

QUALITATIVE AND BIFURCATION ANALYSIS OF AN EPIDEMIC MODEL ACCOUNTING FOR HEART–LUNG COMORBIDITIES AND VACCINATION DYNAMICS

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Abstract. This study develops a novel epidemiological model to investigate the transmission dynamics of COVID-19 in the presence of heart and lung comorbidities, incorporating quarantine measures, vaccination strategies, and natural demographic processes. The model divides the population into seven health states and integrates additional infection pathways arising from pre-existing chronic conditions. Analytical results are presented for the existence, stability, and bifurcation behavior of equilibrium points, while parameter sensitivity highlights the disproportionate influence of comorbid groups on overall transmission. Numerical simulations, calibrated to data, demonstrate how rapid vaccination and strict quarantine effectively suppress infection peaks and drive the system toward a stable, controlled epidemiological state. The findings underscore the importance of prioritizing high-risk comorbid groups in public-health interventions and provide a flexible mathematical framework for forecasting future outbreaks or evaluating alternative control strategies.

Keywords. COVID-19, Comorbidities, Heart-disease, Lung-disease, Stability.

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1 Introduction

Between 2019 and 2022, the COVID-19 had a substantial global impact. Many mathematicians have helped to manage the spread of the COVID-19 by developing mathematical models. Researchers have linked COVID-19 to a variety of health concerns, including those affecting the heart and lungs. Although the virus mostly affects the respiratory system and causes lung disease, it can also have major cardiovascular consequences and exacerbate cardiac problems. The COVID-19 mostly affects the lungs, where it can damage lung tissue and cause inflammation. The virus enters the body through the respiratory tract and, in severe cases, can cause acute respiratory distress