THE COST OF DENGUE VECTOR CONTROL PROGRAMME IN MALAYSIA

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KUALA LUMPUR

2017

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THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PUBLIC HEALTH

FACULTY OF MEDICINE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2017

UNIVERSITY OF MALAYA

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ABSTRACT

Dengue fever, an arbovirus disease transmitted by Aedes mosquitoes, has spread rapidly, especially in the tropical countries of the Americas and Asia-Pacific regions. It is endemic in Malaysia, with an annual average of 35,403 reported dengue cases from 2001 to 2010. The economic burden of dengue for Malaysia in 2009 was MYR 359.79 million (US$102.2 million) but these estimates are incomplete because the public sector costs of disease control had not been considered. This study estimated the costs of dengue control and prevention in Malaysia and measured the overall economic impact of dengue in the country. It also examined the variations in dengue vector control costs and resources consumption between the District Health Departments (DHDs) and Local Authorities (LAs) to assist informed decision making as to the future roles of these agencies in the delivery of dengue vector control services in Malaysia. Data were collected from representative vector control units of DHDs, State Health Departments (SHDs) and Federal Health Department (FHD) from Ministry of Health Malaysia and the corresponding LAs at the sampled districts. The costs and resources consumption by capital and recurrent items in 2010 were captured. The data was recorded by level in a matrix by line items and functions. Line items consist of human personnel, buildings, vehicles, equipment, pesticides, personal protective equipment (PPE) and outsourcing of fogging services to private pest control companies. A cost analysis of functions includes costs of inspection of premises, larviciding and fogging activities, entomological surveillance and health education activities. For the comparison of costs between service providers, namely the DHDs and LAs, only the vector control activities were considered. Those vector control activities were inspection of premises, fogging and larviciding of potential breeding sites. Malaysia spent MYR 235.05 mil (US$ 73.45 mil) or 0.03% of the country's GDPfor dengue vector control and prevention. This expenditure represented MYR 5,091 (US$ 1,591) per reported dengue case and MYR 8.58 (US$ 2.68) per capita population. Notably, 92.2% of this spending occurred in the district-level primarily for fogging activities. From this total expenditure, the national DHDs and LAs expenditure were MYR 169.12 mil (US$ 52.85 mil) and MYR 47.63 mil (US$ 14.88 mil) respectively. The comparison of dengue vector control costs between service providers at the sampled districts revealed that the DHDs spent MYR 17.98 mil (US$ 5.62 mil) or MYR 2,172 (US$ 679) per reported dengue case, and LAs spent MYR 8.34 mil (US$ 2.61 mil) or MYR 1,598 (US$ 499) per reported case. The highest expenditure was fogging, being 51.0% of costs for DHDs and 45.8% for the LAs. The DHDs had higher resource costs for human personnel, vehicles, pesticides and equipment. The findings provide some evidence to rationalize delivery of dengue vector control services in Malaysia. The inclusion of control and preventive activities increased substantially the estimated economic burden of dengue to MYR 594.84 mil (US$ 175.71 mil), or 72% above illness costs alone. The quantification of dengue economic burden informs policy makers and stakeholders regarding the implementation of existing and new technologies for controlling dengue.

ABSTRAK

Demam denggi, satu penyakit Arbovirus yang disebarkan oleh nyamuk Aedes, telah merebak dengan pesat, terutamanya di negara-negara tropika di benua Amerika dan Asia Pasifik. Ia adalah endemik di negara Malaysia, dengan kadar purata tahunan sebanyak 35.403 kes denggi yang dilaporkan dari tahun 2001 hingga 2010. Bebanan ekonomi denggi bagi Malaysia untuk tahun 2009 ialah RM 359.79 juta (US$ 102.2 juta) tetapi anggaran tersebut tidak lengkap kerana kos kawalan penyakit oleh agensi awam tidak dipertimbangkan. Kajian ini menganggarkan kos kawalan denggi dan pencegahan oleh agensi awam di Malaysia dan menaksir kesan ekonomi secara keseluruhan penyakit denggi kepada negara. Ia juga mengkaji variasi dalam kos kawalan dan pengunaan sumber antara Pejabat Kesihatan Daerah (PKD) dan Pihak Berkuasa Tempatan (PBT) untuk membantu membuat keputusan tentang peranan masa depan agensi-agensi ini dalam penyampaian perkhidmatan kawalan vektor denggi di Malaysia. Data telah dikumpulkan dari wakil unit kawalan vektor peringkat daerah (PKD), negeri (JKN) dan persekutuan (Sektor Denggi) daripada Kementerian Kesihatan Malaysia dan PBT yang berkaitan di daerah sampel. Kos dan penggunaan sumber aset dan barangan inventori pada tahun 2010 telah diperolehi daripada tapak kajian. Data telah dicatat mengikut butiran sumber dan fungsi. Butiran sumber terdiri daripada kakitangan, bangunan, kenderaan, peralatan, racun, peralatan keselamatan (PPE) dan semburan kabus oleh syarikat kawalan makhluk perosak swasta. Analisa kos secara fungsi termasuk kos pemeriksaan premis, larvaciding dan aktiviti semburan kabus, penilaian entomologi dan aktiviti pendidikan kesihatan. Bagi perbandingan kos antara pemberi perkhidmatan, iaitu PKD dan PBT, hanya aktiviti kawalan vektor sahaja telah dipertimbangkan. Aktiviti kawalan vektor adalah pemeriksaan premis, semburan kabus, dan larviciding di tempat pembiakan nyamuk. Malaysia telah membelanjakan sebanyak

RM 235.05 juta (AS$ 73.45 juta) atau 0.03% daripada KDNK negara dalam program kawalan dan pencegahan denggi kebangsaan. Perbelanjaan ini adalah RM 5,091 (AS$ 1,591) bagi setiap kes denggi yang dilaporkan dan RM 8.58 (AS$ 2.68) penduduk per kapita. 92.2% daripada perbelanjaan ini berlaku di peringkat daerah terutamanya untuk aktiviti semburan kabus. Dari jumlah ini, perbelanjaan PKD dan PBT peringkat kebangsaan adalah RM 169.12 juta (AS$ 52.85 juta) dan RM 47.63 juta (AS$ 14.88 juta) masing-masing. Perbandingan kos kawalan vektor denggi antara pemberi perkhidmatan di daerah yang disampel mendedahkan bahawa PKD telah membelanjakan RM 17.98 juta (AS$ 5.62 juta) atau RM 2,172 (AS$ 679) bagi setiap kes denggi yang dilaporkan dan PBT pula sebanyak RM 8.34 juta (AS$ 2.61 juta) atau RM 1,598 (AS$ 499) bagi setiap kes yang dilaporkan. Perbelanjaan yang tertinggi adalah semburan kabus, iaitu sebanyak 51.0% daripada jumlah kos untuk PKD dan 45.8% bagi PBT. PKD merekodkan kos sumber yang lebih tinggi untuk kakitangan, kenderaan, racun perosak dan peralatan. Penemuan ini menyediakan beberapa bukti yang boleh digunapakai untuk merasionalisasi penyampaian perkhidmatan kawalan vektor denggi di Malaysia. Penambahan kos aktiviti kawalan dan pencegahan kepada penyakit denggi telah meningkatkan beban ekonomi yang ketara iaitu sebanyak RM 594.84 juta (AS$ 175.71 juta), atau 72% lebih tinggi daripada kos penyakit sahaja. Perhitungan beban ekonomi denggi peringkat kebangsaan memaklumkan pihak perancangan dasar dan pihak berkepentingan mengenai pelaksanaan teknologi baru dan sedia ada untuk mengawal penyakit denggi.

ACKNOWLEDGEMENTS

First of all, I would like to thank my family: my wife, my parents and my daughter for the inspiration and providing the emotional support for me throughout the DrPH programme and life. Their patience and understanding in this 6-year journey coupled with my physical separation through a distant working place are greatly appreciated. Even during the holidays, I was burning the midnight oil instead of spending time with my family. Well, the DrPH journey has come to an end, and I look forward to the future quality time together with my dearest family.

My sincere thanks to my academic supervisors, Professor Dr. Ng Chiu Wan and Professor Dr. Maznah Dahlui from the Social and Preventive Medicine Department, Medical Faculty, University Malaya, Kuala Lumpur. Their continuous support and guidance in this DrPH study, related research, and writing of this thesis had greatly helped me to complete the programme.

I want to personally thank my field supervisors, Dr. Venugopalan K. Balan and Dr. Chong Chee Keong from the Ministry of Health Malaysia. The collection of data from the public sector agencies throughout Malaysia in various districts were possible due to their access and support. Without their esteemed backing, the tedious process of acquiring the costs and resources information would have been an impossible task.

My sincere admiration and gratitude to my advisor, Professor Donald S. Shepard from Brandeis University, United States of America. I am honoured to have him as my mentor and his guidance in this research is invaluable.

I thank all the officers from the public sector agencies, namely the Ministry of Health (federal, state and district administrative levels) and the Local Authorities for extending their cooperation and willingness to provide the necessary data for this research. Their patience for the laborious process of data acquisition and verification is acknowledged.

Last but not the least, I would like to personally thank Dr. Zainol Ariffin bin Mohammed, Dr. Ngaesah binti Hamed, Dr. Raja Mohd Azim bin Raja Haron and the Inspectorate Unit from Batang Padang District Health Department, Perak State, Malaysia. In the 6-year DrPH journey, the final two years was spent working in this organization. Their understanding and support have enabled me to complete the difficult phase of thesis writing. I am thankful for the protected academic time granted to me in these two years period.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATION

MDG	Millennium Development Goal
Mil	Millions
Bil	Billions
HIV-AIDS	Human Immunodeficiency Virus-Auto Immune Deficiency Syndrome
NTDs	Neglected Tropical Diseases
WHO	World Health Organization
DF	Dengue fever
DHF	Dengue haemorrhagic fever
SEA	South East Asia
WPR	Western Pacific Region
WPRO	Western Pacific Regional Office
IVM	Integrated Vector Management
MOH	Ministry of Health
MHLG	Ministry of Housing and Local Government
KPI	Key Performance Indicator
DHD	District Health Department, Ministry of Health
LA	Local Authorities/Local councils/Municipalities
COI	Cost of illness

DALY	Disability-adjusted life years
YLL	Years of Life Lost
YLD	Years Lived with Disability
DDBIA	Destruction of Disease Bearing Insects Act
QoL	Quality of Life
IR	Incidence Rate
EF	Expansion factor
ULV	Ultra Low Volume
MEP	Malarial Eradication Programme
VBDCP	Vector Borne Diseases Control Programme
FHD	Federal Health Department
SHD	State Health Department
PPE	Personal protective equipment
GDP	Gross Domestic Product

LIST OF APPENDICES

CHAPTER 1 : INTRODUCTION

1.1 Introduction

The millennium declaration was adopted by world leaders at the United Nations in September 2000 where a set of eight Millennium Development Goals (MDGs) were established with the primary intention to eliminate poverty, hunger and diseases by 2015(United Nations, 2000). The sixth MDG was to combat Human Immunodeficiency Virus-Auto Immune Deficiency Syndrome (HIV-AIDS), malaria and other diseases whereby it addressed the health and economic impact of infectious diseases specifically. This initiative has resulted in significant global focus of attention and support for the development of control programme towards diseases such as HIV-AIDS, tuberculosis and malaria.

However, many of the “other diseases”, particularly the neglected tropical diseases (NTDs) have not received similar focus of attention and thus control and prevention of these diseases have not benefitted fully from the MDG initiative. The World Health Organization (WHO) defined NTDs as “chronically endemic and epidemic-prone tropical diseases, which have a very significant negative impact on the lives of poor populations and remain critically neglected in the global public health agenda”(World Health Organization, 2007a). Recently, in 2015, countries have adopted a new sustainable development agenda termed as Sustainable Development Goals (SDGs) that have 17 developmental goals with specific targets to be achieved by 2030(United Nations, 2016). The third goal is to ensure healthy lives and promote well-being for all at all ages. NTDs have been acknowledged as a priority in addition to HIV-AIDS, tuberculosis and malaria(United Nations, 2016).

One such example of NTDs is a vector-borne disease called dengue fever (DF). The majority of the dengue-affected countries has made available their dengue case burden information. Despite this, it should be noted that infectious disease burden estimates at a regional or global level may undermine the importance of a specific infection in particular populations(World Health Organization, 2004). This is observed especially for dengue which can vary greatly with environmental and other determinants, and can rapidly assume epidemic proportions(World Health Organization, 2004).

Some of the countries have also provided the economic cost data for burden of dengue in their respective countries. However, many of those country's economic burden of dengue including Malaysia were incomplete because the costs for dengue vector control and preventive activities were not included in their overall economic burden estimate. The focus of this thesis is on dengue and more specifically of the economic costs of dengue vector control, surveillance and prevention programme in Malaysia. The chapter will proceed with Section 1.2 which highlights the motivation behind this study on dengue in Malaysia and followed by Section 1.3 which lists the study objectives. Section 1.4 will discuss the significance and benefits expected from this study. The chapter will conclude with section 1.5 describing the layout of this thesis.

1.2 Study Motivation

NTDs pose a significant burden to public health and constitute the most common infections affecting the world's poorest people(P.J. Hotez et al., 2007). P.J. Hotez, Fenwick, Savioli, and Molyneux (2009) listed the common neglected tropical and zoonotic diseases that are found around the world (Table 1.1).

Table 1.1: The neglected tropical diseases

Disease group	Infections
Helminth infections	Ascariasis; trichuriasis; hookworm infection; strongyloidiasis; toxocariasis and larva migrans; lymphatic filariasis; onchocerciasis; loiasis; dracunculiasis; schistosomiasis; food-borne trematodes; taeniasis; cysticercosis; echinococcosis
Protozoan infections	Leishmaniasis; Chagas disease; human African trypanosomiasis; amoebiasis; giardiasis; balantidiasis
Bacterial infections	Bartonellosis; bovine tuberculosis; buruli ulcer; leprosy; leptospirosis; relapsing fever; rheumatic fever; trachoma; treponematoses
Viral infections	Dengue fever; yellow fever; Japanese encephalitis; rabies; haemorrhagic fevers;
Fungal infections	Mycetoma; paracoccidioidomycosis
Ectoparasitic infections	Scabies; myiasis; tungiasis

Source: (P.J. Hotez et al., 2009)

The NTDs have high endemicity in rural and impoverished urban areas of many affected countries. Although traditionally viewed as a burden in low-income countries, a recent study has shown that NTDs do not occur exclusively in developing countries(P.J. Hotez, 2008). These diseases can cause substantial adverse effects on population health even in developed countries as long as globalization, international migration and pockets of poverty are rampant in these countries.

Despite their significance and outcome on the quality of life and economic development, NTDs have received limited attention and resources from global stakeholders. Recently, there has been increasing scrutiny on NTDs as both a public health issue and a question of human rights(World Health Organization, 2013). Human rights issues such as poor access to health care, inadequate sanitation, lack of clean water, deplorable housing conditions, and lack of education contribute towards rising trend of NTDs(Hunt, 2006). There has been growing body of evidence that demonstrates control of NTDs can help directly to the achievement of several MDGs(P.J. Hotez et al., 2009; P.J. Hotez et al., 2007; Hunt, 2006) and support achievement of SDGs targets.

WHO has developed a Global Plan 2008-2015(World Health Organization, 2007a) in which each WHO region has to prioritize the NTDs according to their local importance. The Western Pacific Region (WPR) has listed four specific diseases as its priorities. They are dengue, lymphatic filariasis, schistosomiasis and soil-transmitted helminthiasis. *"Nine strategic areas were identified in the plan with proposals for series of actions to meet specific targets during 2008-2015. The identified areas are 1) assessment of the burden of NTDs; 2) integrated approach and multi-intervention packages for disease control; 3) strengthening health care systems and capacity building; 4) evidence of advocacy; 5) free and timely access to high-quality medicines, diagnostic and preventive tools; 6) access to innovation; 7) strengthening integrated vector management and capacity building; 8) partnership and resource mobilization and 9) promoting an intersectoral, inter-programmatic approach to NTD control"*(World Health Organization, 2007a). The goal of the plan is to prevent, control, eliminate or eradicate NTDs. The targets for the period 2008-2015 are to reduce the burden of diseases significantly through current interventions and to ensure that interventions using novel approaches are available, promoted and accessible for NTDs.

DF and dengue haemorrhagic fever (DHF) are mosquito-borne diseases. Dengue is found predominantly in urban and semi-urban areas in tropical and subtropical regions around the world. The disease is endemic in the Americas, Southeast Asia (SEA)[1], WPR[2] (a large number of countries overlap in SEA and WPR regions; refer to footnotes 1 & 2), Africa and Eastern Mediterranean with significant disease burden in the first three regions(Guzmán & Kourí, 2001). The challenge posed by dengue has escalated over the past decades and has become a major international public health concern. The primary causes for this have been the rapid urbanization, population growth, the increasing migration trends and travel(Bhatia, Dash, & Sunyoto, 2013; Gubler, 2002).

An estimated 2.5 billion people (40%) worldwide are living in areas of dengue risk. A recent study has estimated an alarming 390 million (mil) infections per year, three times higher than the WHO estimate(Bhatt et al., 2013). More than 70% of those at risk reside in the Asia-Pacific region thus making the region an epicenter of dengue activity(Ng, 2011). Endemic countries, for example, Malaysia, Thailand, Singapore, Philippines, Cambodia, Laos and Vietnam represent the greatest dengue case burden in the SEA region. It is the most widespread vector-borne diseases that have surged in SEA and is the leading cause of hospitalization and death among children(A. Guzman & Istúriz, 2010; Scott B. Halstead, 1993; Scott B. Halstead, 2002; Scott B. Halstead, 2007).

Dengue has become an epidemic globally, and the control and prevention activities do not seem to show a sustained positive result. The primary environmental and social

[1] SEA countries consist of **Brunei**, Myanmar, **Cambodia**, East Timor, Indonesia, **Laos**, **Malaysia**, **Philippines**, **Singapore**, Thailand and **Vietnam**

[2] WPR countries consist of Australia, **Brunei**, **Cambodia**, China, Cook Islands, Fiji, Japan, Kiribati, **Laos**, **Malaysia**, Marshall Islands, Micronesia, Mongolia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, **Philippines**, Korea, Samoa, **Singapore**, Solomon Islands, Tonga, Tuvalu, Vanuatu, **Vietnam**

factors that contribute to its occurrence are not addressed, and the disease often attracted attention only during an outbreak (Cruz, 2010). The control and prevention of dengue in many endemic countries have been reactive in the sense that cascade of control activities are initiated primarily in the vicinity of a reported dengue case. Those control activities have traditionally been environmental management and vector control through the usage of insecticide spraying. Although few other vector control modalities such as biological control through larval predatory fishes(Ghosh et al., 2011; Martinez-Ibarra, Guillen, Arredondo-Jimenez, & Rodriguez-Lopez, 2002), genetically modified sterile mosquitoes(Lacroix et al., 2012; Yean, Lye, & Lee, 2012) and use of Bacillus thuringiensis bacteria(Boyce et al., 2013) has been tried, but implementation in the field not only had its costs and logistics challenges, the results also has been inconsistent. Implementation of prevention and control programmes based on integrated vector management (IVM) and intersectoral collaboration strategy promoted by WHO are being implemented in dengue endemic countries of SEA and South America in varying intensities. The initiatives in these countries differ regarding epidemiological objective, the involvement of stakeholders, availability of resources, socio-political governance and public health infrastructure. Such diversity occurs because these countries may have different entomological and epidemiological settings, hence require a variety of control methods and intervention programmes selected through evidence-based approach(Liaqat, Jahan, & I. Ahmad, 2013).

The interruption of dengue transmission is essential for disease containment, and conventionally many people thought vector control as the only way to control dengue. This approach has been practised in dengue endemic countries for the past decades since there was no effective vaccine to prevent dengue or antiviral to treat the disease (Tun-Lin et al., 2009). It is only recently that, there had been a positive development in the field of vaccine research for dengue. Historically, the conceptual development and research of a dengue vaccine had been ongoing for the past 50 years (Scott B Halstead & Deen, 2002; Kumar, Singh, Tomar, & Baijal, 2010) which, until recently, did not yield any promising candidate vaccine (Coller & Clements, 2011). However, Sanofi Pasteur has lately developed a live tetravalent dengue vaccine(Capeding et al., 2014; Arunee Sabchareon et al., 2012) which was found to be efficacious and had a good safety profile. The dengue vaccine developed by Sanofi Pasteur is named as Dengvaxia, and it has successfully gained licensure and approval for use in four dengue endemic countries to date (Sanofi Pasteur, 2015a, 2015b, 2015c, 2015d). Those countries are Mexico, Brazil, Philippines and El Salvador that have significant dengue case burdens in their respective countries, and the governments are positive the vaccine has the potential to provide a substantial public health benefit to their population. Meantime, the recommendations from the WHO Strategic Advisory Group of Experts (SAGE) stated that vaccination should be considered as an integrated strategy together with a communication strategy, well-executed and sustained vector control, the best evidence-based clinical care for all patients with dengue, and robust dengue surveillance(SAGE, 2016). Furthermore, in the event a country considers the introduction of a dengue vaccine, it will require a careful assessment which consider local priorities, national and subnational dengue epidemiology, predicted impact and cost-effectiveness, affordability and the budget impact to the healthcare sector and the country(SAGE, 2016).

Despite a promising progress for dengue in the field of vaccine development, recent headlines of an emerging vector-borne disease called Zika virus has created a pandemonium globally. The WHO Director-General had lately declared the events surrounding the emergence of Zika virus as a Public Health Emergency of International Concern(World Health Organization, 2016c). There has been growing evidence that implicates the high incidences of microcephaly and Guillain-Barre Syndrome with Zika virus infection in several countries(Mlakar et al., 2016; World Health Organization, 2016d). The rapid geographical spread of the disease to involve over 65 countries and territories (as of 6th July 2016) namely in the South American and SEA regions(Musso, Nilles, & Cao-Lormeau, 2014; World Health Organization, 2016d) has caused severe concerns among public health officials because the vector capable of transmission of Zika is the same Aedes mosquito species(World Health Organization, 2016b) that is responsible for the spread of dengue. The clinical manifestations of Zika virus although thought to be mild, is very similar to other vector-borne diseases viruses that were grouped as flaviviruses (e.g. dengue, chikungunya)(Kwong, Druce, & Leder, 2013). Currently, there is no specific treatment or vaccine for Zika virus(World Health Organization, 2016d) and the primary disease control and prevention strategies advocated are very much similar to dengue illness. The objective is to bring the Aedes mosquito population density to a low level through vector control and prevention activities. Initially, with the positive development of dengue vaccine, cost-savings were thought possible in vector control and prevention activities in the long run. However, the emergence of Zika virus gives utmost importance to a continuous vector control and prevention activities globally including Malaysia. This is evident since the neighbouring countries around Malaysia has reported transmission of Zika virus and presented evidence of circulating virus(Kwong et al., 2013; Marchette, Garcia, & Rudnick, 1969; World Health Organization, 2016d), coupled with a high density of Aedes mosquito population capable of disease transmission(P.-S. J. Wong, Li, Chong, Ng, & Tan, 2013) in the region.

Malaysia is a dengue endemic tropical country of 27.5 mil people located in SEA. The country has a high dengue case burden with an average of 32,831 reported dengue cases (or incidence of about 124 reported cases per 100,000 population) and 85 dengue deaths annually in the first decade of this century(Ministry of Health Malaysia, 2010a; Vector borne diseases control sector, 2010). Despite dengue being labelled as NTDs from the global perspective, Malaysia views the dengue menace as a serious public health threat to the community and health officials has given their top most priority in term of resources and attention in comparison to other vector-borne diseases. The general strategies to control dengue have been good quality surveillance, early diagnosis and treatment of dengue cases, and keeping a low density of vector population(Gubler, 1998; Jacobs, 2000). Among those outlined strategies, the primary strategy practised in Malaysia, similar to other dengue-endemic countries, has been mosquito vector control.

Public sector agencies mainly Ministry of Health (MOH) and Ministry of Housing and Local Government (MHLG) are responsible for dengue surveillance, vector control and prevention activities in Malaysia. These activities exist through a vertical Vector Borne Diseases Control Programme (VBDCP) managed by MOH and assisted by MHLG. The Health Minister and MOH had set a key performance indicator (KPI) based on dengue prevention by targeting a reduction in dengue incidence by 10% annually, but this targeted KPI has consistently not been achieved due to various challenges(Mustaza, 2010; Priya, 2010).

Despite the verbal commitment by the MOH to engage the entire government machinery to combat dengue, there is a problem in acquiring inter-agency cooperation[3] and collaboration at the ground level. The other challenges include limited national

[3] Personal communication with National Vector Borne Diseases Control Sector Head, Ministry of Health Malaysia, Dr Chong Chee Kheong; November 2010

resources devoted to dengue control and prevention, failure of decision makers to recognize that dengue imposes an extraordinary financial burden, absence of proven and sustainable vector control methods, indecisiveness to implement alternative technologies in vector control and the poor support towards the public health sector from the community and other related government agencies (Scott B. Halstead, 2000). It is compounded further by the complexity and variety of activities involved in dengue vector control and prevention. These activities are resource intensive and expensive from its operational aspects to the public sector agencies.

Information on programme costs can enlighten the national decision makers about the operational burden and its consequences. Such knowledge can guide them to make important policy decisions whether to support or reform the strategy for dengue vector control. Cost studies strive to quantify this burden and challenges by expressing it in monetary terms through itemizing, valuing and summing the resources consumed by the public health programme. It offers an alternative perspective on the importance of evaluation of a public health programme as compared to epidemiological indicators such as morbidity and mortality(Kernick, 2002). Costs can be assessed from a micro-angle aspect to provide insight into the individual vector control units and at macro-angle to show the economic performance of a district, state and national vector control programme. A cost analysis can forecast financial and economic implications of any change in implementation and delivery strategies, technological developments and identify possible step up areas for vector control measures(Conteh, Engels, & Molyneux, 2010). It would serve as a valuable economic tool for policy makers and disease control programme managers. Evidence supported with cost data will strengthen the need to sustain and distribute the resources strategically to vector control and prevention programme within public sector agencies.

The intention of this thesis is first to develop a cost profile of dengue vector control activities in Malaysia. The cost profile then can be used to augment or modify the control activities and coordinate them with the suggested strategic areas outlined in the SDGs with a particular focus on dengue vector control and prevention in the country. The study, in essence, will quantify the economic cost of dengue surveillance, vector control and prevention programme in the country. The cost of delivering these activities to the general population will be estimated encompassing micro and macro levels. Economic costs will be assessed from the perspective of the health-care provider, specifically, the costs faced by government-funded health facilities. Since the government predominantly funds the public health activities in Malaysia, the knowledge of these costs is paramount for decision making by the relevant stakeholders. It is important in the background of competing needs between alternative public health programmes, scarcity of resources and competing for new emerging technologies for disease prevention and vector control within the national public health system that is funded by taxpayers in Malaysia.

Basic sanitation problems, rapid urbanization, inadequate funding, limited resources and lack of a concrete strategy to respond to increasing problem of dengue outbreaks may form as an uphill task for government agencies to control dengue vectors(Liaqat et al., 2013). This cost profile of dengue vector control can contribute essential inputs towards a subsequent betterment in the vector control and prevention programme in a dengue endemic country like Malaysia.

1.3 Study Objectives

Malaysia has the combination of regional dengue endemicity, high annual case burden of DF and DHF and a comprehensive vector control programme. Dengue is acknowledged as a grave public health concern in the country and the dengue vector control programme led by MOH involves a contribution from all levels of the government from federal, state to district level agencies. Taking these factors into consideration, the knowledge of full costs of dengue vector control inputs that were not previously known will be significant for Malaysia.

Ferraro, Pfeffer and Sutton (2005) argued that language and economics can exercise a subtle but powerful influence on behaviour, including behaviour in organizations, through the formation of beliefs and norms about behaviour that affects what people do and how they design institutions and management practice. The proposition forms a high motivation for this thesis to deliver economic inputs for the benefit of vector control and prevention programme for dengue with the ultimate goal to reduce dengue case burden in Malaysia.

The aim of this study is to estimate the economic cost for one financial year of the national dengue vector control programme in Malaysia. The cost information was collected for the year 2010. The year 2010 had the average incidence in the latest four outbreak years from 2007 till 2010. Moreover, at the time of data collection, the year 2010 had the most recent and complete expenditures information for analysis. The estimation of the national cost is through an examination of the resources consumed and the resultant costs incurred by public sector agencies at all levels of the government for that particular year.

The specific objectives of this study are as follows:

1. To analyze the dengue situation in Malaysia and the historical development of national vector control programme in the country

2. To identify and define the cost components, cost elements and cost functions related to the provision of dengue vector control services by the national dengue vector-borne diseases control programme.

3. To determine the economic costs of dengue vector control and prevention at different administrative levels, namely the districts, states and federal representatives of public sector agencies and extrapolate the national costs for Malaysia.

4. To determine the economic costs of dengue vector control and prevention at the districts by service providers namely the District Health Departments (DHD) and the Local Authorities (LA) and extrapolate the national district-level costs by service providers for Malaysia.

5. To compare the economic costs of dengue vector control by different service providers in Malaysia namely the District Health Departments (DHD) and the Local Authorities (LA).

6. To discuss the economic costs of dengue vector control and prevention activities in Malaysia and develop recommendations for informed policy discussions and future development of policy for dengue vector control

programme in Malaysia and other dengue endemic countries at similar development level.

1.4 Significance of Study

"Health systems research is concerned with how health services are financed and organized, and how these functions are linked to an overall health system with its associated policies and institutions"(Mills, Gilson, Hanson, Palmer, & Lagarde, 2008). Amidst this broad definition, this thesis focuses specifically on operational and implementation aspects of dengue control and prevention services within the public healthcare system in Malaysia from a cost perspective.

1.4.1 Highlight Operational Burden from Cost Perspective

Essential cost drivers, cost components and cost functions for the programme are identified, and the distribution of resources for each activity in dengue vector control and prevention will be discussed. The cost elements, quantum and distribution of resources for the programme can be distinguished to allow an evidence-based explanation of cost difference between vector control units and districts in the country. In the event there is a choice of alternative vector control methods made available to Malaysia, the characteristics of vector control operational costs may require modification. Therefore, any change in operational expenditure can only be considered by analyzing and comparing the operational costs of multiple sites or units. Moreover, it will provide information to support the vector control functions at different levels of the organization.

1.4.2 Development Of Cost Containment Policies

The study serves as a useful template for future cost data collection exercise. It will provide vector control managers a decision-making tool to recognize specific areas where the distribution of cost and resources can have the greatest operational impact. It can lead to the development of cost containment policies aimed at decisive outcome within the programme.

1.4.3 Setting Research Priorities

Dengue is categorized as a tool-deficient disease(World Health Organization, 2007b) where the disease control strategies depend on costly and difficult to manage methods. DF requires early detection and treatment to prevent serious consequences such as dengue haemorrhagic fever (DHF) and death. The development of simple, safe and cost-effective methods is essential for the treatment of dengue as well as for the control and prevention of the illness. Subsequently, those alternative methods should be accessible to public sector agencies and the general population. The absence of effective alternative curative and preventive options for dengue should stimulate significant effort into health research. Although the mechanisms used to set priorities vary considerably for health research, cost data can be used as a priority-setting tool to identify and drive the prioritization process towards new research opportunities and disease control needs for dengue. Cost information will benefit researchers and policymakers in targeting future dengue control related research that has a potential public health benefit to Malaysia. It will encourage the exploration of new technological innovations in dengue vector control methods apart from the conventional ones that are currently being used.

1.4.4 Provide Evidence To Support Or Reform Vector Control Strategy

Recently, there is some positive advancement in Malaysia which is allowing new opportunities to utilize alternate vector control methods to prevent dengue transmission. Measuring the efficacy of these alternative means under operational conditions is a high research priority(Townson et al., 2005). Cost analysis of the existing vector control and prevention programme will form the precursor ingredient required for cost-effectiveness analysis of the new vector control methods if these alternate instruments and interventions are outlined for future implementation in Malaysia. Strategic planning will be needed for allocation of scarce public health resources in the country among competing public health programmes. Cost evidence could be used to supplement the informed policy discussions among disease control managers, stakeholders and policymakers.

1.4.5 Research Gap In Public Sector Costs Of Dengue Vector Control

The economic cost of treatment and control are often considered from the perspective of the health-care provider, most notably the costs faced by government-funded health facilities(Conteh et al., 2010). The economic burden of disease or cost of illness (COI) is determined by the summation of direct costs of spending on prevention and treatment. The curative cost component of dengue is known from a previous study in Malaysia. The costs of dengue illness, in terms of direct medical costs and costs related to productivity loss and premature mortality, amounted to US$102.2 mil in 2009(Shepard et al., 2012; Shepard, Undurraga, Lees, et al., 2013). These estimates still do not provide a complete picture of the national economic burden of dengue as the costs of disease control and prevention had not been considered. The inclusion of vector control and prevention cost information obtained from this study will complete the total economic burden of dengue in Malaysia. It will add to the existing body of knowledge of dengue cost burden together with epidemiological data on mortality and morbidity. Cost and epidemiological information may help to rank dengue illness according to locality, national level and globally. The importance of vector control and prevention services to the overall burden of dengue can be discussed primarily in a dengue endemic country like Malaysia where the vector control and prevention programme are always engaged throughout the year. It will provide testimony to support the dengue vector control and prevention programme as a continuous strategic investment for the benefit of community and residents in Malaysia.

1.4.6 Setting Health Policies

Cost information can be utilized to nurture relevant policy developments about the vector control and prevention programme and for the advancement of dengue priority setting process. Establishing disease priorities will be the key point for the development of health policy and guide debates about setting research priorities, therefore improving population health(Catalá-López et al., 2011).

1.4.7 Informed Policy Discussions On Rationalization Of Vector Control Service Delivery

There has been a move towards decentralization and intersectoral collaboration in the disease control sector. It allows management of vector control and prevention programme to take place at the most direct operational level, which are the districts, municipalities or local councils in Malaysia. Public sector agencies such as DHD of MOH and LA of MHLG are the proximate units at the districts. They handle delivery of vector control and prevention services to the communities in Malaysia. These vector control and prevention units are financed from different sources, the quantum of which is also determined differently. Such partnership may not function efficiently, especially when uncoordinated; the activities of respective units can overburden developing countries with multiple delivery systems, cumbersome monitoring and reporting requirements, duplicated efforts and fragmented results(World Health Organization, 2008).

Cost comparison between these two public agencies will highlight the differences in resources consumption, cost drivers, cost components and cost functions for the dengue vector control and prevention activities at the district units. The cost evidence can be used as a forerunner to assess the dual delivery system adopted by Malaysia. The pressing challenge is to strengthen the managerial and operational capacity of health systems(Hainesa & Sanders, 2005; Travis et al., 2004) for vector control in dengue endemic countries. Cost data can be used to recommend operational enhancement and contribute to policy discussions to overcome health system constraints and build capacity to attain the MDGs.

1.4.8 Platform For Comparison To Other Dengue-Endemic Countries In The Region

With information on costs of dengue control and prevention, Malaysia will then join the handful of countries worldwide with a comprehensive estimation of dengue economic burden combining both illness and prevention. It will form a platform for comparison of dengue costs in endemic countries. These cost tabulations will inform the public and stakeholders at all levels of the economic impact of dengue fever.

An economic argument can form an influential advocacy material to the health sector and other audiences beyond the area of health(World Health Organization, 1998) with a strong message highlighting beneficial aspects of dengue vector control and prevention. The aim is to rank and prioritize within an overall budget for preventive services, shift the balance towards prevention across a pathway of care or departmental budget, or increase the proportion of resources for preventive services across the system as a whole(Marks, Weatherly, & Mason, 2013).

1.5 Layout of Thesis

The thesis is organized in the following manner:

i. Chapter 2 reviews the epidemiology of dengue illness and explains the global, regional and national burden of dengue. This chapter will also discuss the significance of under-reporting and under-recognition of dengue illness. The conventional dengue vector control measures in endemic countries will be described. The economic burden of dengue and dengue vector control and prevention costs will also be discussed.

ii. Chapter 3 will describe the epidemiology and case burden of dengue in the Malaysian situation. It will discuss under-reporting and under-recognition of dengue in the Malaysian healthcare system. This chapter also highlights the historical development of the national vector-borne diseases control programme and the various hierarchical organization of vector control entities within the Malaysian public sector agencies. The economic burden of dengue and cost of dengue vector control and prevention in Malaysia will also be discussed based on existing studies.

iii. Chapter 4 describes the methods, dengue vector control and prevention cost model and the sources of data for the cost analysis in this thesis.

iv. Chapter 5 examines the dengue vector control and prevention costs at the districts, states, and federal level. The costs at the various administrative levels will then be extrapolated to produce the national cost estimate of dengue vector control and prevention activities for Malaysia.

v. Chapter 6 details the estimation of dengue vector control and prevention costs by public sector service providers, namely the MOH and LAs. The costs are extrapolated to produce the national cost estimate by service providers in Malaysia. The cost comparison between DHDs and LAs focussing on the costs of providing three main vector control activities between them were analysed to determine their cost efficiency.

vi. Chapter 7 discusses the cost of dengue vector control and prevention in Malaysia and analyse the main findings obtained from this study. The policy implications for Malaysia will be discussed, and these results will provide lessons for other countries as well. The limitations of the study and areas for future research in dengue vector control and prevention are also discussed in this chapter.

vii. Chapter 8 will describe the study's conclusion

CHAPTER 2 : THE DISEASE AND ECONOMIC BURDEN OF DENGUE

2.1 Introduction

Dengue represents a significant burden in many countries of the world. It is found predominantly in the Asiatic continent, particularly in SEA but cases continue to escalate in Africa, North and Central America, Europe and even Australia as well (A. Guzman & Istúriz, 2010). The disease and economic burden of dengue are not only heavy on the public health care system but is also significant for households affected by the illness by extension to society in general. In many dengue-endemic countries, the public agencies are responsible for the implementation of dengue control strategies. The delivery of vector control and prevention services to the communities are achieved through the cooperation of various public sector agencies namely the health departments and local councils. The vector control and prevention services are resource intensive, and the efforts are expensive since the community at risk requires constant engagement throughout the time. This chapter aims to reinforce the importance of eliminating or preventing dengue to the countries involved and the world in general. Section 2.2 describes the epidemiology of dengue illness. Section 2.3 will highlight the global and regional dengue case burden. Section 2.4 will discuss the under-reporting and under-recognition of dengue illness in different countries. The available dengue cost of illness (COI) studies involving regions and few countries are described in section 2.5. Section 2.6 will highlight the dengue vector control and prevention strategies that are being practiced to combat dengue illness. The dengue vector control and prevention costs in selected countries are discussed in section 2.7, and the chapter will conclude with section 2.8.

2.2 Epidemiology of Dengue

Dengue in the olden days was thought to be in some way linked with flying insects that are associated with water. Such hypothesis was found in earliest records in the Chinese region during the Chin dynasty (265 to 420 A.D.), and the illness has been described as 'water poison'(Gubler, 1998). The causative agent for dengue illness is a type of virus belonging to the genus Flavivirus (family Flaviviridae). It has four known serotypes called Dengue virus type 1 (DEN-1), Dengue virus type 2 (DEN-2), Dengue virus type 3 (DEN-3) and Dengue virus type 4 (DEN-4). When an individual contracts an infection with one serotype, the person will develop lifetime immunity to that particular serotype as well as a few months cross-immunity to other serotypes. If consecutive infections of two serotypes occur, antibody dependent enhancement may lead to more severe type of disease which can be fatal (M. G. Guzman & Harris, 2015; Simons, Farrar, Nguyen, & Wills, 2012).

Dengue is the most important arboviral disease in the world, and WHO has estimated more than 2.5 billion people are at risk of dengue infection worldwide(World Health Organization, 2012b). Although most of the infected persons will have asymptomatic infections, the disease clinical picture ranges from mild upper respiratory tract infections (URTIs/flu) known as dengue fever (DF) to a severe form which can be fatal. The grave form of dengue will have haemorrhagic episodes and shock called as dengue haemorrhagic fever/dengue shock syndrome (DHF/DSS). Over the years, the pathophysiology of dengue has been identified as plasma leakage-related rather than haemorrhage-related (Barniol et al., 2011). Hence, the conventional classification system of DF/DHF/DSS is not broadly suited for appropriate clinical management(Hadinegoro, 2012). Given this issue, WHO has proceeded to apply levels of disease severity into the new disease classification. The revised classification consists of dengue without warning signs, dengue with warning signs and severe dengue(World Health Organization, 2009).

