THE SOCIAL AND ECONOMIC IMPACT OF DENGUE: A CASE STUDY OF THE NATIONAL HOSPITAL-COLOMBO,SRI LANKA

DHODANDUWA LABUNA HEWAGE ESHANTHA CHANDANA DE SILVA

ASIA e UNIVERSITY
2022

THE SOCIAL AND ECONOMIC IMPACT OF DENGUE: A CASE STUDY OF THE NATIONAL HOSPITAL-COLOMBO, SRI LANKA.

DHODANDUWA LABUNA HEWAGE
ESHANTHA CHANDANA DE SILVA

A Thesis Submitted to Asia e University in
Fulfillment of the Requirements for the
Degree of Doctor of Philosophy
April 2022

ABSTRACT

Dengue has become a significant public health problem in Sri Lanka. In the year 2017, a total of 186,101 cases of dengue have been reported around the country, and the most substantial proportion of 18.42% was reported from the Colombo district. The social and economic impact of dengue has been studied at a very low level so far. Therefore, this study was conducted to have an insight into the number of resources used by the interventions related to dengue case management and the social factors, which influence the disease. Due to the difficulty in obtaining data from the private sector, the scope of this study was limited to the government sector.

The research was conducted in two stages. It involved 200 inward dengue patients in analyzing the direct cost of the disease and conducting a community survey through family members of selected patients to analyze the social impact of the disease. Related data items were gathered from the National Hospital that treated dengue inward patients in the Colombo district. The structured cost elements were examined to identify the variable and fixed costs of each activity within each element and used a systematic sampling protocol to select 200 patients and their families. A cross-sectional approach was used to assess the knowledge, attitudes, and behavioral patterns of family members towards dengue fever.

All data were analyzed by using MS Excel, SPSS 22 software package, and R software and used logistic regression model approach to realize the independent effect of each of these potential variables on the dependent variables (dengue prevention practices) of Knowledge, Attitudes and Practices (KAP) related to dengue prevention and apply quantile regression to analyze the economic impact of dengue. The average economic impact of dengue illness in Sri Lanka was LKR 37,988 in

2017 and knowledge, attitudes and behavioral factors have significant effects on health. This study recommends that the healthcare system in Sri Lanka needs to develop mechanisms to promote preventive care, which is more cost-effective compared to curative care.

APPROVAL

This is to certify that this thesis conforms to acceptable standards of scholarly presentation and is fully adequate, in quality and scope, for the fulfilment of the requirements for the degree of Doctor of Philosophy

The student has been supervised by: Dr. Sarath M Samarage and co-supervised by: Dr. Kithsiri Edirisinghe

The thesis has been examined and endorsed by:

Professor Dato' Dr Sayed Mushtaq
Asia e University
Examiner

Professor Dr Tamat Sarmidi
Universiti Kebangsaan Malaysia
Examiner

Professor Dr Roslan bin Abdul Hakim
Universiti Utara Malaysia
Examiner

This thesis was submitted to Asia e University and is accepted as fulfilment of the requirements for the degree of Doctor of Philosophy.

……

Professor Dr Siow Heng Loke
Asia e University
Chairman, Examination Committee
Date:

DECLARATION

I hereby declare that the thesis submitted in fulfilment of the PhD degree is my own work and that all contributions from any other persons or sources are properly and duly cited. I further declare that the material has not been submitted either in whole or in part, for a degree at this or any other university. In making this declaration, I understand and acknowledge any breaches in this declaration constitute academic misconduct, which may result in my expulsion from the program and/or exclusion from the award of the degree.

Name of Candidate: Dhodanduwa Labuna Hewage Eshantha Chandana De Silva

Signature of Candidate:  **Date:** 10.03.2021

ACKNOWLEDGEMENTS

This project is the fruit of four years of effort in the literature review, data collection, analysis, interpretation, and writing. From the first step, my Supervisor, Dr. Sarath M. Samarage, and Co-supervisor Dr. Kithsiri Edirisinghe, have been mentors and have guided throughout this project with tremendous encouragement at all levels. Also, special thanks to Ms. Kasuni Chamika (Course Coordinator), Mrs. Stephanie Gloria Anthony (Director), Mrs. Sajeeka Nanayakkara, Mr. Damith Rajakaruna, and the staff of IIHS for the support given in making this a success. This thesis would not have been possible without the love and support of several incredibly special people, wife Bharathie and two daughters, Dhanya, Sashri and company Kayak Surgi Pharma (Pvt) Ltd for the funding they provided that allowed me to function as a researcher. Finally, I would like to thank Dr. Anil Jasinghe (Former Deputy Director General, National Hospital), Dr. Cyril De Silva (Chairman-Ethical Review Committee), Mrs. Madhurekha (Hospital Secretary), Dr. G.C.A.U. Patabedige (Head of Infectious Control Department), other staff of the National Hospital Sri Lanka, the patients who were involved in this study and their family members.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

