



Modeling COVID-19 and heart disease interactions through Caputo fractional derivative: memory trace analysis

Preety Kumari^{1,2} · Harendra Pal Singh³ · Swarn Singh⁴

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Abstract

The present work proposes a novel coronavirus model with heart disease using fractional order derivative (FOD). In this model, heart disease is treated as a comorbidity. The proposed model includes compartments such as exposed and infectious with and without comorbidities, hospitalized, and quarantined. System's characteristics, such as existence-uniqueness, boundedness, and positivity of solutions, are illustrated. The proposed model parameters are modified to make fractional order model dimensionally consistent. The stability of disease-free (DF) equilibrium point is established using basic reproduction number (R_0). Sensitivity analysis discusses impact of different parameters on disease transmission or control. Nonlinear least square optimization approach is employed to ascertain model parameters numerically. To numerically solve the proposed model, we use the predictor–corrector method. The simulated results are validated using actual data from India. The numerical findings for various FODs are obtained in the long run, which helps better analyze the actual situation. Furthermore, the impact of memory trace is presented for the proposed model to emphasize benefits of engaging FOD. The impact of parameters, such as quarantine rate (q^v) and co-infection rate (β_2), is investigated through numerical simulations. The prospective model may reduce the worldwide medical difficulty of novel coronavirus and heart disease by optimizing simulation benefits.

Keywords Caputo derivative · Fractional order · Coronavirus model · Existence-uniqueness · Global stability

Introduction

Novel coronavirus is an exceptionally contagious disease triggered by the SARS-COV-2 virus. It exhibits various symptoms, such as breathing difficulties, fever, coughing, loss of sense of taste or smell, etc. Some other minor prevalent symptoms are a sore throat, headache, diarrhea, rash, and red eyes. The symptoms like breathlessness, speech or mobility issues, and chest pain are seen in patients with severe novel coronavirus. These patients need immediate medical interventions. Older people or persons with other

co-existing diseases like diabetes, cancer, heart disease, or respiratory disorders face an increased risk of developing severe complications. Despite common feelings, novel coronavirus can affect individuals in any age group. People with any age group may become critically ill or even die from COVID-19. Since December 2019, around 775.6 million people have been infected, and approximately 7.05 million deaths have been reported till August 01, 2024, by the novel coronavirus disease (WHO 2023). The novel coronavirus commonly spreads through the infected individual after direct contact. However, it is reported that people are also getting infected with the novel coronavirus through environmental factors. Therefore, several studies are conducted to understand environmental factors role in spreading this disease (Masud et al. 2022; Rwezaura et al. 2021). It was found that the novel coronavirus may be present in contaminated areas for many days (Rwezaura et al. 2021). It is essential to disinfect the contaminated areas and restrict the movement of the general public to control the number of infections. Thus, the governments imposed a nationwide lockdown to control the number of infections. The nationwide lockdown restricted the movement of the general public, which helped

✉ Harendra Pal Singh
hpsingh@cic.du.ac.in

¹ Faculty of Mathematical Science, University of Delhi, New Delhi, Delhi 110007, India

² School of Engineering & Technology, Central University of Haryana, Mahendergarh 123031, India

³ Cluster Innovation Centre, University of Delhi, New Delhi, Delhi 110007, India

⁴ Sri Venkateswara College, University of Delhi, New Delhi, Delhi 110021, India