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Dynamics, Control and Stability of a Deterministic Avian Influenza Model

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Avian Influenza is a deadly zoonotic disease that is common in almost all parts of the world. It remain a significant public health concern due to its zoonotic nature and potential to cause wide spread outbreaks. Several mathematical models by different researchers have addressed avian influenza disease dynamics, but gaps remain in understanding the combined effects of education campaigns, vaccination, quarantine, and treatment within a compartmental framework. Thus, this study aims to bridge the gap by constructing a fourteen-compartment model divided between
human and bird populations to evaluate the effectiveness of various control measures. The human population is categorized into uneducated susceptible (S_{uh}), educated susceptible (S_{eh}), Vaccinated human (V_h), exposed (E_h), infected (I_h), quarantine (Q), treatment (T), and recovery classes, while the bird population includes susceptible (S_b), vaccinated (V_b), exposed (E_b), and infected (I_b) compartments. Key intervention measures such as education campaigns, initial stage vaccination, quarantine of infected humans, and treatment of affected individuals are incorporated into the model. The basic properties of the model were fully proved and discussed. The model equilibra were obtained by solving the model system equations simultaneously. Stability analyses of the disease-free equilibrium and endemic equilibrium were conducted through techniques such as the Jacobian matrix and Lyapunov functions, confirming asymptotic stability under these conditions. The reproductive ratio, $R_o^{b,h}$, was computed using the next-generation matrix method,revealing that $R_o^{b,h} < 1$ when controls are applied at a minimum implementation level of 50\% or higher, indicating effective containment of the disease. Findings from the qualitative analysis suggested that education campaigns and related measures are highly effective in controlling avian influenza infections within the society. Quantitative analysis further supports this conclusion, with numerical simulations demonstrating a significant reduction in disease prevalence when control measures were implemented. This study underscores the importance of integrating education, vaccination, quarantine, and treatment measures in avian influenza management, offering valuable recommendations for public health policies and future research.

Key words: Avian Influenza; Mathematical model; Basic reproduction number; Stability; Educational campaign, Control measures.

Primary author: AKINGBADE, AKINSUYI JAMES (University of Ilorin)

Co-author: Prof. BAMIGBOLA, OLABODE MATHIAS (University of Ilorin)

Presenter: AKINGBADE, AKINSUYI JAMES (University of Ilorin)

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