WHO	World Health Organization
ICU	Intensive Care Unit
DENV	Dengue Virus
DF	Dengue Fever
DHF	Dengue Hemorrhagic Fever
DSS	Dengue Shock Syndrome
LKR	Sri Lankan Rupees
USD	United States Dollars
GIS	Geographic Information System
KAP	Knowledge, Attitudes and Practices

CHAPTER 1
INTRODUCTION

The global prevalence of dengue has grown intensely in current decades. About half of the world's population is now at risk. It is estimated that 100-400 million infections occur each year. Dengue inhibition and control are influenced by effective vector control measures. Dengue has many medical, social and environmental impacts. The social and economic impact of dengue is comparable to some of the visible infectious diseases. It is still perceived as unimportant and receives little attention and even less funding for research, prevention, and control. Although this lack of attention is not well understood, the government and health officials demand a quick-fix solution to disease prevention and control.

Dengue fever has become widespread in tropical countries during the 18th and 19th centuries when the shipping industry and commerce were expanding. There are four serotypes of the dengue virus that frequently result in major epidemics that affect numerous countries in the world. Dengue fever is caused by a variety of factors, some of which are unknown. However, demographic and societal changes have played a significant role in the increased incidence and geographic spread of the disease. Also, a lack of public health resources for research, surveillance, prevention, and control programs affected the increase in the number of dengue cases globally.

At the beginning of the 21st century, dengue fever was the most important arboviral disease of humans, occurring in tropical countries where more than 2.5 billion people were at risk of infection, and it was estimated that between fifty and hundred million cases of dengue fever and several hundred thousand cases of dengue

hemorrhagic fever will occur each year. This has led to the use of insecticide sprays to control dengue vectors as a highly visible method over the years which, unfortunately, is ineffective and expensive. The social impact of this type of inefficient method is unknown, but it is clear that the government is in control of the epidemic, giving the public a false sense of security, which leads to them continuing to use it. The result is that neither the government nor the public would do anything to prevent the social disruption that accompanies dengue fever. Instead, they will live from epidemic to epidemic under a misguided belief.

The economic impact of dengue fever is difficult to quantify. Currently, only a few studies on dengue fever have been attempted in Sri Lanka, out of which, the majority have focused on clinical areas or not taken into account the diseases' overall burden. However, some estimates have been made despite many challenges. The estimated total cost of dengue control and hospitalization was at USD 3.45 million by the Colombo District in 2012, with the average cost per hospitalization ranging from USD 216-609 for pediatric cases to USD 196-866 for adults. In 2017, there were 186,101 dengue cases reported across the island, with 215 deaths, with the majority of cases being reported in the Colombo District. The Sri Lankan government spent USD 12.7 million for the control and outbreak response activities of dengue in 2017. Also, it imposes a heavy burden on the national health budget. A large number of public health staff is involved in the management of dengue patients and dengue control activities year-round and it represents a formidable development challenge with developing economies.

Current prevention and control of dengue programs aim to reduce mosquito activity and dengue incidences. However, the allocation of appropriate resources for mosquito control and dengue management programs in Colombo is crucial due to the

increasing nuisance levels, disease risks, and competing demand for resources, currently used to manage the problem. The Ministry of Health and local authorities are faced with a dilemma about whether dengue control and patient management programs are cost-effective or allocation of additional resources is economically desirable. It is necessary to develop an effective methodology to assess the whole range of social and economic impacts of dengue in Sri Lanka. This thesis presents findings of a comprehensive study conducted in Colombo to assess the social and economic impact of dengue fever, using a method that incorporates both theory and methods from medical economics and social epidemiology. This also includes demographic analysis, descriptive statistics, hypothesis testing, and developing models.

