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EPIDEMIOLOGICAL MODELS USING FRACTIONAL CALCULUS

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The Fractional Calculus, or non-integer order Calculus, has attracted attention due to its range of applications in problems of scientific and technological interest, because it generalizes traditional integration and differentiation techniques and introduces nonlocality as the intrinsic property of its operators. Then, the fractional derivatives are very useful to describe physical systems and for biological problems, especially due to the memory property, that allow the recovery of the behaviour of the function in moments before the time slot which it is analysed [1].

In this work, the concepts of Fractional Calculus are used for the construction of the epidemiological models that describe two recent outbreaks: cholera and plague, which were considered extinct diseases, but returned with overwhelming power, due to poor health and hygiene conditions of the countries affected. For such cases, we applied the respective model to describe recent epidemics and to predict the dynamics of each one of these diseases.

Since 2017, Yemen has been suffering with the largest cholera outbreak documented, which has infected more than 1.5 million people and left about 2500 dead [2]. Given this scenario, we built a model which describes the dynamics of the disease, including the vaccination of the population, and using data from the numbers of infected and dead population, we could obtain the epidemiological parameters that describe the behaviour of cholera for this case and this model can be useful to predict the other cholera outbreaks [3].

In 2017, Madagascar health authorities reported more than 2500 cases of the human plague, with a total of 221 deaths [4]. In 2019, many people in China have been diagnosed with the plague. Even though the epidemiology of this case is not stated, China has a population very susceptible to the spread of this kind of epidemic [5]. Typically, plague transmission models consider only fleas and its rodent hosts as the main vector of plague transmission, but some authors propose a model that considers the transmission between humans and the case where the flea bites directly the human, in addition to plague transmission using the mouse as host and the flea as a vector [6]. Based on this model, we built the fractional approach for the system of equations and analyse the consequences of this choice.

For each of the studied cases a model composed by fractional differential equations was proposed and,

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using data provided by the World Health Organization, we were able to estimate the parameters and perform numerical simulations for each of them. The use of fractional derivatives allows a more detailed resolution of the system of equations and thus obtaining a system capable of describing the behaviour of each one of its equations, especially for the equation that describes the infected population. Thus, we conclude that non-integer derivatives allow us to model memory effects and it results in a more powerful approach to describe the dynamics of these diseases analysed.

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