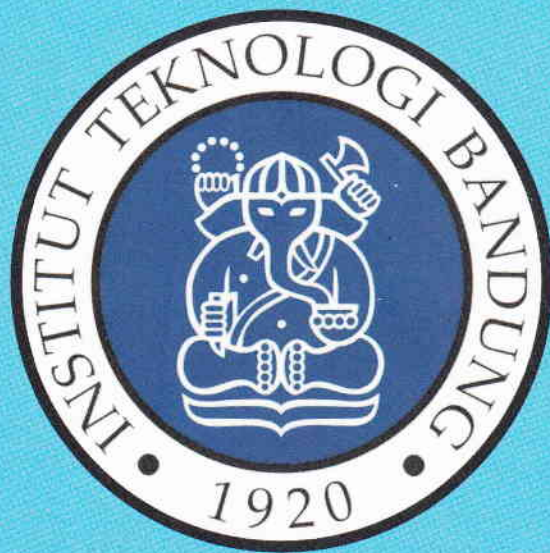


Volume 1587



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Symposium on Biomathematics (Symomath 2013)



West Java, Indonesia

27-29 October 2013

Editors

Hidetaka Arimura and Nuning Nuraini

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Table of Contents

Preface: Symposium on Biomathematics 2013 Hidetaka Arimura and Nuning Nuraini	1
Committees	2
INVITED PAPER	
Application of computational physics: Blood vessel constrictions and medical infuses Suprijadi, M. R. A. Sentosa, P. Subekti, and S. Viridi	3
CONTRIBUTED PAPERS	
Analysis of the dengue disease model with two virus strains F. Adi-Kusumo, A. N. Aini, and M. Ridwan	7
Optimal control problem in correlation between smoking and epidemic of respiratory diseases D. Aldila and M. Apri	14
Model for social interaction, competition and dominance in ant colonies N. Anggriani, I. Aryani, Darmawati, and A. K. Supriatna	22
Coexistence analysis of diploid and triploid hybrid water frogs M. Apri, D. Suandi, and E. Soewono	28
On the robust optimization to the uncertain vaccination strategy problem D. Chaerani, N. Anggriani, and Firdaniza	34
Optimal intravenous infusion to decrease the haematocrit level in patient of DHF infection D. Handayani, N. Nuraini, R. Saragih, K. P. Wijaya, and J. Naiborhu	38
Molecular dynamics simulation of soft grains: Malaria-infected red blood cells motion within obstructed 2-D capillary vessel L. Haris, S. N. Khotimah, F. Haryanto, and S. Viridi	43
Modelling on corrosion inhibitor kinetics in carbon steel pipe used in oil industry A. N. Hasmi, N. Nuraini, D. Wahyuningrum, N. Sumarti, and B. Bunjali	47
Marine biological metapopulation with coupled logistic growth functions: The MSY and <i>quasi</i> MSY H. Husniah and A. K. Supriatna	51

Estimating dynamic transmission parameters of the SIR model based on a kernel-based Gaussian process S. W. Indratno and A. Shabrina	57
A model dynamic for effect latent population to co-epidemic of HIV-TB Jafaruddin, Sutimin, and Ariyanto	61
Local stability of a five dimensional food chain model in the ocean W. M. Kusumawinahyu and M. R. Hidayatulloh	66
Mathematical model of tuberculosis transmission in a two-strain with vaccination J. Nainggolan, S. Supian, A. K. Supriatna, and N. Anggriani	70
Estimating parameter of influenza transmission using regularized least square N. Nuraini, Y. Syukriah, and S. W. Indratno	74
Probabilistic classification method on multi wavelength chromatographic data for photosynthetic pigments identification K. R. Prilianti, Y. Setiawan, Indriatmoko, M. A. S. Adhiwibawa, L. Limantara, and T. H. P. Brotosudarmo	78
A simulation model on the optimization time for the sudden weaning of angelfish (<i>Pterophyllum scalare</i>) D. N. Putri and N. Sumarti	84
Mathematical modeling of nasopharynx carcinoma on cell level Sugiyanto, F. Adi-Kusumo, L. Aryati, and M. S. Hardianti	88
A dynamical system of deposit and loan volumes based on the Lotka-Volterra model N. Sumarti, R. Nurfitriyana, and W. Nurwenda	92
Age structured dynamical model for an endangered lizard <i>Eulamprus leuraensis</i> A. K. Supriatna, Q. Rachmadani, F. Ilahi, N. Anggriani, and N. Nuraini	95
Volume estimation of brain abnormalities in MRI data Suprijadi, S. H. Pratama, and F. Haryanto	101
Numerical simulation of a two-sex human papillomavirus (HPV) vaccination model I. Suryani and F. Adi-Kusumo	105
Stability analysis of a discrete Hutchinson equation with discrete and distributed delay A. Suryanto, I. Yanti, and W. M. Kusumawinahyu	115
A nonlinear SIR with stability Trisilowati, I. Darti, and S. Fitri	119