1.1 Background

1.1.1 Dengue

Dengue is a mosquito-borne disease and estimated that every year there are fifty million dengue infections worldwide and two-fifths of the world's population is at risk of getting infected with dengue (WHO, 2002). The first record of a dengue case was in the Chinese medical encyclopedia from the Jin Dynasty (265-420 AD), which referred to a "water poison" connected with flying insects. Dengue (*Aedes aegypti*) mosquitoes spread out of Africa in the 15th to 19th centuries due in part to expanding globalization, secondary to the slave trade. There have been descriptions of epidemics in the 17th century, but the most believable early reports of dengue epidemics were from 1779 and 1780, when an epidemic swept across Asia, Africa, and North America. From that time until 1940, epidemics were infrequent (Dengue Virus Net, 2018). Dengue virus is an RNA virus of the family; Flaviviridae and genus; Flavivirus. This is also referred to as arboviruses (arthropod-borne viruses).

There are four strains of the virus (serotype) referred to as DENV1, DENV2, DENV3, DENV4 (Christenbury et al., 2010) Dengue virus is transmitted by Aedes mosquitoes which live between the latitudes of 35° north and 35° south below an elevation of 1000 meters (3300ft) (Joshi et al., 2014).

1.1.2 Context of the Research

This study aimed to identify the direct cost of dengue hospitalization, and how social factors would influence the practices towards dengue prevention. This study expounds on the theoretical framework for understanding the underlying circumstances of health care use during dengue hospitalization from a government perspective, as well as integrated social factors such as knowledge, attitudes, and behavioral patterns that influence dengue risk. In addition to that, these findings will help to close the current knowledge gap existing regarding the direct cost of dengue hospitalization and how social factors influence the practices towards dengue prevention.

1.1.3 Epidemiology of Dengue

Dengue is an acute mosquito-borne viral infection. It affects tropical and subtropical countries, causing socioeconomic and disease burdens, and placing 50% of the world's population at risk of dengue fever. It is currently regarded as the world's most important arboviral disease (Wellekens et al., 2020).

There are four dengue virus serotypes from the family Flaviviridae, and genus Flavivirus and serotypes are DENV-1, DENV-2, DENV-3, and DENV- 4. These four serotypes were individually found to be responsible for dengue and any of these four viruses would result in lifelong immunity to that specific serotype (Christenbury et al., 2010).

The complex disease of dengue is often misdiagnosed or unrecognized as other types of fever (Nealon et al., 2016). According to the incubation period, dengue fever can remain 2-7 days with symptoms such as myalgia, anorexia, arthralgia, headache, sore throat, and skin rash. The majority of people with dengue do not progress to dengue hemorrhagic fever or dengue shock syndrome. However, there is no clear consensus on the association of DHF and severe disease with serotype in addition, certain dengue strains, particularly those of DENV-2, have been proposed to be more virulent (Gubler,D. J. 1998). Thrombocytopenia and increased vascular permeability can result in hemorrhagic and shock in severe cases. The case fatality of severe dengue can be lower than 1% with proper case detection and clinical management (Neiderud, 2015).

Aedes aegypti is the main vector for transmission of the dengue viruses whereas Aedes albopictus is also a vector, however, with less effectiveness. Aedes mosquitoes are active during daylight hours and are extensively spread in both the tropics and subtropics. The Dengue mosquito has a high affinity for human blood and high susceptibility to all four dengue virus serotypes. It is also highly adapted to urban areas where regular water containers or disposed water-holding vessels around houses are more common. Aedes aegypti tends to persist in a domestic environment due to the limited flight range and their location of development. Prevention and control of dengue are currently reliant on vector control methods such as environmental, biological, and chemical management strategies (Gubler, 2004).

A similar disease has spread as early as 1635 and 1699 in the West Indies and Central America, respectively. In 1780, a major epidemic occurred in Philadelphia and became common in the USA in the early 20th century. The viral etiology and the transmission of dengue by mosquitoes were determined in the 20th century. Dengue was spread throughout urban tropical coastal cities of the world due

to the commercial shipping vessels by 1800 and epidemics were spaced at 10-40 year intervals. Dengue was heightened during World War II. Geographic expansion of the dengue epidemic from South East Asia and global dengue incidence rates have increased in the late 20th century, as have severe dengue cases (Laserna et al., 2018).

Dengue viruses have the potential to spread and 3.6 billion people living in tropical and subtropical countries are at risk of becoming infected. Approximately 50 to 200 million dengue infections, 500,000 dengue hemorrhagic fever (DHF)/dengue shock syndrome (DSS) cases, and over 20,000 deaths occur annually worldwide (Murray, N. E. A., Quam, M. B., & Wilder-Smith, A. 2013). In 2009, the estimated disability-adjusted life year (DALY) was 700,000 globally (San et al., 2010). In most countries, the main burden of morbidity and mortality due to dengue fever occurs among children. Rainfall and population density are shown to be associated with dengue in most countries (Sirisena et al., 2017).

