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A Global Post Effects of COVID-19: A Mathematical Modelling Study

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Abstract This study presents the global post-effects of COVID-19 through a mathematical modeling approach. A compartmental model, dividing the total population into six epidemiological compartments, is developed to simulate the dynamics of the disease. These compartments include susceptible humans (S), exposed humans (E), infected humans (I), deceased humans (D), individuals in treatment class (T), and recovered humans (R). The study extensively discusses the post-effects of COVID-19 in Africa and the sensitivity analysis reveals that the contact rate of infection exhibits a positive sensitivity index, indicating that interventions aimed at reducing contact rate ϕ would significantly diminish the spread of the virus within the population. Conversely, the treatment rate ω shows a negative sensitivity index, suggesting that promoting higher treatment rates would lead to an increased recovery rate, thereby effectively controlling the spread of the disease. Numerical simulations carried out using MATLAB further confirms that a high treatment rate, avoidance of contact rate with any infected person or infectious surface, coupled with adherence to COVID-19 control measures, could help prevent the spread and outbreaks of COVID-19 in the future. The implications of these findings extend to healthcare workers, policymakers, and the general public, offering valuable insights into disease transmission dynamics and informing preparedness for future pandemics. Overall, this study considers the importance of proactive measures and effective healthcare interventions in mitigating the impact of COVID-19 and preventing the resurgence of infectious diseases in Africa.

Keywords Global stability, sensitivity analysis, COVID-19, endemic equilibrium, numerical simulations

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1. Introduction

The emergence of the novel coronavirus disease 2019 (COVID-19) has posed unprecedented challenges to global public health, economic stability, and social well-being. Belonging to the family Coronaviridae, the causative agent of COVID-19, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first identified in December 2019 in Wuhan, Hubei Province, China [1, 10]. Since then, it has rapidly spread across continents, leading to a pandemic declared by the World Health Organization (WHO) on March 11, 2020 [8]. COVID-19 primarily manifests as a respiratory illness ranging from mild symptoms to severe respiratory distress, multi-organ failure, and death, particularly among older adults and those with underlying health conditions [8]. The virus spreads primarily through respiratory droplets when an infected person coughs, sneezes, or talks, with close contact being the main mode of transmission [8]. Understanding the genetic makeup and evolutionary pathways of SARS-CoV-2 has been instrumental in elucidating its pathogenesis and in aiding the development of diagnostic tools and potential therapeutics [2]. The transmission dynamics of COVID-19 are multifaceted, influenced by factors such as population density, social behaviors, healthcare infrastructure, and public health interventions [7]. Asymptomatic and pre-symptomatic individuals can unknowingly spread the virus, complicating containment efforts [6]. Although transmission primarily occurs through respiratory droplets, emerging evidence suggests the possibility of airborne transmission in certain settings, necessitating continuous monitoring and adaptation of preventive measures [9]. Prompt and accurate diagnosis of COVID-19 is crucial for controlling its spread and mitigating its impact on individuals and communities [4]. Various diagnostic approaches, including reverse transcription-polymerase chain reaction (RT-PCR) testing, antigen testing, and serological assays, play pivotal roles in identifying infected individuals, tracing contacts, and guiding clinical management [3, 4]. Additionally, non-pharmaceutical interventions such as wearing masks, practicing hand hygiene, maintaining physical distancing, and vaccination have proven effective in reducing transmission rates and preventing severe illness [4]. The origin of COVID-19 has been a subject of intense scientific investigation. The virus responsible for COVID-19, SARS-CoV-2, is a betacoronavirus closely related to other coronaviruses known to infect bats and other animals [10]. While the exact origins of SARS-CoV-2 are still being investigated, the prevailing theory suggests zoonotic transmission, meaning the virus likely jumped from animals to humans. Several early cases of COVID-19 were linked to a seafood market in Wuhan, China, leading to initial speculation that the virus originated from there. However, subsequent research has indicated that while the market likely played a role in amplifying the outbreak, the virus may have been circulating in humans before its detection [2]. Genomic analysis suggests that SARS-CoV-2 shares a high degree of similarity with bat coronaviruses, particularly those found in horseshoe bats. It is believed that the virus may have undergone genetic changes through recombination events or mutations, potentially in an intermediate host species, before spilling over into humans. The identification of such an intermediate host remains a key focus of ongoing investigations [2, 10].