Analyzing the Spread of Chickenpox: Implications for Health Planning

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[1] introduces a mathematical model to illustrate the transmission of chickenpox. To emphasize the importance of taking preventive measures, a new metric is created to measure the rate of such actions. Real data from Phuket, Thailand is used to help analyze the model, which involves determining the positivity and boundedness of the solutions. The fundamental reproductive number is calculated using the next-generation matrix technique and is seen to be heavily impacted by the rate of preventive measures. The equilibrium points of the model are identified, and the parameters for the disease-free equilibrium's local and global asymptotic stability are established.

The study of a mathematical model demonstrates the role and utility of a mathematical model in solving the ongoing chickenpox crisis in Phuket. It simulates populations at risk of infection-pathogens, vectors, and those infected-by converting the data into mathematical equations to describe the nature of the outbreak and progression of chickenpox without the researcher needing to study directly with humans, which may endanger the lives of the researcher and the patient. It also helps to reduce the budget for supplementing measures for treatment and prevention of chickenpox in Phuket according to actual needs as quick.When numerous interacting factors are present, an infectious disease can spread in a complex manner. A mathematical model is one of the methods used to investigate and anticipate the spread and severity of a disease. This study developed a biological compartmental model that separates the human population in a Phuket city C into six compartments in order to better understand the dynamics of chickenpox. Susceptible (C_S), Vaccinated (C_V), Exposed (C_E), Infected individuals with complications (C_{IW}), Infected individuals without complications ($C_{I\overline{W}}$), Recovered (C_R) individuals are in a Phuket city C. Let Λ is the total recruitment. Here also we consider that susceptible individuals enter into the infected with or without complication compartment through exposed class. Susceptible people will have a rate of λ_1 contact with infected individuals and η be the modification parameter that accounts for reduced transmission in infected individuals without complications. People move to vaccination class with rate of λ_2. λ_3 be the wanning effect, so that proportion will move to susceptible class. θ be the vaccine efficacy, so $(1-\theta)$ proportion with infected and vaccinated individuals are move to exposed compartment. Disease progression rate of infectious of exposed individuals is λ_4. From there, ϑ proportion move to without complicated infected compartment and remains be in complicated infected compartment. ψ_1 and ψ_2 are rate of recovery of infected with and without complication respectively. γ_1, γ_2 and γ_3 are natural death rate and death rate of infected with and without complication respectively. Rate of loss of infection - acquired (natural) immunity is ψ_3. The system takes the form:

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\begin{aligned}
\frac{dC_S}{dt} &= \Lambda - \lambda_1 C_S(C_{IW} + \eta C_{I\overline{W}}) + \lambda_3 C_V + \mu C_E - (\gamma + \lambda_2) C_S + \psi_3 C_R \\
\frac{dC_V}{dt} &= \lambda_2 C_S - (1-\theta)\lambda_1 C_{IW} C_V - (1-\theta)\lambda_1 \eta C_{I\overline{W}} C_V - (\lambda_3 + \gamma) C_V \\
\frac{dC_E}{dt} &= (1-\theta)\lambda_1 C_{IW} C_V + (1-\theta)\lambda_1 \eta C_{I\overline{W}} C_V + \lambda_1 C_S (C_{IW} + \eta C_{I\overline{W}}) - (\lambda_4 + \gamma + \mu) C_E \\
\frac{dC_{IW}}{dt} &= \vartheta \lambda_4 C_E - (\psi_1 + \gamma + \gamma_1) C_{IW} \\
\frac{dC_{I\overline{W}}}{dt} &= (1-\vartheta)\lambda_4 C_E - (\psi_2 + \gamma + \gamma_2) C_{I\overline{W}} \\
\frac{dC_R}{dt} &= \psi_1 C_{IW} + \psi_2 C_{I\overline{W}} - (\gamma + \psi_3) C_R
\end{aligned}
\tag{1}
$$

Model (1) presupposes that each of its variables are positive. $C_S(0) = C_{S_0} \geq 0,\ C_V(0) = C_{V_0} \geq 0,\ C_E(0) = C_{E_0} \geq 0,\ C_{IW}(0) = C_{I_0} \geq 0,\ C_{I\overline{W}}(0) = C_{A_0} \geq 0,\ C_R(0) = C_{R_0} \geq 0$. The main contributions of the paper [1] are the following:

- The Mathematical model was used to investigate Chickenpox outbreaks in order to assist researchers better understand the mechanisms that control the disease's progress.
- Demonstrate the disease transmission dynamics of infected persons with and without complications.
- The local and global asymptotic stability of equilibrium points were examined through Routh Hurwitz's and Castillo-Chavez's theorems. While studying the influence of the transmission rate λ_1, we ended up with forward bifurcation.
- With varied levels of precautionary measures, this study would be extremely advantageous in lowering the risk of infection and reducing the basic reproductive number.

1. Sayooj Aby Jose, Raja R., Dianavinnarasi J., Baleanu D., Jirawattanapanit A. Mathematical Modeling of Chickenpox in Phuket: Efficacy of Precautionary Measures and Bifurcation Analysis, Biomedical Signal Processing and Control, 2023, 84, 104714.