The annual cost of dengue is estimated to be at USD 201 billion in America alone and 60% of this cost is related to indirect costs or productivity losses (Vásquez- Trujillo et al., 2020). Twelve countries in Southeast Asia suffer an annual economic burden of USD 950 million, with approximately 52% of it occurring due to productivity losses (Gubler, D. J. 2012). However, the true incidence and impact of dengue are significantly higher than the reported cases. This occurs due to inadequate disease surveillance, difficulties in diagnosis, and low level of reporting, and inconsistent comparative analyses.

3.97 billion people from 128 countries are at risk for dengue in the globe. In which 763 million live in peri-urban areas and 824 million live in urban areas. 390 million dengue cases occur annually across the globe (Gubler, D. J. 2012).

Globally, 3.97 billion people living in 128 countries are at risk of dengue,

of which 763 million live in peri-urban areas and 824 million in urban areas (Murray, N.E. A., Quam, M. B., & Wilder-Smith, A. 2013) One modeling estimate indicates 390 million dengue virus infections per year (WHO and Guzman & Isturiz, 2010).

Dengue reported cases in the western Pacific region have increased continuously over the past decade. Dengue burden in the Western Pacific region originates from Malaysia, Singapore, Cambodia, Vietnam, and the Lao People's Democratic Republic and all serotypes have been found in this region. After a long absence of disease, DENV-3 and DENV-2 were reintroduced from the Americas to the Pacific Islands in 1964 and 1971, respectively, and all four serotypes are still in circulation in Asia since then. All countries in the Americas now have dengue transmission and every 3-5 years dengue occurs in the region, as it also does in Southeast Asia. The Americas have strived for dengue prevention over recent decades to reduce the disease and economic burden of dengue (Bhatia, R., Dash, A. P., & Sunyoto, T. 2013).

Most African countries reported dengue outbreaks between 1960 and 2010; all four dengue serotypes have been seen during the epidemic. Due to the misdiagnosis and being treated as malaria, it is difficult to draw a comprehensive picture of cases of dengue in the region (Guzman et al., 2010).

The last reported dengue epidemic in Europe was in 1926 and 1928 and implicated high mortality of cases. There was no dengue transmission reported thereafter until the 1990s, which was due to imported cases. Travelers had been a real threat of dengue. The Eastern Mediterranean region is now classified as an 'emerging disease' and Saudi Arabia, Pakistan and Yemen have had multiple outbreaks in the last two decades. In 2011, the city of Lahore in Pakistan had a major dengue outbreak associated with 21,685 dengue cases including 350 deaths. Sudan and Somalia are

also frequently reporting dengue cases of different serotypes. The geographic expansion of dengue will increase in the future, according to many experts, and some of the potential factors are important to elaborate as a global strategic direction.

Temperature plays a significant role in vector survival, viral replication, and infective periods, and it may increase vectors. Aedes mosquitoes are climate dependent and therefore, meteorological factors can predict useful information about the mosquito life cycle. Weather conditions or patterns can predict dengue activity in a country and climate and environmental changes may create and increase mosquito breeding in areas that are currently non-endemic (Nealon et al., 2016). An increase in dengue outbreaks over the last four decades could be due to global temperature increases. Some studies show a possible increase in dengue incidence due to high temperatures, humidity, and precipitation (Nealon et al., 2016). It is therefore predicted that 50-60% of the global population will be at risk of dengue by 2085 (WHO). In contrast, some studies argue against climate change saying that the main driver for dengue is human-made water containers, improper disposal systems of garbage, industrialization, and modernization (Kovats et al., 2000). Globalization has been a leading factor in global economic development recently. Passenger travelings and intercontinental exchange of goods are the current global realities. Personal travels from dengue-infected areas to the global transmission of dengue virus and transport of cargo and goods from those areas would also help in transmitting primary and secondary vectors of dengue (Wilder-Smith & Gubler, 2008).

Settlement and socioeconomic factors of increased population and economic development of tropical and subtropical areas have affected the expansion of dengue transmission. Other human factors, socioeconomic constraints on control measures, increasing global population, and urbanization would also contribute to the

same. Moreover, improper water storage and disposal, as well as new human-made breeding sites, have been identified as factors that influence dengue transmission and geographic expansion. Mosquitoes breed preferentially in artificial containers, which are mostly created in rapidly urbanizing areas combined with urban human settlement. Rural dengue cases can surpass urban and semi-urban areas (Hossain, M. (2018).