Transmission of dengue illness to the human host occurs through the bite of a mosquito vector. The primary mosquito species are *Aedes aegypti* dan *Aedes albopictus*. Only the female mosquitoes bite multiple people during each feeding period because they need blood to produce eggs. *Aedes aegypti* bites during the day, and they are most active at dusk and dawn.

Figure 2.1: Aedes aegypti (left) and Aedes albopictus (right) mosquito species

Source: (Centers for Disease Control and Prevention, 2014c)

The Aedes mosquitoes live in proximity to human dwelling, especially in urban areas. They lay eggs mostly in man-made containers. Artificial or natural water containers (water storage containers, flower pots, discarded tires, plates under potted plants, cemetery vases, flower pots, buckets, tin cans, clogged rain gutters, ornamental fountains, drums, water bowls for pets, birdbaths)(Centers for Disease Control and Prevention, 2014a) that are within or close to places where humans live are the ideal larval habitats for *Aedes aegypti*. The species has also been found in underground collections of water such as open or unsealed septic tanks, storm drains, wells and water meters(Centers for Disease Control and Prevention, 2014a). *Aedes albopictus* is closely associated with vegetated areas in and around homes, and the larvae can be found in natural habitats such as tree holes, rock holes, hollow bamboo stumps and leaf axils(Centers for Disease Control and Prevention, 2014b). These mosquitos will lay their eggs in those sites inside a container just above the water line. The eggs can endure for many months because they are impervious to long periods of dry weather spells. Whenever rain occurs, and the eggs are exposed to water, they will hatch to produce larvae and subsequently develop into adult mosquitoes.

The ecologic disruption in the Southeast Asia during and following World War II created ideal conditions for increased transmission of mosquito-borne diseases and the subsequent urbanization that followed post-war for economic purposes have resulted in exponential population growth and development in this region(Bhatia et al., 2013; Gubler, 1998). Dengue is widely believed to be an urban disease as the vectors are well adapted to the breeding sites found in the concentration of human houses around developing cities and towns with poorly managed water and solid waste management systems. However, dengue is increasingly seen even in semi-urban and rural areas. There were several factors associated with an increase in dengue incidence trend in rural areas namely increased transport contact, mobility and spread of peri-urbanization(Andrew, Steve, Ulisses, & Jonathan, 2000). In Malaysia, the dengue mosquito vector Aedes aegypti is predominantly found in urban areas whereas Aedes albopictus is more in the peri-urban setting.

Dengue is associated with seasonality and climate variability(Rohani A et al., 2011). The incidence of DF/DHF particularly dengue epidemics has been related to rainy season and the El-Nino phenomenon. The mosquito vector population is sensitive to temperature changes. Due to rise in temperature, the aquatic larvae forms of mosquitoes mature faster producing more offspring, and the transmission intensity of dengue is increased during warmer climates as the adult female mosquitoes digest blood faster resulting in more frequent feeding (Andrew et al., 2000). During the rainy season, the rise of dengue cases has been observed in Malaysia(Chew MH, Rahman Md. M, & Salleh SA, 2012). Such phenomenon occurs due to stagnation of rain water in different locations within city areas. A collection of rainwater in man-made containers and discarded items, such as old tyres serve as ideal breeding sites for Aedes mosquitoes.

Social and economic factors play a factor for the incidence of dengue. Air-conditioning, mosquito screens and safe water supplies help towards prevention of dengue in the communities(Guha-Sapir & Schimmer, 2005). However, such conditions may prove to be an economic challenge to poorer families. Factors that promote dengue transmission are unplanned urbanization and inadequate resources for vector control that are characteristics of a developing country rather than richer countries(Guha-Sapir & Schimmer, 2005).

Dengue has become a global pandemic illness affecting many countries in the world in the 21st century. The interaction of various factors discussed earlier has resulted in a complex epidemiology of dengue disease. Key contributing factors to the worldwide occurrence of dengue have been the rise in number and size of densely populated urban cities(Ng, 2011). These towns are conducive to the spread of illness and the adaptation and proliferation of dengue mosquito vectors. Furthermore, increased global travel has facilitated the spread of the virus to many countries in the world. Dengue has become a significant burden to the communities, nations and regions around the world as the disease incidence steadily increases over the last decade.

2.3 Global and Regional Burden of Dengue Illness

Global disease burden estimates were first made in the 1990s with updates in 2005 and 2010(Murray, Ezzati, et al., 2012). The estimation of illness burden provides a method to quantify the population health from global and regional aspects(MurrayVos, et al., 2012). Disease burden estimates are used to organize health priorities, support decision making and structure the development of research agenda. It is used extensively by the lawmakers, leaders of public health organizations and the government in their policy discussions. Disease burden estimations are done through quantitative assessment using epidemiological parameters, mortality data and its derivative life expectancy. This information's has been widely used in health care settings to inform the overall health status and to identify the significant health problems in a population.

Dengue had become an important disease burden in many tropical and subtropical regions, with an estimate of 100-200 mil dengue infections occurring each year in more than 100 countries(Gubler, 2002). It is the most rapidly advancing vector-borne disease in the world. Guinness World of Records in 2002 has cited dengue as the world's most important viral haemorrhagic fever with the most geographically widespread among the arthropod-borne viruses bearing similarity to that of malaria in having a global distribution(Scott B. Halstead, 2002). As such there are 2.5 billion people from over

100 countries are at risk of dengue infection worldwide(Guzmán & Kourí, 2001). The Global Burden of Disease Study 2010(Lozano et al., 2012) estimated the annual occurrence of 14,700 dengue-related deaths worldwide and for the last two decades, the deaths due to dengue for all ages had increased by 29%. Bhatt et al. (2013) has estimated that 390 mil dengue infections occur each year worldwide and 70% of this burden is in the Asia region. A consistent estimate of dengue case burden is found to be elusive in low income and middle income countries due to poor disease surveillance, low levels of reporting, lack of inexpensive point-of-care diagnostic tests, and inconsistent comparative analyses(Wilder-Smith & Byass, 2016).

Disability-adjusted life years (DALYs) contribute valuable insights into disease burden quantification also to the other mentioned parameters. DALY is a time-based measure of health that enables commensurable measurement of years of life lost (YLL) due to premature mortality with years of life lived with less than ideal health/years lived with disability (YLDs)(Polinder, Haagsma, Stein, & Havelaar, 2012). Globally in 2010, the estimated YLD for dengue was 12,000 years(Vos et al., 2012). The dengue YLD had increased a staggering 104% within two decades. Concurrently, the DALY for dengue had risen by 16% in the similar period from 712 000 to 825 000(MurrayVos, et al., 2012). Based on all these parameters, there is sufficient evidence to indicate a rising trend in dengue burden worldwide.

Based on regional dengue patterns in SEA countries, there was an average of 386,000 reported dengue cases with 2,126 dengue-related deaths over the span of 10 year period from 2001 to 2010(Undurraga, Halasa, & Shepard, 2013). Dengue is a disease that requires compulsory notification by law in the majority of SEA countries.

The annual average DALYs for dengue in SEA region were 214,000 which translates approximately 372 DALYs per mil SEA population. The DALYs per mil SEA populations of dengue ranks higher than certain conditions like poliomyelitis (1 per mil), Japanese encephalitis (199 per mil), otitis media (219 per mil), upper respiratory infections (222 per mil) and hepatitis B (349 per mil) in SEA and the Western Pacific regions combined(Undurraga et al., 2013). These figures highlight dengue as a significant disease burden in the SEA region and its inhabitants. Four countries, in particular, Cambodia, Malaysia, the Philippines and Vietnam, are facing annual epidemics that constitute over 90% of the total dengue cases reported in the region(Chang, Christophel, Gopinath, & Abdur, 2011).

Kularatne (2005) documented the persistence of fatigue among dengue patients in Sri Lanka and Chronic Fatigue Syndrome (CFS) is a clinically defined condition “characterized by severe disabling fatigue and a combination of symptoms that prominently features self-reported impairments in concentration and short-term memory, sleep disturbances and musculoskeletal pain”(Fukuda et al., 1994). Some studies were done recently demonstrated similar CFS presence among dengue patients (Garcıa et al., 2011; Lum, Suaya, Tan, Sah, & Shepard, 2008; Seet, Quek, & Lim, 2007).

Seet et al. (2007) performed a prospective follow-up study in Singapore where the incidence of fatigue was assessed in a cohort of hospitalized patients with laboratory-confirmed dengue infection. He used a questionnaire to determine the presence of fatigue symptoms among the dengue confirmed patients. The fatigue symptoms were grouped to physical exhaustion and mental fatigue. Physical fatigue was described as a subjective feeling of being exhausted and lacking energy whereas mental fatigue was described as a personal feeling of being mentally exhausted, incorporating items on concentration, memory and speech(Seet et al., 2007). The study revealed a significant (25% of study subjects) observation of post-infectious fatigue among the hospitalized dengue patients but neglected to include those with symptomatic infections who do not require hospitalization (ambulatory cases).

These studies reinforce the long-term impact of dengue imposing considerable functional and psychological effects on patients ranging from 13 days even up to two years duration. Bearing these long-term effects of dengue to patient collectively called as CFS, the estimated YLD and DALY for dengue illness could very much underestimate the true burden of dengue to affected patients. The previous estimations of regional and national DALY and YLD for dengue could even be higher if the long term effects of dengue involving both adult and children are considered.

2.4 Dengue Under-Reporting and Under-Recognition

Dengue poses a significant threat to many tropical and sub-tropical countries in the world. As such, an accurate disease burden data will be highly sought after by disease control programme managers and policy makers in those countries. The data will be utilized for informed decision making in setting health priorities, research as well as resources allocation within the particular country as well as the involved regions. These data are obtainable from their respective national surveillance system that is available in most countries. The core functions of a comprehensive monitoring system are detection, reporting, investigation, confirmation, analysis, interpretation and response. (Beatty et al., 2010). There are many variations of disease surveillance systems adapted among countries in the world and despite the commitment and dedication invested in the system, a high proportion of dengue cases were not captured by the country's national surveillance system. This phenomenon is described as under-recognition or under-reporting. A common complicating factor for dengue case detection is the variation seen in the clinical picture, which includes a large number of asymptomatic and mild cases(Bandyopadhyay, Lum, & Kroeger, 2006) and misdiagnosis through confounding dengue with other diseases(Silvia Runge-Ranzinger, Horstick, Marx, & Kroeger, 2008).

DF is characterized by wide range of clinical manifestations with a predominant presence of fever with constitutional symptoms. It is complicated by excessive capillary permeability and bleeding tendencies that are known as DHF. The problems with generalized case definitions for dengue may lead to the reported cases being lower than the actual cases found among the general population. The absence of laboratory confirmation of dengue cases to aid the clinicians to make a diagnosis or having laboratory services only at selected health facilities may contribute to the degree of under-reporting in many countries (Beatty et al., 2010).

Apart from problems in case detection, the process of reporting among confirmed or suspected dengue cases are not guaranteed despite the law of mandatory reporting. The legislation is made to ensure dengue remains a notifiable disease in many dengue endemic countries to improve the capture of cases by surveillance, but additional efforts are needed to develop and maintain a high level of quality reporting. Both the public and private health facilities must play an active role to ensure reporting is done whenever dengue diagnosis is made(Beatty et al., 2010). The outpatient clinic-based (ambulatory cases) surveillance can detect mild symptomatic dengue cases earlier than inpatient facilities (hospitalized cases) which detect more severe dengue cases. Hence, case reporting should be expanded to include ambulatory cases (Beatty et al., 2010).

Some studies have described the degree of under-reporting and under-recognition of dengue cases in their respective national surveillance systems. Puerto Rico, for example, had estimated a multiplication factor of 27 for all cases among age groups older than 15 years old(Meltzer, Rigau-Perez, Clark, Reiter, & Gubler, 1998). Meantime in Bandung, West Java of Indonesia, Porter et al. (2005) examined a prospective cohort of adult textile factory workers for initial two years (August 2000 through July 2002) and the results showed incidence of symptomatic dengue infection in the cohort were 18 cases per 1,000 person-years of follow-up, while the estimated incidence of asymptomatic dengue infection were more than three times of the symptomatic infection at 56 cases per 1,000 person-years. Porter et al. (2005) demonstrated the significant presence of under-recognition or under-reporting of dengue cases in Indonesia.

Two studies from Nicaragua were done with the aim to detect the phenomenon of under-reporting in the country. Balmaseda et al. (2006) conducted a seroprevalence study among schoolchildren aged four to 16 years old for the period of three years from 2001 through 2003. Annual blood samples were taken from those children was studied for anti-dengue antibodies. The study showed incidence of symptomatic dengue infection in the range of 8.3 to 8.5 per 1,000 children in the school and when the data was compared with MOH dengue surveillance system in Nicaragua, it indicates that the study surveillance detected at least ten-fold more dengue cases than their national monitoring system (Balmaseda et al., 2006). Another prospective cohort study was initiated in 2004 in the district of Managua of Nicaragua(Standish, Kuan, Aviles, Balmaseda, & Harris, 2010) and the cohort study participants were children aged two to nine years old. The degree of under-reporting expressed as 'expansion factor' was calculated by dividing the annual incidence of laboratory-confirmed symptomatic dengue among the study participants by the annual incidence of laboratory confirmed in Managua district according to their national surveillance system(Standish et al., 2010). They consistently identified 15 to 30 fold more cases than were reported in that district via their national monitoring system. However, their expansion factor can only be applied to children since they did not include older age groups as their study participants. Both studies are done in Nicaragua confirm the presence of significant under-reporting of dengue cases in the country among children. The expansion factor for Nicaragua could have been greater if the adult population was included. The expansion factor is a rough approximation method that contributes as an essential tool to estimate the actual impact of dengue case burden to a country's general population(Standish et al., 2010).

A dengue seroepidemiological study was conducted in Singapore in 2005 to assess the impact of dengue fever to the general population of the island(Yew et al., 2009). This Singaporean study recruited working adult population with an average age of 42 years old mostly. The study revealed 59% of the study population was seropositive for IgG antibody(Yew et al., 2009), which indicated that they had past dengue infection, and the proportion of study participants with a recently acquired dengue infection was 2.6% (Yew et al., 2009). Yew et al. (2009) estimated that only one out of 22 cases were diagnosed and subsequently notified to the national surveillance system. The authors argued that reported cases only represent a fraction of the actual extent of infection in the Singaporean population and thus proved that under-reporting is an issue that needs to be addressed in the country.

Tien et al. (2010) conducted a prospective cohort study done in Southern Vietnam region involving school children's and in that study, healthy children were followed-up from 2005 to 2007 for four years to describe the incidence rate of laboratory-confirmed acute dengue cases. The group of children who seroconverted (negative to positive IgG antibody) in consecutive surveys was identified, and if the children had an acute dengue episode during the study year, then primary dengue infection is defined as symptomatic. For those children who did not have an acute dengue episode but with positive IgG antibody were classified as asymptomatic. Subsequently, these positive IgG antibody participants were cross-referenced to their national dengue surveillance system. Tien et al. (2010) estimated the incidence of acute dengue illness based on the active monitoring was approximately six times higher than the incidence of suspected dengue cases reported through the passive surveillance system in Southern Vietnam. They concluded that the impact of under-reporting is higher among mild cases(Tien et al., 2010) due to the broad clinical definitions of dengue that implies that cases are not correctly diagnosed as dengue. The study also found that there were three to six times as many asymptomatic dengue infections than there were dengue cases (Tien et al., 2010).

The dengue surveillance system in Cambodia only monitors clinical cases of those less than 16 years old and have been hospitalized. Limitation of resources in the Cambodian national dengue control programme was the reason for the partial monitoring (Huy et al., 2009; Vong et al., 2010). During the year 2006-2008, community-based dengue fever surveillance was done in Kampong Cham, the largest province of Cambodia among the one to 19 years children and adolescent population there(Vong et al., 2010). Study participants were recruited from 32 villages and ten urban areas, and weekly active surveillance[4] was done by the research team members with help from village volunteers. The blood samples were analyzed for the presence of DENV-1, DENV-2, DENV-3 and DENV-4 virus types. During the study period, 6,121 episodes of fever were detected from 4,995 participants. Blood from the study participants was analyzed for laboratory confirmation of dengue infection. 736 subjects (12%) from the total blood samples analyzed had positive dengue infection. From their analysis, it was found that only eight cases were hospitalized among the total of 18 positive dengue virus type DENV-1 infections, and interestingly none of the positive dengue virus type DENV-2 infections required hospitalization(Vong et al., 2010) (either asymptomatic or treated as an ambulatory case). Vong et al. (2010) also found hospitalization was more frequent in those patients associated with DENV-3 infection compared with DENV-1. The active surveillance demonstrated that the burden of dengue is observed both in urban and rural areas of Cambodia. Vong et al. (2010) highlighted the high proportion of under-reporting and under-recognition of dengue cases in Cambodia in this study.

Two more cohort studies were done in Cambodia and were published in the year 2011 and 2012 respectively. Wichmann et al. (2011) compared the field site data of laboratory-confirmed dengue cases with reported dengue case data on the provincial level from the Cambodian national surveillance system from 2003 to 2007. The study computed two types of multiplication factors. The first multiplication factor represented

[4] Active surveillance is an activity where a team of interviewers and allied health staff will go to each houses within a targeted housing area to find ill subjects with fever. The temperature will be measured and if found to have fever, blood specimen will be withdrawn for laboratory analysis.

under-recognition of hospitalized (inpatient) cases and the second multiplication factor accounted for the actual number of ambulatory (outpatient) dengue cases(Wichmann et al., 2011). The study reported 5.3 –fold underestimation of outpatient dengue cases and 1.4 –fold underestimation of inpatient dengue cases in Cambodia for the period 2003 to 2007. Wichmann et al. (2011) concluded that dengue case burden was under-recognized by more than nine times in Cambodia. Vong et al. (2012) performed a capture-recapture analysis during 2006 to 2008 in Cambodia to assess the degree of under-reporting and under-recognition in the Cambodian national dengue surveillance system. The laboratory-confirmed dengue cases in the study population were identified by active surveillance of fever cases in the community for a three-year period (capture technique). The reported dengue cases residing in the study area were then obtained from their national dengue surveillance system for the same period (recapture technique). Vong et al. (2012) compared the dengue cases identified through the capture-recapture method to determine matches and reported a four-fold to the 30-fold degree of under-recognition and under-reporting to their national dengue surveillance system. Both Wichmann et al. (2011) and Vong et al. (2012) not only demonstrated the presence of underestimation of dengue case burden but quantified the severity of dengue's real burden to Cambodia.

In addition to Cambodia, Wichmann et al. (2011) analyzed the dengue seroprevalence of two schoolchildren cohorts in Thailand where the first group of children was recruited from Kamphaeng Phet province between 2004 and 2007 and the second cohort was recruited from Ratchaburi province between 2006 and 2007. For the purpose of detecting under-reported cases, the national and provincial level data of reported dengue cases were obtained from the Thai national dengue surveillance system maintained by the Ministry of Public Health. Wichmann et al. (2011) reported 1.9-fold underestimation of inpatient dengue cases and 3.7-fold underestimation of outpatient dengue cases in Kamphaeng Phet province whereas in Ratchaburi province; he observed 3.3-fold underestimation of inpatient cases and 1.0-fold underestimation of outpatient cases. The authors concluded that dengue incidence in Thailand was underrecognized by more than eight times based on these seroprevalence results. Arunee Sabchareon et al. (2012) analyzed the seroprevalence of schoolchildren who attended seven schools in the sub-district of Namuang of Ratchaburi province in Thailand. Those children were followed up for four years from 2006 to 2009. The authors reported dengue incidence in the study sub-district was 11 to 21 (average 16.5) fold higher than those acquired from their national dengue surveillance database. Both Wichmann et al. (2011) and Arunee Sabchareon et al. (2012) demonstrated a higher incidence of dengue in the respective provinces as compared to corresponding Thailand national dengue surveillance because the national system monitors only DHF cases reported from hospitalized patients in all age groups. Therefore, the eight to 21 fold of unreported dengue cases could represent a significant portion of the ambulatory DF type. Arunee Sabchareon et al. (2012) reported the modal age of children affected with dengue was 11-year-olds in their study. It suggests that the older age group children are presenting with mild disease symptoms at the ambulatory healthcare setting. Although the focus is on the more severe presentation of dengue among hospitalized patients, a large number of older age group patients at outpatient centres are being unnoticed. This group may contribute to the overall under-estimation and under-recognition of dengue case burden in Thailand.

Undurraga et al. (2013) projected the dengue case burden for SEA from 2001-2010 (10 years) using expansion factors. The expansion factors of various countries were obtained through a systematic literature review of articles published from the year 1995 until 2011. The authors included 12 countries in the SEA region which were Bhutan, Brunei, Cambodia, East-Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The authors managed to compile an average of 386,000 dengue episodes that were reported annually to the region's surveillance system in each country. By applying country-specific expansion factors to those reported cases, Undurraga et al. (2013) projected approximately 2.92 mil dengue episodes in the SEA region. The overall expansion factor for SEA was then derived as 7.6 dengue cases for every reported case with a broad range of 3.8 expansion factor in Malaysia to 19.0 in East Timor(Undurraga et al., 2013).

Despite the various surveillance systems instituted in dengue endemic countries within SEA, the official burden of reported dengue cases appears to be significantly under-reported and under-recognized in almost all countries. It is possible for people with natural dengue infections but having inapparent symptoms to contribute to dengue transmission and thereby increasing dengue burden. They do so by efficiently infecting mosquito vectors before traditional surveillance programmes are able to detect any dengue outbreaks. This period of silent transmission can last for up to six months (Duong et al., 2015; Endy et al., 2011; Morrison et al., 2010; Yoon et al., 2012). The intention of this section is to assert this grave issue. The actual burden of dengue once adjusted for under-reporting and under-recognition in most of these endemic countries is at a distressing level. The exponential rise of the true burden of dengue warrants the policy makers in endemic countries to reassess their health priorities and health technologies for dengue. A creative form of advocacy that can be used to secure the attention and commitment of various stakeholders would be from the aspect of finances. The depiction of dengue burden to a country or region from the monetary perspective is called the economic/cost burden. Such attempt can have a positive influence on policymakers, financial planners, health technology industry, pharmaceutics and public health programme managers towards dengue control and prevention.

2.5 The Economic Burden of Dengue

The pressing need to reassess health priorities and health technologies for dengue could be supplemented further with an economic argument. Cost information of DF/DHF combining the treatment and preventive aspects of the illness can be utilized to stress the economic burden of dengue in a country or region. Cost data could function as an excellent tool to convince various stakeholders of the alarming effect of dengue to the country's healthcare system and its resources. The cost information is essential to set aside the required allocation of scarce health resources for a single infectious disease. Some studies have estimated the economic burden of dengue in particular regions and countries at various milestone years. The cost per capita population was then obtained through division of total dengue cost by the average population of those countries(International Monetary Fund, 2013) at the time the studies were performed. The economic burden of dengue in those regions and countries are summarized in Table 2.2.

Garga, Nagpal, Khairnar, and Seneviratne (2008) estimated the economic burden of dengue infections for India as US$27.40 mil (95% CI US$25.7-US$29.1 mil) during the 2006 dengue epidemic year (Garga et al., 2008). Their cost estimation included the costs incurred by private and public health sectors in the country. The cost of dengue case per capita was US$0.02, and these values attribute 0.003% of the Indian Gross Domestic Product (GDP) for the year 2006. Garga et al. (2008) argued that dengue is a fast growing burden on the healthcare resources within India and concluded that the economic burden of dengue has immense implications for India's limited health care budget and financial resources availability for managing other communicable and non-communicable diseases.

Canyon (2008) conducted a historical analysis of the economic cost of dengue in Australia. He argued that vector-borne diseases especially dengue seriously hamper the development of less-developed nations by removing productive time from their populations and using up funds that could be better spent on development. Canyon (2008) extrapolated the average total cost of dengue per annum for Australia as $2.7 mils with cost per capita of $0.14. Australia spent 0.0003% of their GDP for the management of dengue illness in their country. However, the author reminded that these cost estimations were conservative because the intangible costs to individuals and society were not included in the study(Canyon, 2008).

Beauté and Vong (2010) used recent estimates of dengue incidence in Cambodia to determine the cost of dengue. Both public sector expenditure and individuals out-of-pocket payments (private sector) were considered in the cost analysis. The overall annual dengue costs in Cambodia ranged from US$3.33 mil in 2008 up to US$14.43 mil in 2007(Beauté & Vong, 2010). On average, the annual dengue costs for three years were US$7.84 mil. The corresponding cost per capita was US$0.57. The total cost for dengue constitutes 0.09% from the Cambodian GDP. The analysis for Cambodia

Table 2.1: Economic burden and cost per capita of dengue in available regions and countries

Region/Country	Reference	Study year	Study year population (in million)	Economic burden per annum (US$ in million)	Cost per capita (US$)	Percentage of GDP
SEA#	Shepard, Undurraga, and Halasa (2013)	2001-2010	574.24	949.90	1.65	N/A
American*	Shepard, Coudeville, Halasa, Zambrano, and Dayan (2011)	2000-2007	884.80	2,100.00	2.37	N/A
India	Garga et al. (2008)	2006	1,143.29	27.40	0.02	0.003
Australia	Canyon (2008)	1990-2008	19.02	2.70	0.14	0.0003
Vietnam	Luong et al as cited in Shepard, Undurraga, and Halasa (2013)	2004-2007	82.84	30.30	0.37	0.05
Cambodia		2006-2008	13.75	7.84	0.57	0.09
Colombia	Castaneda-Orjuela et al. (2012)	2011	47.08	55.00	1.17	0.02
Thailand	Lim et al. (2010)	2000-2005	64.06	135.00	2.11	0.05
Thailand	Kongsin et al. (2010)	2001-2005	64.40	158.00	2.45	0.09
Malaysia	Shepard et al. (2012)	2009	27.79	102.25	3.68	0.05
Panama	Armien et al. (2008)	2005	3.37	16.86	5.01	0.11
Malaysia	Lim et al. (2010)	2002-2007	25.61	133.00	5.19	0.06
Puerto Rico	Halasa, Shepard, and Zeng (2012)	2002-2010	3.79	46.45	12.26	0.05
Singapore	Carrasco et al. (2011)	2000-2009	4.37	200.00	45.76	0.16

Average study year population and average Gross Domestic Product (GDP) was obtained from International Monetary Fund (2013).

*American region (Bolivia, Colombia, Ecuador, Peru, Venezuela, Belize, Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Suriname, Canada, United States of America, Argentina, Brazil, Chile, Paraguay, Uruguay, Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, French Guiana, Guadeloupe, Martinique, Grenada, Haiti, Jamaica, Aruba, Curaçao, Saint Kitts and Nevis, Saint Lucia, St. Vincent and Grenadines, Trinidad and Tobago, Anguilla, Bermuda, British Virgin Islands, Cayman Islands, Montserrat, Turks and Caicos Islands, American Virgin Islands, Puerto Rico).
SEA region (Bhutan, Brunei, Cambodia, East-Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam).

confirms the high societal burden of dengue for the country. For the cost estimation method, all the resources were identified, and the primary cost data from Cambodian health care centres were obtained for the analysis. However, Beauté and Vong (2010) conceded the cost figures could still represent a conservative estimation due to an underreporting and under-recognition phenomenon seen among dengue patients in general. Beauté and Vong (2010) has established a methodological approach by using more accurate estimates of dengue disease burden to convey the importance of dengue and its prevention to the decision makers in the country.

Thailand is a country in the SEA region which has a significant number of dengue cases and has been actively involved in dengue research. Few studies have been made in Thailand to estimate their dengue economic burden (Clark, Mammen Jr., Nisalak, Puthimethee, & Endy, 2005; Kongsin et al., 2010; Lim et al., 2010). One of the studies was done in the year 1994 where the authors estimated the cost of dengue from three public hospitals in Thailand. Cost data from 184 patients of those hospitals were extrapolated to the national level to be US$12.60 mil(Okanurak, Sornmani, & Indaratna, 1997). Okanurak et al. (1997) acknowledged that all information related to cost were not covered in their analysis due to a short time availability with limited resources.

Lim et al. (2010) estimated the annual cost of dengue in Thailand between the period 2000 and 2005 (6 years). The authors included the treatment costs of DF and DHF, vector control cost as well as research and development (R&D) costs at public institutions. By multiplying the cost per case data to the average reported dengue cases and adding the vector control as well as R&D costs, Lim et al. (2010) estimated the average cost of dengue in Thailand as US$135.00 mil(Lim et al., 2010). He acknowledged several parameters that contributed to the significant variation of cost in his study and recommended for refined methods to be employed in future attempts of the cost of illness estimations. Those parameters were cost per ambulatory case, cost per hospitalized case and the reporting rate(Lim et al., 2010). Based on the total cost of dengue estimated for Thailand by Lim et al. (2010), the cost per capita population were US$2.11. The total cost for dengue represented 0.05% of Thailand's GDP.

Kongsin et al. (2010) conducted a study on disease burden and cost of dengue cases in Thailand, which analyzed data from a provincial hospital. The medical costs and non-medical costs of dengue diagnosed patients were derived and subsequently their division by the number of patients gave the average cost per case for dengue illness. The national costs of dengue in Thailand were then estimated by multiplying the average annual reported dengue cases in the country by its cost per case for dengue. The authors then obtained the vector control programme costs from the national level and included them in the costs for dengue. The aggregate cost of dengue in Thailand was estimated to be US$158.00 mil(Kongsin et al., 2010) with cost per capita US$2.45. The burden of dengue to Thailand's GDP was 0.09%. The authors demonstrated the high burden of each dengue case in the country. Since the majority of the cost was borne by the government, Kongsin et al. (2010) emphasized the importance of dengue to public policymakers in Thailand.

Singapore, Malaysia's neighbour has joined the fray in the national estimation of their dengue cost burden. Carrasco et al. (2011) argued that high income countries and those countries that will become high income in the coming decade are equally affected by the broad geographic range of Aedes mosquito vectors, and the impact of dengue will be substantial in those countries. He proceeded to estimate the cost burden of dengue illness in Singapore for ten years beginning from the year 2000 to 2009. The reported dengue cases were adjusted for underreporting and then the authors estimated direct costs and indirect costs for dengue illness(Carrasco et al., 2011; Dechant, Rigau-Pe´ Rez, & The Puerto Rico Association Of Epidemiologists, 1999; Yew et al., 2009). (Carrasco et al.) estimated an average of US$415.00 mil using the human capital method from 2000 to 2009 whereas using friction cost method, the average was US$351.00 mil for the same period. Total vector control costs were US$500.00 mil (Carrasco et al., 2011) with the assumption that it was constant for the ten-year period. Hence, the total economic burden for Singapore from 2000 to 2009 was US$0.91 billion (bil) using human capital method or US$0.85 bil using the friction cost method (Carrasco et al., 2011). The average cost burden per year of dengue to Singapore in the ten-year period was US$200.00 mil. The cost per capita was US$45.70 and the total dengue cost burden represented 0.16% of Singapore's GDP. Although Carrasco et al. (2011) have demonstrated the high economic burden of dengue to Singapore, the costs estimated were deemed conservative as it did not include the extra costs associated with dengue outbreaks to the national health system.

Shepard, Undurraga, and Halasa (2013) studied the economic burden of dengue in SEA because dengue is among the greatest disease burdens in the region and has been hyperendemic for decades. Their study estimated the cost burden of dengue illness involving 12 countries (Bhutan, Brunei, Cambodia, East-Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam) in the SEA region. The economic burden of dengue is calculated as the total number of dengue cases multiplied by the total costs per dengue episode. Shepard, Undurraga, and Halasa (2013) obtained the average reported dengue cases in 2001 to 2010 from each of the countries and then adjusted for underreporting using estimates of expansion factor by Undurraga et al. (2013). The cost of providing medical services to dengue patients was determined through literature review of articles associated with economic costs of dengue in SEA countries (Beauté & Vong, 2010; Carrasco et al., 2011; Huy et al., 2009; Kongsin et al., 2010; Lim et al., 2010; Luong, Coudeville, Pollisard, Do, & Bricout, 2012; Shepard et al., 2012; Suaya, Shepard, Armien, et al., 2007; Suaya et al., 2009). For countries in which no cost data were available, the authors relied on expert opinion and extrapolation of data based on regression analysis using unit costs as the dependent variable and GDP per capita as the independent variable(Shepard, Undurraga, & Halasa, 2013).

The average annual number of reported dengue cases in SEA region was 386,000 patients (2001 to 2010) and once the corresponding expansion factors to adjust for underreporting was applied, the authors derived an average of 2.9 mil dengue cases per year for the SEA region(Shepard, Undurraga, & Halasa, 2013; Undurraga et al., 2013). Shepard, Undurraga, and Halasa (2013) obtained an overall yearly economic cost of US$950.00 mil with the share of costs for direct costs amounted to US$451.00 mil and the indirect costs were US$499.00 mil. The average population for SEA region was 574.24 mil and hence the cost per capita was US$1.65. Shepard, Undurraga, and Halasa (2013) had demonstrated that dengue poses a substantial economic and disease burden in the SEA region. The authors predicted the economic burden of dengue would have been even higher should the costs of prevention and vector control, overloads of health systems during outbreaks, opportunity costs lost in tourism and the long-term sequelae of dengue infections were included in the analysis(Shepard, Undurraga, & Halasa, 2013).

Dengue is an endemic-epidemic disease in Colombia with a high number of dengue cases (Castaneda-Orjuela et al., 2012). Castaneda-Orjuela et al. (2012) first estimated the Colombian annual dengue case burden for three year period from 2011 to 2014 through a dynamic transmission model and then used bottom-up cost identification method from the third-party payer (Colombian healthcare system) to derive the average cost of care per patient with dengue and severe dengue. The dengue treatment costs were derived by extrapolating the costs per patient obtained from the medical records multiplied by the number of dengue disease burden estimates from the dynamic transmission model. A sample of vector control programs at various administrative levels provided the information for costs of dengue community control activities in Colombia. The costs from sample vector control programs were extrapolated to reflect the country's estimate. The overall national estimate was obtained by summing the treatment cost and prevention cost. The disease dynamic transmission model predicted 35,739 dengue cases for Colombia in the year 2011. Based on the medical records, the treatment costs of dengue projected by the model was US$16.9 mil in Colombia (Castaneda-Orjuela et al., 2012). The total annual costs of dengue community control in Colombia were between US$37 mil and US$42 mil (Castaneda-Orjuela et al., 2012). Hence, the combined costs of dengue treatment and prevention were between US$54 mil and US$56 mil (Castaneda-Orjuela et al., 2012). The cost per capita for dengue in Colombia for the year 2011 was US$1.17. Through these cost figures, Castaneda-Orjuela et al. (2012) proved evidence of a high economic impact by dengue in the

Colombian health care system. The cost burden of dengue represented 0.02% of 2011 Colombian GDP. The study's strength was the use of primary cost data obtained from a sample of medical records whereby the authors believed this method accurately addressed the cost of medical management in real practice (Castaneda-Orjuela et al., 2012). However, there is a possibility for conservative dengue case burden estimation by the authors because their dengue dynamic transmission model does not adjust for under-reporting of dengue cases in Colombia. If this factor were taken into account, their prediction of dengue cases for 2011 would be somewhat higher and subsequently lead to a higher dengue cost burden estimate.

Panama experienced the most severe epidemic of dengue cases in the year 2005, and it affected primarily adults(Armien et al., 2008). Armien et al. (2008) collected data to analyze clinical and economic aspects of the 2005 dengue epidemic in the entire country. His economic analysis included national estimations of medical costs associated with dengue illness as well as costs of dengue surveillance, laboratory costs and mosquito vector control activities(Armien et al., 2008). Panama's MOH estimated that for every reported dengue case, there were six actual dengue cases(Armien et al., 2008). Hence, to estimate the total number of dengue cases for Panama, the authors multiplied the number of reported dengue cases by six. The aggregate national cost of dengue for Panama was derived from the product of the number of dengue cases adjusted for under-reporting by the average medical costs(Armien et al., 2008). The aggregate national cost of dengue for Panama were US$16.86 mil(Armien et al., 2008) with US$5.01 as their cost per capita for dengue. The total cost for dengue represented 0.05% of their national GDP. This estimate of dengue cost burden for Panama was deemed conservative because the authors did not include the costs of patients treated entirely in the private health care setting or for those who were treated outside the Panama Province(Armien et al., 2008). Through this study in Panama, Armien et al. (2008) quantified the substantial economic burden of dengue posed to the country's economy.

Puerto Rico is an unincorporated territory of the United States where substantial dengue transmission occurred between 2002 and 2010. Halasa et al. (2012) used data collected from multiple sources, including patients, insurers, clinicians and vector control programme to estimate the annual average aggregate economic costs of dengue illness in Puerto Rico during 2002 through 2010. To adjust for under-reporting, Halasa et al. (2012) used the expansion factor of 2.42 for hospitalized and fatal cases and 10 for ambulatory cases from Dechant et al. (1999)'s capture-recapture study done in Puerto Rico during 1991 to 1995. Halasa et al. (2012) proceeded to estimate the total cost by multiplying the average cost per case by the projected number of cases (adjusted for under-reporting). Their analysis estimated an annual aggregate dengue illness cost of US$38.7 mil for Puerto Rico where 48% of the cost was attributed to direct medical costs and 50% to the indirect costs(Halasa et al., 2012). The authors then incorporated the costs associated with dengue surveillance and vector control activities estimated from Pérez-Guerraa et al. (2010) for the years 2002 to 2007 in Puerto Rico. Once the vector control costs were included, the total economic cost of dengue in Puerto Rico became US$46.45 mil(Halasa et al., 2012) corresponding to US$12.26 per capita. The dengue cost burden for Puerto Rico was estimated to be 0.05% from their national GDP. Halasa et al. (2012) argued from these findings that the burden of dengue illness is high for Puerto Rico and sound investments related to dengue would benefit the Puerto Rican government and their people.

The economic impact of dengue illness in the Americas was estimated by Shepard, Coudeville, et al. (2011). They utilized data of reported cases from the Pan American Health Organization (PAHO), the regional body of the WHO. PAHO handles 35 countries and nine territories of the Americas(Shepard, Coudeville, et al., 2011). They analyzed the number of reported cases for the period of 2000-2007 (8-years). For the cost data, the authors performed a systematic review of articles on dengue costs and focused on the results of two prospective cost studies (Coudeville, Shepard, Zambrano, & Dayan, 2009; Suaya et al., 2009) to derive the cost per dengue case. The average national economic burden of dengue in the Americas for the period 2000-2007 was US$2.1 billion. The cost per capita population was US$2.37. The authors demonstrated a substantial economic burden of dengue illness to these countries within the American region. The absence of country-specific cost data for all the American countries may limit the validity of this cost per dengue case extrapolation method. These countries in the American region may differ significantly from the number of dengue case load, disease presentation and characteristics (hospitalization and ambulatory cases), national healthcare system and the degree of healthcare resources utilization. Therefore, the authors' assumption that the cost per dengue case in each of these countries will be similar requires reconsideration.

Shepard, Undurraga, Halasa, and Stanaway (2016) estimated the total annual global cost of dengue illness to be US$8.9 bil (95% CI US$3.7 bil – US$19.7 bil) and demonstrated the global cost of dengue to be substantial. Dengue illness imposes costs greater than other major infectious diseases with comparable data such as cholera (US$3.1 bil) and rotavirus gastroenteritis (US$2.0 bil)(Shepard et al., 2016). Through these dengue cost studies, many researchers have successfully demonstrated the cumbersome and significant burden of dengue illness in their respective countries, regions and worldwide. It served as a valuable tool to convince the decision-makers in their countries the alarming effect of dengue to their health care system and resources. These cost studies also promoted the necessity to commit a sound investment into dengue research and public health vector control measures to lower the burden of dengue in their national health care system and the general population. However, many of the cost estimations discussed earlier did not elaborate sufficiently on the costs that incur for their public health vector control activities, surveillance and national prevention programme for dengue. In fact, some studies did not even include the dengue control and prevention costs as their cost components. Therefore, the estimations of the overall dengue cost burden are incomplete in those countries.

2.6 Dengue Vector Control and Prevention

The primary vector for dengue transmission is *Aedes (Ae.)* mosquitoes precisely the species, *Ae. aegypti* and *Ae. albopictus* that has been implicated in dengue fever occurrence. Although *Ae. Albopictus* is a less likely vector responsible for large-scale dengue outbreaks, the potential role of Ae. albopictus in the transmission of other arboviruses[5] should remain a concern for public health officials(Lambrechts, Scott, & Gubler, 2010). Dengue infection in humans occurs when the susceptible individuals are bitten by infectious female mosquitoes[6] during a blood meal. Yang and Ferreira (2008) emphasized, the per capita incidence rate among humans will depend on the fraction of infectious mosquitoes present in the environment and takes into account the encounter

[5] Arbovirus is a term used for a group of viruses that are transmitted by arthropod vectors. Among the viruses, the Dengue (DENV), Japanese encephalitis (JE) and Chikungunya are present in Malaysia.

