**The Numerical Simulation and Mathematical Analysis on a Model Predicting and Preventing the Measles Epidemic**

Ashana Evans, North Carolina Agricultural State University

Dr. Liping Liu, NCAT

Mathematical models of epidemics have a long history of contributing to the understanding of the impact of vaccination strategies. Simple, one-line models can predict target vaccination coverage that will eradicate an infectious virus, while other questions require complex numerical simulations. This research introduces some simple ordinary differential equation models of mass vaccination strategies that can be used to address important questions for predicting an epidemic. Measles is a “childhood infection caused by a virus. Once quite common, measles can now almost always be prevented with a vaccine”. Generally, Measles is a highly contagious virus that is transmitted airborne and by direct contact. With this disease one has to create some vaccination strategies, to allow for eradication. The method is known as pulse vaccination strategy, which is a “method used to eradicate an epidemic by repeatedly vaccinating a group at risk, over a defined age range, until the spread of the infectious agent has been stopped”.

In 1996, *Predicting and preventing measles epidemics in New Zealand: application of a mathematical model*, was published to identify future measles outbreaks and aid in the development of vaccination strategies. The author divided the population into 4 homogeneous groups for the prediction model and 8 homogeneous groups for the prevention model. The groups correspond to age groups, ages 0.5 years-25 years. Each groups are then divided into susceptible, infected, or recovered individuals. With a small initial number of infected individuals, the model is created.

The purpose of this research is so we can provide important information about the Measles outbreak. This includes epidemic trends, risk factors, and the outcomes of various vaccinations strategies. With these findings it can be used to predicting future outbreaks, and ultimately preventing them. Essentially, such research allows us to:

1. Understand of the age grouped SI (or SVI) model for predicting and preventing the measles epidemic.
2. Find the realistic value for each parameter from the historical (or observational) data.
3. Use prior parameter values found to predict the epidemic in history for New Zealand, and validate it with the historical data.

In this study, we will be looking at two-aged groups. This is to understand the dynamics of the vaccination strategies as it pertains to the Measles epidemic. First, the Four-Age class group model for prediction to model the old vaccination policy, then the Eight-Age class group model for prevention with various vaccination strategies to understand how the infectious disease can be prevented. This research utilizes a deterministic SI/SVI model, which is a certain type of compartmental model with three different compartments with respect to time.

1. **S(t)** is for the number of susceptible people.

2. **V(t)** is for the number of people vaccinated.

3. **I(t)** is for the number of infected people.

Furthermore, its assumed that the population is a closed population. Which means that, the only way a person can leave the susceptible group is to become infected or vaccinated. Now this SI/SVI model for measles, is used to investigate the process of how an epidemic of measles occurs within a closed population over the years where a portion of the population has been vaccinated. This developed model should take into account the two major factors: age structure and seasonality. In addition, with modeling the endemic cycles, and considering seasonal effects, we look into if it comes from the cultures, school periods, as well as the calendar seasons. Various contact rates and transition rates among the groups are used to reflect the age and seasonality.

Moreover, with the SI/SVI model with the estimated parameters, we are able to capture the endemic cycles in the history and to predict the possible future outbreaks of measles under various vaccination strategies. This research numerical simulation results captured the endemic cycles in the history and can be used to predict the possible future outbreaks of measles under various vaccination strategies. For my future simulation experiments, there will be numerical simulations to further explore the effects of some chosen parameters on the system dynamics. Also, explore various vaccination rates for difference age groups.

References:

* Roberts, M. G. and Tobias, M. I., Predicting and preventing measles epidemics in New Zealand: Application of a Mathematical Model. Epidemiol. Infect. (2000) 124, 279-281.
* Liu, X, Takecuchi, Y., Iwami, S., A Mathematical Investigation of Vaccination Strategies to Prevent Measles Epidemics. Journal of Theoretical Biology 253 (2008) 1–11.
* Scherer, A., McLean, A., Mathematical models of Vaccination. The British Council 2002. British Medical Bulletin 2002;62: 187–199.

Funder Acknowledgement(s):

This study was supported, in part, by a grant from NSF HBCU-UP funded TALENT-21 Program at North Carolina A&T State University