The role of socio-economic development on dengue transmission and control was highlighted in some studies, comparing dengue endemicity and seroprevalence within border cities in Europe and the US (Olive et al., 2020). In those studies, researchers examined climate, geography, mosquito habitat, density, social factors, household size, basic sanitation levels, as well as household income, water storage methods, waste disposal methods, and cross-border travel. In addition to that, proper environmental management aims to reduce the dengue vector population in an urban area as a critical mechanism (Mulanovich, 2014).

Dengue has been classified as a "neglected tropical disease" by the World Health Organization (WHO) and it is essential to reflect on policy and strategic direction to reduce the impact of the disease. The key objectives identified in controlling dengue are improved decision making, financial allocation, research, epidemiological data, etc. (WHO). Vector control is one element of dengue prevention and control in the global strategy. Therapeutic strategies, effective vaccines, and effective vector control methods are also essential for the reduction of dengue mortality and morbidity by 2020 (Olive et al., 2020).

1.1.4 Burden and Economic Impact

The dengue burden is uncertain, but policymakers must have the ability to prioritize and allocate resources and other interventions. The burden of dengue is often

expressed as the number of infected populations, years of life lost, years lived with disability, disability-adjusted life years, and the key parameters of the cost-effectiveness of interventions (Gubler, D. J. 2012). This economic burden can be conceptualized in terms of the costs imposed on society. This cost includes the direct or indirect cost associated with treatment outcome, diagnosis, and prevention.

There are about 100-200 million dengue infections per year in more than 100 countries in the world. Dengue is among the most significant disease burden in Southeast Asian countries and the regions which report the highest incidence for decades. Past studies have estimated the economic burden of dengue in Southeast Asian countries in 2010. Cambodia, Thailand, and Malaysia's annual costs of dengue were USD 3.1, 53.1, and 42.4 million, respectively (Shepard et al., 2010). Lim et al. estimated yearly cost, including vector control and research, development activities of USD 133 million in Malaysia in 2002-2007 and USD 135 million in Thailand (2000-2005), which represent 41.3% of the total cost in Malaysia and 49% in Thailand. Carrasco et al, estimated that in Singapore, dengue illness costs were USD 41.5 million, and vector control costs were USD 50 million. Luong et al. (2013) estimated that the average annual cost in Vietnam was USD 50 million.

Dengue ranks fifth on the list of Neglected Tropical Diseases in the Americas. The real burden may be underestimated, and serological surveys suggest the occurrence of millions of dengue cases annually. The total costs per ambulatory case were USD 72 and USD 2300 in Cuba and Bermuda, respectively. The total cost per hospitalized case ranged from USD 306 in Nicaragua and USD 17,803 in the United States (Shepard et al., 2013). The aggregate annual total cost of dengue in the Americas in 2000-2007 was USD 2.1 billion. According to Zavala et al. (2016), the estimated average cost per case of dengue fever in Mexico in 2016, was USD 486.

Sonia et al. (2009), estimated the economic impact of dengue in Argentina in 2009, and the individual medical costs on average would be USD 130 for the Central Region, USD 90 for the Northwest Region, USD 102 for the NorthEast Region, USD 190 for the Central region and USD 149 for the NEA region. Zhang et al. (2013) estimated the direct cost of dengue hospitalization in China and the average direct hospitalization cost of dengue cases in the study was USD 499.64 during 2013, which was 3.71% of the gross domestic product per capita. Bhavasar et al. (2010) estimated costs associated with dengue illness in Surat, India in 2010, and that came to an average of USD 33.92 for a dengue illness episode in a public hospital, and USD 585.57 was estimated for direct and indirect costs in the private sector. Thalagala et al. (2016) published an article estimating the cost of dengue control activities and hospitalizations in the public health sector during an epidemic year in urban Sri Lanka. The total cost of dengue control and hospitalizations were estimated at USD 3.45 million (USD 1.50 per capita) in 2012. The average cost per hospitalization ranged between USD 216-609 in pediatric cases and USD 196-866 in adult cases.

The Sri Lankan Ministry of Health (MoH) is responsible for controlling dengue disease and prevention and is currently limited to the control of mosquito vectors. There is a large number of health staff involved in dengue control activities, which is also a formidable financial burden to the country.

1.2 Scope of the Study

It is currently estimated that there are fifty million dengue-infected patients worldwide. The disease burden is often expressed as the number of infections and lives lost. The incidence and spread of dengue depend on a variety of factors, such as socio- economic, demographic, knowledge, attitude, and behavioral patterns and are considered to be critical factors that influence the incidence and transmission of