[6] Female mosquitoes have to feed on man or animal and get sufficient blood meal before she can develop eggs. Without a blood meal, the female mosquito will die without laying viable eggs. In order for dengue transmission to occur, the female mosquito must harbor dengue virus. An infectious mosquito can transmit the virus to a susceptible host during the bite and feeding.

between susceptible individuals and infectious mosquitoes. Since, there are no specific medical therapies or a sustained prevention method till date (A. Guzman & Istúriz, 2010; Scott B Halstead & Deen, 2002; Kumar et al., 2010), the foundation for disease control and prevention for dengue has been predominantly mosquito vector control. There are several available mosquito vector control options that are being practiced worldwide, however, no single intervention is deemed sufficient to control dengue(Achee et al., 2015).

The core principle of vector control is to target and destroy the breeding sites where the aquatic phase of mosquito (larvae) develops and multiply as well as the elimination of adult mosquitoes. Most of the dengue endemic countries employ this concept in their vector control programme. The traditional method of vector population control is achieved through several measures such as environmental, chemical or biological control measures(Kumar et al., 2010). Environmental control measures entail the targeted destruction of mosquito breeding habitats. This action is also known as "search and destroy" method. Vector control workers will actively search and eliminate all the possible breeding sites of mosquitoes. The breeding sites include improperly discarded containers such as vessels, vases, cans, buckets, bottles, stored and discarded vehicle tyres. The search activity will also focus individual inner and outer building structures that can be a source of stagnant water collection and deemed at high risk for mosquito breeding sites. Examples of such structures are roof gutters, clogged drainage pipes, septic tanks, toilet flush system, flower pots, watering cans, water dispensing units and the base of refrigerators to be least expected. Environmental control measures require active participation and cooperation from an individual level of each household and the community as a whole for the intervention to be effective. Having said that, there is limited evidence to indicate that premise inspections and community based environmental management could reduce risk of dengue infection(Bowman, Donegan, & McCall, 2016). Positive behavioural changes, effective social mobilization and continuous communication efforts are vital for the sustainability of environmental control measures(Al-Muhandis & Hunter, 2011; Renganathan et al., 2003; Toledo et al., 2007) instead of reliance on the vector control workers to eliminate potential mosquito breeding sites in the community.

Chemical control measures comprise the use of insecticides in fogging and larviciding activities. Fogging involves spraying of insecticides in and around of houses and buildings (indoor residual spraying) situated in the vicinity of a dengue case (a predetermined radius area from the house where an identified dengue patient resides). Space spraying involves the application of small droplets of insecticide into the air in an attempt to kill adult mosquitoes(Esu, Lenhart, Smith, & Horstick, 2010). Space spraying can be done through two conventional methods. The first method is called thermal fogging. It involves workers carrying hand-held machines dispensing thermal fog from house to house covering both the inner and outer perimeter. The second method is called cold fogging or ultra-low volume (ULV) fogging. It involves a machine mounted on a truck spraying insecticide droplets in the housing area (outdoor residual spraying). Fogging activities have been in the forefront of vector control activities because it is a highly visible action that can be shown to the public. There are several issues related to fogging especially related to effectiveness and achieving appropriate coverage. Many households are reluctant and will not allow vector control staff to perform indoor residual spraying due to the odorous nature of the insecticide and staining of the furniture and curtains. Despite fogging being used as main response in dengue vector control, no studies or trials have evaluated the effectiveness of this intervention method and few available studies have a very weak evidence base(Bowman et al., 2016). Larviciding is the process of applying pesticides at stagnant water collection areas proven to be a high source of mosquito breeding sites. It is targeted to destroy the aquatic phase of mosquito life cycle (larvae). Larviciding spraying is done through a worker's back-mounted machine that sprays a jet of insecticide stream to the intended areas. Larviciding sprays are commonly done in clogged pipes, drainage pipes, septic tanks, illegal garbage dumping sites, abandoned dilapidated houses and poorly maintained vacant parcel of land. However this method unfortunately is not sustainable in their gains and its effectiveness is doubtful(Achee et al., 2015) because the vector control staff simply could not achieve adequate coverage of all sites deemed as high-risk and has the water holding potential to breed mosquitoes.

There are several issues related to the use of insecticides in dengue control and prevention. The first issue is related to the development of mosquito resistance towards the common pool of insecticides used for vector control(Reiner et al., 2016). Resistance is defined as a heritable change in the sensitivity of a population to an insecticide, which is reflected in the repeated field failure of that product to achieve the expected level of control when used according to the label recommendations for that pest species, and where problems of product storage, application, and unusual climatic or environmental conditions can be eliminated(Nauen, 2007). Major classes of insecticides used to control mosquito population are pyrethroids, organophosphates, carbamates, and dichloro—diphenyl-trichloroethane a.k.a DDT and the best strategy for controlling the population of disease-bearing vectors is the rotational use of insecticides of different modes of action(Nauen, 2007). However, it is a common practice to use the same insecticide repeatedly in a dengue endemic locality(Reiner et al., 2016). The issue is further aggravated when the public sector agencies are often burdened with frequent requests for fogging from the public as well as the politicians as a solution for nuisance mosquitoes. Once insecticide resistance has occurred, it can contribute to a higher disease transmission rate and pose a real danger of the re-emergence of vector-borne diseases that had been presumed to be under control(Eisen, Beaty, Morrison, & Scott, 2009; Nauen, 2007; Shafie, Mohd Tahir, & Sabri, 2012; Vontas et al., 2012).

The second issue is concerned with the transitory and irregular effect of peridomestic space spraying. Koenraadt et al. (2007) determined that seven days after insecticide spraying, 50% of the original number of mosquitoes were re-established in the area sprayed. Esu et al. (2010) reviewed 15 studies and concluded that the use of space spraying interventions not only showed mixed results in reducing larval indices, oviposition indices, and adult population, but these reductions were also not sustained for long periods. The mosquito population was observed to be returning to at least the same level or higher than before spraying within few days or weeks. Similarly, Thammapalo, Meksawi, and Chongsuvivatwong (2012) established that space spraying in an urban area of southern Thailand was inadequate and often failed to prevent secondary DF/DHF infections in the sprayed area. There are possible reasons for such outcome observed in those studies. The spraying process does not treat water holding containers, and larviciding activity will not be possible to cover all potential containers and sites. Therefore, larvae and pupae stages of mosquitoes will continue their development and contribute to the restoration of Aedes mosquito population in the following days. Both fogging and larviciding activities are highly visible to the communities and are a favorite choice among health authorities as it conveys the message that these agencies are actively combating the disease(Esu et al., 2010). Fogging is considered as an emergency control measure when an outbreak of dengue has occurred(World Health Organization, 2009) and constitute a popular activity among many health departments worldwide.

Biological control is based on the introduction of organisms that prey upon, parasitize, compete with or otherwise reduce populations of the target species(World Health Organization, 2014). Examples are certain larvivorous fish species and predatory small freshwater crustaceans that found to be promising in the elimination of larvae and pupae stages of Aedes mosquitoes. Poecilia, an omnivorous fish species that survives well in confined habitats (e.g. open dug wells) and Gambusia, a cannibalistic fish species are the most preferred poeciliid[7] larvivorous fish tested against Aedes aegypti larvae (Ghosh et al., 2011; Liaqat et al., 2013). Neng et al. (1987) reported that in the 1980s, Chinese catfish was also used to control Aedes aegypti larval breeding to overcome dengue outbreak in fishing villages in Chinese coastal provinces. Several Mexican indigenous fishes namely Lepisosteus tropicus (Gill), Astyanax fasciatus (Cuvier), Brycon guatemalensis (Regan), Ictalurus meridionalis (Gunther) and Poecilia sphenops (Valenciennes) are reported to be effective against Aedes aegypti larvae in water storage tanks in Southern Mexico(Martinez-Ibarra et al., 2002). Mesocyclops, a predatory small freshwater crustacean also has been reported widely in several Vietnam provinces as efficient against Aedes aegypti and Aedes albopictus larvae in large water storage containers (Brian H. Kay & Sinh-Nam, 2005; Brian H. Kay et al., 2002; Sinh-Nam, Thi-Yen, Holynska, W. Reid, & H. Kay, 2000). Although biological control

[7] Any small fish of the family Poeciliidae, of fresh or brackish tropical and temperate waters including the mosquito fish, guppies and mollies.

measures are promising, their stringent ecological requirements are a challenge. These predators can only survive if their preferred living environment is fulfilled, a condition that requires active monitoring and constant maintenance(Liaqat et al., 2013). The mass rearing and release of these predators involves high cost and mostly not easy to achieve at targeted breeding sites(Liaqat et al., 2013).

In the recent years, there has been some research advancement that incorporate genetic component to the biological control agents. Two methods that are discussed in the literature are genetically modified mosquitoes and entomopathogenic bacteria but despite having the potential of dengue vector control, these interventions have yet been evaluated sufficiently to draw conclusions about their effectiveness(Silvia Runge-Ranzinger et al., 2016).

Genetic modification method aims to produce sterile male mosquitoes. Subsequent mating of released sterile males with wild females leads to a decrease in female's reproductive potential (Lacroix et al., 2012; Yean et al., 2012). However, the genetic manipulation method faced strong concerns from the community over their effects in the long run to the environment and the mosquito species. Further, repeated releases of genetically modified mosquitoes were required over an infinite time horizon to continue to sustain a low wild mosquito population(Yean et al., 2012).

Entomopathogenic bacteria are Gram-positive, spore-forming bacteria that are almost exclusively active against the larval stages of mosquitoes and act by releasing a variety of toxic proteins. One example is Bacillus thuringiensis where the mosquito larvae will ingest the toxins produced by the bacteria and subsequently this will cause disruption of cell membranes and death of the larvae(Boyce et al., 2013). Similarly to genetically modified mosquitoes, the community was uncomfortable with the introduction of bacteria into the environment. Moreover, given the broad potential of breeding sites and habitats of Aedes mosquitoes, the widespread application of the bacteria to all potential sites was deemed not practical(Boyce et al., 2013).

Despite the few available methods of dengue vector control, the environmental control and chemical control has been the forefront way for many dengue endemic countries. Both these methods are found to be consistent and convey a positive message to the community that the health authorities are fighting the dengue menace. There has been suggestions for integrated intervention but no consensus has been reached regarding the details of how and what combination of approaches can be most effectively implemented(Achee et al., 2015). Another factor that required serious attention is the cost implications of these interventions. There is lack of cost effectiveness analysis for dengue vector control options(Achee et al., 2015). Such effort is fundamentally required in the future for appropriate selection and implementation of dengue vector control intervention choices.

Vaccination has been a promising method for infectious disease control and prevention. Research and development for a dengue vaccine has been on-going for the past 30 years(Coller & Clements, 2011; Scott B Halstead & Deen, 2002). Many dengue-endemic countries fall in the range of middle to high income economies and could serve as a platform and provide a large market to drive positive developments in term of dengue vaccine research(Vannice, Durbin, & Hombach, 2016). The advantage of a vaccine is that all vulnerable and at-risk population can be covered through a national vaccination programme. An efficacious dengue vaccine that protects against all four serotypes (DENV1 to DENV4) of the virus, ideally can be given as a single dose vaccine, attracts usage in young children as well as in adults and safe to be used will be effective to control dengue and reduce the cases(Christofferson & Mores, 2015; Vannice et al., 2016). Provided sufficient population coverage is achieved, there will be significant herd immunity and subsequently the disease could be eliminated or prevented. However a weakly efficacious vaccination strategy will be counterproductive to disease control efforts and will have cost implications if the vaccine and conventional vector control methods are to be implemented synergistically(Hendron & Bonsall, 2016). For any potential dengue vaccine that plans to enter the market, a country specific cost effectiveness analysis will be a fundamental requirement before it can be rolled out.

The economic analysis or cost data for dengue vector control is essential to sustain the public health programme, prioritize the vector control interventions based on their potential to prevent the disease and convince the stakeholders the significant burden of dengue to the country. More research is also required in the form of controlled experimental studies and field based studies to assess the health impact of dengue vector control interventions based on epidemiological and entomological indices(Achee et al., 2015) and cost-effectiveness analyses. Such studies will provide the required evidence to support the effectiveness of any one intervention or few integrated form of interventions for dengue vector control.

2.7 The Cost of Dengue Vector Control and Prevention

In the preceding sections, it was emphasized that dengue pose a significant economic burden in many countries and its public health systems. The importance of mosquito vector control for the prevention of dengue in the population has been understood. The cost of dengue vector control and prevention is essential in the overall dengue economic burden to know the fraction of the cost contributed by different countries for vector control and prevention. Moreover, it will be interesting to compare the fraction of control and preventive efforts to the curative efforts from a cost perspective in those countries. The cost assessment will provide critical feedback to the managerial and operational capacity of the dengue vector control programme and may encourage policy discussions toward sustained active investments into the dengue public health programme. Costs from few published dengue vector control studies worldwide have been adjusted to 2010 US Dollars using the US GDP deflator(International Monetary Fund, 2013). Subsequently, the cost per capita population was then obtained through division of total vector control and prevention cost by the average population of those countries(International Monetary Fund, 2013) at the time these studies were performed. Table 2.3 shows the public sector cost of dengue vector control and prevention in selected countries.

The average annual cost for vector control and prevention in Australia between 1990 to 2008 (10-years) was US$0.50 mil(Canyon, 2008). The cost per capita for the Australian population was US$0.03. The Australian vector control and prevention expenditure represented 15% of the total dengue cost burden and formed 0.0005% from the country's total health spending in the same period. Canyon (2008) derived the cost of dengue vector control and prevention through series of correspondence with several Australian cities' LAs. The labour costs, direct costs and annual maintenance costs associated with dengue vector control and prevention activities were roughly estimated by local city council officers. The study did not include economic costs and did not take into account the specific resources consumption and their respective unit costs for the total cost estimation at the particular LAs. The exact methods used by the author to extrapolate the LAs costs to the Australian national estimate were vague.

The cost of dengue vector control and prevention for Cambodia between 2006 to 2008 was estimated by Beauté and Vong (2010) to be US$0.52 mil. Their cost per capita was US$0.04. The dengue vector control and prevention cost formed 6% to their overall dengue cost burden and 0.1% of their total health expenditure. Direct control costs of the dengue vector control programme and prophylaxis were included in this estimate, but the source of data was not clearly explained by the authors. Upon further scrutiny of listed references in the said article, it was found that the vector control cost estimate was adapted from a study done by Suaya, Shepard, Moh-Seng, et al. (2007) in Cambodia. That study assessed the cost-effectiveness of annual targeted larviciding campaigns from 2001 to 2005 against dengue vector *Ae. aegypti* in two urban areas of Cambodia(Suaya, Shepard, Moh-Seng, et al., 2007). The authors estimated the average cost of the intervention to be US$0.62 mil per year. The cost per capita was US$0.05. From this study, the cost of vector control and prevention was 8% of their overall dengue cost burden, and the fraction of total health expenditure was similar to Beauté and Vong (2010) estimation.

Suaya, Shepard, Moh-Seng, et al. (2007) incorporated both operational and administration costs as well as annual media and communications campaigns expenditures. However, it is important to note that Suaya, Shepard, Moh-Seng, et al. (2007) only estimated the cost of one specific vector control activity. They focused on two rounds of annual larviciding activity which targeted medium to large size water storage containers located at households and other premises in densely populated areas of Cambodia(Suaya, Shepard, Moh-Seng, et al., 2007). Routine dengue vector control activities such as community-based clean-up campaigns, environment control measures and insecticide fogging around houses close to reported dengue cases were not included in their cost analysis(Suaya, Shepard, Moh-Seng, et al., 2007). The main cost inputs in that study were insecticides (larvicide) forming 59% of total cost followed by operational cost (33%) and administrative cost (6%). It is also interesting to note that Beauté and Vong (2010) marked down the total cost estimation of Suaya, Shepard, Moh-Seng, et al. (2007) by 16% from US$0.62 mil to US$0.52 mil without a logical explanation(Beauté & Vong, 2010; Suaya, Shepard, Moh-Seng, et al., 2007). Beauté and Vong (2010) also assumed the estimated annual cost to be a constant for the three consecutive years from 2006 to 2008. This is despite the authors reporting the range of estimated number of dengue cases in Cambodia to be from 76,933 to 404,165 during those years. Such variation in the number of cases as well as the population dynamics will cause alteration of resources consumption and the associated costs for dengue vector control. Hence, the costs for some given years can be averaged, but it should not be assumed as a constant.

Kongsin et al. (2010) performed another dengue vector control and prevention cost estimation for Thailand in 2005. She estimated the costs involving all levels of the vector control programme administration from the national to sub-districts. Personnel costs and other expenses which the details were not discussed were collected at the national level as well as from representative examples of lower-level administrative units from the province to the sub-districts(Kongsin et al., 2010). Once the costs at each administrative level were ascertained, she divided the respective costs by the population each level served to acquire the cost per capita population. For the peripheral vector control units, the costs from urban and rural localities were averaged using appropriate weights(Kongsin et al., 2010). The determination of such weights was not elaborated sufficiently. The summation of cost per capita from all administrative levels was used to estimate the national cost per capita. However, these costs were unilaterally assessed only from the public health departments of the central government. The costs for municipalities (local councils) which handle dengue vector control and prevention in urban and sub-district rural areas were roughly estimated. The original per capita estimation have been inflated by 20% and 80% respectively to represent the shares of Thailand's population served by these LAs (Kongsin et al., 2010). Once the adjusted national cost per capita was determined, it was then multiplied by the total population size of Thailand to estimate their national dengue vector control and prevention cost for the country. The total cost estimated by Kongsin et al. (2010) were US$68.21 mil with cost per capita of US$1.06. The total cost for vector control and prevention formed 39% of their overall dengue cost burden and 1% of Thailand's total health expenditure. The authors advocated moderate increases in Thailand's vector control and prevention costs would be justified from economic perspective even if such efforts achieved only a small reduction in the number of dengue cases in the country.

The dengue vector control and prevention cost for Singapore was estimated by Carrasco et al. (2011) for the period of 10 years from 2000 to 2009. The direct costs were obtained from the National Environment Agency that handles dengue vector control in Singapore(Carrasco et al., 2011). The details of cost breakdowns and resources consumed were not specified by the authors. Carrasco et al. (2011) estimated the average annual costs of vector control and prevention to Singapore to be US$50.50 mil with cost per capita of US$11.55. Singapore has the highest cost per capita for dengue vector control among SEA countries that had published detailed cost estimates of their dengue vector control programme. The island's relatively high GDP and a small population size of 4.37 mil contributed to this finding. The dengue vector control and prevention cost formed 25% of the overall dengue cost burden to Singapore and constituted 1.1% of their total health expenditure. Similar to Beauté and Vong (2010) assumption in Cambodia, Carrasco et al. (2011) also assumed the vector control costs to remain constant in Singapore. Probably such assumptions were deduced because public health programmes operate within a given budget annually. The variation and endemicity of dengue cases in Singapore with its robust population dynamics and constant movement of persons and commodities between the countries(Carrasco et al., 2011) may prove such assumption to be erroneous. Taking account of these factors, increasing the operations of dengue vector control and prevention activities would positively contribute to a lower dengue incidence in the country.

Dengue vector control and prevention costs in Panama were estimated by Armien et al. (2008) during the 2005 dengue epidemic. He used secondary data from expenditure reports and interviews with the main public health officials to estimate personnel, supplies, equipment, vehicles and overhead costs by three major dengue-related activities of MOH, which are dengue surveillance, laboratory and vector control(Armien et al., 2008). The dengue vector control in Panama is part of a larger public health programme that includes among others, control of nuisance mosquitoes, ticks, and rodents. Hence, Armien et al. (2008) apportioned only on activities related to dengue control and prevention such as inspection of premises, elimination of breeding sites, larviciding, fogging, enforcement, education, and community participation. He outlined the annualized[8] costs of vehicles and equipment but due to lack of access to detailed records, the fees associated with maintenance and repairs were roughly estimated. The building costs and general administration costs were also estimated as 20% of the direct costs(Armien et al., 2008). The national vector control and prevention costs for Panama were US$5.54 mil with cost per capita of US$1.65. Panama's expenditure for the year 2005 formed 30% of their overall dengue cost burden and 0.4% of their total health spending. Given the significant costs associated with dengue vector control, the authors concluded the need for exploration and development of potential new mosquito control innovations for Panama.

Halasa et al. (2012) estimated the average annual dengue vector control and prevention cost per year for Puerto Rico in the period of nine years from 2002 to 2010 as US$15.51 mil with cost per capita US$4.09. The fraction of cost attributed to dengue vector control and prevention was 33% of the overall dengue cost burden and formed 0.2% of Puerto Rico's total health expenditure. She adapted the vector control and prevention costs from an earlier study done by Pérez-Guerraa et al. (2010) which estimated the dengue vector control and prevention costs for Puerto Rico for the period

[8] cost per year of owning and operating an asset over its entire lifespan

of six years from 2002 to 2007. The estimated average annual national costs by Pérez-Guerraa et al. (2010) were US$8.58 mil with cost per capita of US$2.25. A comprehensive analysis of the Puerto Rican dengue vector control and prevention programme was performed. The authors identified the principal players involved in these activities in Puerto Rico. The vector control activities, educational campaigns and surveillance are primarily done by the Puerto Rico Department of Health (PRDH) while certain municipalities (local councils) have their vector control programme(Pérez-Guerraa et al., 2010). The authors sent out a pre-validated questionnaire for collection of cost data from PRDH as well as selected municipalities that were identified to have a vector control programme. The said municipalities were identified by enquiry through a phone call, and the questionnaire was sent to the selected municipality either through e-mail, mail or fax. The questionnaire was subdivided into four major parts dealing with personnel cost and time allocation to dengue prevention activities, recurrent expenditures, annualized capital costs of buildings, vehicles, equipment and finally the type and number of activities performed during the study years(Pérez-Guerraa et al., 2010). Post-delivery of a questionnaire to the respective study sites, an average of four on-site interviews involving executive directors and other key personnel involved in dengue vector control and prevention activities were done. The purpose of the meetings was to elicit the breakdown of all resources, according to the core functions of vector control and prevention activities. The core activities were inspections of premises, fogging, health education, clean-up campaigns, surveillance and general management(Pérez-Guerraa et al., 2010).

Pérez-Guerraa et al. (2010) estimated the average annual cost of dengue vector control and prevention by PRDH and municipalities as US$1.44 mil and US$7.12 mil respectively. Based on resources, the largest cost component was recurrent costs US$6.21 mil (72% of total cost) followed by personnel costs US$2.13 mil (25% of total cost)(Pérez-Guerraa et al., 2010). The clean-up campaigns contributed the highest annual expenditure of US$5.56 mil (68% of total cost) followed by fogging activities US$1.13 mil (14% of total cost), surveillance US$0.81 mil (10% of total cost), inspection of premises US$0.48 mil (6% of total cost) and health education US$0.20 mil (2% of total cost)(Pérez-Guerraa et al., 2010). Pérez-Guerraa et al. (2010) have performed a detailed cost analysis of dengue vector control and prevention programme in Puerto Rico as well as in comparison to other studies elsewhere till date.

Colombia's fraction of dengue vector control and prevention costs to overall dengue cost burden was 72% and represented 0.2% from their total health care expenditure. So far, these figures are the highest documented control and preventive cost commitments among all the studies reviewed. Castaneda-Orjuela et al. (2012) selected two study sites to represent the department of health vector control units and two study sites to represent the municipal vector control units. A cost data collection instrument was developed based on the country's programme budget and was used to collect data from the four selected study sites. The description of the cost data collection instrument and the methods were not elaborated well in the published article. The authors estimated the average cost per entity and built a model aimed to explain the costs of vector control programme according to the size of the population and of the geographical area(Castaneda-Orjuela et al., 2012). Through this model, Castaneda-Orjuela et al. (2012) identified the annual cost per inhabitant/km^2 and then extrapolated the costs to 23 departments of health and 27 municipalities in the country. The average annual national dengue vector control and prevention costs for Colombia in 2011 was

US$38.74 mil(Castaneda-Orjuela et al., 2012) with cost per capita US$0.82. The authors have demonstrated the importance of dengue vector control in the decreasing the total cost of dengue by a lower fraction of medical costs especially in a Latin American country where the dengue is endemic, and their vector control and prevention programmes are running continuously throughout the year(Castaneda-Orjuela et al., 2012).

The national vector control and prevention cost estimation in many countries utilized the step-down allocation techniques and used secondary data in their study. In those methods, the average costs of departmental outputs were calculated based on standard financial accounting reports. Some these studies also estimated the national cost based on an expert judgment. In this method, experts from vector control and prevention programme had a rough estimation of the cost of delivering vector control activities to the population.

In conclusion, dengue vector control and prevention contribute a significant fraction of costs (ranging from 6% to 72%) to the overall national economic burden of dengue in many countries. In fact, it has been acknowledged as an important direct cost component for the economic burden of dengue. It is crucial to include these direct costs in any future national estimation of the economic burden of dengue. Studies from all these countries further confirmed that the implementation of dengue vector control and prevention strategies are resource intensive and expensive. Thus, it is critical to know in detail the cost of delivering vector control and prevention programme activities. It will enable us to understand the resources required to conduct the said activities.

Table 2.2: The average annual costs of dengue vector control and prevention

Country	Reference	Study year	Study year population (million)	Total cost (US$, million)	Cost per capita (US$)	Fraction of overall dengue cost burden (%)	Fraction of vector control cost to total health expenditure (%)
Australia	Canyon (2008)	1990-2008	19.02	0.50	0.03	15	0.0005
Cambodia	Beauté and Vong (2010)	2006-2008	13.75	0.52	0.04	6	0.1
	Suaya, Shepard, Moh-Seng, et al. (2007)	2001-2005	12.92	0.62	0.05	8	0.1
Colombia	Castaneda-Orjuela et al. (2012)	2011	47.08	38.74	0.82	72	0.2
Thailand	Lim et al. (2010)	2000-2005	64.06	27.79	0.43	20	0.3
	Kongsin et al. (2010)	2001-2005	64.40	68.21	1.06	39	1.0
Malaysia	Lim et al. (2010)	2002-2007	25.61	26.60	1.04	20	0.3
Panama	Armien et al. (2008)	2005	3.37	5.54	1.65	30	0.4
Puerto Rico	Halasa et al. (2012)	2002-2010	3.79	15.51	4.09	33	0.2
	Pérez-Guerraa et al. (2010)	2002-2007	3.81	8.58	2.25	n/a	0.1
Singapore	Carrasco et al. (2011)	2000-2009	4.37	50.50	11.55	25	1.1

Average study year population and average Gross Domestic Product (GDP) was obtained from International Monetary Fund (2013)

n/a denotes not applicable

Decision makers could use the cost data to sustain or improve the funding to vector control and prevention programme especially in the background of competing needs between different health programmes within a country.

2.8 Summary

In this chapter, we had seen dengue emerging as a global pandemic disease. It has become an important public health problem in many tropical and subtropical regions. The official burden of dengue is severely under-reported and under-recognized. In fact, once these official numbers are adjusted for under-reporting, the burden is exponentially raised and appears very distressing to endemic countries. Dengue vector control and prevention is imperative especially when there is the absence of an effective vaccine or definitive curative options for DF/DHF. Among the available options for dengue vector control and prevention, environment control and chemical control has been forefront in many endemic countries. These methods are favoured as it conveys visually and affirmatively to the community that governments and health authorities are combating the disease.

Apart from epidemiological data such as burden of cases and fatalities, cost data function as a creative form of advocacy to convince various stakeholders the astounding effect of dengue to the country's healthcare system. By looking at published cost estimates of dengue in different countries, one critical shortcoming is the lack of vector control and prevention cost. Many studies did not include vector control and prevention cost. Those few available studies had methodology limitations, and the cost data were inferior. Therefore, the estimations of dengue cost burden can only be deduced as incomplete. It is worthwhile to assess the degree of a fraction of curative and preventive efforts from a cost perspective in dengue endemic countries to their overall dengue economic burden. These cost assessments will provide critical feedback to the managerial and operational capacity of the dengue vector control programme. It will encourage policy discussions toward sustained active investments into the dengue public health agenda and promote new research opportunities in alternative technologies for vector control. In this chapter, dengue and its related issues were discussed from the global and regional perspectives. The next chapter will highlight the dengue situation specific to the Malaysian scenario.

CHAPTER 3 : DENGUE SITUATION IN MALAYSIA –THE DISEASE AND ECONOMIC BURDEN AND DISEASE CONTROL PROGRAMME

3.1 Introduction

Before any attempt can be made to estimate the costs of providing the specific public health services, it is important to understand the structure, workflow, and practices of the public health entities that perform dengue vector control and prevention activities in Malaysia. This is achieved through interaction and discussion with various public health officials and the scrutiny of technical reports, protocols, and guidelines available in the public domain. The historical development of Malaysian National Vector Borne Diseases Control Programme will be examined to gain insight from the programme's conception and its evolution throughout the time. The operational structure of dengue vector control and prevention entities within various administrative levels of the Malaysian national programme will be described. The chapter will begin with the epidemiology of dengue in Malaysia in section 3.2 and followed by the dengue case burden to the country in section 3.3. The dengue under-reporting and under-recognition in Malaysia will be discussed in section 3.4. The development history of the Malaysian vector control programme will be described in section 3.5. The programme organization structure and functions of different administrative levels within the MOH will be highlighted in section 3.6. The vector control entity within the LAs is mentioned in section 3.7. The cost burden of dengue to Malaysia will be discussed in section 3.8 and the fragmentary currently available information on costs of dengue vector control and prevention will be described in section 3.9. The chapter will conclude with section 3.10.

3.2 Epidemiology of Dengue in Malaysia

The intricate involvement of host, viral and vector population results in the complex epidemiology of dengue. It is complicated by demographic, economic, behavioural and societal factors. DF used to be a disease of early childhood with less presentation among adults. The illness was initially reported mostly in children aged 2-15 years old. However, there is recent evidence of increasing dengue incidence seen among the older aged individuals(Chareonsook, Foy, Teeraratkul, & Silarug, 1999).

Studies were done in Singapore(Yew et al., 2009), Indonesia(Porter et al., 2005) and Malaysia(Chew MH et al., 2012). These have demonstrated the shift of incidence trend in their respective countries. It has been noted that currently DF mainly involves the young adult population who fall in the age range of 20-29 years old. Mohd-Zaki, Brett, Ismail, and L'Azou (2014) analyzed the Malaysian data on dengue disease and found the number of reported cases of dengue declined in children but was more stable in adults from the year 2000 to 2012. They noted the highest proportion of dengue disease occurred among people aged 10-29 years old(Mohd-Zaki et al., 2014).

There were two studies from the Asia region which described the racial distribution of dengue. One study was conducted over a period of 15 years and reported a significantly higher incidence of DHF among Malaysian men of Chinese ethnic origin as compared to Malays and Indians. Another six-year surveillance study in Singapore revealed the race-specific morbidity rate among the Chinese to be three times that of Malays and 1.7 times that of Indians (Shekhar KC, 1992 and Goh KT, 1997 as cited in Guha-Sapir & Schimmer, 2005).

In term of gender differentiation, dengue was observed more in males than females. Surveillance data from Malaysia indicated a male preponderance among the ethnic Indian and Malay patients, but the ratio was almost equal for those of Chinese ethnic origin (Shekhar KC, 1992, as cited in Guha-Sapir & Schimmer, 2005). The gender preponderance toward males was also observed in other studies in Malaysia (Chew MH et al., 2012; Mohd-Zaki et al., 2014). The authors reasoned that males had the tendency to travel and spend more time outdoors doing work than females. Therefore, the males have a higher risk of exposure to Aedes mosquitoes.

Although there were four serotypes of dengue virus as described previously, the predominant serotype differs from region to region. In Malaysia, the national data showed that the dominant DEN serotypes circulating in the country changed continually during the period 2000 to 2011 from DEN-2 in 2000, to DEN-3 in 2001-2002, DEN-1 in 2003-2005, DEN-2 in 2006-2009 and DEN-1 in 2010-2011 (Arima Y & Matsui T, 2011; Mohd-Zaki et al., 2014). The DEN-4 serotype was observed to be less prevalent as compared to the remaining three serotypes in Malaysia and it constituted less than 20% of the serotypes from 2000 to 2011(Mohd-Zaki et al., 2014).

3.3 Burden of Dengue in Malaysia

Malaysia is a tropical climate country located in SEA region (Figure 3.1). The country has the landmass of 329, 847 square kilometres. South China Sea separates it into two similarly sized regions called Peninsular Malaysia and East Malaysia (Malaysian Borneo). The Peninsular Malaysian region shares land and maritime borders with Thailand and maritime boundary with Singapore, Vietnam and Indonesia. The area called East Malaysia shares land and sea borders with Brunei and Indonesia and a sea border with the Philippines. In 2010, the population of Malaysia was 27.5 mil people(Department of Statistics Malaysia, 2010).

Cases of DF were first described in the northern port city of Penang in 1902(Lam, 1993; Poovaneswari, 1993). Since then, the presence of dengue has been endemic[9] in Malaysia. The first case of DHF was reported in 1962, and a major outbreak of DHF took place in 1973 involving the whole nation(Poovaneswari, 1993). After this, a plan of action was organized for control and prevention of dengue with immediate effect in 1974.

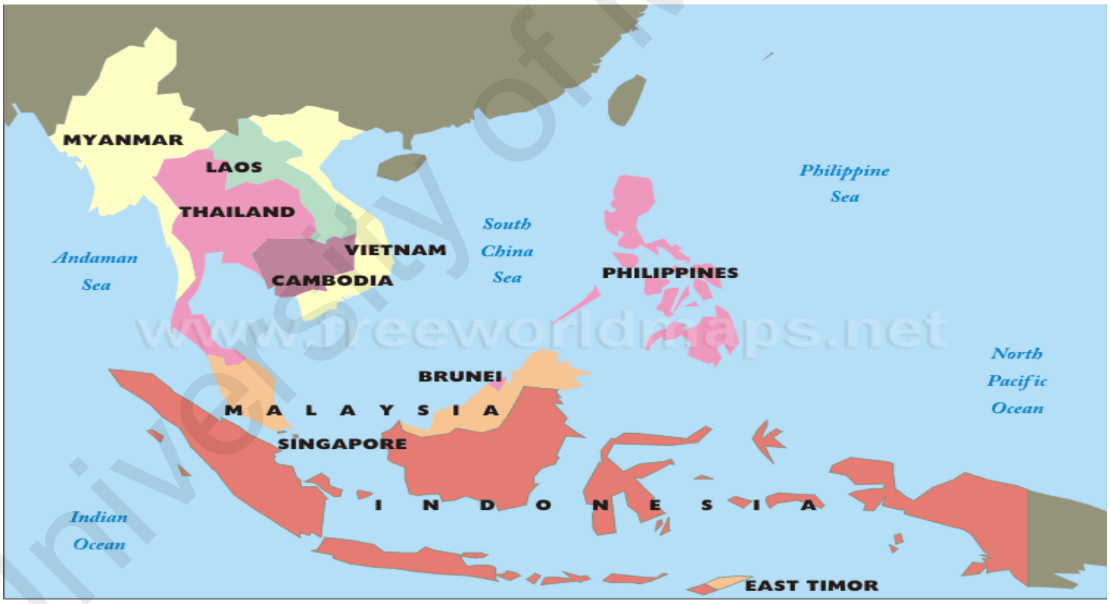

Figure 3.1: Political map of South East Asian region

Source: Free World Maps (2014)

The Destruction of Disease Bearing Insects Act (DDBIA) was introduced in the year 1975 to facilitate legal empowerment to the public sector agencies(Poovaneswari, 1993)

9 An endemic disease is a disease that is always present in a certain population or region

and was enforced throughout the country with effect from August 1982(Seng, 2001). All suspected[10] dengue cases must be notified by telephone to the nearest health office within 24 hours followed by written notification within seven days using the standard infectious diseases notification form (Health 1 Rev.2005). Failure to adhere to this rule is liable to be compounded under the Prevention and Control of Infectious Diseases Act 1988.

Dengue cases were reported predominantly from the more developed and populated regions of Peninsular Malaysia in the early 1970s and by the end of the 70s decade, dengue was reported in both the Peninsular and East Malaysian regions(Lam, 1993). From the 1990s, the incidence of reported dengue cases began to rise dramatically in Malaysia (Figure 3.2).

National and subnational disease burden studies highlight the total number of dengue cases and its pattern to the respective country and its community. It can be used to design specific national health policies and garner support for relevant health policy changes. For the first decade of this century, there had been an annual average of 32,831 reported dengue cases and 85 dengue deaths in the country. Malaysia's annual incidence of reported dengue cases has been high with an average of 124 cases per 100,000 populations in the similar period of 2000-2010. With the recent persistent rise in dengue cases from 2006-2010 (4-year) in Malaysia, the incidence of reported dengue cases has remained high ranging from 148 to 181 cases per 100,000 populations. This period

[10] Clinical diagnosis based upon symptoms and signs are sufficient for suspected dengue cases. Lab confirmation is not necessary.

coincided with a period of rapid and, at times, less organized expansion of urban centres in the country which could have contributed to the high numbers of cases. The annual number of deaths from dengue cases increased from 50 in 2001 to 134 in 2010 giving the average death of 95 cases per year. The case fatality rates were relatively constant from 0.2% to 0.3%, however, except the year 2006 where a high case fatality rate of 0.7% was observed in Malaysia (Figure 3.3).

For the year-2010, there were 46,171 total number of reported dengue cases in Malaysia. The national dengue incidence for Malaysia in 2010 was 162 per 100,000 populations with 134 deaths. Figure 3.4 shows the dengue incidence rate (IR) per 100,000 by respective states in Malaysia for 2010. The state Selangor (IR=306) had the highest dengue incidence followed by Federal Territories of Kuala Lumpur (IR=254) and east-coast state Kelantan (IR=243). States with lowest IR are Labuan (IR=23), Kedah (IR=41) and Sabah (IR=67). In term of dengue-related deaths, concurrent to reported cases, the state of Selangor had the highest (45) number of deaths followed by Sarawak state (14)(Ministry of Health Malaysia, 2010a). Regionally, the west peninsular states of Malaysia were most affected by dengue disease(Mohd-Zaki et al., 2014).