Self-motion mechanism of chained spherical grains cells S. Viridi and N. Nuraini	123
Optimization model of vaccination strategy for dengue transmission H. Widayani, M. Kallista, N. Nuraini, and M. Y. Sari	127
Simulation of mosquitoes population dynamic based on rainfall and average daily temperature H. Widayani, Seprianus, N. Nuraini, and J. Arum	132
A comparison of binary and continuous genetic algorithm in parameter estimation of a logistic growth model Windarto, S. W. Indratno, N. Nuraini, and E. Soewono	139



Mathematical model of tuberculosis transmission in a two-strain with vaccination

J. Nainggolan, S. Supian, A. K. Supriatna, and N. Anggriani

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Mathematical Model of Tuberculosis Transmission in A Two-Strain with Vaccination

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Abstract: This paper deals with the mathematical analysis of the spread of tuberculosis with vaccination in a two-strain model. The vaccination reproduction ratio (\mathfrak{R}_{r_s}) and equilibria quantities for the models are determined and stability of the solution is analyzed. We prove that if the vaccination reproduction ratio $\mathfrak{R}_{r_s} < 1$ the disease free equilibrium is locally and asymptotically stable on the nonnegative orthant and if $\mathfrak{R}_{r_s} > 1$ of the other equilibria is locally and asymptotically stable. At the end of this study, the numerical computation presented and it shows that vaccination and treatment capable to reduce the number of exposed and infected compartments.

Key Words: Tuberculosis model, vaccination, drug resistant, stability, the vaccination reproduction ratio.

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INTRODUCTION

Tuberculosis (TB) is a disease that affects human and animal population. The disease is able to spread quickly through the air medium and becoming the second most killer among all transmission disease [5]. This report on global TB in 2011, there were an estimated 8.7 million incident cases of TB (range, 8.3 million–9.0 million) globally. The five countries with the largest number of incident cases in 2011 were an estimated India (2.25 million), China (1 million), South Africa (0.5 million), Indonesia (0.45 million) and Pakistan (0.4 million) [8].

Prevention of TB WHO (World Health Organization) recommended intervention is by giving BCG (*Bacillus Calmette Guerin*) vaccination to newborn baby at ages 2 to 3 months and in general population, while in some of these studies the vaccine is only given to people newly recruited into the population [5, 8]. An example of the person that is vaccinated with BCG could be protected 70% - 80% from TB infection [5].

Some past models of TB, particularly the predictive models attempting to calculate a threshold for the basic reproductive ratio \mathfrak{R}_0 , have incorporated drug treatment and/or vaccination, and have discussed control of the disease by looking at the role of disease transmission parameters in the reduction of \mathfrak{R}_0 and the prevalence of the disease [6].

The antibiotic treatment for an active TB patient requires a much longer period of time and a higher cost than that for those who are infected with sensitive TB but have not developed the disease. Lack of compliance with drug treatments not only may lead to

a relapse but to the development of antibiotic resistant TB, one of the most serious public health problems facing society today [4].

Coexistence of different pathogens (strains) in the same host were studied (Bhunu and Garira, [2]; Castillo-Chavez and Song, [3]; Feng et al., [7]), studied TB model without consider multi-drug resistant TB (MDR-TB) and vaccination compartment, (Bhunu and Garira, [1]; and Feng, [4]) studied a two strain TB model in the context of treatment without vaccination compartment. Our work differs from all these studies that, we consider that vaccination compartment. We have also added a scenario where an individual vaccination can be infected and move to sensitive or resistant MDR-TB stage. We have also incorporated a scenario where an individual in the vaccination and exposed can become recovered compartment.

The contributions of the proposed model is the development of a mathematical model of tuberculosis prevention, and health fields as information to take on the spread of tuberculosis control policies.

The paper is organized as follows: Section 2, we discussed a two strain tuberculosis transmission models with vaccination. Section 3 numerical simulation, and section 4 conclusion our results.

MODEL

The state variable on population of studied the dynamical model divided into seven compartments: Susceptible (S), vaccination (V), those exposed to DS-TB (E_1), infected to DS-TB with (I_1), those who have recovered (R), those exposed to MDR-TB (E_2), and