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Research Article

Global Stability of Pneumococcal Pneumonia with Awareness and Saturated Treatment

Fulgensia Kamugisha Mbabazi,[1] **J. Y. T. Mugisha,**[2] **and Mark Kimathi**[3]

[1]*Department of Mathematics, Busitema University, Tororo, Uganda*
[2]*Department of Mathematics, Makerere University, Kampala, Uganda*
[3]*Department of Mathematics and Statistics, Machakos University, Machakos, Kenya*

Correspondence should be addressed to Fulgensia Kamugisha Mbabazi; fmbaba1zi@gmail.com

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Pneumocccal pneumonia, a secondary bacterial infection that follows influenza A infection, is responsible for morbidity and mortality in children, elderly, and immunocomprised groups. A mathematical model to study the global stability of pneumococcal pneumonia with awareness and saturated treatment is presented. The basic reproduction number, R_0, is computed using the next generation matrix method. The results show that if $R_0 < 1$, the disease-free steady state is locally asymptotically stable; thus, pneumococcal pneumonia would be eradicated in the population. On the other hand, if $R_0 > 1$ the endemic steady state is globally attractive; thus, the disease would persist in the population. The quadratic-linear and Goh–Voltera Lyapunov functionals approach are used to prove the global stabilities of the disease-free and endemic steady states, respectively. The sensitivity analysis of R_0 on model parameters shows that, it is positively sensitive to the maximal effective rate before antibiotic resistance awareness, rate of relapse encountered in administering treatment, and loss of information by aware susceptible individuals. Contrarily, the sensitivity analysis of R_0 on model parameters is negatively sensitive to recovery rate due to treatment and the rate at which unaware susceptible individuals become aware. The numerical analysis of the model shows that awareness about antibiotic resistance and treatment plays a significant role in the control of pneumococcal pneumonia.

1. Introduction

Pneumonia is one of the severe forms of pneumococcal diseases caused by pneumococcus [1]. Pneumococcal pneumonia is preventable through vaccination, diagnostic testing, environmental control measures, and appropriate treatment [2]. However, treatment of pneumococcal pneumonia has become tricky due to antibiotic selection that increases resistance of *Streptococcus pneumoniae* to penicillin and the successive evolution of resistance to numerous classes of antibiotics [3]. Bacteria develop resistance against antibiotics, causing severe illness to an individual. Ultimately, it requires costly treatment to control and eradicate the disease [4]. The emergence of antimicrobial resistance threatens the successful treatment of pneumococcal infections [5]. Repeated and improper use of antibiotics is on an increase and identified as the main cause of the emerging resistance [6]. In the event of acute side effects, patients tend to discard their treatment, only to return to the hospital with persistent infections of a more virulent and resistant strain of the bacteria [7]. Antibiotic resistance is a major worldwide threat to the provision of safe and effective health care. To control antibiotic resistance, vaccines have been proposed as an essential intervention, complementing improvements in antibiotic stewardship and drug pipelines [8].

In treatment of pneumonia, microorganisms occasionally persevere, emerge or remerge despite the good clinical responses. Thus, recovered individuals may relapse and return to the infective class [9]. However, relapse may occur due to treatment failure with regard to elimination of an infecting causative agent. Recurrence of disease is a significant feature of some animal and human diseases; for