For Malaysia, the 2008 data from the notified infectious diseases database, placed dengue as the seventh biggest cause of reduced survival(Shepard, Lees, et al., 2011). Dengue was seen as the seventh biggest cause of lost life years in males and the fifth in females(Shepard, Lees, et al., 2011). It demonstrates that dengue contributes significantly to reduced life expectancy in Malaysia. From the aspects of DALY, it wass

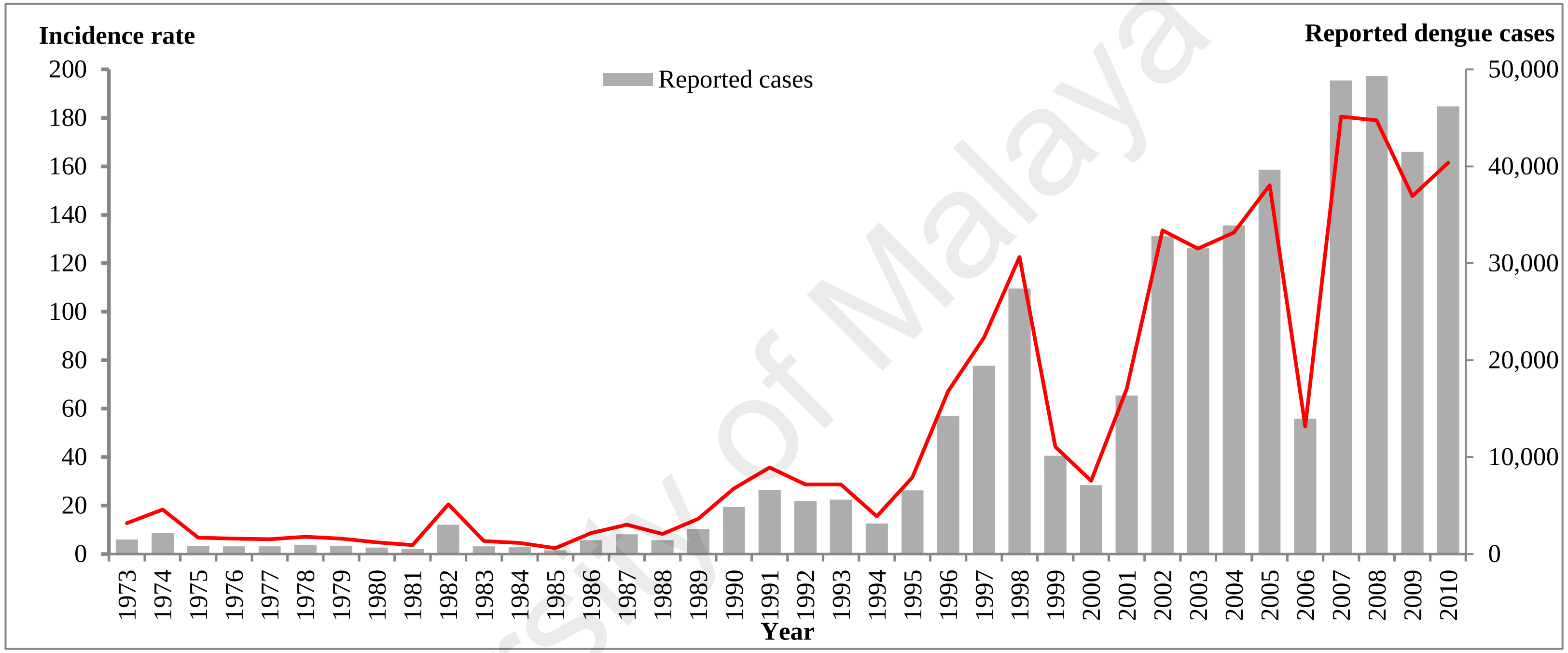

Figure 3.2: The reported dengue cases and incidence rate in Malaysia (1990-2010)

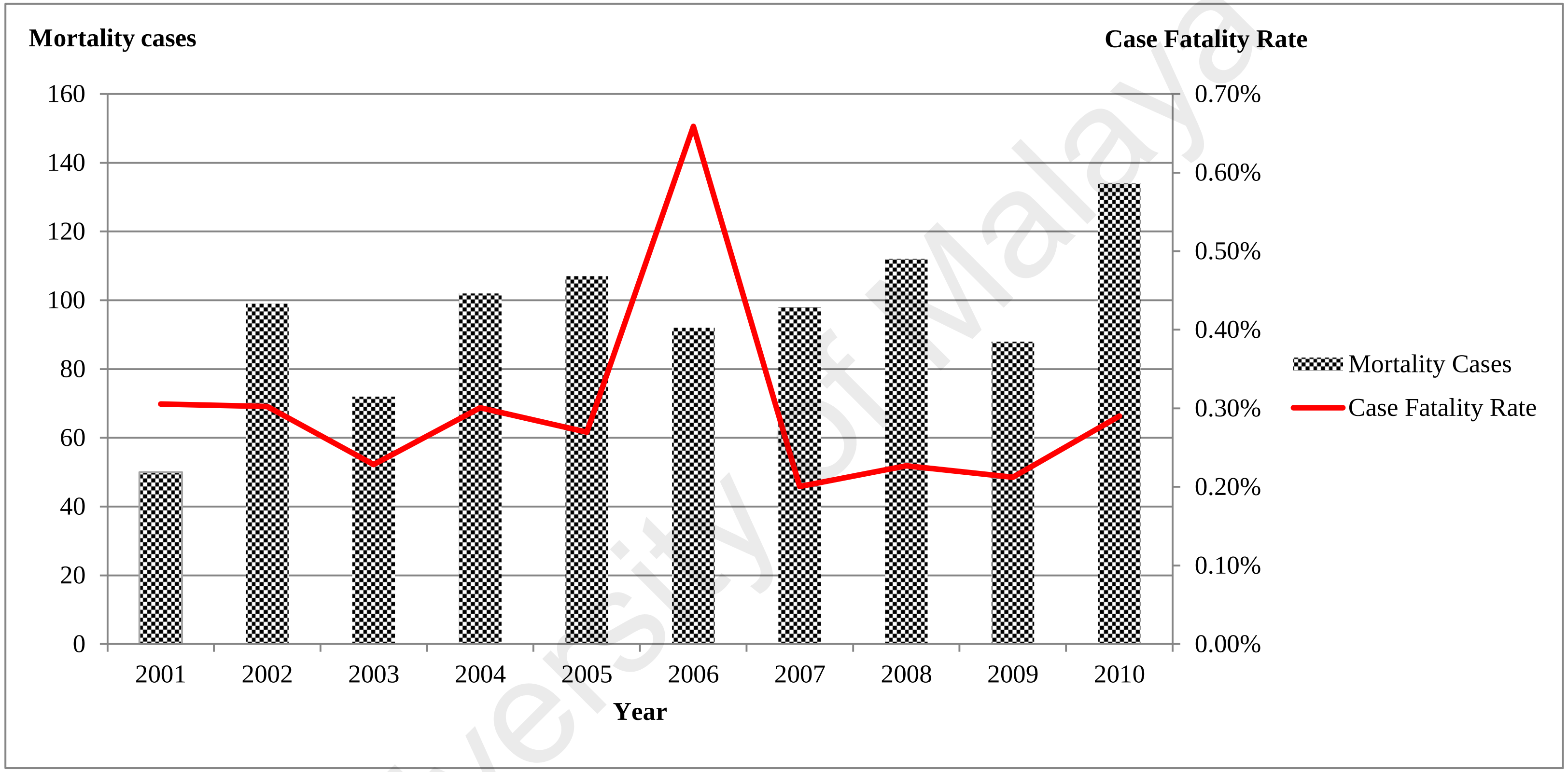

Figure 3.3: The dengue mortality cases and case fatality rate in Malaysia (2001-2010)

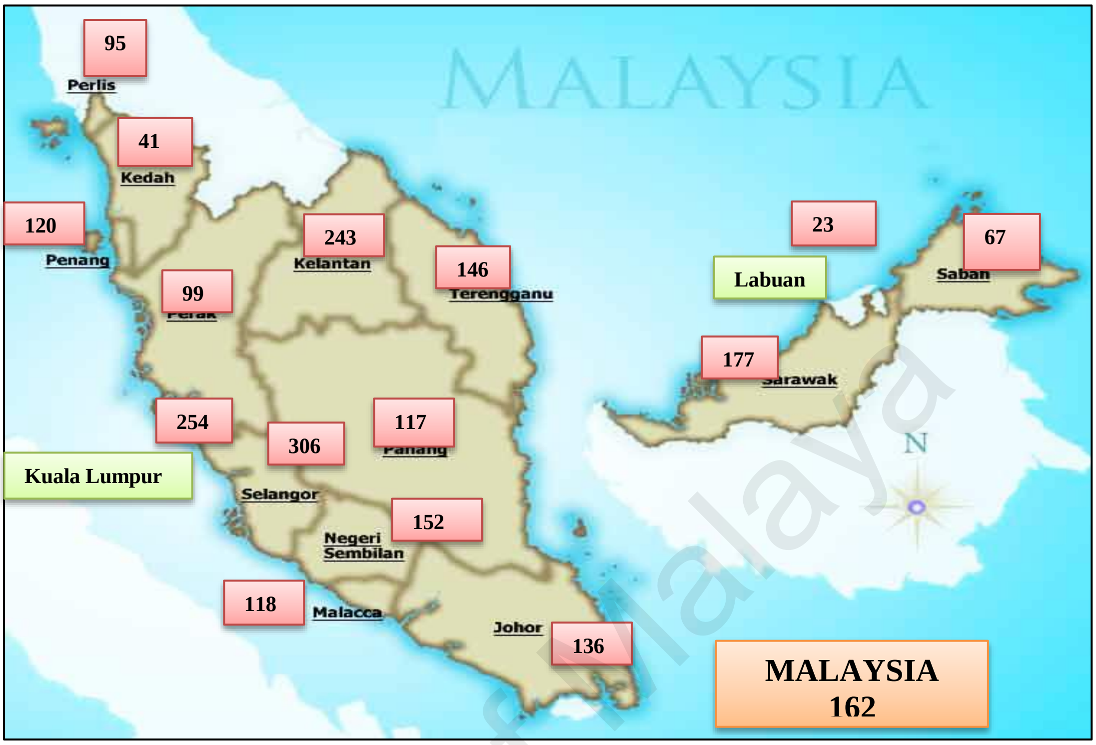

Figure 3.4: The dengue incidence rate (per 100,000 populations) by states for Malaysia 2010

Source: Map of Malaysia with individual States and Federal Territories (green) (Travel Guide Malaysia, 2014)

Number of reported dengue cases in Malaysia by state for 2010 (Vector borne diseases control sector, 2008)

2010 Population Census by respective states in Malaysia (Department of Statistics Malaysia, 2010) ranked number ninth in 2008 (DALY=8,144) as compared to other communicable diseases[11] in Malaysia(Shepard, Lees, et al., 2011). Apart from substantial reduced life expectancy of patients inflicted with dengue, the disease does cause significant reduction in quality of life in patients during the course of their infection(Garcıa et al., 2011; Kularatne, 2005; Lum et al., 2008; Seet et al., 2007).

Malaysia, Lum et al. (2008) performed a quality of life (QoL) study involving both outpatient and inpatient dengue confirmed cases. Although the dengue patients experienced a short duration of acute illness, the disease could have a significant impact on the patient's daily activities, social function, and emotional well-being. The study revealed that QoL during illness episode has been severely affected in all the patients, and it lasted more than 13 days. Garcıa et al. (2011) assessed the sequelae of dengue among dengue confirmed patients in Cuba and found that more than half of the study participants reported having dengue symptoms for two years following hospital discharge. They only assessed adult patients in their study and it would be interesting to know the long-term effects on children and people in younger age group.

Dengue fever is a notably prevalent illness seen worldwide, SEA region as well as Malaysia. Dengue is endemic in Malaysia with high incidence distribution involving the whole country. It even secured the ninth ranking spot among other communicable diseases in Malaysia for DALY burden in 2008 without taking into account the long-term disabilitie caused by a post dengue infection called Chronic Fatigue Syndrome

[11] Septicaemia, Lower respiratory infections, Tuberculosis, Otitis media, HIV/AIDS, Meningitis, Hepatitis B, Other diarrhoeal diseases, Upper respiratory infections, Malaria and Varicella (Chicken pox)

Dengue poses a significant disease burden not only to many countries worldwide but involving regional (WPR and SEA regions) as well as to Malaysia.

3.4 Dengue Under-Reporting and Under-Recognition in Malaysia

Malaysia adopted a passive dengue surveillance system similar to many dengue endemic countries in the world. However, in contrast to its neighbor countries, all DF and DHF cases irrespective of age groups as well as both ambulatory and hospitalized cases are being captured by the national surveillance data. A suspected case that fulfills dengue clinical case definition popularly mentioned in Malaysia as "1 + 2" without a laboratory confirmation is enough to be reported to the nearest district public health department. The "1" denotes the presence of sudden onset of fever for two to five days duration while the "2" refers to the presence of at least two of constitutional symptoms[12]. Such broad presentations of symptoms make the diagnosis of dengue difficult. Moreover, disease notification heavily relies on health care professionals, and there are differences in reporting pattern from public and private health facilities and between an epidemic and non-epidemic periods(Shepard et al., 2012).

The degree of under-reporting and under-recognition of dengue cases in Malaysia was estimated by Shepard et al. (2012) through a method called Delphi process. The authors gathered some dengue-related experts in Malaysia which consist of academicians, hospital clinicians, public health physicians and the private sector. These experts held two rounds of consultations to reach a consensus on the estimation of

[12] Constitutional symptoms for dengue is a broad set of clinical symptoms such as headache, eye pains, muscle pain, joint pain, rash, nose bleed, gum bleed

under-reporting and under-recognition of dengue cases in Malaysia. In the event of insufficient research-based data, the Delphi process utilizes a systematic use of expert knowledge to solve complex issues(Shepard et al., 2012).

Multiple sources of data(Shepard, Lees, et al., 2011) were used in the discussion process. One such source of data was from the FOMEMA system that routinely performs a compulsory medical screening examination for foreign workers in Malaysia. In the year 2009, which was used for reference year by Shepard et al. (2012), the data from FOMEMA system revealed the number of identified communicable diseases that were notified to the MOH are considerably fewer than the actual positive cases screened. The authors illustrated the example of malaria (like dengue, malaria is a common mosquito-borne disease of humans), where the FOMEMA data analysis estimated the degree of underreporting to be eight cases for every one case detected(Shepard et al., 2012). However, the panel of experts did not use these data directly to estimate the underreporting for dengue. Instead, they were presented as evidence of generally underreporting among communicable diseases in Malaysia.

Another source of data used in the consultation was the number of laboratory tests for dengue requested from the private sector in Malaysia. Based on data from Pantai Holdings (owns seven private hospitals nationwide), Shepard, Lees, et al. (2011) then generated a preliminary estimate of the number of dengue cases from the private health care sector. The number of reported dengue cases from public hospitals was readily available from the Ministry of Health Malaysia. Few rounds of the Delphi process of estimation allowed the authors to refine further the estimates of total dengue cases for both private and public health sectors and to determine the proportion of ambulatory and hospitalized cases. The summary of estimated dengue cases by Shepard et al. (2012) are shown in Table 3.1 below.

Shepard et al. (2012) estimated the actual burden of dengue for Malaysia in the year 2009 to be 157,140 cases instead of the 41,454 reported cases from the surveillance data of MOH Malaysia. However, the authors acknowledged that these estimates were probably conservative. When this workshop was conducted in Malaysia, the recent EF estimates from a thorough study in Thailand (EF=8.7) and Cambodia (EF=9.1) (Wichmann et al., 2011) were not available. The Malaysian EF estimates could have been higher than the present one if the Thailand and Cambodia estimates were known to the participants of the workshop(Shepard et al., 2012).

Table 3.1: Estimation of dengue cases in Malaysia using expansion factors (EF) by public and private sectors and treatment setting in 2009

Sector	Hospitalized cases	Ambulatory cases	Overall
Adjusted EFs (combining mean factors, 58% share ambulatory)			
Public	1.30	43.08	2.97
Private	2.45	178.84	5.73
Both	1.65	65.38	3.79
No. of reported dengue cases			
Public	27,955	1,165	29,120
Private	12,105	229	12,334
Both	40,060	1,394	41,454
Adjusted dengue cases using EFs (58% share ambulatory)			
Public	36,341	50,186	86,527
Private	29,658	40,955	70,613
Total	65,999	91,141	157,140
Row (%)	42.0	58.0	100.0

Source: Adapted from Shepard et al. (2012)

Despite the presence of surveillance system in Malaysia, the true burden of dengue cases are found to be under-reported and under-recognized in the country. The actual case burden of dengue estimated by Shepard et al. (2012) to Malaysia is a grave public health issue and warrants an examination of the country's vector control and preventive efforts. The following sections will look at the historical development of the national vector control and prevention programme in Malaysia and the various vector control units by different administrative levels

3.5 Historical Development of National Vector Borne Diseases Control Programme (VBDCP)

There were several disease-specific control and prevention programmes which were vertical programmes implemented by MOH Malaysia namely the National Tuberculosis Disease Control Programme in 1961, the Malarial Eradication Programme in 1967 and the National Leprosy Control Programme in 1969(Ministry of Health Malaysia, 2000). These vertical public health programmes are designed to deliver selected interventions, usually individually tailored with the specialized administration, logistics and delivery mechanisms(Victora, Hanson, Bryce, & Vaughan, 2004). The hierarchical structures in vertical programmes are evident and have clear reporting and growth direction(Gray, 1997).

The Malarial Eradication Programme's (MEP) objectives were to eradicate malaria from Peninsular Malaysia by the year 1982. Malaria is caused by parasites known as the Plasmodium species. The vector responsible for the spread of malarial disease is the Anopheles mosquitoes. However, the control and eradication of malaria could not be achieved within the specified time frame. This was due to developmental activities such as the clearing of vast tracts of jungle, road and dam constructions, mobile indigenous population rooted deep in the Malaysian jungles, the constant movement of the security forces tracking the communist guerrillas and the high movement of people across countries sharing the land borders with Malaysia such as Thailand and Indonesia(Ministry of Health Malaysia, 1981).

The fragmentary disease control and prevention services for malaria were performed by the LAs in the early years. However, due to high incidences of malaria cases in Malaysia during the 1960s till 1980s, the implementation of malarial disease control services were taken over completely by the federal government in 1981 from the LAs. This is due to the inability of the local government to fulfill the expectations and needs of malaria vector control services and the lack of sufficient resources (i.e. human resource, vehicles, and equipment) to implement the programme uniformly nationwide. The MOH, a federal government agency, was then tasked to implement and achieve the objectives of the MEP. The malaria vector control services was consolidated by MOH and integrated with MEP to form the Anti-Malaria subprogramme of Vector Borne Diseases Control Programme (VBDCP)(Ministry of Health Malaysia, 1981). Other mosquito-borne diseases commonly prevalent in Peninsular Malaysia were filariasis with Mansonia and Anopheles mosquito species as vectors, DF/DHF with Aedes mosquito species as vectors and Japanese Encephalitis with Culex mosquito species as a vector. However, due to low incidences of these mosquito-borne diseases at that time, the focus of resources and control efforts were channeled toward controlling the malarial disease from the 1960s till 1990s(Ministry of Health Malaysia, 1980, 1981, 1982, 1983/1984, 1985, 1986, 1987, 1988, 1989, 1990).

A major outbreak of dengue occurred in 1974 which prompted MOH to acknowledge that dengue is a public health problem in the country(Ministry of Health Malaysia, 1980). This is further compounded with increasing trends of disease detections among the local population and endemicity in many regions of the country. . The principle control measures for dengue advocated by MOH centers around environmental control and chemical control measures. The focus of activities was the targetted destruction of mosquito breeding sites through the elimination of artificial water-holding containers, application of insecticide (Abate) by householders, delivery of health education to the local community to increase the awareness and enforcement of the DDBIA 1975 (Ministry of Health Malaysia, 1980). Once a dengue case or a cluster of cases are reported, prompt fogging was carried out periodically for the whole locality(Ministry of Health Malaysia, 1980).

Historically, the responsibility for maintaining hygiene, sanitation and vector control in the towns and urban areas rests with the LAs(Kuppusamy, 2008). Hence, the responsibility of delivering dengue vector control and prevention services to the population had been left under the domain of LA with MOH assisting them occasionally or in the event of an outbreak situation. Unlike the malaria disease control programme, the implementation of dengue vector control and prevention services were never taken over formally by the MOH from the LAs. No major dengue outbreaks were reported in Malaysia from the 1970s to early 1980s, but isolated dengue cases continued to occur. The MOH performed an intensive health education campaign lasting for one month in every three-month intervals with vigorous enforcement of the DDBIA 1975 in selected areas with no dengue outbreaks as a form of preventive measure (Ministry of Health Malaysia, 1981). During the intensive campaign, the MOH enlisted the participation of the LAs in varying degrees especially in vector control activities (fogging) and the enforcement of DDBIA 1975 in areas under the control of respective LAs(Ministry of Health Malaysia, 1981). During this period, significant overlap of dengue vector control and prevention services by two public sector agencies (MOH & LA) had been observed in the country.

A reorganization of structure within the MOH took place in the period of 1981 to 1985 during the fourth Malaysian economic plan and this brought forward the formation of Vector Borne Diseases Control Programme (VBDCP) (Ministry of Health Malaysia, 1981). The formation and development of VBDCP were done in three phases over the duration of five years. Phase one consisted of the formation of Anti-Malaria sub programme that took two years from 1981 to 1982 to organize(Ministry of Health Malaysia, 1981, 1982). During this time, the malaria control services that were initially under the responsibility of local government (LAs) were formally taken over by the central government (MOH)[13]. Once taken over, these services were integrated with MEP to form the consolidated Anti-Malaria subprogramme. This move unified and incorporated the malarial control services into a single central entity under MOH.

Phase two involved the formation of VBDCP, which took two years from 1983 to 1984(Ministry of Health Malaysia, 1983/1984). The new programme scope and activities were expanded to include other common mosquito-borne diseases in Malaysia such as Filariasis, DF/DHF, and Japanese B. Encephalitis. During phase three, the scope of the programme was expanded to include control of more diseases like scrub typhus

[13] Dr Devan Kurup, Assistant Directorof Surveillance, Outbreak and Disaster Management, Ministry of Health Malaysia (personal communication, 6th June 2011)

and murine typhus that was transmitted by mites and fleas(Ministry of Health Malaysia, 1985). The new integrated VBDCP was fully operational by 1985 and MOH explicitly announced that the new programme was aimed to control the vector-borne diseases as one consolidated entity instead of the fractional individual based vector control programme which was tailored for control of only specific diseases in the past (Ministry of Health Malaysia, 1981, 1982, 1983/1984, 1985). Despite this official stand from MOH, there were special exemptions for malaria control services that were still being implemented disease-specific through the Anti-Malaria subprogramme. That decision may be attributed to the high incidences of malaria cases in the country and the priority of the government to implement public health measures to control the disease in Malaysia.

During 1982, a serious outbreak of dengue occurred with a significant number of cases being reported far surpassing the average Malaysian incidence of 6.2 per 100,000 populations since the 1960s. There were a total of 3,006 reported dengue cases with the incidence of 20.5 per 100,000 populations. The 1982 dengue outbreak lasted for three months and accounted for 85% of the national cases reported in that year(Ministry of Health Malaysia, 1982). Both of the public sector agencies (MOH and LAs) intensified the strategies for control and prevention of DF given the epidemic. However, the scrutiny of MOH reports in 1982, 1983 and 1984 did not reveal how the strategies were intensified and to which degree was the cooperation between the public sector agencies. However, judging based on the previous malaria control services experience, the MOH would have taken significant effort and resources to control the dengue cases with minimal input from the LAs[14].

By the year 1985, the VBDCP was monitoring seven vector-borne diseases which are malaria, DF/DHF, plague, yellow fever, Japanese B. Encephalitis, scrub and murine typhus. The 1985 annual report stated that emphasis VBDCP placed is to control of the vector-borne diseases and not the vector population whether it transmits illness or not(Ministry of Health Malaysia, 1985). The statement implied that VBDCP's core responsibilities were only focused towards case surveillance and disease preventive activities such as health educations and campaigns to the communities. Their scope of functions does not involve the regular environmental and chemical control activities that are targetted to keep a low density of the Aedes vector population[15]. However, VBDCP contradicted their official stand and was involved actively to control the Aedes vector population in the year 1986. MOH dengue case surveillance over the years revealed a pattern of four-year peak cycle. A high number of dengue cases with outbreaks had occurred in the year 1974 (3,200 cases), 1978 (929 cases) and 1982 (3,006 cases)(Ministry of Health Malaysia, 1986). From their analysis, MOH had forecasted for another surge of dengue cases and outbreaks for the year 1986. This resulted in MOH taking a lead in implementing dengue vector control activities in Malaysia for that year. Hence, the strategy taken by MOH through full involvement in the dengue vector control and prevention activities had succeeded to contain the dengue cases to 1,408(Ministry of Health Malaysia, 1986).

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[14] Dr Devan Kurup, Assistant Directorof Surveillance, Outbreak and Disaster Management, Ministry of Health Malaysia (personal communication, 6th June 2011)

[15] Dr Devan Kurup, Assistant Directorof Surveillance, Outbreak and Disaster Management, Ministry of Health Malaysia (personal communication, 6th June 2011)

From the year 1987 till 1990, the dengue vector control activities were continued to be delivered by two separate public sector agencies in Malaysia (Ministry of Health Malaysia, 1990). The 1991 annual report documented a total of 5,679 dengue cases (86%) had been reported from areas/localities serviced by the LAs and 949 cases (14%) were reported from the areas/localities serviced by the MOH. From the year the 1990s onward, an exponential rise in dengue cases was observed in Malaysia with an average incidence of 49.1 per 100,000 populations. The high surge of dengue cases resulted in increased responsibilities and large area coverages for the LAs to perform vector control activities. As a result of that, there were significant delays in carrying out fogging activities and premises inspections by the LAs as they lacked sufficient manpower and resources to deliver adequate vector control services to the affected localities(Ministry of Health Malaysia, 1991). As the LAs were unable to meet the operational demands in vector control, these in turn, resulted in more active and vigorous involvement of the MOH in vector control activities to contain the disease transmission. The MOH annual report documented the inability of the LAs to perform adequate vector control activities and outlined specific recommendations to the LAs. Their remedial measures suggested the LAs to increase hiring of workers to perform fogging and to ensure that fogging activities were carried out immediately after a dengue case has been notified(Ministry of Health Malaysia, 1991).

By the late 1990s, the numbers of reported dengue cases in Malaysia continued to rise rampantly. The VBDCP attributed the phenomenon to population growth, industrialization and rapid, poorly planned urbanization(Ministry of Health Malaysia, 1992, 1993). The analysis of DF cases by geographical distribution revealed that it occurred predominantly in the urban population. Two new disease preventive strategies were introduced by the VBDCP between the years 1994 to 1996(Ministry of Health Malaysia, 1994, 1995, 1996). The first approach was named Dengue Free School Programme. The programme targeted school going children and their teachers with the aim to increase their knowledge and awareness towards the dengue illness and Aedes mosquito breeding patterns. Dengue teaching kits were distributed to all teachers who acted as facilitators for the Dengue Free School Programme(Ministry of Health Malaysia, 1995). The package consisted depictions of the mosquito life cycle and a documentary film showcasing the roles of students in dengue prevention activities. The DHDs were tasked to train selected teachers from the schools located in the district. The training consists of actively searching and eliminating all possible breeding sites of mosquitoes within the school compound. All potential breeding sites were taught and shown to the teachers. The teachers were expected to educate and mobilize the students to carry out search and destroy activities in their school compounds. The teacher facilitators were then required to send data from such activities by monthly schedule to the nearest DHD. The VBDCP hoped through the training, and active involvement of school children, positive participation from the community can be elicited once these children bring back these simple dengue disease preventive methods back to their homes.

The second strategy was the introduction of Aedes Free Health Facilities with a focus to intensify dengue preventive activities within the premises of government health facilities(Ministry of Health Malaysia, 1995, 1996). In this strategy, health care workers from public hospitals, community health clinics, and rural health clinics were trained by the DHD to perform search and destroy activities at their workplace. The aim was to instill a clean and Aedes free working environment within the MOH grounds and facilities. Facilitators from MOH facilities were tasked to perform weekly inspections and required to send data from such activities by monthly schedule to the nearest DHD. It was hoped that by MOH taking the lead to promote these practices, other government agencies in Malaysia would join to adopt a similar policy in their respective workplaces. Despite introducing these two strategies, no published studies or subsequent analysis to evaluate the outcome or challenges faced by MOH in the implementation of these programmes were available. Subsequent annual reports of MOH did not elaborate further the progress of these programmes (Ministry of Health Malaysia, 1998, 1999, 2001, 2002).

In the year 1999, VBDCP launched a nationwide dengue disease preventive programme titled as National Cleanliness and Anti-Mosquito Campaign(Ministry of Health Malaysia, 1999). There were intense campaigns in the mass media aimed to increase the knowledge and awareness among all citizens on environmental sanitation and the elimination of mosquito breeding sites. The annual reports did not specify the duration of the programme but positively attributed the reduced dengue cases incidence of 44.3 per 100,000 populations in that year from 122.6 per 100,000 populations in the previous year due to the successful implementation of the said programme(Ministry of Health Malaysia, 1999).

Communication for Behavioural Impact (COMBI) programme was introduced by VBDCP in 2001(Ministry of Health Malaysia, 2001). The objective of the programme was to elicit a sustained community participation in the prevention of dengue. The first step was to engage the village leaders in rural areas and resident associations in urban housing areas. These leaders were briefed on the importance of environmental sanitation and measures to keep their neighbourhood free from potential Aedes mosquito breeding sites. They were tasked to form a committee of volunteers to engage the residents of their respective housing areas. Whenever the DHDs or LAs organized periodical community cleanup activities in their neighbourhood, the committee of volunteers was responsible to elicit maximal mobilization and participation from the local community in the cleanup activities. A pilot programme was initiated in the southernmost state in Malaysia called Johor and the programme subsequently expanded to involve more states in Malaysia including Negeri Sembilan, Pahang, Selangor, Perak and Kedah(Ministry of Health Malaysia, 2002, 2004).

During this period, another community participation effort was advocated by the VBDCP. This effort was termed as Community Fogging (COMFOG)(Ministry of Health Malaysia, 2002, 2004). It encouraged the involvement of the community volunteers in fogging activities. Fogging equipment was bought through public donations or contributions from the local parliamentary or state representatives. These community volunteers were then encouraged to perform periodic fogging activities in their neighbourhood as a form of preventive measure against dengue. However, the implementation of this programme had its challenges. The choice of insecticides, the dilution ratio of fuel to insecticides, the training of volunteers to operate fogging equipment and the systematic method of spraying insecticide fog demanded a high degree of technical expertise. Moreover, for an effective fogging activity, the volunteers required consistent training and supervision by the MOH personnel. The annual reports did not elaborate the specifics of COMFOG implementation or the challenges faced at the community-level and the sustainability of the said community programme was highly doubtful. By the end of the year 2004, the VBDCP concluded that dengue cases continued to rise markedly in Malaysia due to public apathy towards environmental sanitation and the unresponsiveness of the community to eliminate potential Aedes mosquito breeding sites in their neighbourhood (Ministry of Health Malaysia, 2004).

From the year 2004 onwards, the MOH continued its active role in the implementation of dengue vector control activities in Malaysia (Ministry of Health Malaysia, 2004, 2005, 2006, 2007, 2008a, 2009a). As the responsibilities increased for MOH with larger service area coverage, MOH ultimately became the primary implementers of dengue vector control and preventive activities in majority of the districts in Malaysia. As a reactive measure, the central government continued to provide the MOH the human resource personnel, technical expertise and the resources (i.e. vehicles, equipment, and pesticides) required for the operational demands of dengue vector control and prevention activities in Malaysia. Such phenomenon was clearly against the policy declared by the MOH in early years that distinctly mentioned the LAs as the principal players and dominant service providers to perform dengue vector control and prevention activities to the general population.

In the past 50 years, Malaysia has faced increasing burden of dengue. The number of dengue cases reported in the country in the last 5-years are by far many times higher than those for other known vector-borne diseases in Malaysia such as malaria and chikungunya(Ministry of Health Malaysia, 2008b, 2009b, 2010b). Rapid industrialization and urbanization of cities in Malaysia, increased population densities in urban localities and public apathy in environmental sanitation has contributed to the rise of dengue cases in the country. As such, keeping to the demands of healthcare and in response to the public call for action, the vector control programme in Malaysia has shifted its focus and responsibilities primarily to the control and prevention of dengue whereas previously it was for malaria. MOH has become the primary public sector agency delivering dengue vector control services to the communities in Malaysia with minimal assistance from the LAs. The least and inconsistent participation from the LAs in dengue vector control and prevention activities are compounded by resource limitations and lack of expertise as compared to MOH[16]. Currently, looking from the perspective of service providers, there appears a significant overlap of function between two public sector agencies namely the MOH and LAs. The dual delivery system practiced in Malaysia may have cost implications in term of cost efficiency to the country. The next section will describe the organization structure and the function of dengue vector control entities within the MOH and LAs.

3.6 Ministry Of Health Malaysia (MOH)

MOH of Malaysia is the branch of federal government responsible for delivery of healthcare services, public health services, pharmaceutical services, research and technical support and food safety and quality services to the Malaysian population (Figure 3.5). The public health services have four major divisions namely the Disease Control Division, Family Health Development Division, Health Education Division and Nutrition Division (Figure 3.6). The Disease Control division has four sectors responsible for the public health programme and control measures of major communicable diseases (Figure 3.7). The four sectors are tuberculosis and leprosy

[16] Datuk Seri Dr Hasan Abdul Rahman, Health Ministry Director General of Malaysia (personal communication, 10th May 2010)

disease control sector, HIV/sexually transmitted infections control sector, zoonotic diseases control sector, vector-borne diseases control sector and vaccine preventable/food and water borne diseases control sector. This federal department (FHD) is supported by state health departments (SHD) which in turn are supported by DHDs. The three levels of the MOH (FHD, SHDs, and DHDs) have similar organizational structures, with units to administer major health programmes replicated at each level of the MOH. However, departments at different levels of the MOH perform different functions.

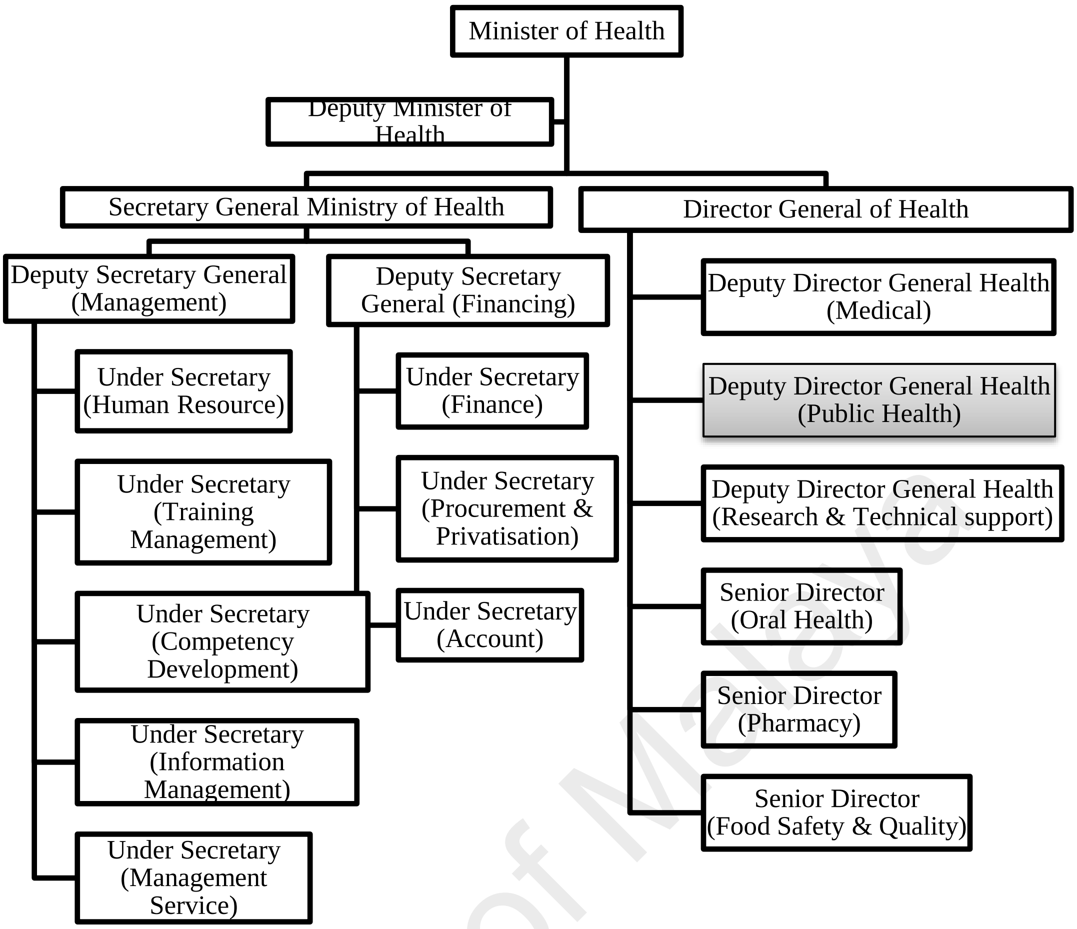

Figure 3.5: Organization chart of MOH

Source: (Ministry of Health Malaysia, 2010a)

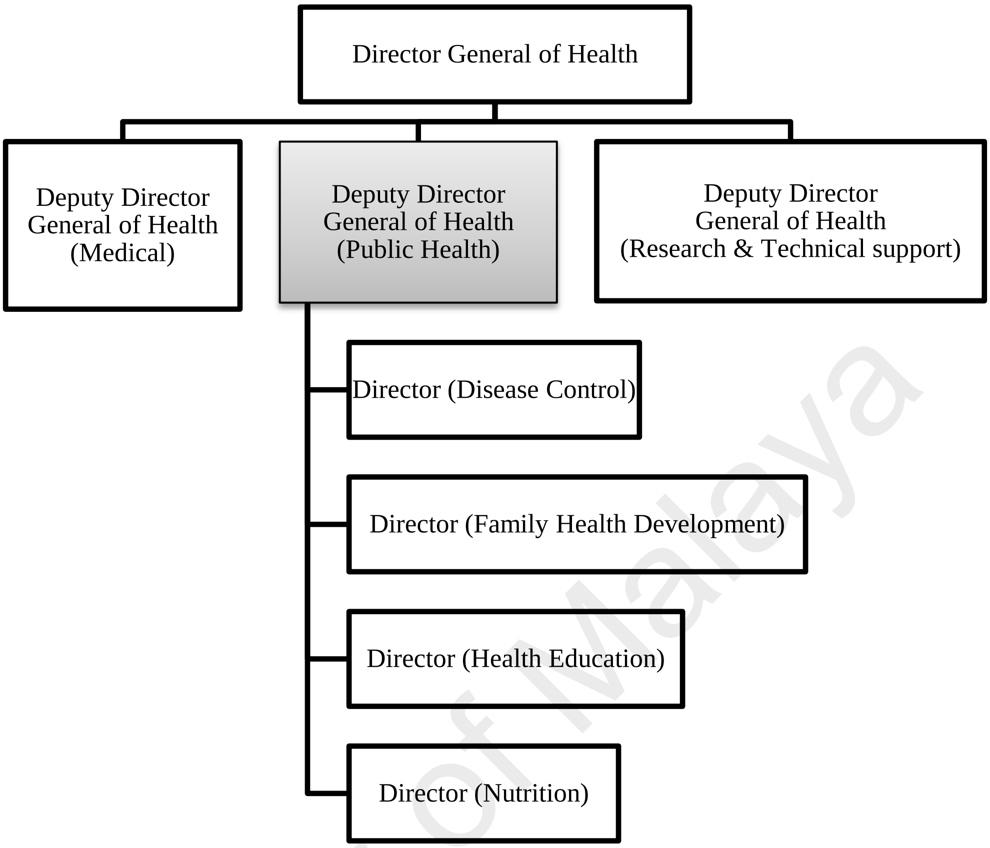

Figure 3.6: Organization chart of Public Health Services

Source: (Ministry of Health Malaysia, 2010a)

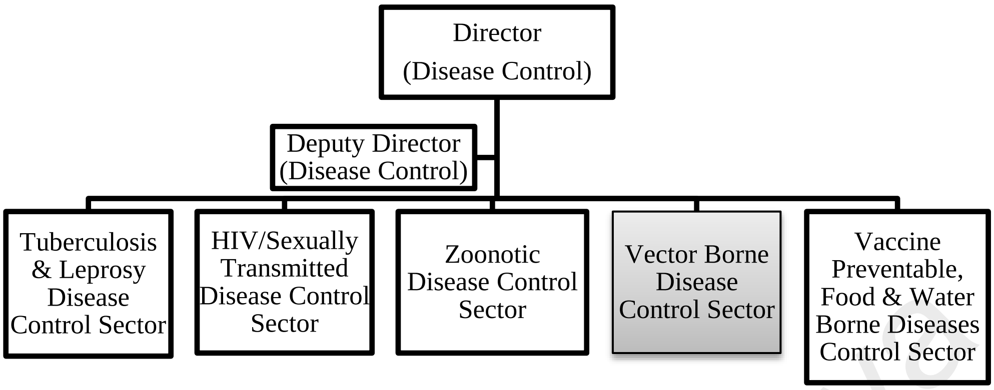

Figure 3.7: Organization chart of Disease Control Division

Source: (Ministry of Health Malaysia, 2010a)

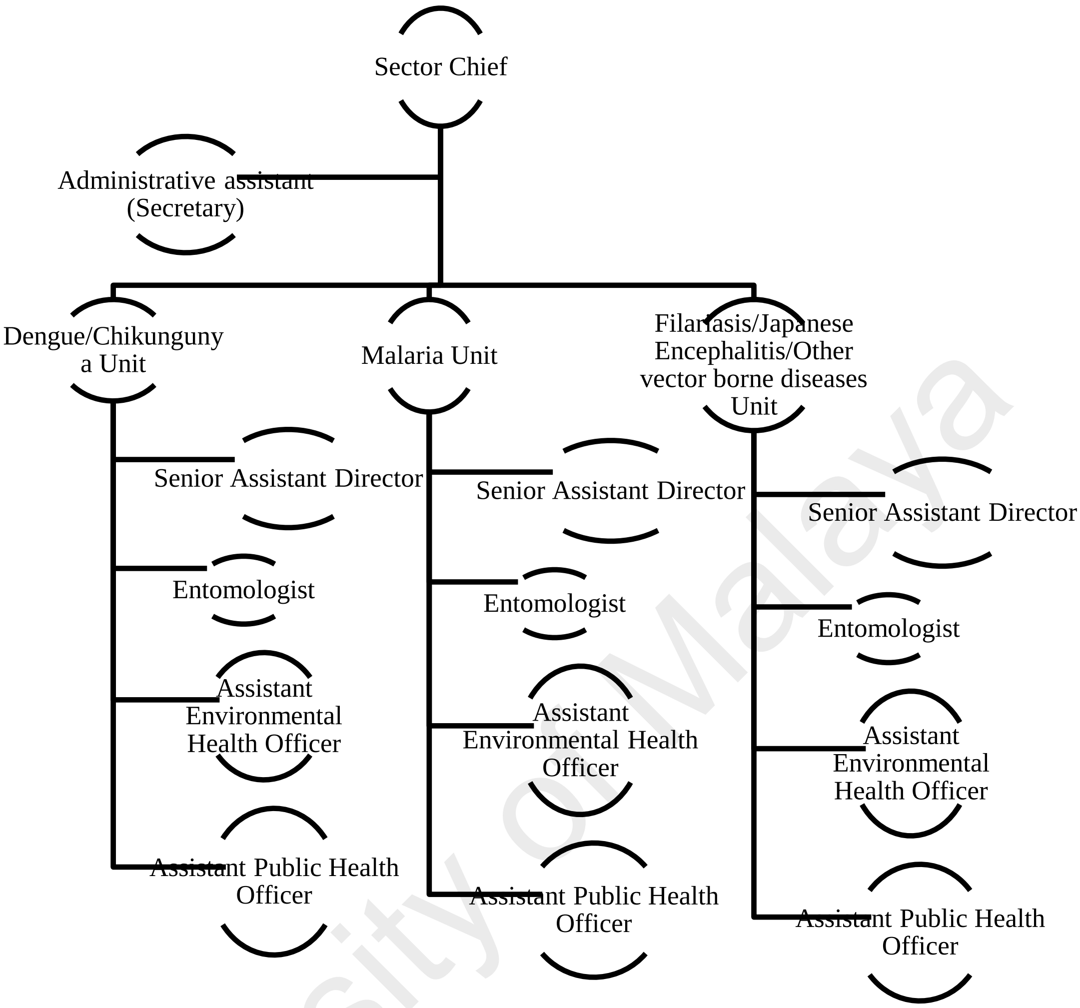

Figure 3.8: Organization chart of Vector Borne Diseases Sector

3.6.1 Vector-Borne Diseases Control Sector (FHD)

The MOH vector-borne diseases sector has three units namely the Dengue/Chikungunya unit, Malaria unit and other vector-borne diseases such as filariasis, Japanese b. Encephalitis, scrub typhus, and murine typhus are grouped into the third unit. The organizational chart of vector-borne diseases sector is depicted in Figure 3.48. The vector-borne diseases control sector of FHD handles macro-level administrative functions such as policy setting, programme structure and development, budget allocations, services and facility planning[17]. Although the vector-borne diseases control sector is also responsible for the control of malaria, chikungunya, Japanese encephalitis, plague, yellow fever, filariasis and other vector-borne diseases, due to low incidence or absence of these other diseases(Ministry of Health Malaysia, 2008b, 2009b, 2010b), this programme focuses overwhelmingly on the control of dengue.

