

ABSTRACT

PNEUMONIA TRANSMISSION DYNAMICS MODEL WITH AGE-STRUCTURED POPULATIONS INCORPORATING VACCINATION AND TREATMENT

by

Arum Qurrotulaini Pradjna Paramita

NIM 24010123410006

Pneumonia is a major cause of mortality among children under five worldwide, including in Indonesia and specifically in Central Java Province. The high number of deaths associated with this disease highlights the importance of studying its transmission dynamics and developing more effective control strategies. This research is a case study using pneumonia case data in Central Java Province obtained from the Central Java Provincial Health Office. This thesis develops a mathematical model describing pneumonia transmission dynamics by dividing the population into seven compartments: susceptible children, vaccinated children, infected children, susceptible adults, infected adults, individuals under treatment, and recovered or immune individuals. The study investigates the positivity and boundedness of solutions, analyzes the stability of the disease-free and endemic equilibrium points, and performs numerical simulations of the model both with and without control strategies. The basic reproduction number is derived using the Next Generation Matrix method to assess the potential for disease transmission. The local stability of the disease-free equilibrium is examined using the Routh–Hurwitz criterion, while the Lyapunov function is employed to establish the global stability of the system. Furthermore, an optimal control problem is formulated to identify the most effective strategies for mitigating pneumonia transmission. The control variables considered include nutritional improvement and health education promoting clean and healthy living practices. The optimal control problem is solved using Pontryagin’s minimum principle and numerically simulated through the fourth-order Runge–Kutta method. The results of the analysis show that when the basic reproduction number is less than one, the system reaches the disease-free equilibrium. Meanwhile, when the basic reproduction number is greater than one, the system is stable at the endemic equilibrium, indicating that the disease persists in the population. Numerical simulations further demonstrate that implementing a combination of both control strategies is more effective in reducing the number of infected individuals than applying either control independently.

Keywords: *Pneumonia, stability analysis, basic reproduction number, optimal control.*