A Mathematical Model Analysis of Meningitis with Treatment and Vaccination in Fractional Derivatives

Article *in* International Journal of Applied and Computational Mathematics · April 2022

DOI: 10.1007/s40819-022-01317-1

6 authors, including:

Olumuyiwa James Peter
University of Medical Sciences, Ondo
70 PUBLICATIONS **636** CITATIONS
SEE PROFILE

Abdullahi Yusuf
The Federal University Dutse
259 PUBLICATIONS **5,595** CITATIONS
SEE PROFILE

Mayowa Micheal Ojo
Thermo Fisher Scientific
22 PUBLICATIONS **223** CITATIONS
SEE PROFILE

Sumit Kumar
Indian Institute of Technology Mandi
5 PUBLICATIONS **50** CITATIONS
SEE PROFILE

Int. J. Appl. Comput. Math (2022) 8:117
https://doi.org/10.1007/s40819-022-01317-1

ORIGINAL PAPER

A Mathematical Model Analysis of Meningitis with Treatment and Vaccination in Fractional Derivatives

Olumuyiwa James Peter[1] · Abdullahi Yusuf[2,3] · Mayowa M. Ojo[4,5] · Sumit Kumar[6] · Nitu Kumari[6] · Festus Abiodun Oguntolu[7]

Accepted: 2 April 2022

Abstract
In this paper, we develop a new mathematical model based on the Atangana Baleanu Caputo (ABC) derivative to investigate meningitis dynamics. We explain why fractional calculus is useful for modeling real-world problems. The model contains all of the possible interactions that cause disease to spread in the population. We start with classical differential equations and extended them into fractional-order using ABC. Both local and global asymptotic stability conditions for meningitis-free and endemic equilibria are determined. It is shown that the model undergoes backward bifurcation, where the locally stable disease-free equilibrium coexists with an endemic equilibrium. We also find conditions under which the model's disease-free equilibrium is globally asymptotically stable. The approach of fractional order calculus is quite new for such a biological phenomenon. The effects of vaccination and treatment on transmission dynamics of meningitis are examined. These findings are based on various fractional parameter values and serve as a control parameter for identifying important disease-control techniques. Finally, the acquired results are graphically displayed to support our findings.

Keywords Meningitis · Atangana Baleanu Operator · Fixed point theorem · Numerical results

✉ Olumuyiwa James Peter
peterjames4real@gmail.com

1 Department of Epidemiology and Biostatistics, School of Public Health, University of Medical Sciences, Ondo City, Ondo State, Nigeria

2 Department of Mathematics, Federal University Dutse, Jigawa, Nigeria

3 Department of Computer Engineering, Biruni University, Istanbul, Turkey

4 Department of Mathematical Sciences, University of South Africa, Florida, South Africa

5 Thermo Fisher Scientific, Microbiology Division, Lenexa, Kansas, USA

6 School of Basic Sciences, Indian Institute of Technology Mandi, Mandi, Himachal Pradesh, India

7 Department of Mathematics Federal University of Technology Mina, Minna, Nigeria

Published online: 26 April 2022