The central government is committed towards dengue control and prevention programme, and this is demonstrated through a regular dengue agenda discussion in the National Cabinet Committee for cleanliness and health. The cabinet through a memorandum from the Minister of Health on 23rd August 2006 had approved Dengue Prevention Activities Enhancement Programme at the national level for five years (2006-2010) with a budget allocation of Malaysian Ringgit (MYR) 50 mil. The purpose of the budget approval among others was to increase human resource personnel in MOH to assist the LAs in dengue control and prevention activities as well as to develop and execute programmes designed to involve community participation in dengue vector control activities.

[17] Dr Chong Chee Keong, Sector Chief of Vector Borne Diseases Control Sector in Ministry of Health Malaysia (personal communication, 10th June 2011)

The Dengue Prevention and Control Strategic Plan 2009-2013 were prepared by the vector-borne diseases control sector of FHD with the primary goal to reduce the burden and death related to DF/DHF. The strategic plan aimed to decrease the number of reported dengue cases by 10% annually. The plan targeted to achieve dengue outbreak locality control within the period of two weeks from the onset of the outbreak. The strategic plan also outlined to achieve a case fatality rate for dengue not more than 0.2% with a 50% annual reduction in dengue-related mortalities. The vector-borne diseases sector had developed several key performance indicators for the control and prevention of dengue in Malaysia. These indicators are used to guide and establish the performance standard of the dengue vector control units at the district level.

Table 3.2: National dengue key performance indicators

No.	Key performance indicators	Target (%)
1	Number of registered cases that fulfills dengue case definition	100
2	Number of registered cases confirmed through IgM serological test	70
3	Number of notified cases detected by primary clinic	85
4	Number of registered cases detected within three days after onset of symptoms	85
5	Number of registered cases where fogging activities were carried out within five days after onset of symptoms	85
6	Number of outbreak localities controlled within two weeks	
7	Percentage of reduction in annual registered cases	10
8	Percentage of reduction of annual outbreak localities	25

The FHD functions as the command center for national surveillance activities in Malaysia. A team of officers will receive daily surveillance data from the SHDs. These surveillance data will be checked, verified and analyzed by technical officers. Daily single case vector control activities and outbreak control activities will be reviewed and analyzed collectively from all the states. A national dengue report will be prepared daily and discussed by a team of technical officers, which consists of a public health physician, entomologist, and environmental health officers. Other than the daily national surveillance duties, the Vector Borne Diseases Control Sector of FHD executes predominantly macro-level administrative functions related specifically to vector borne diseases such as national policy setting, national programme development, national budget allocation, funds and resources distribution, vector control services planning and development. The FHD oversees the duties of the Vector Borne Diseases Control departments of SHDs and offers policy and technical guidance to them.

3.6.2 State Health Departments (SHD) Vector-Borne Diseases Control Unit

Malaysia is a federation of 13 states and three federal territories. The organizational chart of SHDs is depicted in Figure 3.9. The SHDs handle the overall implementation of policies and programmes related to vector-borne diseases in their states/federal territories. SHDs are also responsible for staff training, provision of technical inputs/advice, budget allocations and distributions to the districts, resources distribution and vector control facilities planning for the districts[18]. The SHDs functions as a command center and are involved in surveillance activities for the districts located within each state. The SHDs will monitor dengue outbreaks[19], uncontrolled outbreaks[20] and hotspot[21] areas in the districts. A team of SHD officers will receive daily surveillance data from the districts. These surveillance data will be checked, verified and analyzed by technical officers. Daily vector control activities and outbreak control activities will be reviewed and analyzed collectively from all the districts. The dengue

[18] Dr Venugopalan K. Balan, Senior Assistant Director of Selangor State Vector Borne Diseases Control Department (personal communication, 23rd June 2011)

19A dengue outbreak which lasts within one incubation period i.e. two weeks duration

20 A dengue outbreak which lasts for two incubation period i.e.four weeks duration

21 A dengue outbreak which lasts for more than two incubation period i.e. more than weeks duration

state daily report will be prepared and discussed by a team of technical officers at the SHDs. The team consists of public health physician, entomologist, and environment health officers. The organizational chart of the SHDs vector-borne diseases control unit is depicted in Figure 3.10.

3.6.3 District Health Department (DHD) Vector-Borne Diseases Control Unit

There is a total of 140 administrative districts in Malaysia for the year 2010. Each administrative district has a health department referred to as the District Health Department (DHD). The organizational chart of DHDs is depicted in Figure 3.11. The DHDs deliver primary healthcare services as well as health promotions and public heath preventive services to the communities. The DHDs are directly responsible for providing dengue vector control and prevention services to the communities in each district.

Malaysia's passive surveillance system will require medical doctors to notify the nearest DHD of suspected DF/DHF cases within 24 hours of encountering such cases. Once the patient's particulars are received from the doctors or nursing staff from clinics and hospitals, the district public health officers will investigate the said case. Case investigations involve officers eliciting further information from the notified patients either through a telephone call (if the patient treated as an outpatient or discharged from medical facility) or by visits to the hospital wards where the patient is hospitalized. The notified patient will be interviewed to gain critical case histories such as date of symptoms onset, verification of home/work/school addresses, occupation, and recent outdoor travel. All notified dengue cases are required to be investigated within 24 hours from the time the notification was received. Once all these information has been obtained and verified, the case details will be presented to the district epidemiological health officer. Cases that fulfill dengue clinical definition with positive history will then be registered for control activities.

A team of officers from the DHDs will proceed to perform premises inspections and larviciding activities around the areas of the notified case. Both the residential and work/school areas will be covered up to the extent of 200 meters radius from the index premise[22]. During the premises inspection, if any breeding sites were identified, officers will proceed to look for dengue larvae/pupae[23] in the water holding containers. Once dengue larvae/pupae were found, the premise owners will be issued notices of impending summon. The officer will bring the preserved[24] larvae/pupae back to the health office, and identification will be made using light-assisted microscopes by a trained officer in mosquito larval identification process. For those larvae/pupae positively identified as Aedes aegypti or Aedes albopictus, a Malaysian Ringgit (MYR) 500 penalty under the DDBIA 1975 will be issued to the premise owner. During the premises inspection, if the officers found any buildings with potential breeding sites (water holding containers), they will issue a work order notice under the DDBIA 1975. The notice will have specific cleaning instructions to the premise owner and are required to perform the said cleaning instructions within seven days. On the eighth day, the officers will return to the said premises to conduct a repeat inspection. If the premise

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[22] The residential/work/school addresses of the patient notified as suspected DF/DHF

[23] Aquatic breeding phase of Aedes mosquitoes

[24] The larvae/pupae found during premise inspections will be preserved in a small bottles containing alcohol solution as a fixating agent

owner failed to obey the cleaning instruction, then the owner is liable for a fine of MYR500 or will be taken court action. Such notices are usually issued to business premises and construction sites that have plenty of potential water holding containers and pose a high risk for Aedes mosquito breeding sites.

Fogging activities such as thermal fogging and ULV fogging will be performed in the evenings/early dawn[25]. Fogging activities concentrate on the residential and work/school areas of the notified cases. It is done covering up to 200 meters radius area from the index premise. Health promotion, education activities and active case detections[26] will be performed simultaneously in each household that was visited during the premise inspections session. Public health announcements are made in the residential/work/school areas before fogging activities.

In the event, there is an outbreak[27]of dengue, the premises inspection, and fogging activities will be expanded to include 400-meter radius area from the index premise. Banners and buntings displaying hazards of DF/DHF as well as notifying the population of the dengue outbreak situation will be put up in strategic areas around the outbreak localities. The resident associations and village heads will be engaged to mobilize the local community for an immediate clean-up session within a week from the date outbreak were declared.

[25] Fogging activities are done either in the evenings from 6pm-8pm or early dawn between 5am-7am because that is the prime time for Aedes mosquitoes to seek blood meal.

[26] The officers will interview household occupants during premise inspection to elicit any symptomatic individuals and if anyone with positive symptoms is found, a memo will be given to the individual with specific instructions to the nearest health clinic. Those presenting to the health clinic with the memo will be investigated by the medical doctor with a high degree of dengue suspicion.

[27] An outbreak of dengue is defined as the occurrence of two or more cases within a 200 meter radius

The DHD also perform entomological risk assessments and ovitrap studies in addition to vector control activities. The entomological indices such as Aedes index[28], Breateau index[29], and Container index[30] are used for risk assessments and vector control activities will be stepped up if those indices are found to be high. Ovitrap cup is a small, black coloured cylinder with a strip of filter paper submerged into the water in the cylinder. The mosquitoes will be attracted to the black coloured cups and lay its eggs. After a period, these cups will be collected and the mosquito eggs found on the filter paper will be examined. It can detect Aedes mosquito populations and serve as an early warning signal for potential dengue outbreaks.

A team of officers will monitor daily surveillance data received from the hospitals and health clinics from various localities within a district. These surveillance data will be verified and analyzed by technical officers in the DHD. Daily vector control activities and outbreak control activities in the localities will be examined. A report will be prepared daily by a team of technical officers at the DHDs. The team consists of public health physician/medical doctors, entomologist, and assistant environment health officers. The organization chart of the DHD vector-borne diseases control unit is depicted in Figure 3.12.

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[28] Percentage of houses infested with mosquito larvae/pupae among the total number of houses examined

29 Percentage of positive containers per 100 houses inspected

30 Percentage of water holding containers infested with mosquito larva/pupae

The MOH VBDCP is a vertical programme (Gray, 1997; Victora et al., 2004) with different levels of administrative functions. The federal department (FHD) is supported by the state departments (SHDs) and in turn backed by the district departments (DHDs). Each level of the administrative units has its specific roles and defined functions. Each administrative levels of MOH are supported by relevant human resource personnel and highly trained staff. The dengue vector control and prevention strategies implemented by the MOH at each administrative level are guided by officers with technical expertise (public health specialists, entomologists and environmental health officers) with clear guidelines and operating protocols. This is possible because the central government has provided MOH with the resources and capacity development opportunities to function as the primary workforce to execute dengue vector control and prevention activities in Malaysia. Dengue is recognized as a grave public health concern in the country and the national dengue vector control programme led by the MOH involves contributions from all levels of government – from the federal to the state and district level agencies. The next section will describe the administrative setup of the LAs.

3.7 Local Authorities (LAs)

The LAs[31] are a public sector agency. The role of these agencies is to provide urban services to the communities in Malaysia. Examples of urban services are maintenance of township, roads, street lights, drains, the collection and disposal of solid wastes including sewerage, trimming of trees and grass cutting, landscaping and beautification, licensing of hawkers and businesses, control of building plans and advertisements,

[31] The term 'local authority' is sometimes used interchangeable with the term 'local government'. Both these terms describe a public sector agency that provides urban services to the communities.

vector control, maintenance of public recreation facilities, issuance of pets licensing, maintenance of public toilets, car parks and markets.

Malaysia has a three-tier hierarchy system of government namely the federal, states and LAs. LA is the lowest public sector agency of the system(Kuppusamy, 2008). The constitution stipulates the LAs to be under the direct responsibility of the respective state governments. A central government agency named the Ministry of Housing and Local Government (MHLG) oversees the affairs of LAs in Malaysia, but its influence is only through nominal financial grants, and there is no direct control over them. The LAs are only answerable to their respective state governments.

Each town, cities and big cities have their own LA. These LAs are categorized as district councils, municipal councils, city councils or city halls. They are categorized based on a set of parameters that are the size of the population the agency serves, the annual income generated, the infrastructure management, the administration centre and financial management. There is a total of 151 LAs in Malaysia(Ministry of Local Government & Housing, 2010). Each of the districts has a minimum of one LA to a maximum of three LAs. The organization chart of the LAs is depicted in Figure 3.13.

Each LA has a vector control unit. The organization chart of the vector control unit is depicted in Figure 3.14. The core function of the unit is to deliver specific dengue vector control services to the general community the LA serves[32 33 34 35]. The DHD will receive all dengue notification through the passive surveillance system. Once a notified case is received, the DHD team will investigate and verify the suspected dengue case. Based on the residential/work address, the case particulars will be communicated to the corresponding LA.

The LA team will proceed to perform environmental control method through premises inspections and larviciding activities around the areas of the notified case. However, due to limited workforce, the area coverage will be less and not as extensive as the DHD vector control teams who are required to cover up to 200 meter area radius from the index case house. Fogging and larviciding operations will be performed either by their in-house team or in certain LAs the services will be outsourced to private companies. Apart from these activities, few other urban services such as solid waste management, drainage cleaning and grass cutting are also outsourced. The intention of outsourcing is to reduce the need for the LAs to maintain a large workforce, and not many employees will be required to supervise, monitor and enforce LA functions in general(Kuppusamy, 2008). The aim of the outsourcing process is to lessen the burden faced by the LAs. However, the area coverage for chemical control by the outsourced

[32] Mazlan bin Mohd Nor, Senior Assistant Environmental Health Officer, Health Department, Subang Jaya Municipal Council, Petaling district, Selangor (personal communication, 2nd August 2012)

[33] Nur Hellena Ngabong bte Abdullah, Senior Assistant Environmental Health Officer, Health and Licensing Department, MelakaHistoric City Council, Melaka (personal communication, 5th April 2013)

[34] Zulkifli bin Ariffin, Senior Assistant Environmental Health Officer, Health Department, Selayang Municipal Council, Gombak district, Selangor (personal communication, 10th April 2013)

[35] Nurhanani binti Ariffin, Assistant Environmental Health Officer, Health Department, Batu Pahat Municipal Council, Batu Pahat district, Johor (personal communication, 28th August 2013)

companies is not clearly defined by the LAs. The fogging coverage is acknowledged not as extensive as compared to the DHDs vector control teams[36]. Moreover, there is no supervision from technical officers or the presence of quality assessments to determine fogging effectiveness using entomological studies.

Existing legal frameworks for the enforcement power among the LAs vector control units are the Local Government Act 1974, Environmental Quality Act 1974, Streets, Drainage and Building Act 1976 and Town and Country Planning Act 1976[37]. Although there is sufficient and vast legislative authority within the LAs, they are not actively enforced as compared to the DHDs using the DDBIA 1975[38] [39].

Over the years, lack of infrastructure, inefficient institutional setup and weakness in financial and technical resources(Omran, Mahmood, Abdul Aziz, & Robinson, 2009) has led to an inadequate and inefficient provision of services at various stages by the LAs vector control units[40]. Over the year, many of the countries in which vector-borne diseases (e.g. malaria, dengue) are endemic, have undergone health services reforms through the process of decentralization for decision making and resources allocation(World Health Organization, 2012a). These improvements are implemented at

[36] Noruzana binti Rozaiman, Assistant Environmental Health Officer, Urban Services and Health Department, Kajang Municipal Council, Hulu Langat district, Selangor (personal communication, 16th July 2013)

[37] Dr Roslan bin Mohamad Hussin, Medical Officer, Health Department, Subang Jaya Municipal Council, Petaling district (personal communication, 2nd August 2012)

[38] Nur Hellena Ngabong bte Abdullah, Senior Assistant Environmental Health Officer, Health and Licensing Department, Melaka Historic City Council, Melaka (personal communication, 5th April 2013)

[39] Zulkifli bin Ariffin, Senior Assistant Environmental Health Officer, Health Department, Selayang Municipal Council, Gombak district, Selangor (personal communication, 10th April 2013)

[40] Dr Venugopalan K. Balan, Senior Assistant Director of Selangor State Vector Borne Diseases Control Department (personal communication, 23rd June 2011)

the most appropriate lower level of administration responsible for delivery of vector control and prevention activities to the general population. It involves the process of transferring the responsibility for planning, budgeting and implementation of selected functions from the central government i.e. the MOH to the LAs. It is high time for Malaysia to empower the LAs functioning in urban and semi-urban localities adequately with the required technical expertise and resources for dengue vector control and prevention activities. From the legislative point of view, vector control is under the jurisdiction of the LAs and hence a full transfer of responsibilities from the MOH to the LAs especially in urban areas should be the agenda in the near future. The vector control and prevention services delivery by two separate public sector agencies, namely the DHDs and LAs may appear redundant with overlapping functions and responsibilities between the service providers. There is also a high possibility of duplication of vector control activities in certain areas/localities among the agencies. All these elements may lead to negative impact in term of cost efficiency of service delivery among the public sector agencies in Malaysia

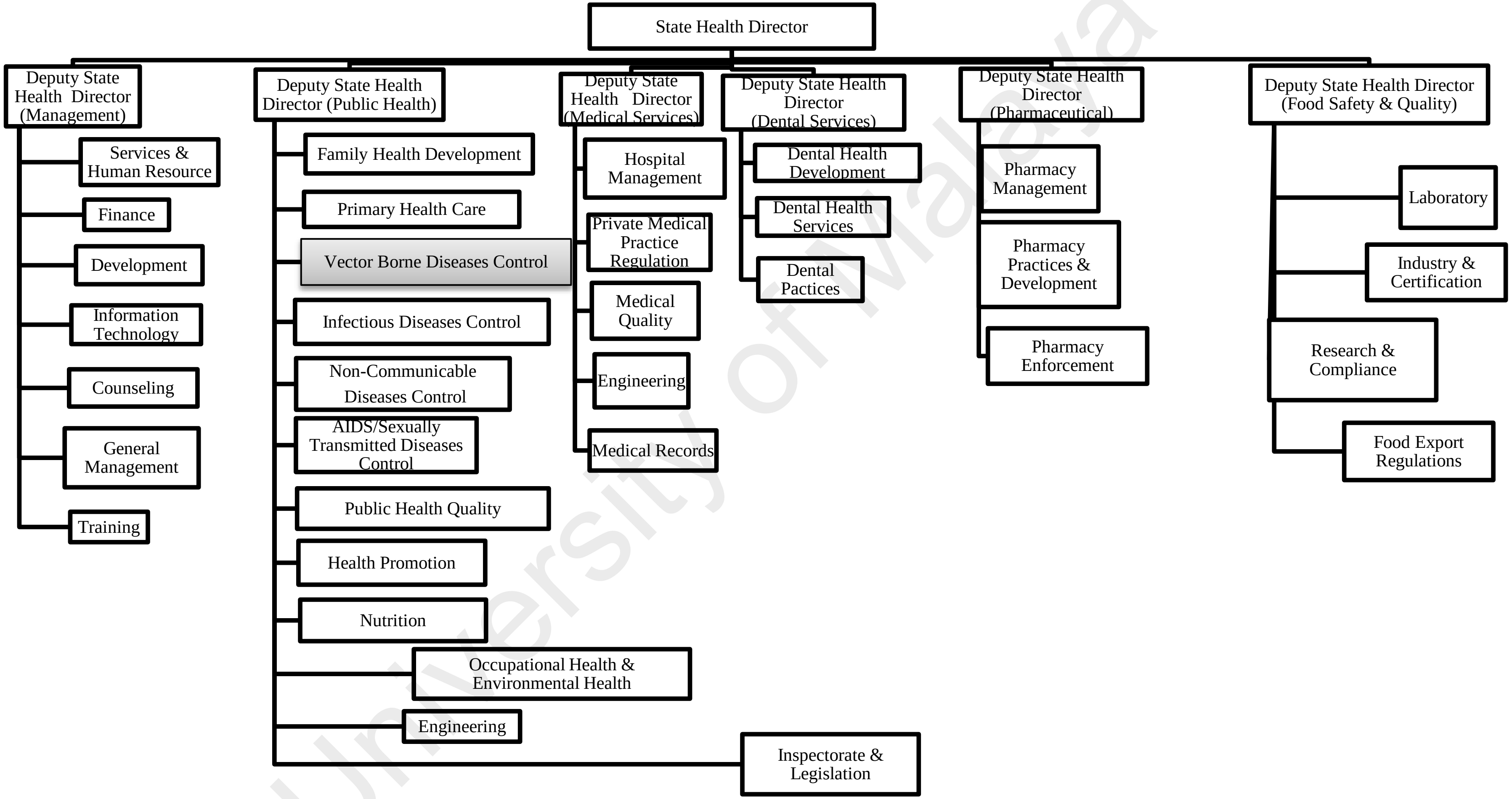

Figure 3.9: Organization chart of SHD

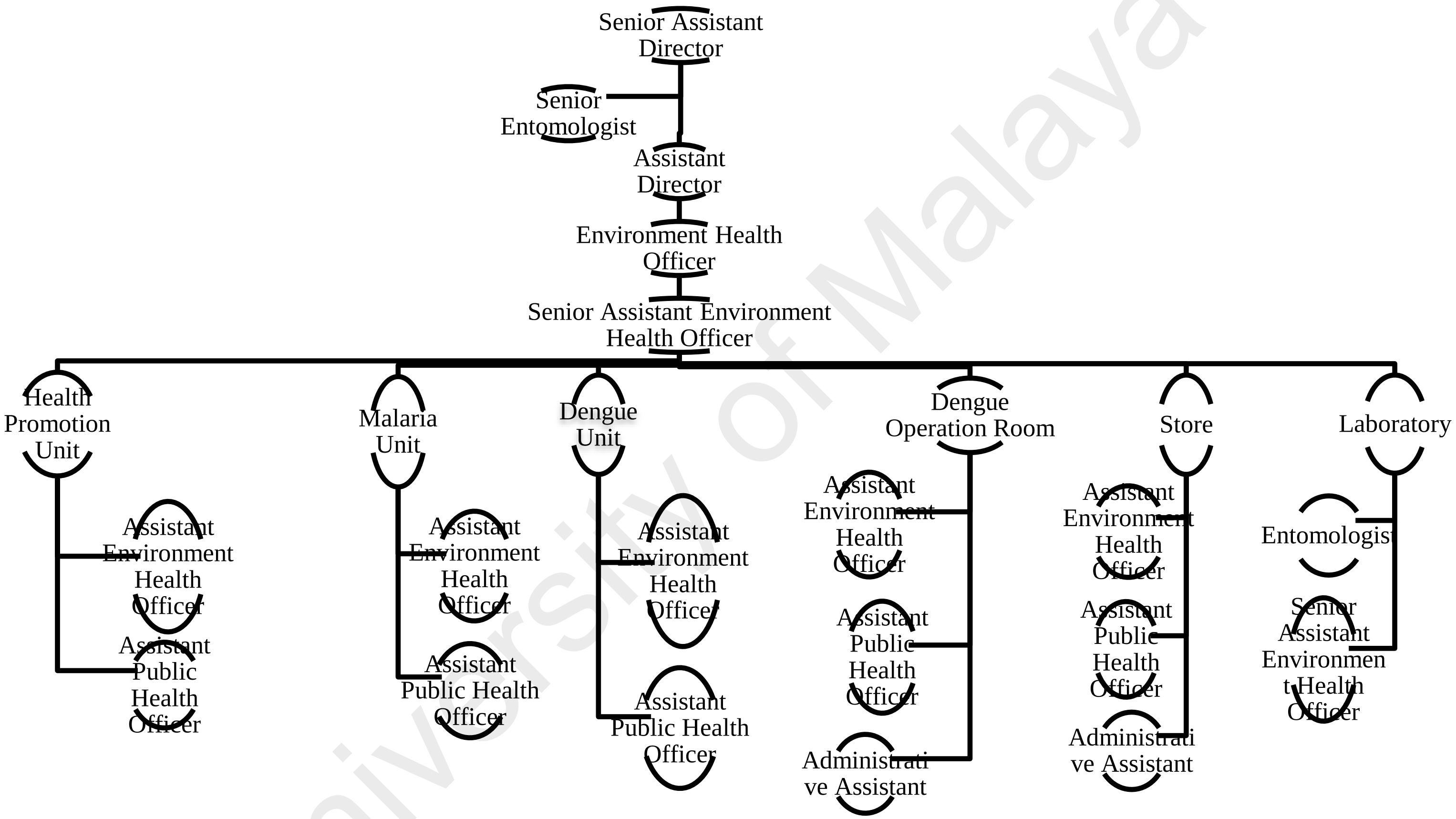

Figure 3.10: Organizational chart of SHDs vector-borne diseases control unit

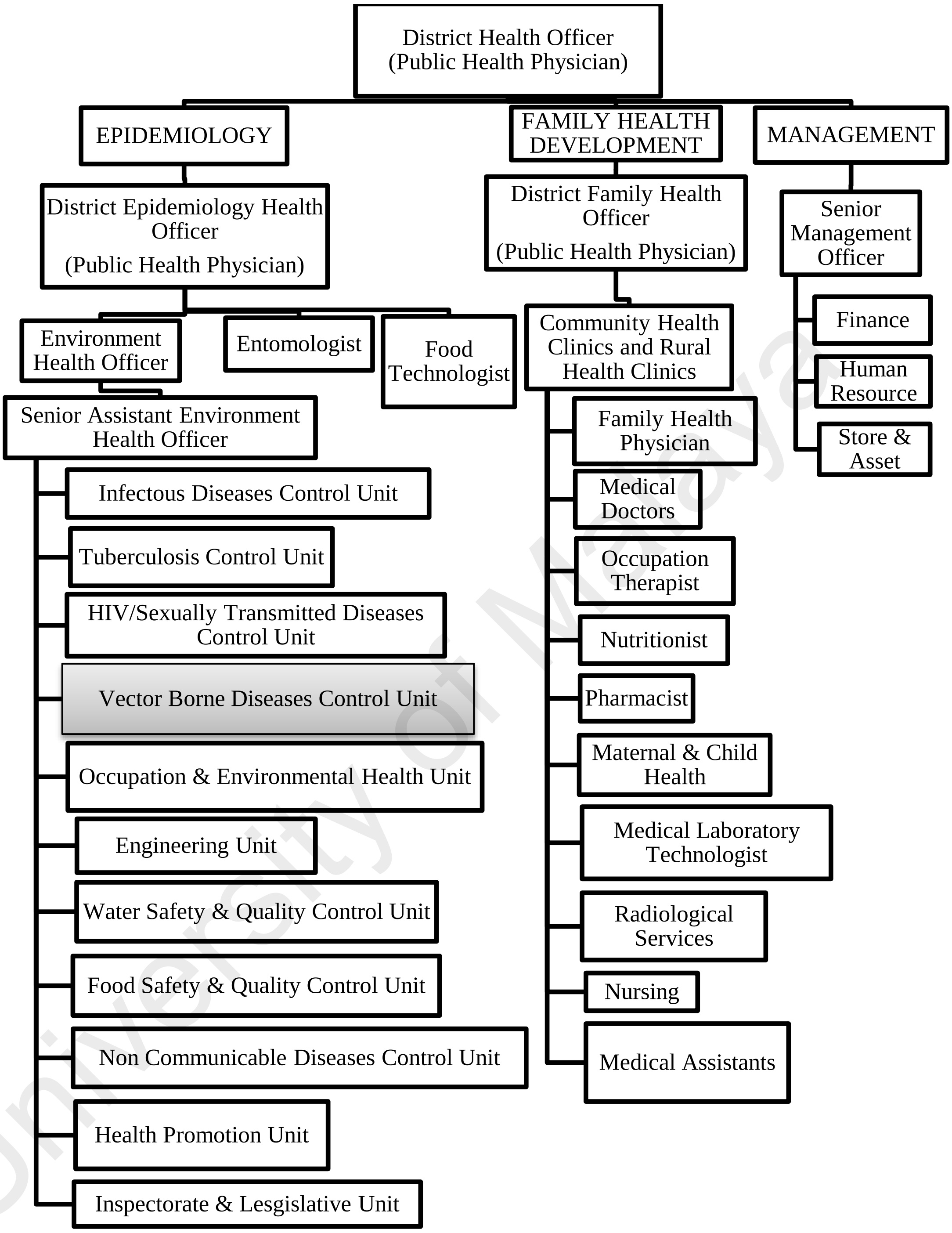

Figure 3.11: Organization chart of DHD

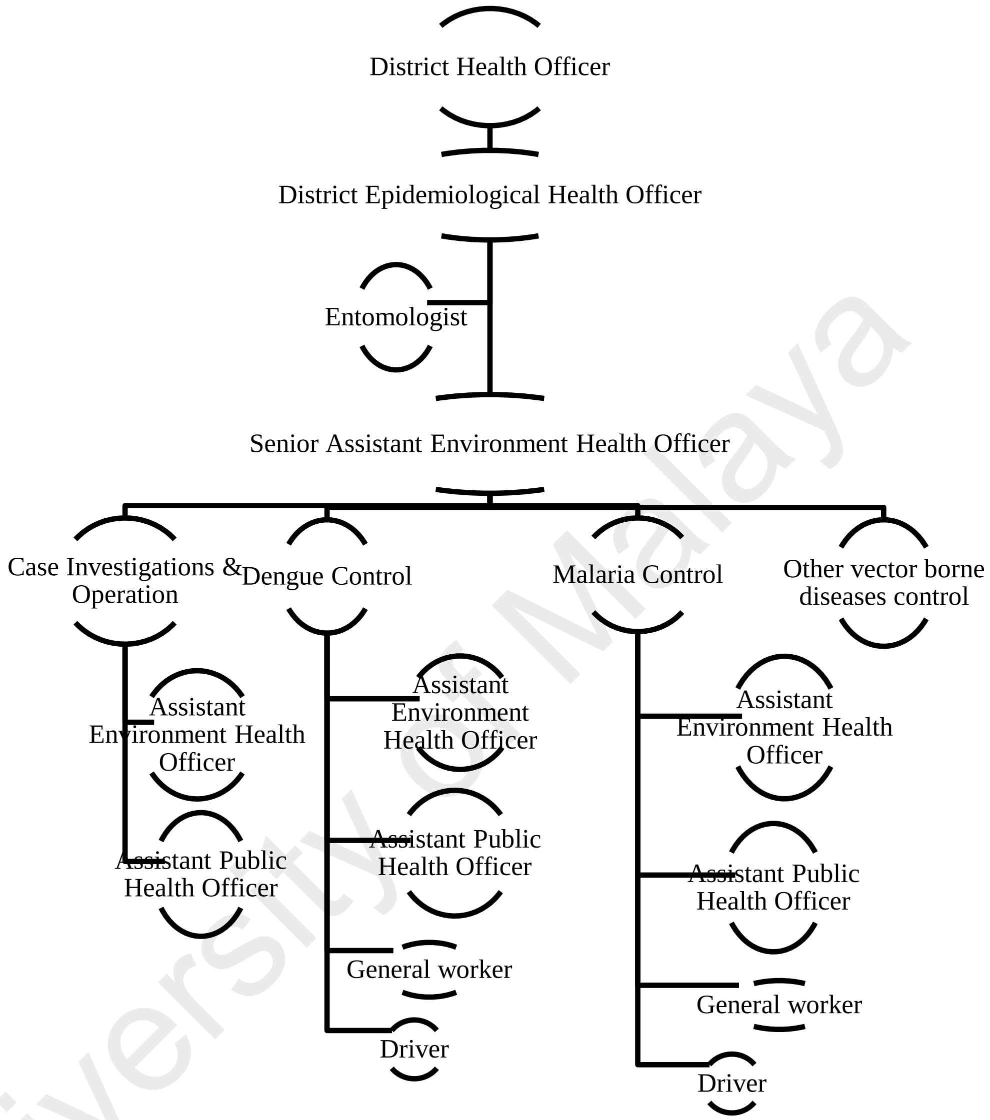

Figure 3.12: Organization chart of DHDs vector-borne diseases control unit

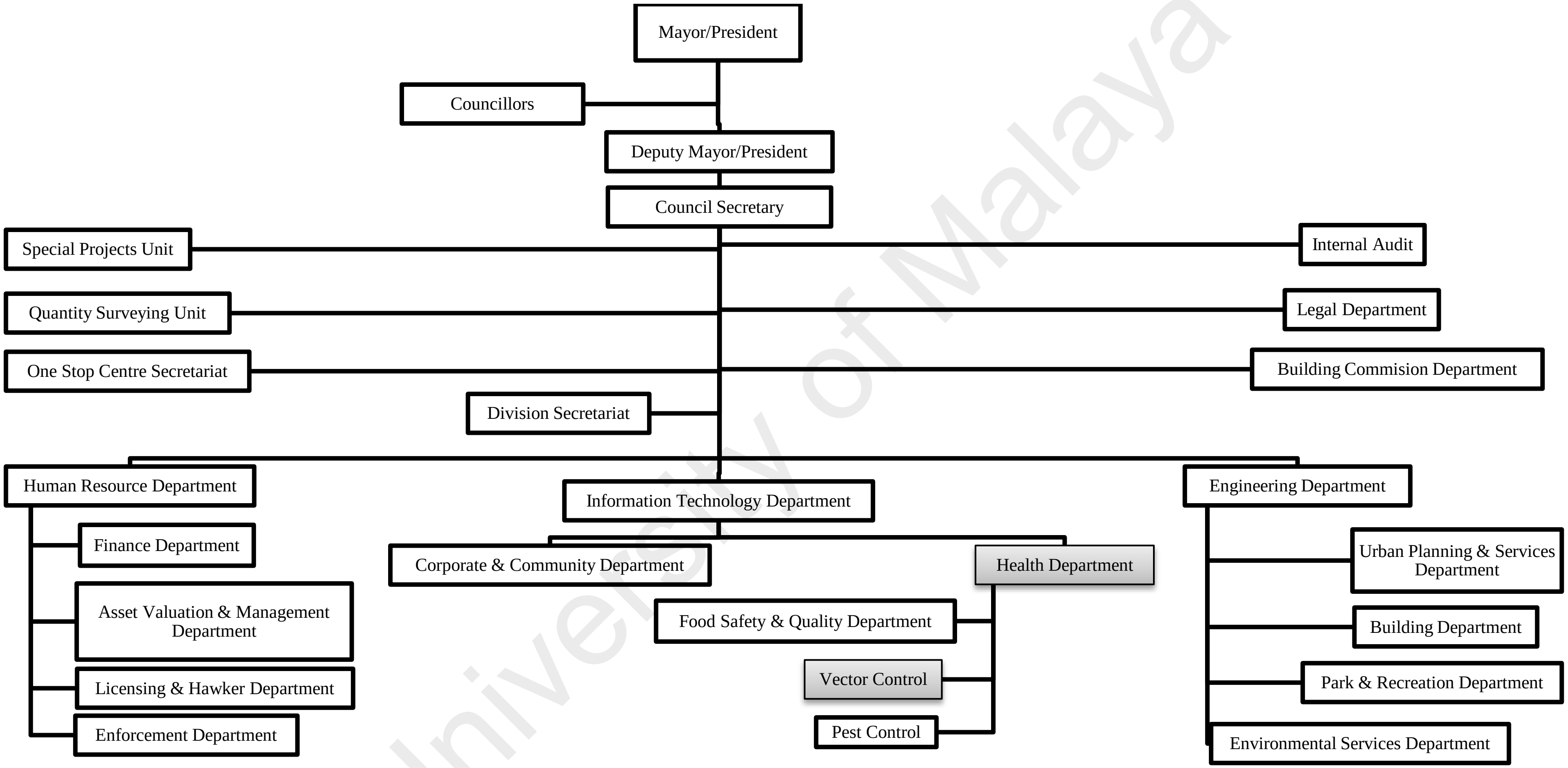

Figure 3.13: The organization chart of LAs

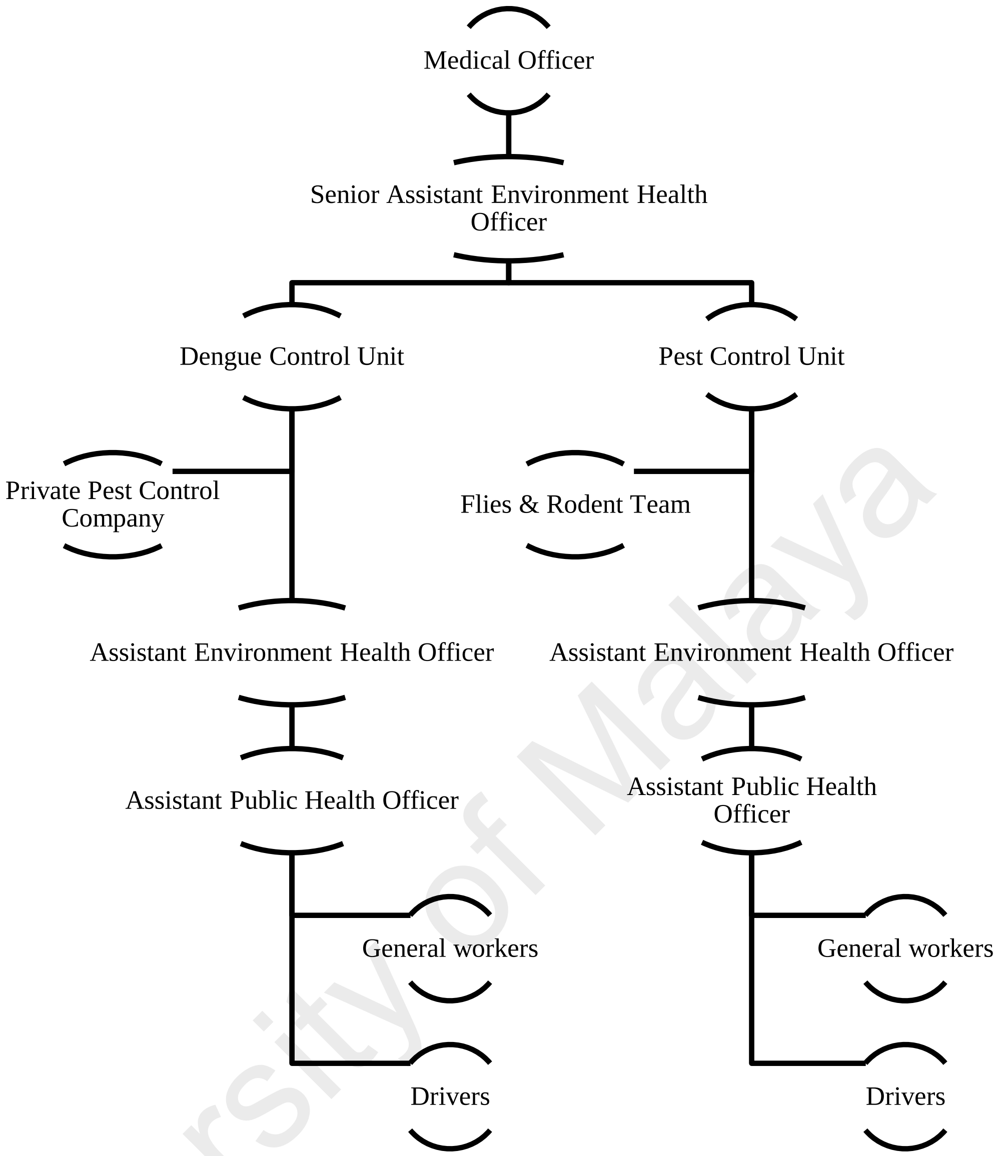

Figure 3.14: Organization chart of vector control units of LAs

3.8 The Economic Burden of Dengue to Malaysia

Lim et al. (2010) and Shepard et al. (2012) estimated the national cost burden of dengue to Malaysia by using different methodologies. In the first study, Lim et al. (2010) incorporated RUHA(Mavalankar, Puwar, Govil, Murtola, & Vasan, 2009) framework (**R**eported case, **U**nreported case, **H**ospitalized case and **A**mbulatory case) to estimate Malaysia's dengue case burden. Through similar methods used in his Thailand's study, the number of reported dengue cases in Malaysia during 2002-2007 varied from 31,545 to 50,341 and the authors utilized the mean reported case of 37,793 per year for the purpose of cost analysis. By multiplying the cost per case value to the average reported dengue cases and then adding the vector control as well as R&D costs, Lim et al. (2010) estimated the average cost of dengue in Malaysia as US$133.00 mil. The corresponding cost per capita was US$5.19. The country's dengue burden formed 0.11% of the Malaysian's GDP. The authors observed the average cost per case in Malaysia (US$445.25) was higher than that of its neighbouring country Thailand (US$97.38)(Lim et al., 2010). The higher average cost per case and cost per capita for dengue between Thailand and Malaysia was observed because the GDP per capita of Malaysia is almost two times that of Thailand.

