6] ACE2 serves a dual role: on one hand, it converts angiotensin II to angiotensin (1-

7), which has a protective effect on blood vessels; on the other, it serves as a receptor for coronaviruses and enables their entry into the cell.[6]

The cell entry process occurs in three main steps:

- Binding — the Spike protein binds to the ACE2 receptor on the epithelial cell surface.
- Cleavage — the enzyme TMPRSS2 cleaves the S1-S2 junction of the Spike protein, enabling direct plasma membrane fusion.
- Fusion — the viral membrane fuses with the cell membrane, allowing the viral genetic material to enter the cell.

Protease Pathways

- TMPRSS2 (Transmembrane Serine Protease 2) — a protease expressed on lung cell surfaces, dominant in specialized lung cells.[5] [7]
- Cathepsin B/L — lysosomal proteases acting via the alternative endocytic pathway.[7]
- Furin — the S1/S2 site of the Spike protein contains a unique furin-sensitive sequence absent from SARS-CoV-1, constituting an important distinguishing feature. Cleavage by furin enables "early activation" of the virus and enhances its infectivity.[8]

Important mutation: The virus underwent a mutation in the SPIKE gene — substitution of aspartate with glycine (D614G) — which significantly increased infection efficiency, apparently without a notable effect on disease severity.[2] [9]

After entering the cell, the genomic RNA is translated into a polyprotein that is cleaved into non-structural proteins (nsps) that