



# The study of stability analysis of the Ebola virus via fractional model<sup>☆</sup>

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## ABSTRACT

This paper presents a fractional mathematical model for analyzing the dynamics of Ebola virus diseases. The model consists of five categories: individuals with low susceptibility to the virus  $S_1(t)$ , individuals with high susceptibility  $S_2(t)$ , infected individuals  $I(t)$ , exposed individuals  $E(t)$ , and recovered  $R(t)$  individuals. In this study, we have proven the positive bounded solutions for the model under consideration. Additionally, it assesses the durability of a state without disease by utilizing the fundamental reproduction number. Moreover, an examination is conducted to assess the stability of the model. In order to validate and exemplify the research, a computational model is employed, and its results correspond with the analysis outlined in the paper.

## 1. Introduction

Ebola virus disease, which derives its name from the Ebola River in the Democratic Republic of the Congo, is recognized as an extremely contagious illness characterized by a high fatality rate. The virus encompasses various strains that were previously identified as Ebola hemorrhagic Fever. Some individuals infected with Ebola did not exhibit bleeding symptoms, leading to the adoption of the term Ebola virus disease.<sup>1–9</sup> Cases of this disease have been reported since its emergence in Zaire in 1976, with a fatality rate of approximately 79% until 2008.<sup>10</sup> The ongoing outbreak of Ebola virus disease is impacting countries in Central and Western Africa. The initial occurrence of the Ebola virus was recorded in 1976 in northern Zaire, which is now known as the Democratic Republic of Congo.<sup>11–16</sup>

The epidemic caused numerous cases, with approximately 350 individuals affected, and tragically, over two-thirds of them succumbed to the infection.<sup>10</sup> Unfortunately, healthcare workers who cared for the patients were eventually exposed to the virus, resulting in fatalities. Over the last four decades, Africa has experienced periodic outbreaks of the Ebola virus. Out of the 20 outbreaks, excluding the one in 2014, the highest fatality rate recorded was 66.3%, although this can vary depending on the specific outbreak.<sup>17–20</sup> The primary mode of transmission among humans is through direct contact with bodily fluids.<sup>21–25</sup> Health workers and family members of infected individuals are particularly susceptible to the infection because they often lack adequate personal protective equipment.<sup>14,15,26–31</sup> The customary funeral practices observed in Africa, encompassing rituals such

as body cleansing, physical contact, and affectionate gestures, have played a role in exacerbating the issue. The precise origin of the virus remains uncertain; however, it is widely hypothesized that fruit bats of the Pteropodidae family serve as the primary reservoir for the Ebola virus. Furthermore, it is widely believed that transmission can occur through direct contact with primates such as monkeys, gorillas, and chimpanzees. Nevertheless, the predominant method of human-to-human transmission occurs via direct contact with the bodily fluids of an infected individual. In contrast to influenza, Ebola does not possess an airborne transmission mechanism, nor does it propagate through ingestion of contaminated food or water, as observed in other diseases like cholera, dysentery, or typhoid.

Furthermore, it is crucial to acknowledge that the transmission of the Ebola virus does not occur during the incubation period, denoting the interval between the primary infection and the manifestation of symptoms. The duration of this period for the Ebola virus typically ranges from 2 to 21 days. Therefore, in the event that an individual has been in close proximity to an Ebola patient or an individual suspected of being infected with Ebola, and subsequently experiences the onset of fever, it is imperative that immediate actions, including isolation, provision of medical treatment, and appropriate management by healthcare facilities, are undertaken in order to effectively halt the spread of the outbreak. Nevertheless, even following the individual's recuperation from the ailment, the presence of the virus in bodily fluids may persist for a prolonged duration. A study revealed the detection of the Ebola virus in the seminal fluid of a patient even after

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