Shepard et al. (2012) estimated the economic burden of dengue illness in Malaysia for 2009 and cited that accuracy of past estimates (Suaya et al., 2009) was limited due to incomplete data. The real dengue case burden was determined in Malaysia (number of cases per year) by adjusting to the expansion factor determined through Delphi's method (Shepard, Lees, et al., 2011). It was then multiplied by the direct medical costs and indirect societal costs per case to calculate the national estimate for the country.

Several data sources were combined to derive the unit cost of direct medical costs and indirect societal costs(Shepard et al., 2012).

The economic burden of dengue illness in Malaysia is US$102.25 mil per year(Shepard, Undurraga, Lees, et al., 2013). It corresponds to approximately US$3.68 per capita and forms 0.06% of Malaysian GDP. Shepard et al. (2012) demonstrated a considerable heavy burden of dengue to the Malaysian economy. However, the authors conceded that the cost estimate is conservative due to an underestimation of the expansion factor in Malaysia. A thorough study of expansion factors in neighbouring countries Thailand (EF=8.7) and Cambodia (EF=9.1) was not available at the time of the workshop in Malaysia(Shepard et al., 2012). The authors also cited several cost components that were unavailable for complete dengue burden estimation in Malaysia.

The first element was the cost estimation of dengue chronic fatigue syndrome. Few published studies(Fukuda et al., 1994; Garcıa et al., 2011; Kularatne, 2005; Lum et al., 2008; Seet et al., 2007) have investigated this phenomenon but not from the cost perspective. The second component was the estimation of true indirect cost estimates. Shepard et al. (2012) used minimum wages for private security guards as the proxy cost estimate instead of the GDP or gross national income per capita. The third component was the cost of prevention, surveillance and dengue vector control activities in Malaysia(Shepard et al., 2012). Those actions were implemented predominantly by the Malaysian government and no known published studies have investigated the actual costs of vector control and prevention activities in the country.

Despite these limitations, the recent cost estimates improve the previous cost estimates done by Suaya et al. (2009). The dengue burden cost estimation for Malaysia by Shepard, Undurraga, Lees, et al. (2013) (US$102.25 mil) is close to the estimate by Lim et al. (2010) (US$133.00 mil). The cost results were close although significant methodological differences were observed between the respective authors. Both the dengue cost estimation studies have shown the significant economic burden dengue exerts to the Malaysian healthcare system and the general population. The next section will discuss the cost of dengue vector control and prevention in Malaysia.

3.9 Cost of Dengue Vector Control and Prevention to Malaysia

There are no published reports or articles that describe comprehensive cost estimates of dengue vector control and prevention activities in Malaysia. As discussed in previous sections, two public sector agencies, namely the MOH and LAs deliver primary dengue vector control and prevention services to the communities in Malaysia and the actual public sector (government) cost is not known apart from published annual reports that mention their organization's operating budget.

One particular study done by Lim et al. (2010) estimated the costs for dengue vector control from the societal perspective only. Lim et al. (2010) estimated the annual vector control, prevention and research for Malaysia as US$26.60 mil and Thailand as US$27.79 mil. The cost per capita population was US$1.04 for Malaysia and US$0.43 for Thailand. The fraction of cost attributed to vector control, prevention and research to overall dengue burden were 20% and 0.3% of total health expenditure for respective countries. The vector control costs were estimated by Lim et al. (2010) based on the total market size of household insecticides reported by the Malaysian CropLife and Public Health Association (MCPA). From the reported total market size, the authors assumed 10% of these reported household insecticides were used for the control of Aedes mosquitoes in Malaysia and 7.5% in Thailand. The basis for this assumption was not explained by the authors. Once the Malaysian cost was derived through this method, for the Thailand counterpart, the authors adjusted the Malaysian cost for the relative size of Thailand population as well as for the relative size of Thailand GDP per capita(Lim et al., 2010). Next, the authors estimated the costs for research and development for vector control and prevention. For this cost input, Lim et al. (2010) allocated by assumption 7% of the cost across the board for both countries. In the end, the authors rightly asserted the need for more refined and rigorous studies on the cost associated to dengue.

There is no comprehensive cost analysis of vector control and prevention programme in Malaysia published to date. A thorough cost analysis will involve the identification of all presumed cost elements in the vector control and prevention programme. Examination of all inputs, their unit costs and the quantity of resources consumed for all material, services, equipment and labour at all administrative level would constitute a comprehensive cost analysis and such attempt would be beneficial to Malaysia.

3.10 Summary

In chapter three, we have reviewed the epidemiology of dengue in Malaysia and demonstrated significant dengue case burden to the country. The official number of dengue cases in Malaysia is under-reported and under-recognized. Once these official numbers are adjusted for under-reporting, the burden is exponentially raised and appears very distressing to Malaysia. Similar to many other dengue endemic countries, Malaysia adopted primarily environmental and chemical vector control strategies to combat the transmission of dengue. The dengue vector control and prevention services are delivered by two separate public sector agencies in Malaysia namely the MOH and the LAs. The MOH over time has been the lead implementer of dengue vector control and prevention activities in majority of the districts in Malaysia with varying degree of assistance from the LAs. Since dengue is associated with environmental sanitation; the LAs are better tasked to perform the vector control services to the communities through their consolidated urban services and the enforcement of vast legislature options available to them. It will benefit Malaysia in term of cost implications in the long term once the full responsibility of vector control is transferred from the central government (MOH) to the local government (LAs).

The economic burden of dengue to the Malaysian healthcare system is significant although it is concluded as incomplete due to absence of vector control and prevention cost from the public sector agencies in the country. The knowledge of comprehensive cost estimates of providing dengue vector control and prevention services at the national level is important to complete the total economic burden estimation of dengue for Malaysia. The vector control and prevention activities cost estimates will stimulate policy discussions for continuous investments into the dengue public health agenda and may promote new research opportunities in alternative technologies for vector control in Malaysia. The vector control cost dynamics and resources consumption between the public sector agencies may assist in informed decision making as to the future roles of these agencies in the delivery of dengue vector control services in Malaysia. The process of cost estimation of the delivery of dengue vector control and prevention services by the public sector agencies will be explained in the next chapter.

CHAPTER 4 : METHODOLOGY OF PROGRAMME COST ESTIMATION

4.1 Introduction

The public health programme cost analysis is used to determine the actual cost of delivering a programme. The analysis can provide detailed information about exact types and quantities of resources consumed by the said programme as well as generate data about how to improve a public health intervention programme. The cost related recommendations can be analyzed and integrated to the existing VBDCP thus form a reliable support to enhance and reform the current vector control programme framework.

This chapter will describe the methodology used to estimate the costs of the dengue vector control programme in Malaysia. Section 4.2 will explain the study design, areas of study and the associated time frame for the cost data. Section 4.3 will proceed to discuss the sample size for the programme cost estimation. Section 4.4 will describe the procedures used to derive the different administrative level sample units for the study. Section 4.5 will discuss the programme cost estimation model, and section 4.6 will describe the methods used to collect primary data on costs and resources. Section 4.7 will outline methods used to estimate the districts and national costs. Section 4.8 will illustrate the data analysis methods used for the programme cost estimation. The ethics approval, relevant agencies permissions and financial sources for the study are described in section 4.9. The chapter will conclude with section 4.10.

4.2 Study Design and Study Areas

The Malaysian VBDCP's cost estimation exercise is a quantitative descriptive study using a cross-sectional survey design. The study involved vector control units within the MOH and LAs. The MOH has several layers of administrative units, namely the federal (FHD), state (SHDs) and districts (DHDs). These administrative units have been described in the previous chapter. The FHD administrative unit involved in vector control is the Vector Borne Diseases Control Sector, Disease Control Division, MOH and is located in Putrajaya, the federal administrative capital of Malaysia. The FHD is supported by 14 SHDs, which in turn are supported by 140 DHDs. The three levels of MOH (FHD, SHDs, and DHDs) have similar organizational structure to administer public health interventions.

Table 4.1: The administrative levels of VBDCP of MOH and LA

Administrative level	Unit	Quantity	Location
Federal Health Department (FHD)	Vector Borne Diseases Control Sector, Disease Control Division, Ministry of Health Malaysia	1	Federal government administrative capital, Putrajaya
State Health Department (SHD)	State Vector Borne Diseases Control Department, Ministry of Health Malaysia	14	Respective State capital cities
District Health Department (DHD)	District Vector Borne Diseases Control Unit, Ministry of Health Malaysia	140	Respective health administrative districts
Local Authorities (LA)	Vector Borne Diseases Control Unit, Local Authority	151	Respective towns/cities

Primary unit cost and resources utilization data for one financial calendar year of 2010 was collected for the purpose of cost evaluation and analysis. The study proposal and planning stages took place in the year 2010 and the same year was chosen as the reference year. Moreover, this was the most recent year for which complete data were available at the study sites.

4.3 Sample Size Estimation

Sample size for studies can be determined from published tables. These tables will provide the required sample size for a given set of criteria. However, it is practical to calculate the required sample size from different combinations of precision levels, confidence levels and the variability (Israel, 1992; Kasiulevičius, Šapoka, & Filipavičiūtė, 2006; Xu, 1999). If the analysis involves data that are quantitative and continuous in nature, there are two options(Israel, 1992; Kasiulevičius et al., 2006) that can be used to estimate the required sample size for a study.

The first option is to combine the responses into two distinct categories and then use a sample size estimation method based on proportion (Israel, 1992; Kasiulevičius et al., 2006; Xu, 1999). The second option is to use a sample size estimation method based on the mean (Israel, 1992; Kasiulevičius et al., 2006; Xu, 1999). The second option was applied to this study because the study's purpose is to estimate the overall cost of dengue vector control and prevention. The objective is to report the mean costs of national expenses, state costs, district costs, costs per case reported and costs per capita of dengue vector control and prevention in Malaysia.

The formula used to estimate the sample size based on the mean(Israel, 1992; Kasiulevičius et al., 2006) is shown below:

$$n_0 = \frac{Z^2\sigma^2}{e^2}$$

Where n_0 is the sample size, z is the abscissa of the normal curve that cuts off an area at the tails, e is the desired level of precision (in the same unit of measure as the variance), and the σ^2 is the variance of an attribute in the population(Israel, 1992; Kasiulevičius et al., 2006).

The variable of interest in this study is the mean cost, and the estimation of cost standard deviation will be required. However, in Malaysia, there is no precedent data from previous studies that can be adapted to complete the given formula. Given this situation, the coefficient of variation (CV) was substituted in place of the lacking information. CV is a dimensionless number that quantifies the degree of variability in relative to the mean. A CV of 0.5 indicates the maximum variability in any given population and often used to determine a conservative sample size(Israel, 1992; Kasiulevičius et al., 2006). Once this was established, algebra was used to identify the relationship and reorganize the above formula as shown:

$$CV = \frac{\sigma}{\mu}$$

$$\mu = \frac{\sigma}{CV}$$

$$ME\ (sandard\ error) = \% \times \mu$$

$$ME = \% \times \frac{\sigma}{CV}\ \text{(Substitution)}$$

$$ME^2 = \%^2 \times \frac{\sigma^2}{CV^2}$$

$$n_0 = \frac{Z^2\sigma^2}{ME^2} \text{ (Sample size formula, ME=e)}$$

$$n_0 = \frac{Z^2\times\sigma^2}{\%^2\times\sigma^2/_{CV^2}} \text{ (Substitution)}$$

$$n_0 = \frac{Z^2\times\sigma^2\times CV^2}{\%^2\times\sigma^2} \text{ (Simplify)}$$

$$n_0 = \frac{Z^2\times CV^2}{e^2} \quad \text{ (Simplify)}$$

$$\sqrt{n_0} = \frac{Z\times CV}{e} \quad \text{ (Simplify)}$$

$$e = \frac{Z\times CV}{\sqrt{n_0}} \text{ (Simplify)}$$

Table 4.2 was constructed to show the permutable levels of precision obtained by using various sample sizes. The maximum variability (CV) proportion 0.5 and confidence level of 95% (Z=1.96) are the fixed variables. A sample size of 20 was selected for this study. The maximum sample error will be 22% of the estimated mean value. Sample sizes of more than 20 will only achieve a reduction of 2% to 4% in sample error determination. Furthermore, discretion was used taking into consideration of available personnel, resources and time for the completion of this study.

Table 4.2: Various levels of precision by using different samples sizes

Coefficient variation (CV=0.5) Confidence level 95% (Z=1.96)	
Sample size (n)	**Margin of error (ME)**
5	43.83%
6	40.01%
7	37.04%
8	34.65%
9	32.67%
10	30.99%
11	29.55%
12	28.29%
13	27.18%
14	26.19%
15	25.30%
16	24.50%
17	23.77%
18	23.10%
19	22.48%
20	21.91%
30	17.89%
40	15.50%
50	13.86%

4.4 Sampling Procedure and Study Sites

The primary objective of this study is to estimate the cost of dengue vector control and prevention at all levels of public sector administrative levels namely the federal, state and districts components. The determination of sampling method for district representatives was a challenge. Several factors required careful considerations such as the dengue cases geographical distribution, the dengue incidence rates and case burdens by administrative health districts (DHDs) in Malaysia.

At present, the geographic distributions of dengue cases are not available. The VBDCP of MOH does not have the technology or the capabilities yet to project the distribution of dengue cases in Malaysia using a Geographical Information system (GIS)[41].

Another promising option was the distribution of dengue cases incidence rates by administrative health districts. However, this method was compounded by varying population sizes of the districts in Malaysia. For example, the district with highest dengue incidence per 10,000 populations in Malaysia for the year 2010 was Kuala Penyu. It is a small district located in Borneo Sabah, and this district recorded an incidence rate of 106 per 10,000 populations. Kuala Penyu district had 183 cases, and the district's population is merely 17,200. Larger and more urbanized districts like Petaling district in the state of Selangor and Johor Bahru district in the state of Johore reported lower incidence rates of 41 and 24 per 10,000 populations respectively due to their large population size. The population of Petaling district was 1.25 mil and for Johor Bahru district was 1.18 mil. Petaling district reported 5,147 dengue cases and Johor Bahru district reported 2,846 cases for the year 2010. Therefore, public sector agencies like MOH and LAs would go for more personnel and resources allocation and their distribution to districts with higher dengue case burdens[42]. Districts that have higher dengue cases will have considerable vector control and prevention activities and greater utilization of resources to accommodate their vector-borne diseases control units' capacity. Hence, contrary to the dengue incidence rate, the case burden

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[41] Dr Chong Chee Keong**,** Sector Chief of Vector Borne Diseases Control Sector in Ministry of Health Malaysia (personal communication, 10th June 2011)

[42] Dr Chong Chee Keong**,** Sector Chief of Vector Borne Diseases Control Sector in Ministry of Health Malaysia (personal communication, 10th June 2011) and Dr Venugopalan K. Balan, Senior Assistant Director of Selangor State Vector Borne Diseases Control Department (personal communication, 23rd June 2011)

distribution was considered the best indicator to be used in the study's sampling methodology.

The sampling method known as Probability Proportional to Size (PPS)(Henry, 1990; McGinn, 2004; Teck, 2005; Turner, 2003) became the best candidate in the search for a solution to pick representative district samples. Size in this study context will be the dengue case burden. They correspond to the reported dengue cases in each district captured by the MOH's passive surveillance system. This approach will increase the likelihood of selecting districts with a higher amount of dengue reported cases but ensured that districts with few reported cases retained a chance for selection. Selection bias can be controlled by the random selection component included in this sampling method(McGinn, 2004; Teck, 2005).

Malaysia had 140 health administrative districts in the year 2010(Department of Statistics Malaysia, 2010; Vector borne diseases control sector, 2010). The distribution of reported dengue cases captured by the MOH surveillance system in all the 140 health administrative districts was mined at the FHD's vector-borne diseases control sector. Each administrative health district and its corresponding reported dengue cases were computed into the Microsoft Office programme Excel. Once the list of total reported dengue cases was keyed-in to the respective health administrative districts, it was then sorted in ascending order of the reported dengue cases. A new column was created, and the running cumulative value of reported dengue cases was calculated in the list. The final number in the running cumulative column would be the nationally reported dengue cases in Malaysia for 2010 which corresponded to 46,171 cases.

The aim is to select and determine eight health administrative districts for this study. For this process, the sampling interval (SI)(McGinn, 2004; Teck, 2005) was identified. SI was acquired through the division of the national dengue reported cases (46,171) by eight which yielded a figure of 5,771 (SI). The next step required a number termed as Random Start (RS)(McGinn, 2004; Teck, 2005) which corresponded to 1,720. The RS was determined through the Microsoft Excel programme by selecting a random number between one and the SI. Once the RS and SI have been established, the following series of figures were calculated(McGinn, 2004; Teck, 2005):

RS; RS + SI; RS + [2 x SI]; RS + [3 x SI], RS + [4 x SI]; ..………..RS + [7 x SI]

Each of the eight numbers calculated will identify a sample district on the national list of reported dengue cases and administrative health districts. The districts selected are those for which the cumulative reported dengue cases contain the numbers of the series calculated. The PPS method selected eight sample districts that were Sik, Batu Pahat, Melaka Tengah, Kuala Langat, Klang, Gombak, Hulu Langat and Petaling.

At the sample districts, the study sites are the vector-borne diseases control units of the DHDs representing the MOH and also the LAs in the same districts. However, there were multiple LAs in three of the eight selected districts: two LAs in each of two districts (Batu Pahat and Hulu Langat districts) and three in the remaining district (Petaling district). In these three districts, a sole representative LA was randomly selected from all LAs in each of the districts by using a simple random selection process.

Malaysia is a federation of 13 states and three federal territories. The MOH is supported by 14 SHDs. The DHDs in the eight selected districts were found to report to four different SHDs. From these SHDs, three SHDs vector-borne diseases control units were randomly chosen to provide state-level dengue vector control and prevention costs for this study. Since the state-level activities are not dependent on the number of reported dengue cases, the sample size for SHDs was deemed sufficient. The SHDs have minimal variation in their roles and functions, especially from the organizational perspective and resources consumptions[43] [44]. For the federal-level activities, the sole representative of FHD was the Vector Borne Diseases Control Sector of the Disease Control Division from MOH.

Thus, the final list of 20 study sites includes vector-borne diseases control units from 12 MOH sites and eight LA sites. The MOH sites were made up of vector-borne diseases control units from eight DHDs, three SHDs, and the sole FHD. All these public sector agencies were invited to participate in this study, and all agreed to do so. The list of the 20 study sites is summarized in the table below.

[43] Dr Chong Chee Keong, Sector Chief of Vector Borne Diseases Control Sector in Ministry of Health Malaysia (personal communication, 10th June 2011)

[44] Dr Venugopalan K. Balan, Senior Assistant Director of Selangor State Vector Borne Diseases Control Department (personal communication, 23rd June 2011)

Table 4.3: The list of 20 study sites

Level of organization	Study site		Sample method
Federal-level (FHD)	Vector Borne Diseases Control Sector, Disease Control Division, MOH administrative complex, Putrajaya		Purposive
State-level (SHD)	Selangor State Vector Borne Diseases Control Department		Random
	Malacca State Vector Borne Diseases Control Department		
	Kedah State Vector Borne Diseases Control Department		
District-level (DHD & LA)	Sik DHD Vector Borne Diseases Control Unit	Sik LA Vector Borne Diseases Control Unit	Probability Proportional to Size
	Batu Pahat DHD Vector Borne Diseases Control Unit	Batu Pahat LA Vector Borne Diseases Control Unit	
	Melaka Tengah DHD Vector Borne Diseases Control Unit	Melaka Tengah LA Vector Borne Diseases Control Unit	
	Kuala Langat DHD Vector Borne Diseases Control Unit	Kuala Langat LA Vector Borne Diseases Control Unit	
	Klang DHD Vector Borne Diseases Control Unit	Klang LA Vector Borne Diseases Control Unit	
	Gombak DHD Vector Borne Diseases Control Unit	Selayang LA Vector Borne Diseases Control Unit	
	Hulu Langat DHD Vector Borne Diseases Control Unit	Kajang LA Vector Borne Diseases Control Unit	
	Petaling DHD Vector Borne Diseases Control Unit	Subang Jaya LA Vector Borne Diseases Control Unit	

4.5 Vector Control and Prevention Cost Model

Cost is defined as the total money, time, and resources associated with a purchase or activity and forms the elementary building block of any economic evaluations(Netten & Kernick, 2002; Ruth, 2008). There are two categories of cost namely accounting cost and economic cost. Accounting costs are financial expenditures necessary for the provision of activities and are not concerned with the value that is placed on the expenditure(Netten & Kernick, 2002). Economic cost places emphasis on the importance of value to the resources and applies opportunity cost(Netten & Kernick, 2002). Opportunity cost is the value of the best alternative foregone to provide a service. Interests in cost information and cost measurements are driven by the need for planning, management and performance measurement especially in the field of public health interventions due to competing needs of many programmes within the healthcare delivery system of a country(Netten & Kernick, 2002).

There are several techniques of cost estimation(Ruth, 2008) that are used in the field of health economics. The top-down approach is used when fine details are not available or restricted. Budgetary information, cost allocations and activities performed are obtained from public domain sources such as annual financial reports, activity reports, and official websites. The total cost is then divided by the resources or activities published in the reports. Many critical resource inputs may be overlooked in this approach, and it may pose a problem to link resources to the activities. This is observed where several resources are used in combination to produce activities. Bottom up or activity based cost approach identifies and attaches value to all resources associated with particular activity or programme. This method requires fine details and involves a laborious and time-consuming process. However, the effort may be justified as the results will yield detailed cost information. The expert judgment approach is used when data is scarce or difficult to obtain. A team of experts will be sought, and they will roughly estimate the costs incurred based on their knowledge and experiences with a particular activity or programme. Different cost methods have their advantages and disadvantages, but they all have their purpose in particular situations, and no single method can be considered as appropriate for every situation(Netten & Kernick, 2002; Ruth, 2008).

The bottom-up approach was selected to estimate the Malaysian national dengue vector control and prevention cost study. All elements of the national vector-borne disease control programme were first identified. Information on resources utilization and unit costs of each resource were obtained (Creese & Parker, 1994; Netten & Kernick, 2002; Shepard, Hodgkin, & Anthony, 2000). The total costs were then derived from the sum of the product of resource utilization and unit costs of each element(Creese & Parker, 1994; Shepard et al., 2000). The process was executed at all levels of vector control and prevention programme administration levels (FHD, SHDs, DHDs, and LAs). The common cost perspectives are societal, public sector or governmental, patient, healthcare providers, employers or funding agencies (Creese & Parker, 1994; Muennig, 2002; Shepard et al., 2000). This study takes the perspective of the government which is the funder of the vector control and prevention programme and thus only the direct costs borne by the public sector agencies were considered for analysis.

The cost elements of a public health programme or intervention are called as line items. Line items are all the resources required for the implementation and execution of an activity, and they are classified into capital items and recurrent items (Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009). Capital items are inputs that have a working life for more than one year and are associated with buildings and machinery that are not used up in the process of providing the activity or service (Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009). Recurrent items are inputs that are used up within a year and are regularly purchased (Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009). In this study, all the capital and recurrent items required for dengue vector control and prevention activities were identified, and their costs were included. The seven line items, groupings of similar resources, are human personnel (regular salaries and allowances, such as overtime payments), buildings, personal protective equipment (PPE), vehicles, fogging equipment, pesticides and fogging services outsourced to private companies. The line items and their associated capital and recurrent inputs are listed in Table 4.4.

A capital item such as buildings or machinery' has a working life expectancy of several years. The purchase price of the said capital items will not be equal to its cost. The real costs of any capital items will be spread out over the useful working life of the said item. Furthermore, capital items will depreciate its value as time progresses. The technique to calculate actual economic costs of capital items is known as annualization(Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009). The first process in annualization technique is to identify the annual depreciation value of the said capital item. The next step is to calculate the opportunity cost of the said item. Opportunity costs are allowances that represent the monetary interest that could have been potentially earned if the funds that were used to buy the capital item were instead invested elsewhere (Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009). The rate of return on investments was estimated based on the Malaysian Central Bank's discount rate. The discount rate for Malaysia was 3% for the year 2010(Central Bank of Malaysia, 2011).

Two details will be required to calculate the annualized cost of capital item namely the replacement cost of the capital items and the annualization factor. The formula to calculate annualized capital item cost is as follows(Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009):

$$Annualized\ capital\ cost = \frac{Replacement\ cost\ of\ the\ capital\ item}{Annualization\ factor}$$

The replacement cost of capital items was estimated using the Malaysian Consumer Price Index (CPI). The CPI is a national index that measures the percentage of change over time in the cost of purchasing a constant basket of goods and services representing the average pattern of purchases made by a particular group of population in a specified period(Department of Statistics Malaysia, 2011).

The annualization factor for a capital item is derived using the following formula(Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009):

$$Annualization\ factor = \left[{}^{1}/_{r}\right] \times \left[{}^{1}/_{(1+r)^{n}}\right]$$

r = discount rate

n = the life expectancy of the capital item (in years)

The formula to calculate the annualization factor is complicated, and the process is made simple through standard published tables. The replacement cost of the capital item, the estimated life expectancy of the capital item and the discount rate will be required to obtain the annualization factor from published tables(Creese & Parker, 1994; Shepard et al., 2000; Tsolmongerel, 2009).

Table 4.4: The line items and their associated capital and recurrent inputs

Line items	Capital inputs	Recurrent inputs
Building	• Administrative/Storage building cost (purchase price or construction price) • Administrative/Storage building rental value/Office space rental value in the event the construction cost is unavailable • Building basic furnishing and built-in equipment	• Utilities • Electricity • Water • Telephone • Postal services • Building cleaning services • Building insurance • Building maintenance
Human personnel	NA	• Basic salary • Allowances • Incentives • Overtime claims • Annual bonus • Emergency hires
Vehicle	• Purchase price of vehicle (if owned) • Rental price of vehicle (if rented)	• Fuel consumption (Diesel/Petrol) • Vehicle maintenance and repair • Vehicle insurance and road tax
Equipment (fogging/larviciding)	• Purchase price of equipment (if owned) • Rental price of equipment (if rented)	• Fuel consumption • Diesel consumption • Petrol consumption • Equipment maintenance and repair
Pesticide	NA	• Quantity used in litres/kg • Purchase price (unit cost)
PPE[#]	NA	• Quantity used • Purchase price (unit cost)
Outsourcing[¥]	NA	• Duration of engagement • Cost of services

[#]PPE denoted Personal protective equipment

[¥] Fogging and larviciding activities sub-contracted to private companies

NA denoted not applicable

Table 4.5: The assumptions for capital items cost annualization

Parameters	Assumptions	Annualization Factor
Discount rate	3%	NA
Expected working life of administrative building/storage building	20 years	14.877
Expected working life of storage cabin container	10 years	8.530
Expected working life of vehicles	5 years	4.580
Expected working life of equipment	5 years	4.580

The discount rate for the year 2010 was obtained from (Central Bank of Malaysia, 2011)

The expected working life of capital items and their annualization factors were obtained from (Creese & Parker, 1994; Shepard et al., 2000)

NA denotes not applicable

Some of the common resources may be shared by different public health programmes or intervention. These shared resources could also represent the same items used for various activities within the programme. The technique to calculate the proportion of the shared costs is known as cost allocation. The cost allocation principles are used to estimate dengue vector control and prevention activities are outlined in Table 4.6.

Table 4.6: The key dimensions used for allocation of shared costs

Line items	Allocation method	Units
Human personnel	Time worked	Percentage
Building	Space used	Floor area ratio used
Vehicles	Time used/Mileage	Percentage
Equipment	Time used	Percentage
Pesticide	Quantity used	Litres/Kilogramme
PPE	Quantity used	Number used

All the line items were combined with their capital costs (buildings, vehicles, equipment) and recurrent costs (utilities, fuel, maintenance). After that, costs for the line items were summed up to provide the total cost of vector control and prevention activities of each study unit. Similar to line items, five functional groups were identified to describe vector control and prevention activities by functions. They are premise inspection, entomological surveillance, fogging, larviciding and health education. The disaggregation of costs by functions was not obviously discernible unlike the breakdown of line items. A senior vector control officer (i.e. a person with more than five years' experience in supervising and managing dengue vector control and prevention activities) were identified at each study sites. The key officer was interviewed to elicit the assigned percentage allocation of costs at each study sites based on their regular activities and workload. Table 4.7 describes the line items and functional groups.

4.6 Data Collection Methods

Primary data involving the costs, unit costs, and resources consumptions were obtained from all the study sites. A series of structured data collection forms (Appendices C to I) were developed for this study. The forms had details of specific groupings of vector control resource inputs and cost (refer Table 4.4). A trained data collector[45] approached key personnel at all study sites known to be in possession of the data required for this study. These key personnel are officers from various units within the organization such as vector control, human resource, engineering and accounts departments.

[45] The DrPH candidate himself

Table 4.7: Description of line items and functional groupings

Category	Description
LINE ITEMS	
Human personnel	Annual salaries and other allowances for staff such as overtime claims, housing, and uniform allowances
Buildings	Buildings used for administration of programmes as well as for storage of equipment and is inclusive of both capital (annualized purchase price or annual rentals) and recurrent costs (e.g., insurance, utilities, maintenance)
Vehicles	Vehicles used in vector control activities such as fogging activities and is inclusive of both capital (annualized purchase price or annual rental) and recurrent costs (e.g., fuel, maintenance, insurance)
Equipment	Fogging/larviciding equipment either ultra-low volume equipment mounted on pick-up trucks, or thermal fogging machines carried on the back of vector control officers and is inclusive of both capital costs (annualized purchase price) and recurrent costs (fuel and maintenance)
Pesticides	Insecticides used for larviciding and fogging activities
PPE	Personal protective equipment including goggles, mask, gloves, respirator, boots used during larviciding and fogging activities
Outsourced services	Costs of fogging and larviciding activities sub-contracted to private companies
National Dengue Prevention Advertisement Campaign	Costs of national broadcasting in radio, television and local newspapers, including the hiring of celebrities to promote dengue prevention campaigns. This line item only applies at the FHD level.
FUNCTIONAL GROUPS	
Inspection of premises	Inspection of buildings including houses, shops, construction sites and schools for mosquito breeding sites
Entomological surveillance	Activities to collect data for entomological indices, such as *Aedes* and Breteau indices
Fogging	Back-mounted thermal fogging and truck-mounted ultra-low volume (ULV) fogging at premises and areas found to have dengue cases
Larviciding	Application of insecticides at potential breeding sites of buildings and areas found to have dengue cases
Health education	Activities to educate the community including distributing flyers, pamphlets, brochures, giving educational talks, banners, and buntings, engaging local community leaders through the Communication for Behavioral Impact (COMBI) programmes to spearhead campaigns to keep their living environment clean and mosquito free

During the first encounter, the data collector met each key personnel and explained in detail the precise vector resource inputs, costs and unit costs that were required for this study. The key personnel and targeted staff members will acquire the specific data and fill in the information into the data collection forms. A week after the first encounter, the data collector will meet the key personnel's and discuss the collected data. If the officers were unable to provide the requested information at this time, the data collector provided added advice and assistance. If further information was needed, the data collector issued weekly reminders, either in person or via the telephone until all the requested information had been acquired. These were done until the forms were completed and collected. Data collection started in March 2012 and ended in August 2013. Examples of the data collected from sampled vector control units are included in the appendices (Appendices J to O).

Despite the advice and reminders, some study sites could not provide all the required data. Complete information for the salaries of some staff was not available in the five study sites. However, the list of the staff, their hierarchical position in the unit's organization chart and their respective pay grades were obtained. For these personnel, the subsequent analysis used the average annual salaries of staff of similar categories and pay grades obtained from other study sites. Similarly, building costs were not available at one site; complete vehicle prices were not available at five sites, and complete fogging equipment costs were not available at three sites. However, the building specifications, vehicles and equipment models and year of make were obtained. For these missing data, the average annual costs for similar resources obtained from other study sites were used as a proxy.

4.7 Estimation of District and National Costs

The vector control and prevention costs for the DHD and LA in each sample district were combined to derive the total cost for the said district. However, there was more than one LA in three of the sampled districts. In each of those sampled districts, data on costs, unit costs, and resources consumption were collected from one LA. That LA was selected randomly from all the LAs in each of the three districts. Also, data on the number of reported dengue cases responded by these agencies were collected for all the LAs, both selected and non-selected in those three districts. Once the data for all line item costs were obtained from the each sampled LA, the costs for each line item were broken down to per reported case. Many dengue endemic countries inclusive Malaysia adopted the system of passive surveillance of cases. Once a suspected dengue case is notified by a health practitioner, the dengue vector control units will perform a series of vector control and prevention activities around the notified locality. As the vector control activities in these LA units were oriented in response to reported dengue cases, the resultant costs incurred was deduced to be a reactive cost. The derived estimates of per reported case by each line item at the sampled LAs were then applied to the number of reported dengue cases responded in each of the non-sampled LAs within the same sampled district. Then, each line item costs were then summed to derive the total cost for the non-sampled LAs. Finally, the total district-level costs and their cost breakdowns by line items and by functions were derived by combining all the costs of DHDs and those of LAs in each of the sampled districts.

The vector control and prevention costs collected from the sampled districts (DHDs and LAs), states (SHDs) and federal (FHD) levels were then used to estimate the national costs for dengue control and prevention in Malaysia. The total costs from each of the sampled districts were inflated by using sampling weights (Table 4.8). The weights were determined by calculating the inverse of the probability of sampling each district(Yansaneh, 2003). The weights were obtained by applying the following formula:

$$Probability\ of\ sampling\ in\ each\ sample\ district$$
$$= \frac{(Number\ of\ reported\ dengue\ cases\ in\ the\ sampled\ district)(total\ sample\ districts)}{national\ reported\ dengue\ cases}$$

Total sample districts = 8

National reported dengue cases = 46, 171

$$Sampling\ weights = \frac{1}{Probability\ of\ sampling\ in\ each\ sample\ district}$$

Table 4.8: The sample weights

Sampled districts	Reported dengue cases	Sample weights
Sik	71	81
Batu Pahat	175	33
Kuala Langat	524	11
Melaka Tengah	1,048	6
Klang	1,752	3
Gombak	3,107	2
Hulu Langat	4,852	1
Petaling	5,147	1

The inflated districts costs were then summed to provide the estimated national districts costs for all the health administrative districts (N=140) in Malaysia. Contrary to the vector control activities at the level of the districts, technical supervision and monitoring provided by the SHDs are not wholly dependent on the number of reported cases or population size in each of the state. Moreover, there was minimal variation observed in the organization, staffing, and functions of each SHD. Therefore, in this study, the average costs of the line items and the average total costs from the sampled SHDs was multiplied by 14 to generate the national costs and costs by line items for all SHDs in the country. Finally, the estimates of the national districts costs, national states costs and the sole federal representative (FHD) cost were summed to provide the estimated national dengue vector control and prevention costs for Malaysia for the year 2010. Examples of costs calculations by line items at the study sites are illustrated in Appendices J-O.

4.8 Data Analysis

Data were analysed using Excel (Microsoft Corp., Redmond, WA, USA) and the statistical package IBM SPSS Statistics version 21 (IBM Corporation, Armonk, NY, USA). First, cost estimates are reported by total vector control and prevention costs, by line items costs, by functions costs, costs per reported dengue case and costs per capita at the district, state, federal and finally national levels. Then, cost estimates are reported by total vector control costs, by line items costs, by functions costs and costs per reported dengue case responded by the respective DHDs and LAs. All the cost estimates were bootstrapped(Campbell & Torgerson, 1999; Efron & Tibshirani, 1986) with 10,000 repetitions to generate 95% confidence intervals (CIs). All costs are reported in Malaysian Ringgit (MYR) and the United States Dollars (US$). The US$ denominations were obtained by using the average 2010 exchange rate of US$ 1.00 being equivalent to MYR 3.20 (Central Bank of Malaysia, 2011).

4.9 Ethics, Relevant Agencies Approval and Study Funding

The study was registered with National Medical Research Registry of Malaysia (NMRR) (Appendix A). The research identification number is NMRR-11-263-9217. Study design and protocol approval were obtained from Malaysian National Institutes of Health (NIH) and Institute for Health Systems Research (IHSR). Ethics approval was obtained from the Ethics Committee of NMRR (Appendix B). An institutional approval was obtained from MOH Malaysia to collect data from all of their sampled study sites (DHDs, SHDs and FHD). Individual consent was obtained from all the LAs. All the sampled study sites (DHDs, LAs, SHDs and FHDs) agreed to participate in the study.

The study was supported by the University of Malaya/Ministry of Higher Education High Impact Research Grant (E000010-20001). Also, the study received support in part through a research agreement from Sanofi Pasteur through Brandeis University to the University of Malaya. The sponsors had no control over the study protocol, its execution or the results of the performed analysis.

4.10 Summary

The methodology of a comprehensive cost estimation exercise for dengue vector control and prevention activities was discussed in this chapter. The sample of vector control units selected for the study included all the different administrative levels of the public sector agencies responsible for the delivery of dengue vector control and prevention activities to Malaysia. A bottom-up approach and the meticulous data capture of all the resources consumed together with the corresponding unit costs of capital and recurrent items had ensured a detailed cost estimate possible for Malaysia. The results of the cost analysis are discussed in the following chapter.

CHAPTER 5 : COSTS OF DENGUE VECTOR CONTROL AND PREVENTION BY DIFFERENT ADMINISTRATIVE LEVELS

5.1 Introduction

In this chapter, the costs of the Malaysian dengue vector control and prevention programme will be presented in detail by different administrative levels namely district-level, state-level, federal-level and national-level. Section 5.2 will describe characteristics of sample study sites. Section 5.3 will report the results of dengue vector control and prevention costs and resources use at the district-level. Section 5.4 will describe the results of dengue vector control and resources use at the state-level. Section 5.5 will describe the results of dengue vector control and resources use at the federal-level. Section 5.6 will report the national-level costs for Malaysia. The chapter will conclude with section 5.7.

5.2 Characteristics of Study Sample Sites

Malaysia had a total of 46,171 reported dengue cases and 27.41 mil population in 2010. The eight sampled districts included in this study reported total 16,676 cases or 36.1% of all the dengue cases in the country. This study included the district of Sik with 71 reported cases, which was one of the lowest dengue case burdens in the country. It also included three districts with the highest dengue case burden in the country, namely Petaling, Hulu Langat and Gombak, which in 2010 had 13,106 reported dengue cases or 28.4% of the cases reported for the entire country (Table 5.1). The average reported dengue cases per district was 2,085 (95% CI=835-3,466) among the sampled districts. The median reported dengue cases were 1,400.

