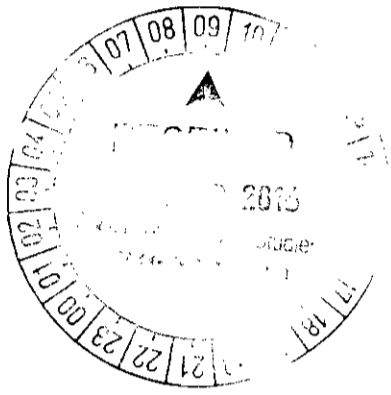
Stochasticity in Susceptible, Infected, Recovered and Vaccinated (SIRV) models for the transmission of the epidemic Diseases

By

N.H.E. Hasanthika, B.Sc.
FGS/06/02/04/2012/01



A Dissertation

in

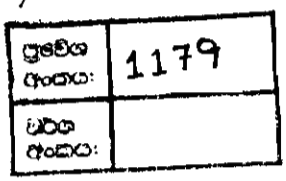
Mathematics

Submitted to the University of Kelaniya in

Partial Fulfillment of

the Requirements for the Degree of

Master of Philosophy



May, 2015

Abstract

This thesis is concerned with comparing the dynamical role of stochasticity in current epidemic models. Although the simulation of stochastic models could capture, to a certain extent, the qualitative epidemic patterns of most of the epidemic diseases, there is still a considerable variations concerning the basic mechanisms of the patterns these models generate. The main objective of this research is to use numerical simulations to investigate the qualitative and quantitative variations that results in after introducing stochasticity into deterministic epidemic models. Each model is formulated as a stochastic differential equation model which decomposes the full stochastic dynamics into a macroscopic part, described by deterministic equations, plus a stochastic fluctuating part. Traditionally, there are two ways in which a stochastic model is different from a deterministic one. Most trivially, because the process is random, different realizations will show variation. Secondly (and traditionally why stochastic epidemic models were first investigated), because there is the chance of extinction even when low vaccination rates are used and tranmission rate is high, which cannot happen in a deterministic model.

The first part examines the inclusion of stochasticity in a standard susceptible-infectious-recovered (SIR) model through numerical simulations with known parameter values. Then we discuss the role of delayed time in stochastic SIR epidemic models with numerical simulations and make comparisons with deterministic models. In the final part of this thesis, the effect of seasonal forcing is studied with an analysis of the stochastic differential equation(SDE) SIR models. In all sections, we introduce vaccination strategies for SDE-SIR models with various characteristics.

keywords: stochasticity, delay time, seasonal forcing, vaccination, epidemic model