MATHEMATICAL MODELLING OF DENGUE DYNAMICS AND CLIMATE VARIABILITY IN SRI LANKA

Thiyanga Shamini Talagala

Degree of Master of Science

Department of Mathematics

University of Moratuwa

Sri Lanka

August, 2015

MATHEMATICAL MODELLING OF DENGUE DYNAMICS AND CLIMATE VARIABILITY IN SRI LANKA

Thiyanga Shamini Talagala

(128912F)

Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Financial Mathematics

Department of Mathematics

University of Moratuwa

Sri Lanka

August 2015

Declaration of the candidate

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 27 - 8 - 2015

Declaration of the supervisor

The above candidate has carried out research for the Master's thesis under my supervision.

Signature of the supervisor: Date: 27 - 8 - 2015

Dr. R. S. Lokupitiya
B.Sc. Special (Stat), M.Sc. (Stat.) (USA), Ph.D. (Stat.) (USA)
Head/ Department of Statistics
University of Sri Jayewardenepura

Dedication

This thesis is dedicated to my mother and father who have supported me throughout my studies.

Acknowledgements

This thesis would not have come to the conclusion as it is today without the help and support of several people at various stages. All the help I have received has been warmly appreciated.

First and foremost, I would like to express my sincere gratitude to my supervisor Dr. R. S. Lokupitiya, Head/ Department of Statistics, University of Sri Jayewardenepura for his advices regarding my research. His advices and prompt comments on written work were highly valuable. I would like to convey my utmost gratitude to Mr. T. M. J. A Coorey, Coordinator/ MSc in Financial Mathematics, Department of Mathematics, University of Moratuwa and Mr. A. R. Dissanayeka, Senior Lecturer, Department of Mathematics, University of Moratuwa for their valuable guidance.

I would like to gratefully acknowledge the staff of Department of Statistics, University of Sri Jayewardenepura for their support given to me.

It is my parents who are always behind with me, caring about me in every second of my life, whose heartiest love, encouragement, guidance and motivation enables me to build better foundation for my life. Hence certainly my deep appreciation is expressed to my parents for their endless love and caring.

Abstract

Dengue fever (DF) is a life threatening infectious mosquito borne disease that places a heavy burden on public health system in Sri Lanka as well as on most of the tropical countries around the world. Currently, there is no antiviral drug for treatment of DF. The objective of this study is twofold, first is to analyze the epidemic outbreak patterns of dengue cases in 25 districts in Sri Lanka, second is to identify the association between climatic variables and dengue counts in Colombo district where dengue is predominant. Weekly data on dengue cases were obtained between January, 2009 – September, 2014. Temperature (maximum, minimum, mean), precipitation, visibility, humidity, and wind speed were also recorded as weekly averages. Wavelet analyses were used to explore the periodicity of dengue cases. Wavelet coherence was performed to identify the association between dengue and climatic factors. Further, a Poisson regression combined with distributed lag nonlinear model (dlnm) was used to quantify the impact of climatic factors on dengue counts while taking the lag time into account. Change point analysis was performed as a complementary analytic method to identify changes in variance of dengue and climate time series. Dengue dynamics showed multiple periodic patterns (1-8 weeks, 26 weeks and 52 weeks) across twenty five districts which can be divided into two groups based on wavelet cluster analysis. Wavelet coherency revealed a significant non-stationary association between climatic variables and dengue incidence in annual and semi-annual scale. Results of dlnm revealed mean temperature around 25^0C – 26^0C prior to 5 weeks, high precipitation (>30mm), humidity 65% - 75% prior to lag of 10-15 weeks, and high visibility have an harmful impact on increasing relative risk of dengue incidence. These findings can aid the targeting of vector control interventions and planning for dengue vaccine implementation.

Keywords: Dengue, Wavelet Analysis, Climate, Distributed lag nonlinear model, Change point analysis

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST of ABBREVIATIONS

CWT – Continuous Wavelet Transformation

DF – Dengue Fever

DHF – Dengue Hemorrhagic Fever

DLNM – Distributed Lag Nonlinear Models

DSS – Dengue Shock Syndrome

GAM – Generalized Additive Models

GAMAR – GAM with Autoregressive terms

GLM – Generalized Linear Models

PELT – Pruned Exact Linear Time

RR – Relative Risk

SARIMA – Seasonal Autoregressive Integrated Moving Average

WER – Weekly Epidemiological Report

WHO – World Health Organization

LIST OF APPENDICES