The sampled districts had 5.59 mil population or 20.4% from the national population. The average population among the sampled districts were 0.70 mil (95% CI=0.37 mil-1.08 mil). The median population was 0.58 mil. The incidence of dengue in all the sampled districts was 298.43 per 100,000 populations as compared to the national dengue incidence of 168.46 for 2010. The median incidence rate among the sampled districts in this study was 227.04 per 100,000 populations.

The three sampled SHDs included in this study reported a total 18,634 cases or 40.4% of the national cases. This study included the Kedah SHD with 782 reported cases, which was one of the lowest dengue case burdens in the country. It also included two SHDs namely from Selangor and Melaka, which in 2010 had 17,852 reported dengue cases or 38.7% of the cases reported for the entire country (Table 5.1). The average reported dengue cases was 6,211 (95% CI=782-16,367) among the sampled SHDs. The median reported dengue cases were 1,485. The sampled SHDs had 8.04 mil population or 29.3% from the national population. The average population among the sampled SHDs were 2.68 mil (95% CI=0.79 mil-5.35 mil). The median population was 1.90 mil. The incidence of dengue in all the sampled SHDs was 231.90 per 100,000 populations as compared to the national dengue incidence of 168.46. The median incidence rate among the sampled SHDs in this study was 187.94 per 100,000 populations.

Table 5.1: The population and dengue cases at sample districts/SHDs, 2010

Study site	Reported dengue cases	Population (in millions)	Incidence rate (per 10^5)
DISTRICT			
Sik#	71	0.07	106.95
Batu Pahat§	175	0.40	43.54
Kuala Langat*	524	0.22	237.95
Melaka Tengah†	1,048	0.48	216.13
Klang*	1,752	0.84	208.04
Gombak*	3,107	0.67	464.64
Hulu Langat*	4,852	1.14	426.29
Petaling*	5,147	1.77	298.43
TOTAL	**16,676**	**5.59**	**298.43**
Mean (95% CI)	2,085 (835-3,466)	0.70 (0.37-1.08)	250.25 (159.75-345.14)
Median	1,400	0.58	227.04
Standard deviation (95% CI)	2,050 (903-2,432)	0.55 (0.22-0.73)	144.24 (72.84-182.02)
SHD			
Selangor	16,367	5.35	306.19
Kedah	782	1.90	41.16
Melaka	1,485	0.79	187.94
TOTAL	**18,634**	**8.04**	**231.90**
Mean (95% CI)	6,211 (782-16,367)	2.68 (0.79-5.35)	178.43 (41.16-306.19)
Median	1,485	1.90	187.94
Standard deviation (95% CI)	8,802 (0-8,998)	2.38 (0-2.63)	132.77 (0-153.02)
NATIONAL			
Malaysia	46,171	27.41	168.46

SHD denotes State Health Department; CI denotes Confidence Interval;*Districts in Selangor State; †District in Melaka State; §District in Johor State; #District in Kedah State

5.3 Costs and Resources Use at the District-Level (DHDs & LAs)

In this section, the costs results are described for the sample districts (n=8) in subsection 5.3.1 and the extrapolated costs for all the districts (N=140) in Malaysia are described in subsection 5.3.2.

5.3.1 Costs and Resources Use at the Sample Districts (n=8)

The dengue vector control and prevention costs at the sampled districts ranged between MYR 0.62 mil (US$ 0.20 mil) in Sik to MYR 9.12 mil (US$ 2.85 mil) in Gombak. The sum of the costs in the eight districts was MYR 36.17 mil (US$ 11.30 mil). The average sampled districts total cost was MYR 4.52 mil (US$ 1.41 mil). In general, the cost per reported case appeared to be lower in districts with a higher burden of cases compared to those with lower burdens. The cost per reported case at the sampled districts was MYR 2,169 (US$ 678). The cost per capita populations was MYR 6.47 (US$ 2.02). The main cost drivers in the sampled districts were human personnel and pesticides. Human personnel costs formed 55.8% of the total costs and pesticides costs was 15.4%.

In term of functions, the highest cost was attributed to fogging activities followed by premises inspections. The costs for fogging activities were MYR 12.18 mil (US$ 3.81 mil), and premises inspections were MYR 8.68 mil (US$ 2.71 mil). Chemical control measures formed the largest proportion of costs with MYR 18.76 mil (US$ 5.86 mil) or 51.9% of the total costs. The costs characteristics by line items and functions are listed in Table 5.2.

The total costs of capital items were MYR 3.13 mil (US$ 0.98 mil), and total costs of recurrent items were MYR 33.04 mil (US$ 10.32 mil). The costs proportions of recurrent items were the largest, and it formed 91.3% from the total costs. The average total cost of capital items was MYR 0.39 mil (US$ 0.12 mil) and for recurrent items were MYR 4.13 mil (US$ 1.29 mil). The costs characteristics by capital items and recurrent items are summarized in Table 5.3. The costs and resources specific information of the each sampled districts are listed in Appendices P-W.

A standard linear regression was performed to assess the ability of reported dengue cases to predict the total cost of dengue vector control and prevention at the sampled districts. Preliminary analyses were carried out to ensure there was no violation of the assumption of normality, linearity, and homoscedasticity in the dataset. A significant regression equation was found: District cost (in MYR) = MYR 1.99 mil + Cases X MYR 1,214 or District cost (in US$) = US$ 0.62 mil + Cases X US$380 ($R^2$=0.790, N=8, p=0.019). Linear regression confirmed that districts with more annual reported dengue cases tended to have more costly vector control expenditures (Appendix X).

A total of 826 government staff contributed to dengue vector control and prevention activities in the sampled districts. The average personnel in the districts were 103 people. However, only 685 FTE staff dedicated to dengue-related activities. Among the government staff, 89.5% were health care professionals or individuals who had received specific training for dengue vector control activities such as doctors, entomologists and allied health professionals, such as health inspectors. There were 121 vehicles allocated to the vector control units. Among those vehicles, the average time dedicated exclusively to dengue-related activities was 87.6%. On average, 33.3% of those vehicles were aged more than five years. There was total 414 fogging and larviciding equipment in the sampled districts and MYR 0.53 mil (US$ 0.16 mil) were spent for their annual servicing and maintenance purposes. These districts used 53,952 litres of liquid-based pesticides and 4,721 kg of powder-based pesticides for dengue control activities. The resources characteristics for sampled districts are outlined in Table 5.4.

Table 5.2: Costs characteristics of the sampled districts (n=8)

Parameters	Sum of cost		Mean cost		Standard deviation		Cost per case reported		Cost per capita	
	MYR	US$	MYR	US$	MYR	US$	MYR	US$	MYR	US$
LINE ITEMS										
Human personnel	20,181,099	6,306,594	2,522,637	788,324	1,498,217	468,193	1,210	378	3.61	1.13
Buildings	2,293,754	716,797	286,719	89,600	294,635	92,074	138	43	0.41	0.13
Vehicles	3,295,938	1,029,980	411,992	128,748	453,944	141,858	198	62	0.59	0.18
Equipment	2,863,310	894,785	357,914	111,848	424,310	132,597	172	54	0.51	0.16
Pesticides	5,586,772	1,745,867	698,347	218,233	728,586	227,683	335	105	1.00	0.31
PPE[a]	624,250	195,079	78,031	24,385	47,690	14,903	37	12	0.11	0.03
Outsourcing[b]	1,325,528	414,228	165,691	51,779	319,836	99,949	79	25	0.24	0.07
TOTALc	**36,170,649**	**11,303,329**	**4,521,331**	**1,412,916**	**3,142,834**	**982,136**	**2,169**	**678**	**6.47**	**2.02**
FUNCTION										
Premise inspection	8,679,706	2,712,408	1,084,963	339,051	862,346	269,483	520	163	1.55	0.49
Entomological surveillance	3,138,835	980,887	392,354	122,611	283,505	88,595	188	59	0.56	0.18
Fogging	12,176,313	3,805,098	1,522,039	475,637	1,092,621	341,444	730	228	2.18	0.68
Larviciding	6,584,349	2,057,609	823,044	257,201	619,999	193,750	395	123	1.18	0.37
Health education	5,591,444	1,747,326	698,931	218,416	495,234	154,761	335	105	1.00	0.31

[a]PPE denoted Personal protective equipment; [b]Fogging and larviciding activities sub-contracted to private companies; [c]Sum of line items costs

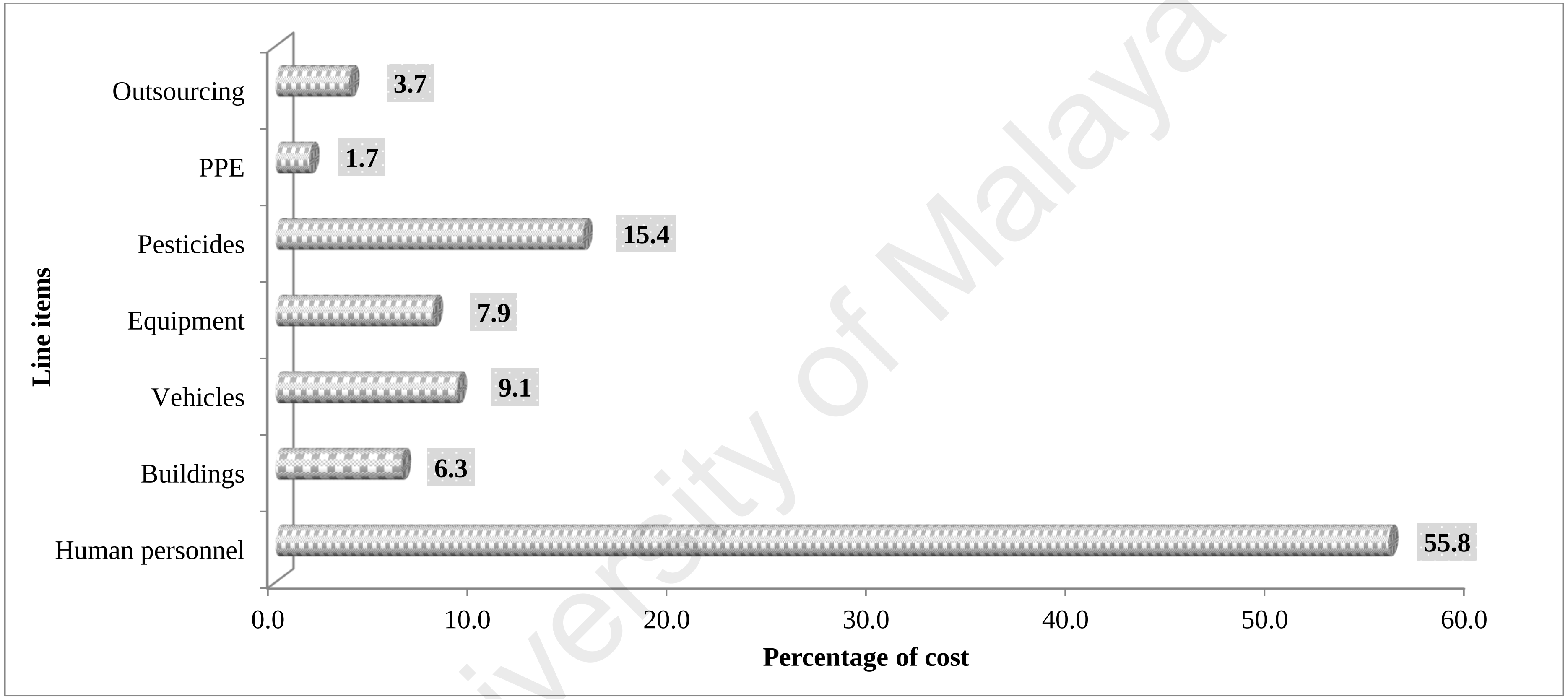

Figure 5.1: Percentage of costs by line items at sampled districts (n=8)

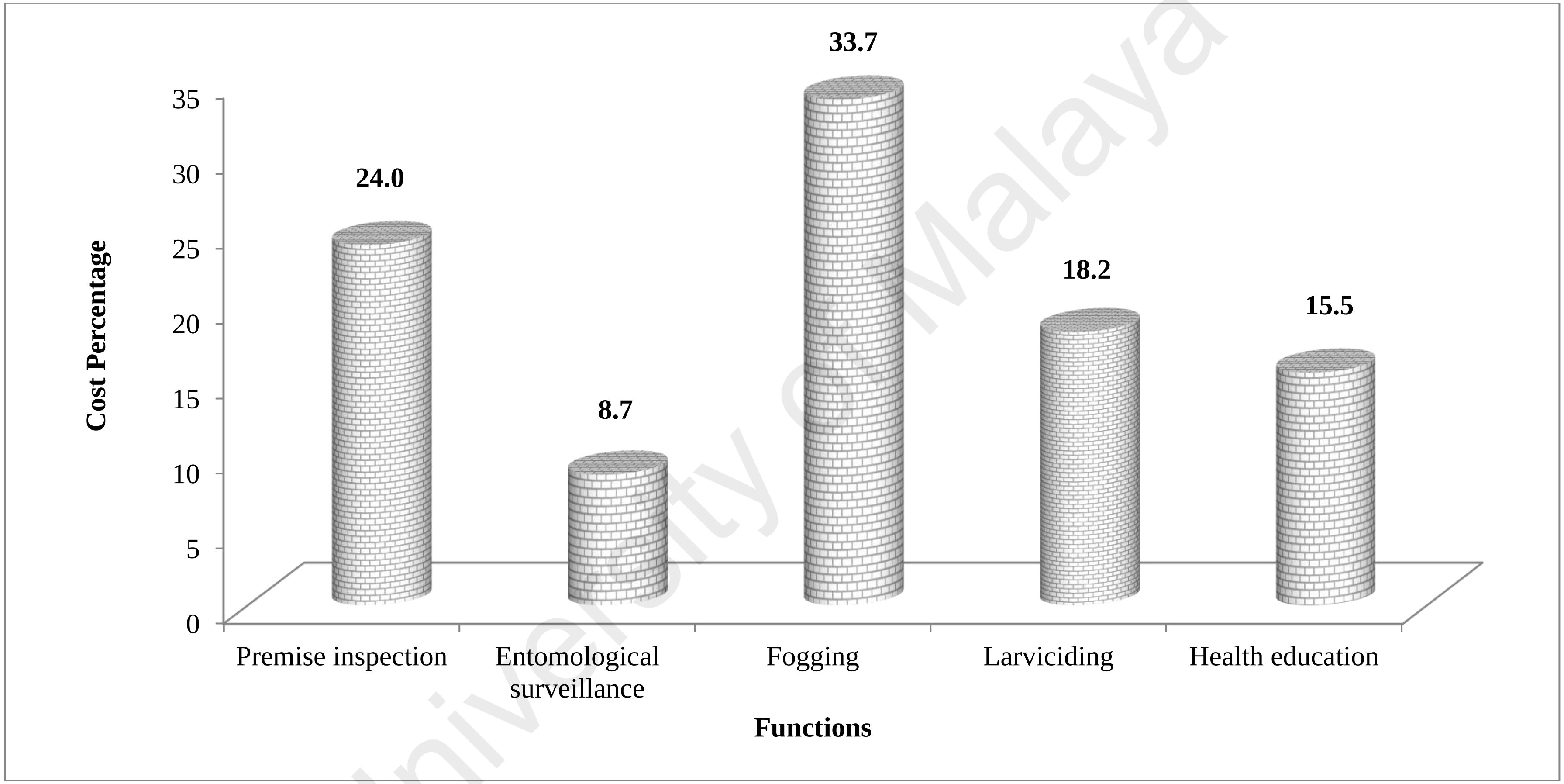

Figure 5.2: Percentage of costs by functions at sampled districts (n=8)

Table 5.3: Capital and recurrent items cost characteristics of the sampled districts (n=8)

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported		Cost per capita	
	MYR	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**
CAPITAL ITEMS										
Buildings	1,749,495	546,717	218,687	68,340	265,641	83,013	105	33	0.31	0.10
Vehicles	909,009	284,066	113,626	35,508	122,160	38,175	55	17	0.16	0.05
Equipment	475,334	148,543	59,417	18,568	45,905	14,345	29	9	0.09	0.03
TOTAL[a]	**3,133,839**	**979,325**	**391,730**	**122,416**	**350,781**	**109,619**	**188**	**59**	**0.56**	**0.18**
RECURRENT ITEMS										
Human personnel	20,181,099	6,306,594	2,522,637	788,324	1,498,217	468,193	1,210	378	3.61	1.13
Buildings	544,255	170,079	68,032	21,260	37,542	11,732	33	10	0.10	0.03
Vehicles	2,386,927	745,915	298,366	93,239	378,150	118,172	143	45	0.43	0.13
Equipment	2,387,974	746,241	298,497	93,280	393,878	123,087	143	45	0.43	0.13
Pesticides	5,586,772	1,745,867	698,347	218,233	728,586	227,683	335	105	1.00	0.31
PPE[b]	624,250	195,079	78,031	24,385	47,690	14,903	37	12	0.11	0.03
Outsourcing[c]	1,325,528	414,228	165,691	51,779	319,836	99,949	79	25	0.24	0.07
TOTAL[d]	**33,036,810**	**10,324,003**	**4,129,601**	**1,290,500**	**2,958,002**	**924,375**	**1,981**	**619**	**5.91**	**1.85**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

Table 5.4: Resources characteristics of sampled districts (n=8)

Resources	Sum		Mean		Median		Std deviation	
Total number of staff	826		103		93		63	
-Medical officer	20		3		3		2	
-Public health physician	12		2		2		1	
-Entomologist	2		0		0		0	
-Percentage of professional staff[a]	89.5		89.3		93.5		NA	
-Percentage of administrative staff[b]	10.5		10.7		9.7		NA	
-Percentage of FTE[c] for dengue vector control	82.9		82.1		85.0		NA	
Vehicles	121		15		14		11	
-Percentage dedicated to dengue vector control	NA		87.6		92.5		NA	
-Percentage more than five years old	33.9		33.3		28.6		NA	
-Annual servicing and maintenance costs (in millions)	MYR 0.41	US$ 0.13	MYR 0.05	US$ 0.02	MYR 0.05	US$ 0.02	MYR 0.03	US$ 0.01
Equipment (fogging & larviciding)	414		52		58		25	
-Annual servicing and maintenance costs (in millions)	MYR 0.53	US$ 0.16	MYR 0.07	US$ 0.02	MYR 0.05	US$ 0.01	MYR 0.07	US$ 0.02
Pesticides								
-Liquid-based pesticides (litres)	53,952		6,744		5,589		7,096	
-Powder based pesticides (kg)	4,721		590		491		550	
-Diesel[#] (litres)	851,448		106,431		38,593		183,058	

[a]Professional staff is persons trained for dengue vector control, surveillance and prevention activities and they include doctors, entomologist, public health inspectors; [b]Administrative staff is persons performing administrative or general duties such as clerks, drivers, cleaners; [c]FTE refers to full-time equivalent; [#]Refers to diesel used to dilute oil-based pesticides for fogging activities; NA denotes not applicable

5.3.2 Extrapolated Costs for all the Districts (N=140) in Malaysia

The sampled districts costs were inflated using probability weights and then summed up to derive the national economic costs of dengue vector control and prevention at district-level. The weighted average cost per district in Malaysia was MYR 1.57 mil (US$ 0.49 mil). The standard error of the mean cost per district was MYR 0.14 mil (US$ 0.04 mil). The weighted average cost of capital items per district was MYR 0.13 mil (US$ 0.04 mil) and for recurrent items were MYR 1.44 mil (US$ 0.45 mil). The weighted average costs by line items and functions are listed in Table 5.5 (costs in MYR) and Table 5.6 (costs in US$).

The national costs at district-level were MYR 216.74 mil (95% CI= MYR 182.22 mil – MYR 255.37 mil). The corresponding costs in US dollars were US$ 67.73 mil (95% CI = US$ 57.20 mil – US$ 79.85 mil). The national cost per reported dengue case was MYR 4,694 (US$ 1,467). The national cost per capita populations was MYR 7.91 (US$ 2.47). The national district-level costs by line items and functions are summarized in Table 5.7 (costs in MYR) and Table 5.8 (costs in US$). The national costs at district-level by capital items were MYR 18.45 mil (US$ 5.76 mil) and by recurrent items were MYR 198.30 mil (US$ 61.97 mil). The national cost per reported dengue case by capital items were MYR 400 (US$ 125), and the corresponding cost per capita populations were MYR 0.67 (US$ 0.21). The national cost per reported dengue case by recurrent items was MYR 4,295 (US$ 1,342), and cost per capita populations were MYR 7.24 (US$ 2.26). The national district-level costs by capital and recurrent items are summarized in Table 5.9 (costs in MYR) and Table 5.10 (costs in US$).

Table 5.5: Average district level dengue vector control and prevention costs for all districts in Malaysia (N=140), (MYR)

Parameters	**Mean Cost**	**Standard error**	**95% Confidence Interval**	
			Lower	***Upper***
LINE ITEMS				
Human personnel	1,029,710	74,973	887,973	1,180,122
Buildings	89,693	11,833	69,119	115,167
Vehicles	119,410	13,558	95,819	148,942
Equipment	90,269	15,081	64,308	122,813
Pesticides	185,916	27,526	137,959	245,130
PPE[a]	42,457	2,606	37,517	47,734
Out-sourcing[b]	13,183	7,818	0	29,943
TOTAL[c]	**1,570,637**	**135,946**	**1,318,062**	**1,847,162**
FUNCTIONS				
Premise inspection	406,440	31,492	350,580	472,983
Entomological surveillance	126,026	15,754	96,726	158,312
Fogging	516,560	43,540	437,401	606,045
Larviciding	301,691	29,882	246,535	362,553
Health education	219,920	21,343	180,669	263,553
CAPITAL ITEMS				
Buildings	60,940	10,466	42,757	83,867
Vehicles	53,939	10,466	49,026	60,762
Equipment	18,791	2,336	14,315	23,425
TOTAL[d]	**133,670**	**13,030**	**110,612**	**161,805**
RECURRENT ITEMS				
Human personnel	1,029,710	74,973	887,973	1,180,122
Buildings	28,752	2,444	24,056	33,515
Vehicles	65,470	11,650	45,971	91,167
Equipment	71,478	13,484	48,894	100,555
Pesticides	185,916	27,526	138,215	244,772
PPE	42,457	2,606	37,421	47,652
Out-sourcing	13,183	7,818	0	29,943
TOTAL[e]	**1,436,967**	**127,243**	**1,201,809**	**1,700,754**

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

[d]Sum of capital items costs

[e]Sum of recurrent items costs

Table 5.6: Average district level dengue vector control and prevention costs for all districts in Malaysia (N=140), (US$)

Parameters	Mean Cost	Standard error	95% Confidence Interval	
			Lower	*Upper*
LINE ITEMS				
Human personnel	321,785	23,429	277,991	368,285
Buildings	28,029	3,698	21,645	35,960
Vehicles	37,315	4,237	30,190	46,402
Equipment	28,209	4,713	20,233	38,375
Pesticides	58,099	8,602	43,192	76,491
PPE[a]	13,268	814	11,694	14,891
Out-sourcing[b]	4,120	2,443	0	9,357
TOTAL[c]	**490,824**	**42,483**	**413,709**	**577,558**
FUNCTIONS				
Premise inspection	127,012	9,841	109,503	147,519
Entomological surveillance	39,383	4,923	30,226	49,591
Fogging	161,425	13,606	136,560	189,719
Larviciding	94,279	9,338	77,023	113,686
Health education	68,725	6,670	56,423	82,698
CAPITAL ITEMS				
Buildings	19,044	3,271	13,370	26,155
Vehicles	16,856	946	15,287	18,943
Equipment	5,872	730	4,488	7,326
TOTAL[d]	**41,772**	**4,072**	**34,693**	**50,401**
RECURRENT ITEMS				
Human personnel	321,785	23,429	277,017	369,065
Buildings	19,044	764	7,522	10,514
Vehicles	20,459	3,641	14,327	28,462
Equipment	22,336	4,214	15,328	31,661
Pesticides	58,099	8,602	43,382	76,868
PPE	13,268	814	11,705	14,907
Out-sourcing	4,120	2,443	0	9,357
TOTAL[e]	**449,052**	**39,763**	**374,876**	**530,475**

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

[d]Sum of capital items costs

[e]Sum of recurrent items costs

Table 5.7: Estimated total dengue vector control and prevention costs for all districts in Malaysia (N=140), (MYR)

Parameters	**Costs**	**95% Confidence Interval**		**Cost per case**	**Cost per capita**
		Lower	*Upper*		
LINE ITEMS					
Human personnel	142,099,979	122,762,106	163,151,738	3,078	5.18
Buildings	12,377,603	9,555,629	15,921,795	268	0.45
Vehicles	16,478,529	13,246,897	20,591,196	357	0.60
Equipment	12,457,105	8,890,628	16,978,917	270	0.45
Pesticides	25,656,387	19,072,753	33,889,143	556	0.94
PPE[a]	5,859,069	5,186,691	6,599,158	127	0.21
Out-sourcing[b]	1,819,203	0	4,139,563	39	0.07
TOTAL[c]	**216,747,868**	**182,221,887**	**255,369,875**	**4,694**	**7.91**
FUNCTIONS					
Premise inspection	56,088,755	48,467,593	65,389,856	1,215	2.05
Entomological surveillance	17,391,524	13,372,355	21,886,668	377	0.63
Fogging	71,285,261	60,470,642	83,785,627	1,544	2.60
Larviciding	41,633,367	34,083,442	50,122,889	902	1.52
Health education	30,348,949	24,977,428	36,436,203	657	1.11

[a]PPE denoted Personal protective equipment; [b]Fogging and larviciding activities sub-contracted to private companies; [c]Sum of line items costs

Table 5.8: Estimated total dengue vector control and prevention costs for all districts in Malaysia (N=140), (US$)

Parameters	Costs	95% Confidence Interval		Cost per case	Cost per capita
		Lower	*Upper*		
LINE ITEMS					
Human personnel	44,406,302	38,432,226	50,915,410	962	1.62
Buildings	3,867,993	2,992,457	4,971,500	84	0.14
Vehicles	5,149,509	4,173,815	6,415,059	112	0.19
Equipment	3,892,884	2,797,151	5,305,380	84	0.14
Pesticides	8,017,656	5,971,350	10,574,914	174	0.29
PPE[a]	1,830,969	1,616,708	2,058,740	40	0.07
Out-sourcing[b]	568,502	0	1,293,616	12	0.02
TOTAL[c]	**67,733,702**	**57,195,147**	**79,847,263**	**1,467**	**2.47**
FUNCTIONS					
Premise inspection	17,527,714	15,138,812	20,394,428	380	0.64
Entomological surveillance	5,434,862	4,178,801	6,855,951	118	0.20
Fogging	22,276,674	18,879,381	26,228,600	482	0.81
Larviciding	13,010,438	10,648,462	15,717,110	282	0.47
Health education	9,484,013	7,800,463	11,432,943	205	0.35

[a]PPE denoted Personal protective equipment; [b]Fogging and larviciding activities sub-contracted to private companies; [c]Sum of line items costs

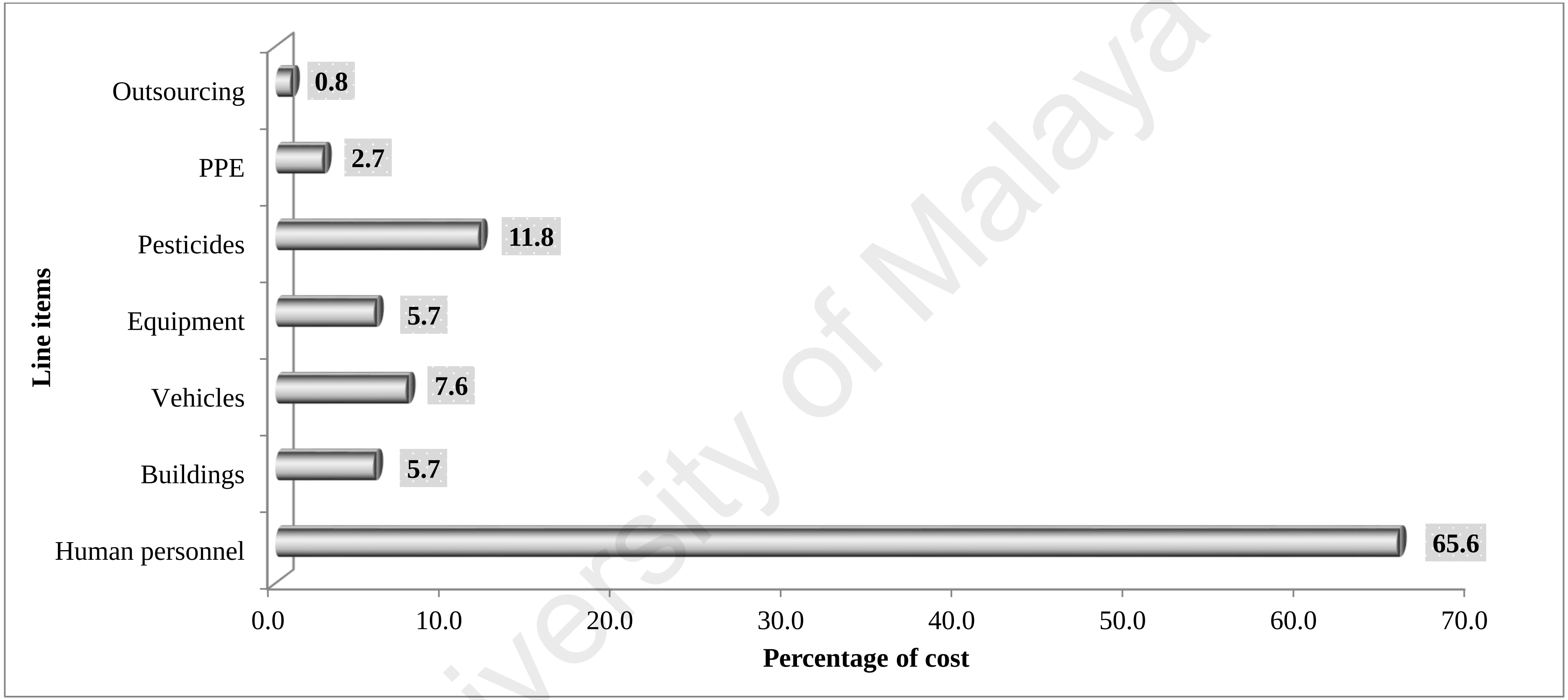

Figure 5.3: Percentage of costs by line items for all districts in Malaysia (N=140)

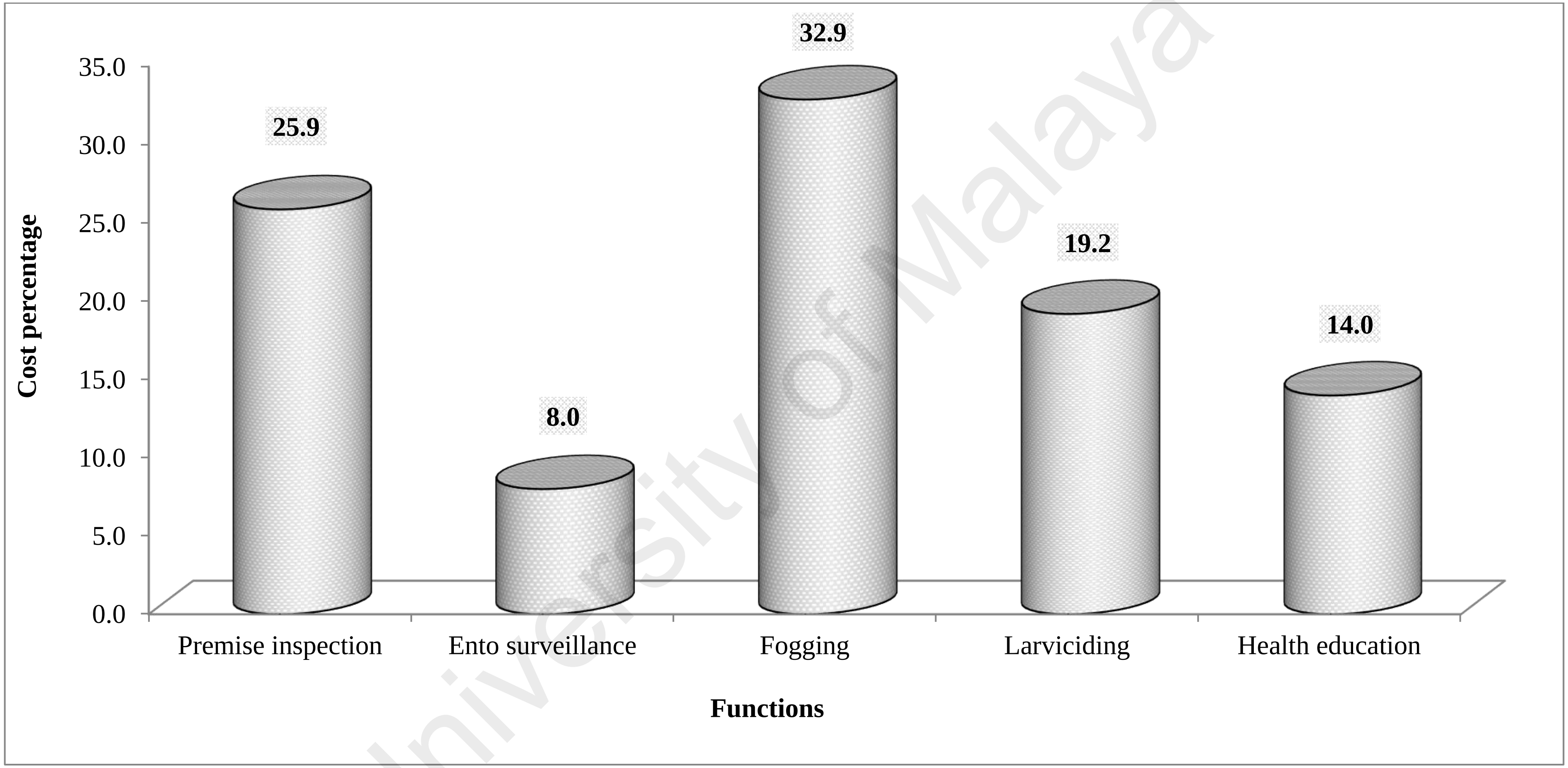

Figure 5.4: Percentage of costs by functions for all districts in Malaysia (N=140)

Table 5.9: Estimated total dengue vector control and prevention costs for all districts in Malaysia by capital and recurrent items (N=140), (MYR)

Parameters	Costs	95% Confidence Interval		Cost per case	Cost per capita
		Lower	*Upper*		
CAPITAL ITEMS					
Buildings	8,409,671	5,911,205	11,594,651	182	0.31
Vehicles	7,443,586	6,777,871	8,400,287	161	0.27
Equipment	2,593,192	1,978,993	3,238,522	56	0.09
TOTAL[a]	**18,446,458**	**15,292,080**	**22,369,458**	**400**	**0.67**
RECURRENT ITEMS					
Human personnel	142,099,979	122,736,369	163,041,981	3,078	5.18
Buildings	3,967,839	3,325,746	4,633,510	86	0.14
Vehicles	9,034,926	6,355,552	12,603,829	196	0.33
Equipment	9,863,905	6,759,567	13,901,760	214	0.36
Pesticides	25,656,387	19,108,197	33,839,635	556	0.94
PPE[b]	5,859,069	5,173,437	6,587,926	127	0.21
Out-sourcing[c]	1,819,203	0	4,139,563	39	0.07
TOTAL[e]	**198,301,410**	**166,149,932**	**235,128,952**	**4,295**	**7.24**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of recurrent items costs

Table 5.10: Estimated total dengue vector control and prevention costs for all districts in Malaysia by capital and recurrent items (N=140), (US$)

Parameters	Costs	95% Confidence Interval		Cost per case	Cost per capita
		Lower	*Upper*		
CAPITAL ITEMS					
Buildings	2,628,029	1,848,367	3,615,895	57	0.10
Vehicles	2,326,123	2,113,422	2,618,799	50	0.08
Equipment	810,376	620,408	1,012,862	18	0.03
TOTAL[a]	**5,764,490**	**4,796,283**	**6,967,885**	**125**	**0.21**
RECURRENT ITEMS					
Human personnel	44,406,302	1,039,858	1,453,514	962	1.62
Buildings	1,239,961	1,980,705	3,934,817	27	0.05
Vehicles	2,823,389	2,119,045	4,377,170	61	0.10
Equipment	3,082,427	5,997,588	10,626,988	67	0.11
Pesticides	8,017,656	1,618,222	2,060,919	174	0.29
PPE[b]	1,830,969	0	1,293,616	40	0.07
Out-sourcing[c]	568,502	51,826,557	73,338,149	12	0.02
TOTAL[e]	**61,969,206**	**1,039,858**	**1,453,514**	**1,342**	**2.26**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of recurrent items costs

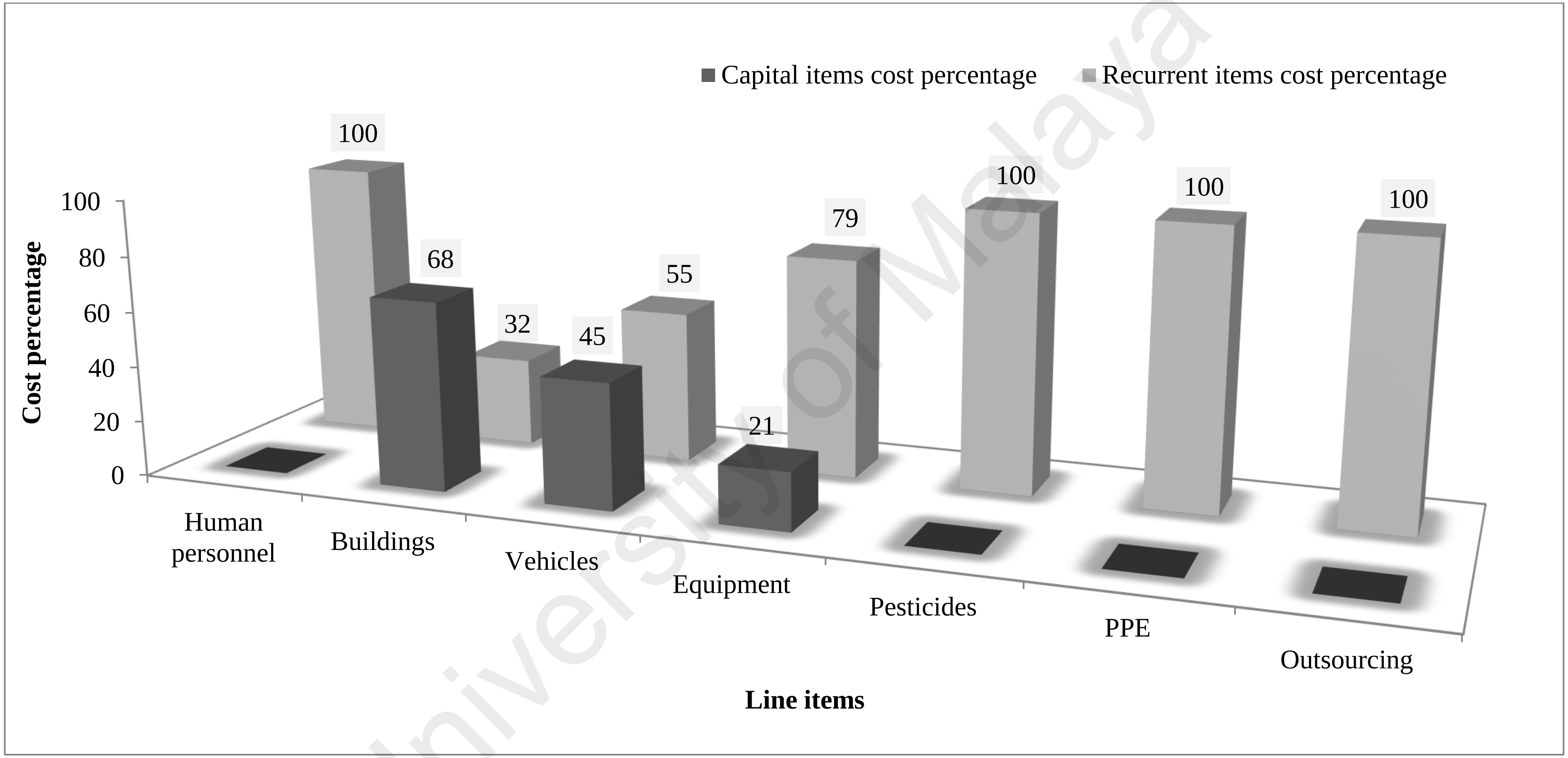

Figure 5.5: Cost percentage of capital and recurrent items by line items for all districts in Malaysia (N=140)

5.4 Costs and Resources Use at the State-Level (SHDs)

In this section, the costs results are described for the sample SHDs (n=3) in subsection 5.4.1 and the extrapolated costs for all the SHDs (N=14) in Malaysia are described in subsection 5.4.2.

