Analysis and Applications of Mathematical Models to Biology

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Abstract

Many mathematical models have been formulated to analyze complex biological systems. The mathematical analysis and computer simulations of these mathematical models have provided valuable insights to researchers and clinicians interested in understanding the underlying mechanisms governing the biological systems that might otherwise be elusive. This minisymposium will highlight current applications of mathematical models to biology, including ecology, epidemiology, and medicine.

Session 1:

- **Speaker:** *Anna Mummert* (mummerta@marshall.edu), Marshall University

  Title: A perspective on multiple waves of influenza pandemics

  Abstract: A striking characteristic of the past four influenza pandemic outbreaks in the United States has been the multiple waves of infections. However, the mechanisms responsible for these waves are uncertain. In this talk several distinct mechanisms are exhibited each of which can generate two waves of infections for an acute infectious disease. Each is incorporated into a susceptible-exposed-infected-removed model. The models are used to examine the effects of border control and vaccination.

- **Speaker:** *Christina Allan* (callan@my.apsu.edu), Austin Peay State University

  Title: Agent Based Avian Influenza Model with Human-Human Transmission

  Abstract: In this project we develop an agent based model involving humans with seasonal influenza, H5N1 and a laboratory modied H5N1 with domestic birds and wild birds. We aim to find insight to the following questions: What if this modified highly pathogenic virus, which is highly transmissible in humans, is unleashed into the public? At what rate would the virus transfer from human to human? Would this modified virus react the same way as if it had naturally mutated on its own? If control interventions were to be used, what would be the results of a timely intervention versus an untimely intervention?

- **Speaker:** *Folashade Agusto* (agustof@apsu.edu), Austin Peay State University

  Title: The Impact of Bed-net Use on Malaria Prevalence

  Abstract: Malaria infection continues to be a major problem in many parts of the world including the Americas, Asia, and Africa. Insecticide treated bed-nets have shown to reduce malaria cases by 50%; however, improper handling and human behavior can diminish their effectiveness. We formulate and analyze a mathematical model that considers the transmission dynamics of malaria infection in mosquito and human populations and investigate the impact of bed-nets on its control. The effective reproduction number is derived and existence of backward bifurcation is presented. The backward bifurcation implies that the reduction of $\mathcal{R}$ below unity alone is not enough to eradicate malaria, except when the initial cases of infection in both populations are small. Our analysis demonstrates that bed-net usage has a positive impact in reducing the reproduction number $\mathcal{R}$. The results show that if 75% of the population were to use bed-nets, malaria could be eliminated. We conclude that more data on the impact of human and mosquito behavior on malaria spread is needed to develop more realistic models and better predictions.

- **Speaker:** *Jessica Lunsford* (jessicalunsford1234@yahoo.com), East Tennessee State University

  Title: Iron Accumulation in the Cell: A Mathematical Model of Friedreich's Ataxia

Abstract: Using a mathematical model that incorporates both the cytoplasm and mitochondria, we simulated the pathway of iron regulation in the cell with seven nonlinear differential equations. The iron homeostasis model is applied in the context of frataxin protein deficiency. This robust feature is the disease mechanism for the genetic disorder Friedreich's Ataxia. We use sensitivity analysis to identify key homeostasis processes. Our mathematical findings suggest some potential treatment options.

Session 2:

- **Speaker:** *Michele Joyner* (joynerm@mail.etsu.edu), East Tennessee State University

  Title: Modeling the Effects of Admission and Discharge Rates on the Overall Spread of Antimicrobial Resistance in a Hospital

  Abstract: Antimicrobial resistance continues to cause a considerable increase in yearly health care costs and proves to be a major public health risk especially in hospitals. Mathematical models have been developed to study the transmission of resistant bacteria in a hospital and the effects of different preventive measures to slow its spread. However, the majority of these models have assumed a constant total hospital population with the admission and discharge rates being equal throughout the duration. A typical hospital population varies from day to day and season to season, with a significant correlation between the length of stay and the day of admission. In this talk, we will investigate the effect of including varying admission and discharge rates in a mathematical model which examines the spread of bacteria resistant to both single and multiple antibiotics.

- **Speaker:** *Donna Daulton* (donna.daulton287@topper.wku.edu), Western Kentucky University

  Title: Optimal control of oxygen therapy for treatment of a bacterial infection in wound healing

  Abstract: A mathematical model was formulated to use optimal control theory for the analysis of treatment for a bacterial infection in a wound using oxygen therapy. An optimal control example will be given with both its analytical and numerical solutions. Preliminary findings, with analysis, will also be presented in this talk.

- **Speaker:** *Brandon Russell* (brandon.russell700@topper.wku.edu), Western Kentucky University

  Title: Using Partial Differential Equations to Model and Analyze Treatment of a Chronic Wound With Oxygen Therapy Techniques

  Abstract: Chronic wounds plague approximately 1.3-3 million Americans. The treatment of these wounds requires knowledge of the complex healing process of typical wounds. With mathematical modeling, we can simulate the intricate process. Researchers can potentially use the model to understand the effects of various therapies, and thus modify their treatments to maximize healing capabilities. Our model describes the interaction within the wound site among oxygen, bacteria, and neutrophils, a type of leukocyte. We analyze the model to determine whether it accurately describes the biological processes that occur during wound healing.

- **Speaker:** *Fang Wu* (fang.wu121@topper.wku.edu), Western Kentucky University

  Title: Parameter Estimations of Sigmoidal Models of Cancer

  Abstract: We develop discrete fractional Gompertz, Logistic, Richards and Weibull models of tumor growth for a given data of twenty-eight mice and estimate parameters of these models in order to have better data tting. We compare continuous, discrete, continuous fractional and discrete fractional forms of these sigmoidal curves. We illustrate the discrete fractional and the continuous fractional forms of sigmoidal curves which have the best data fitting results when they are compared to the previously used continuous time models.