5.4.1 Costs and Resources Use at the Sample SHDs (n=3)

The total costs at the sampled SHDs ranged between MYR 0.71 mil (US$ 0.22 mil) in Melaka to MYR 1.09 mil (US$ 0.34 mil) in Kedah. The sum of the costs in the three SHDs was MYR 2.74 mil (US$ 0.86 mil). The average total cost among the sampled SHDs was MYR 0.91 mil (US$ 0.29 mil). In general, the cost per reported case appeared to be lower in SHDs with a higher burden of cases compared to those with lower burdens. The cost per reported case at the sampled SHDs was MYR 147 (US$ 46). The cost per capita populations was MYR 0.34 (US$ 0.04). The main cost drivers in the sampled SHDs were human personnel and buildings. Human personnel costs formed 76.6% of the total costs and buildings costs was 16.3%.

The total costs of capital items were MYR 0.37 mil (US$ 0.12 mil), and total costs of recurrent items were MYR 2.37 mil (US$ 0.74 mil). The costs proportions of recurrent items were the largest, and it formed 86.5% from the total costs. The average total cost of capital items was MYR 0.12 mil (US$ 0.04 mil) and for recurrent items were MYR 0.79 mil (US$ 0.25 mil). The economic costs characteristics of sampled SHDs by line items, capital items, and recurrent items are summarized in Table 5.11. The costs and resources specific information of the each sampled SHD is listed in Appendices Y-AA.

There was 110 government staff contributed to dengue vector control and prevention activities in the sampled SHDs. Median personnel in the districts were 40 people. However, only 63 FTE staff dedicated to dengue-related activities. Among the government staff, 72.7% were health care professionals or individuals who had received specific training for dengue vector control activities such as doctors, entomologists and allied health professionals, such as health inspectors. There were 12 vehicles allocated to the vector control units. Among those vehicles, the average time dedicated exclusively to dengue-related activities was 76.0%. On average, 50.0% of those vehicles were aged more than five years. The resources characteristics for sampled SHDs are outlined in Table 5.12.

Table 5.11: Costs characteristics at the sampled SHDs (n=3)

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported		Cost per capita	
	MYR	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**
LINE ITEMS										
Human personnel	2,101,507	656,720	700,502	218,907	213,626	66,758	113	35	0.26	0.03
Buildings	446,783	139,619	148,928	46,540	22,535	7,043	24	7	0.06	0.01
Vehicles	195,768	61,178	65,256	20,393	11,972	3,742	11	3	0.02	0.003
TOTAL[a]	**2,744,057**	**857,519**	**914,686**	**285,840**	**192,517**	**60,161**	**147**	**46**	**0.34**	**0.04**
CAPITAL ITEMS										
Buildings	266,204	83,189	88,735	27,730	47,806	14,939	14	4	0.03	0.01
Vehicles	103,408	32,316	34,469	10,772	13,965	4,364	6	2	0.01	0.004
TOTAL[b]	**369,613**	**115,504**	**123,204**	**38,501**	**59,665**	**18,646**	**20**	**6**	**0.05**	**0.014**
RECURRENT ITEMS										
Human personnel	2,101,507	656,720	700,502	218,907	213,626	66,758	113	35	0.26	0.08
Buildings	180,579	56,430	60,193	18,810	26,744	8,358	10	3	0.02	0.01
Vehicles	92,360	28,862	30,787	9,621	7,415	2,317	5	2	0.01	0.004
TOTAL[c]	**2,374,445**	**742,014**	**791,482**	**247,338**	**242,881**	**75,900**	**127**	**40**	**0.30**	**0.09**

[a]Sum of line items costs; [b]Sum of capital items costs; [c]Sum of recurrent items costs

Table 5.12: Resources characteristics of the sampled SHDs (n=3)

Resources	Sum	Mean	Median	Std. deviation
Total number of staff	110	37	40	9
-Medical officer	6	2	2	1
-Public health physician	4	1	1	1
-Entomologist	5	2	2	1
-Percentage of professional staff[a]	72.7	73.0	72.5	NA
-Percentage of administrative staff[b]	27.3	27.0	20.0	NA
-Percentage of FTE[c] for dengue vector control	57.3	56.8	57.5	NA
Vehicles	12	4	4	1
-Percentage dedicated to dengue vector control	NA	76.0	77.0	NA
-Percentage more than five years old	50.0	50.0	50.0	NA
-Annual servicing and maintenance costs (in millions)	MYR 73,569; US$ 22,990	MYR 24,523; US$ 7,663	MYR 25,068; US$ 7,834	MYR 4,033; US$ 1,261

[a]Professional staff is persons trained for dengue vector control, surveillance and prevention activities and they include doctors, entomologist, public health inspectors; [b]Administrative staff is persons performing administrative or general duties such as clerks, drivers, cleaners; [c]FTE refers to full-time equivalent;

5.4.2 Extrapolated Costs for all the SHDs (N=14) in Malaysia

The average cost per SHD in Malaysia was MYR 0.91 mil (US$ 0.29 mil). The standard error of the mean cost per SHD was MYR 0.12 mil (US$ 0.04 mil). The average cost for capital items per SHD was MYR 0.12 mil (US$ 0.04 mil) and for recurrent items were MYR 0.79 mil (US$ 0.25 mil). The average costs of line items, capital items, and recurrent items are listed in Table 5.13(costs in MYR) and Table 5.14 (costs in US$). The national extrapolated costs at state-level were MYR 12.81 mil (95% CI= MYR 9.95 mil – MYR 15.30 mil). The corresponding costs in US dollars were US$ 4.00 mil (95% CI = US$ 3.11 mil – US$ 4.78 mil). The national state-level cost per reported dengue case was MYR 277 (US$ 87). The national state-level cost per capita populations was MYR 0.47 (US$ 0.15). The national costs at state-level by capital items were MYR 1.72 mil (US$ 0.54 mil) and by recurrent items were MYR 11.08 mil (US$ 3.46 mil). The national state-level cost per reported dengue case by capital items was MYR 37 (US$ 12), and the corresponding cost per capita populations were MYR 0.06 (US$ 0.02). The national state-level cost per reported dengue case by recurrent items was MYR 240 (US$ 75), and cost per capita populations were MYR 0.40 (US$ 0.13). The national extrapolated state-level costs by line items, capital items, and recurrent items are summarized in Table 5.15 (costs in MYR) and Table 5.16 (costs in US$).

Table 5.13: Average state level dengue vector control and prevention costs for all SHDs in Malaysia (N=14), (MYR)

Parameters	Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*
LINE ITEMS				
Human personnel	700,502	123,337	482,352	909,297
Buildings	148,928	13,011	124,997	169,743
Vehicles	65,256	6,912	58,278	79,080
TOTAL[a]	**914,686**	**111,150**	**710,373**	**1,092,703**
CAPITAL ITEMS				
Buildings	88,735	27,601	34,043	122,567
Vehicles	34,469	8,062	20,265	48,181
TOTAL[b]	**123,204**	**34,448**	**54,309**	**157,775**
RECURRENT ITEMS				
Human personnel	700,502	123,337	482,352	909,297
Buildings	60,193	15,440	42,450	90,953
Vehicles	30,787	4,281	23,316	38,145
TOTAL[c]	**791,482**	**140,228**	**552,844**	**1,038,395**

[a]Sum of line items costs; [b]Sum of capital items costs; [c]Sum of recurrent items costs

Table 5.14: Average state level dengue vector control and prevention costs for all SHDs in Malaysia (N=14), (US$)

Parameters	Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*
LINE ITEMS				
Human personnel	218,907	38,543	150,735	284,155
Buildings	46,540	4,066	39,061	53,045
Vehicles	20,393	2,160	18,212	24,713
TOTAL[a]	**285,840**	**34,734**	**221,992**	**341,470**
CAPITAL ITEMS				
Buildings	27,730	8,625	10,639	38,302
Vehicles	10,772	2,520	6,333	15,057
TOTAL[b]	**38,501**	**10,765**	**16,971**	**49,305**
RECURRENT ITEMS				
Human personnel	218,907	38,543	150,735	284,155
Buildings	18,810	4,825	13,265	28,423
Vehicles	9,621	1,338	7,286	11,920
TOTAL[c]	**247,338**	**43,821**	**172,764**	**324,498**

[a]Sum of line items costs; [b]Sum of capital items costs; [c]Sum of recurrent items costs

Table 5.15: Estimated total dengue vector control and prevention costs for all SHDs in Malaysia (N=14), (MYR)

Parameters	Costs	95% Confidence Interval		Cost per case	Cost per capita
		Lower	*Upper*		
LINE ITEMS					
Human personnel	9,807,033	6,752,928	12,730,158	212	0.36
Buildings	2,084,987	1,749,958	2,376,402	45	0.08
Vehicles	913,584	815,892	1,107,120	20	0.03
TOTAL[a]	**12,805,599**	**9,945,222**	**15,297,842**	**277**	**0.47**
CAPITAL ITEMS					
Buildings	1,242,285	476,602	1,715,938	27	0.05
Vehicles	482,571	283,710	674,534	10	0.02
TOTAL[b]	**1,724,861**	**760,326**	**2,208,850**	**37**	**0.06**
RECURRENT ITEMS					
Human personnel	9,807,033	6,752,928	12,730,158	212	0.36
Buildings	842,702	594,300	1,273,342	18	0.03
Vehicles	431,013	326,424	534,030	9	0.02
TOTAL[c]	**11,080,743**	**7,739,816**	**14,537,530**	**240**	**0.40**

[a]Sum of line items costs

[b]Sum of capital items costs

[c]Sum of recurrent items costs

Table 5.16: Estimated total dengue vector control and prevention costs for all SHDs in Malaysia (N=14), (US$)

Parameters	Costs	95% Confidence Interval		Cost per case	Cost per capita
		Lower	*Upper*		
LINE ITEMS					
Human personnel	3,064,693	2,110,290	3,978,170	66	0.11
Buildings	651,555	546,854	742,630	14	0.02
Vehicles	285,497	254,968	345,982	6	0.01
TOTAL[a]	**4,001,755**	**3,107,888**	**4,780,580**	**87**	**0.15**
CAPITAL ITEMS					
Buildings	388,215	148,946	536,228	8	0.01
Vehicles	150,808	88,662	210,798	3	0.01
TOTAL[b]	**539,019**	**237,594**	**690,270**	**12**	**0.02**
RECURRENT ITEMS					
Human personnel	3,064,693	2,110,290	3,978,170	66	0.11
Buildings	263,340	185,710	397,922	6	0.01
Vehicles	134,689	102,004	166,880	3	0.00
TOTAL[c]	**3,462,732**	**2,418,696**	**4,542,972**	**75**	**0.13**

[a]Sum of line items costs

[b]Sum of capital items costs

[c]Sum of recurrent items costs

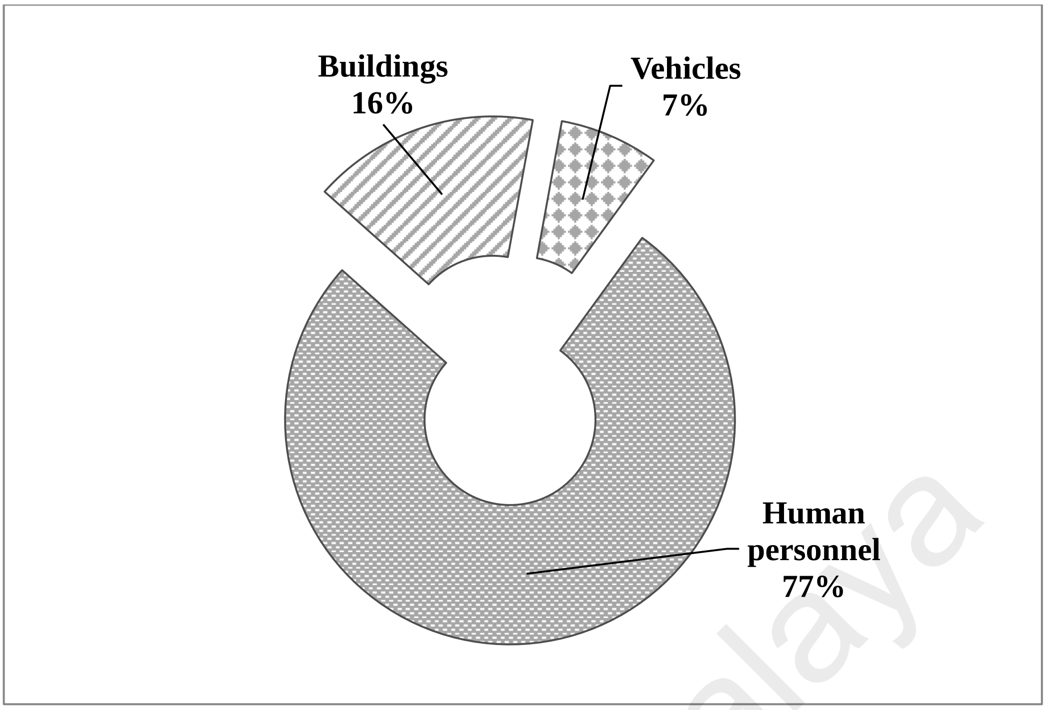

Figure 5.6: Cost percentage by line items for all SHDs in Malaysia (N=14)

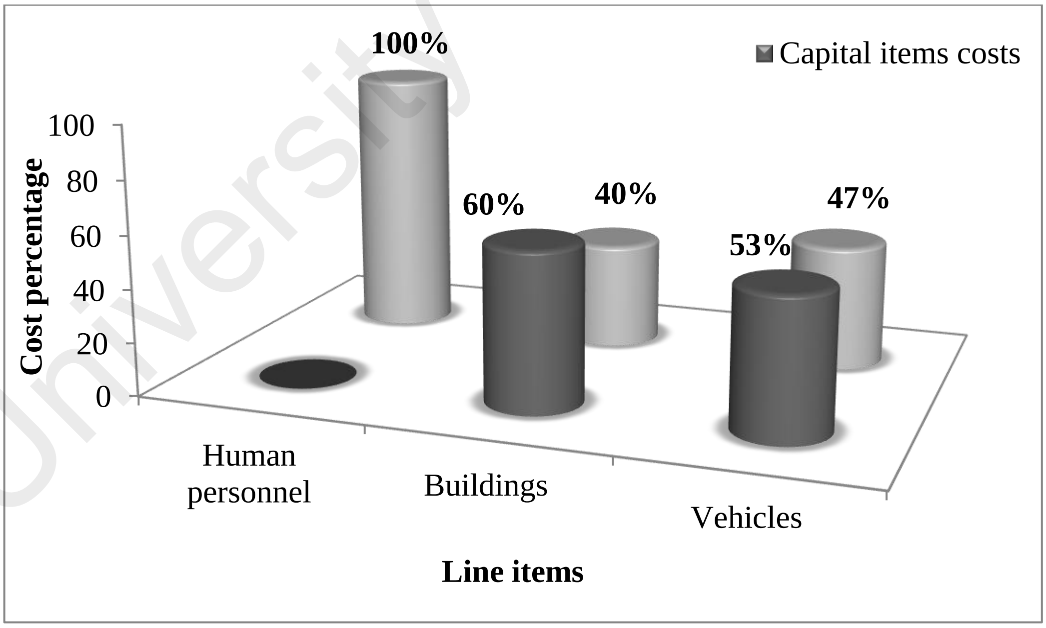

Figure 5.7: Cost percentage by capital and recurrent items for all SHDs in Malaysia (N=14)

5.5 Costs and Resources Use at the Federal-Level (FHD)

The total costs for FHD were MYR 5.50 mil (US$ 1.72 mil). Costs by line items revealed the highest proportion was for national dengue prevention advertisement campaigns (89.1%) followed by the human personnel (8.0%). The total cost per reported case for FHD was MYR 119 (US$ 37), and the total cost per capita populations were MYR 0.20 (US$ 0.06). Costs of capital items were MYR 0.12 mil (US$ 0.04 mil), and costs of recurrent items were MYR 5.38 mil (US$ 1.68 mil). Recurrent items formed the largest cost proportions of 97.8% from the total cost. The economic costs characteristics for FHD are listed in Table 5.17.

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There were ten government staff at FHD-level. The FTE staff dedicated to dengue-related activities was six. Among the government staff, 90.0% were health care professionals or persons who had received specific training for dengue vector control activities such as doctors, entomologists and allied health professionals, such as health inspectors. There were two vehicles allocated to the vector control units and 65.0% of usage time was dedicated to dengue-related activities. All the vehicles used were aged less than five years. FHD spent MYR 3,805 (US$ 1,189) for annual servicing and maintenance costs of their vehicles. The resources characteristics for FHD are outlined in Table 5.18.

Table 5.17: Costs characteristics of FHD

Parameters	Cost		Cost per reported case		Cost per capita	
	MYR	**US$**	**MYR**	**US$**	**MYR**	**US$**
LINE ITEMS						
Human personnel	438,405	137,002	9	3	0.02	0.005
Buildings	135,445	42,327	3	1	0.005	0.002
Vehicles	24,386	7,621	1	0.2	0.001	0.0003
Dengue prevention advertisement campaign	4,900,000	1,531,250	106	33	0.18	0.06
TOTAL[a]	**5,498,236**	**1,718,199**	**119**	**37**	**0.20**	**0.06**
CAPITAL ITEMS						
Buildings	105,482	32,963	2.28	0.71	0.004	0.001
Vehicles	17,610	5,503	0.38	0.12	0.001	0.0002
TOTAL[b]	**123,092**	**38,466**	**2.67**	**0.83**	**0.004**	**0.001**
RECURRENT ITEMS						
Human personnel	438,405	137,002	9	3	0.02	0.005
Buildings	29,963	9,363	0.6	0.2	0.001	0.0003
Vehicles	6,776	2,118	0.1	0.05	0.0002	0.0001
Dengue prevention advertisement campaign	4,900,000	1,531,250	106	33	0.18	0.06
TOTAL[c]	**5,375,144**	**1,679,733**	**116**	**36**	**0.20**	**0.06**

[a]Sum of line items costs

[b]Sum of capital items costs

[c]Sum of recurrent items costs

Table 5.18: Resources characteristics of FHD

Resources parameter	Quantity/Amount	
Total number of staff	10	
-Medical officer	2	
-Public health physician	2	
-Entomologist	1	
-Percentage of professional staff[a]	90.0	
-Percentage of administrative staff[b]	10.0	
-Percentage of FTE[c] for dengue vector control	61.5	
Vehicles	2	
-Percentage dedicated to dengue vector control	65.0	
-Percentage more than five years old	0	
-Annual servicing and maintenance costs	MYR 3,805	US$ 1,189

[a]Professional staff is persons trained for dengue vector control, surveillance and prevention activities, and they include doctors, entomologist, public health inspectors

[b]Administrative staff is persons performing administrative or general duties such as clerks, drivers, cleaners

[c]FTE refers to full-time equivalent

5.6 National Dengue Vector Control and Prevention Costs for Malaysia

The national dengue vector control and prevention costs for Malaysia in 2010 were MYR 235.05 mil (95% CI = MYR 197.67 mil – MYR 276.17 mil). The corresponding costs in US Dollars were US$ 73.45 mil (95% CI = US$ 62.02 mil – US$ 86.35 mil). The national costs per reported case were MYR 5,091 (US$ 1,591) and costs per capita populations were MYR 8.58 (US$ 2.68). Human personnel costs represented the largest proportion of the total cost (64.8%) followed by the costs of pesticides (10.9%). The costs at the district-level where most of the activities occurred were 92.2% from the total costs. The dengue vector control and prevention costs by line items and level of government in Malaysia are summarized in Table 5.19 (costs in MYR) and Table 5.20 (costs in US$). The costs for Malaysia in 2010 by capital items were MYR 20.29 mil (95% CI = MYR 16.18 mil – MYR 24.70 mil). In US Dollars, it was US$ 6.34 mil (95% CI = US$ 5.07 mil – US$ 7.70 mil). The costs of capital items per reported case were MYR 440 (US$137), and costs per capita populations were MYR 0.74 (US$0.23). As for recurrent items, the costs were MYR 214.76 mil (95% CI = MYR 172.08 mil – MYR 241.54 mil). The costs in US Dollars were US$ 67.11 mil (95% CI = US$ 55.92 mil – US$ 79.56 mil). The costs of recurrent items per reported case were MYR 4,651 (US$ 1,454) and costs per capita populations were MYR 7.84 (US$ 2.45). Overall, 91.4% of the total national costs for dengue vector control activities were for recurrent expenditures, mainly for payment of the salaries and allowances of the health care personnel involved either directly or indirectly in these activities. The dengue vector control and prevention costs for Malaysia by capital and recurrent items are summarized in Tables 5.21-5.24.

Table 5.19: Costs by line items and level of government, Malaysia 2010 (MYR)

Line items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Human personnel	142.10	122.76 – 163.15	9.81	6.75 – 12.73	0.44	152.35	129.95 – 176.32
Buildings	12.38	9.56 – 15.92	2.08	1.75 – 2.38	0.14	14.60	11.44 – 18.43
Vehicles	16.48	13.25 – 20.59	0.91	0.82 – 1.11	0.02	17.42	14.09 – 21.72
Equipment	12.46	8.89 – 16.98	NA[c]			12.46	8.89 – 16.98
Pesticides	25.66	19.07 – 33.89				25.66	19.07 – 33.89
PPE[a]	5.86	5.19 – 6.60				5.86	5.19 – 6.60
Outsourcing	1.82	0 – 4.14				1.82	0 – 4.14
National dengue prevention campaign	NA[c]				4.90	4.90	NA[c]
TOTAL[b] (in million)	**216.75**	**182.22 – 255.37**	**12.81**	**9.95 – 15.28**	**5.50**	**235.05**	**197.67 – 276.17**
Per reported case	**4,694**	**3,947 – 5,531**	**277**	**215 – 331**	**119**	**5,091**	**4,281 – 5,981**
Per capita population	**7.91**	**6.65 – 9.32**	**0.47**	**0.36 – 0.56**	**0.20**	**8.58**	**7.21 – 10.08**

[a]PPE denotes personal protective equipment
[b]Total denotes sum of line items costs
[c]NA denotes not applicable

Table 5.20: Costs by line items and level of government, Malaysia 2010 (US$)

Line items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Human personnel	44.41	38.43 – 50.92	3.06	2.11 – 3.98	0.14	47.61	42.55 – 55.03
Buildings	3.87	2.99 – 4.97	0.65	0.55 – 0.74	0.04	4.56	3.78 – 5.76
Vehicles	5.15	4.17 – 6.42	0.29	0.25 – 0.35	0.008	5.44	4.53 – 6.77
Equipment	3.89	2.80 – 5.31	NA[c]			3.89	2.80 – 5.31
Pesticides	8.02	5.97 – 10.57				8.02	5.97 – 10.57
PPE[a]	1.83	1.62 – 2.06				1.83	1.62 – 2.06
Outsourcing	0.57	0 – 1.29				0.57	0 – 1.29
National dengue prevention campaign	NA[c]				1.53	1.53	NA[c]
TOTAL[b] (in million)	**67.73**	**57.20 – 79.85**	**4.00**	**3.11 – 4.78**	**1.72**	**73.45**	**62.02 – 86.35**
Per reported case	**1,467**	**1,239 – 1,729**	**87**	**67 – 104**	**37**	**1,591**	**1,343 – 1,870**
Per capita population	**2.47**	**2.09 – 2.91**	**0.15**	**0.11 – 0.17**	**0.06**	**2.68**	**2.26 – 3.15**

[a]PPE denotes personal protective equipment
[b]Total denotes sum of line items costs
[c]NA denotes not applicable

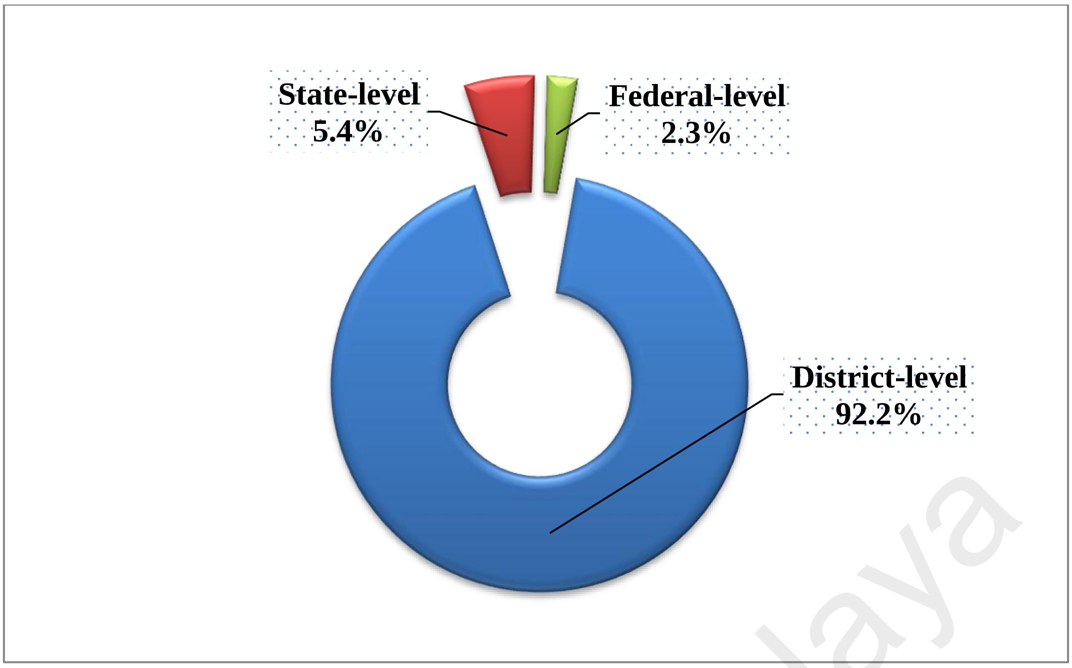

Figure 5.8: National cost percentage by level of government, Malaysia 2010

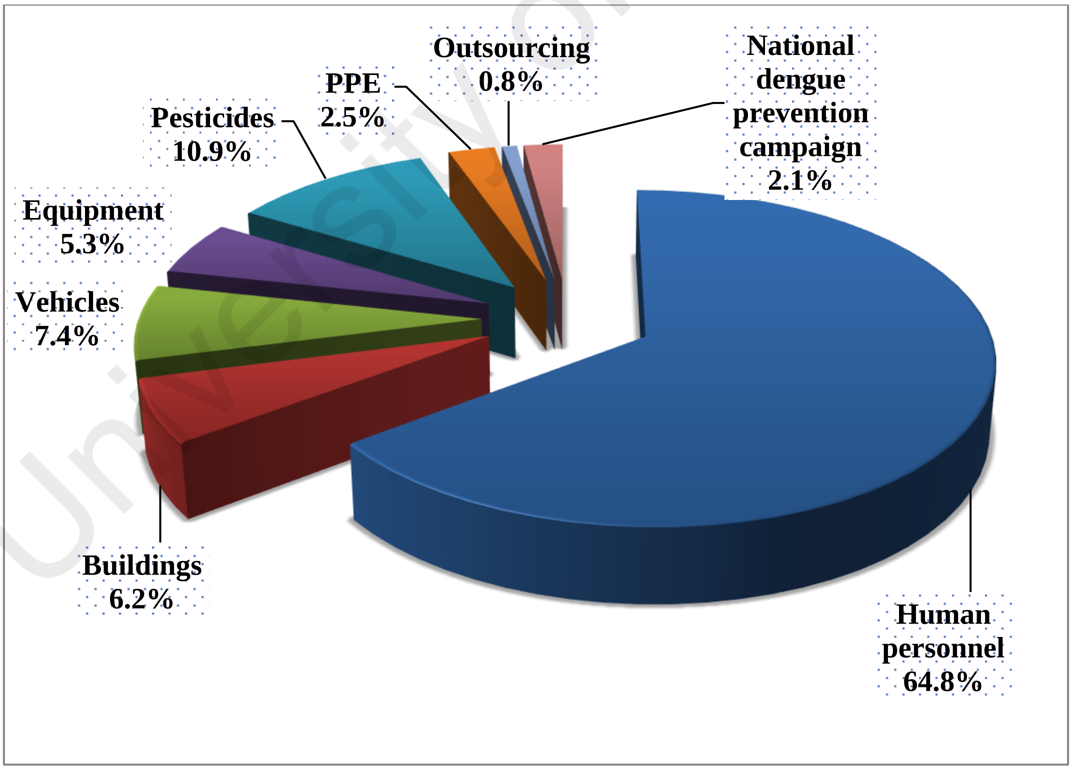

Figure 5.9: National cost percentage by line items, Malaysia 2010

Table 5.21: Costs by capital items and level of government, Malaysia 2010 (MYR)

Capital items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Buildings	8.41	5.91 - 11.59	1.24	0.48 – 1.72	0.11	9.76	6.49 – 13.42
Vehicles	7.44	6.78 - 8.40	0.48	0.28 – 0.67	0.02	7.94	7.08 – 9.09
Equipment	2.59	1.98 – 3.24	NA[c]			2.59	1. 98 – 3.24
TOTAL[a] (in million)	**18.45**	15.29 – 22.37	**1.72**	20,294,410	**0.12**	**20.29**	**16.18 – 24.70**
Per reported case	**400**	**331 - 484**	**37**	**16 - 48**	**3**	**440**	**350 - 535**
Per capita population	**0.67**	**0.56 – 0.82**	**0.06**	**0.03 – 0.08**	**0.004**	**0.74**	**0.59 – 0.90**

[a]Sum of capital items costs; [c]NA denotes not applicable

Table 5.22: Costs by capital items and level of government, Malaysia 2010 (US$)

Capital items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Buildings	2.63	1.85 – 3.62	0.39	0.15 – 0.54	0.03	3.05	2.03 – 3.97
Vehicles	2.33	2.11 – 2.62	0.15	0.09 – 0.21	0.01	2.48	2.21 – 2.84
Equipment	0.81	0.62 – 1.01	NA[c]			0.81	0.62 – 1.01
TOTAL[a] (in million)	**5.76**	**4.80 – 6.97**	**0.54**	**0.24 – 0.69**	**0.04**	**6.34**	**5.07 – 7.70**
Per reported case	**125**	**104 - 151**	**12**	**5 - 15**	**1**	**137**	**110 - 167**
Per capita population	**0.21**	**0.17 – 0.25**	**0.02**	**0.01 – 0.03**	**0.001**	**0.23**	**0.19 – 0.28**

[a]Sum of capital items costs; [c]NA denotes not applicable

Table 5.23: Costs by recurrent items and level of government, Malaysia 2010 (MYR)

Recurrent items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Human personnel	142.10	122.74 – 163.04	9.81	6.75 – 12.73	0.44	152.35	123.66 – 164.39
Buildings	3.97	3.33 – 4.63	0.84	0.59 1.27	0.03	4.84	3.40 – 4.75
Vehicles	9.03	6.36 – 12.60	0.43	0.33 – 0.53	0.01	9.47	6.39 – 12.65
Equipment	9.86	6.76 – 13.90	NA[c]			9.86	6.76 – 13.90
Pesticides	25.66	19.11 – 33.84				25.66	19.11 – 33.84
PPE[a]	5.86	5.17 – 6.59				5.86	5.17 – 6.59
Outsourcing	1.82	0 – 4.14				1.82	0 – 4.14
National dengue prevention campaign	NA[c]				4.90	4.90	NA[c]
TOTAL[b] (in million)	**198.30**	**166.15 – 235.13**	**11.08**	**7.74 – 14.54**	**5.38**	**214.76**	**172.08 – 241.54**
Per reported case	**4,295**	**3,599 – 5,093**	**240**	**166 – 315**	**116**	**4,651**	**3,883 – 5,524**
Per capita population	**7.24**	**6.06 – 8.58**	**0.40**	**0.28 – 0.53**	**0.20**	**7.84**	**6.54 – 9.31**

[a]PPE denotes personal protective equipment
[b]Total denotes sum of recurrent items costs
[c]NA denotes not applicable

Table 5.24: Costs by recurrent items and level of government, Malaysia 2010 (US$)

Recurrent items and totals	District-level	95% CI	State-level	95% CI	Federal-level	All-levels	95% CI
Aggregate (in million)							
Human personnel	44.41	38.30 – 51.02	3.06	2.11 – 3.98	0.14	47.61	40.54 – 55.14
Buildings	1.24	1.04 – 1.45	0.26	0.19 – 0.40	0.01	1.51	1.23 – 2.00
Vehicles	2.82	1.98 – 3.94	0.13	0.10 – 0.17	0.002	2.96	2.08 – 4.10
Equipment	3.08	2.12 – 4.38	NA[c]			3.08	2.12 – 4.38
Pesticides	8.02	6.00 – 10.63				8.02	6.00 – 10.63
PPE[a]	1.83	1.62 – 2.06				1.83	1.62 – 2.06
Outsourcing	0.57	0 – 1.29				0.57	0 – 1.29
National dengue prevention campaign	NA[c]				1.53	1.53	NA[c]
TOTAL[b] (in million)	**61.97**	**51.83 -73.34**	**3.46**	**2.42 – 4.54**	**1.68**	**67.11**	**55.92 – 79.56**
Per reported case	**1,342**	**1,122 – 1,588**	**75**	**52 – 98**	**36**	**1,454**	**1,211 – 1,723**
Per capita population	**2.26**	**1.89 – 2.68**	**0.13**	**0.09 – 0.17**	**0.06**	**2.45**	**2.04 – 2.90**

[a]PPE denotes personal protective equipment
[b]Total denotes sum of recurrent items costs
[c]NA denotes not applicable

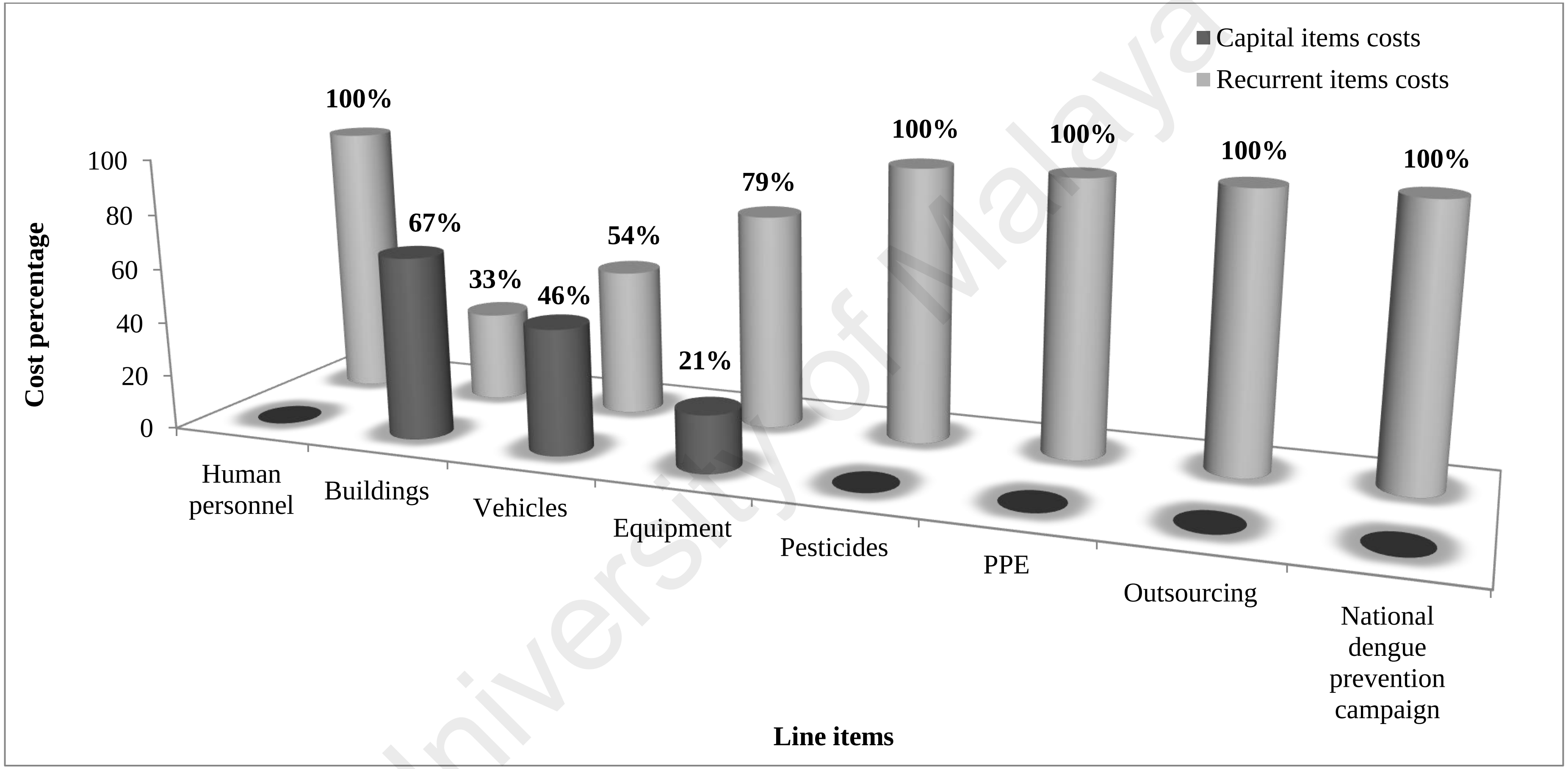

Figure 5.10: National cost percentage by capital and recurrent items for Malaysia, 2010

5.7 Summary

In chapter five, the dengue vector control and prevention costs at all administrative levels of both public sector agencies in Malaysia had been gathered. The national dengue vector control and prevention costs were estimated using costs from the sampled study sites. The dengue vector control and prevention services are resource intensive and involve a large number of workforce. The major portion of the costs incurred was at the district-level involving the DHDs and LAs where the primary activities occur and the services are delivered to the communities. The costs to provide dengue vector control and prevention services to the general population in the year 2010 were substantial amounting to MYR 235.05 mil and form an enormous economic burden to the healthcare system in Malaysia.

CHAPTER 6 : COSTS OF DENGUE VECTOR CONTROL AND PREVENTION BY DIFFERENT SERVICE PROVIDERS

6.1 Introduction

In chapter six, the costs of dengue vector control and prevention activities at district-level were analyzed separately by respective public sector service providers. The costs of providing only vector control services, focusing on three main activities namely the inspection of premises, larviciding and fogging activities were also compared between the DHDs and LAs. Section 6.2 will present the sample study sites characteristics by DHDs and LAs. Section 6.3 will describe the economic costs and resources use for dengue vector control and prevention activities at the districts-level by the DHDs and LAs. Section 6.4 will report the national cost extrapolation of dengue vector control and prevention activities at the district-level by the DHDs and LAs. Section 6.5 will report the vector control unit characteristics by service providers. Section 6.6 will describe the cost comparisons of providing vector control services by the DHDs and LAs. The chapter will conclude with section 6.7.

6.2 Sample Study Sites Characteristics by DHD and LA

The eight sampled districts included in this study reported total 16,676 cases or 36.1% of the national cases. There were eight DHDs and 12 LAs in the sampled districts. The DHDs responded to 8,275 reported dengue cases (49.6%) and the LAs responded to 8,401 cases (50.4%) from the total reported dengue cases in the sampled district. The average reported dengue cases responded by the DHDs were 1,034 (95% CI=305-2,125), and the LAs were 700 (95% CI=340-1,096). The median reported dengue cases were 429 for the DHDs and 460 for the LAs. Table 6.1 summarizes the dengue cases responded by service providers at the sampled districts. The distribution of reported dengue cases by DHDs and LAs in the sampled district are depicted in figure 6.1.

Table 6.1: The dengue cases responded by service providers at sampled districts

Sample district	Quantity		Reported dengue cases		Total cases
	DHD	LA	DHD	LA	
Sik	1	1	67	4	71
Batu Pahat	1	2	144	31	175
Kuala Langat	1	1	367	157	524
Melaka Tengah	1	1	943	105	1,048
Klang	1	1	257	1,495	1,752
Gombak	1	2	1,598	1,509	3,107
Hulu Langat	1	1	4,408	444	4,852
Petaling	1	3	491	4,656	5,147
TOTAL	**8**	**12**	**8,275**	**8,401**	**16,676**
Mean (95% CI)	1	2	1,034 (305-2,125)	700 (340-1,096)	2,085 (835-3,466)
Median	1	1	429	460	1,400
Standard deviation (95% CI)	0	1	1,453 (252-2,091)	698 (447-832)	2,050 (903-2,432)

The number of reported dengue cases by DHDs and LAs were obtained directly from study sites

The data for population coverage by both service providers were not distinguishable due to unclear and overlapped geographic demarcation of operational areas

CI denotes Confidence Interval

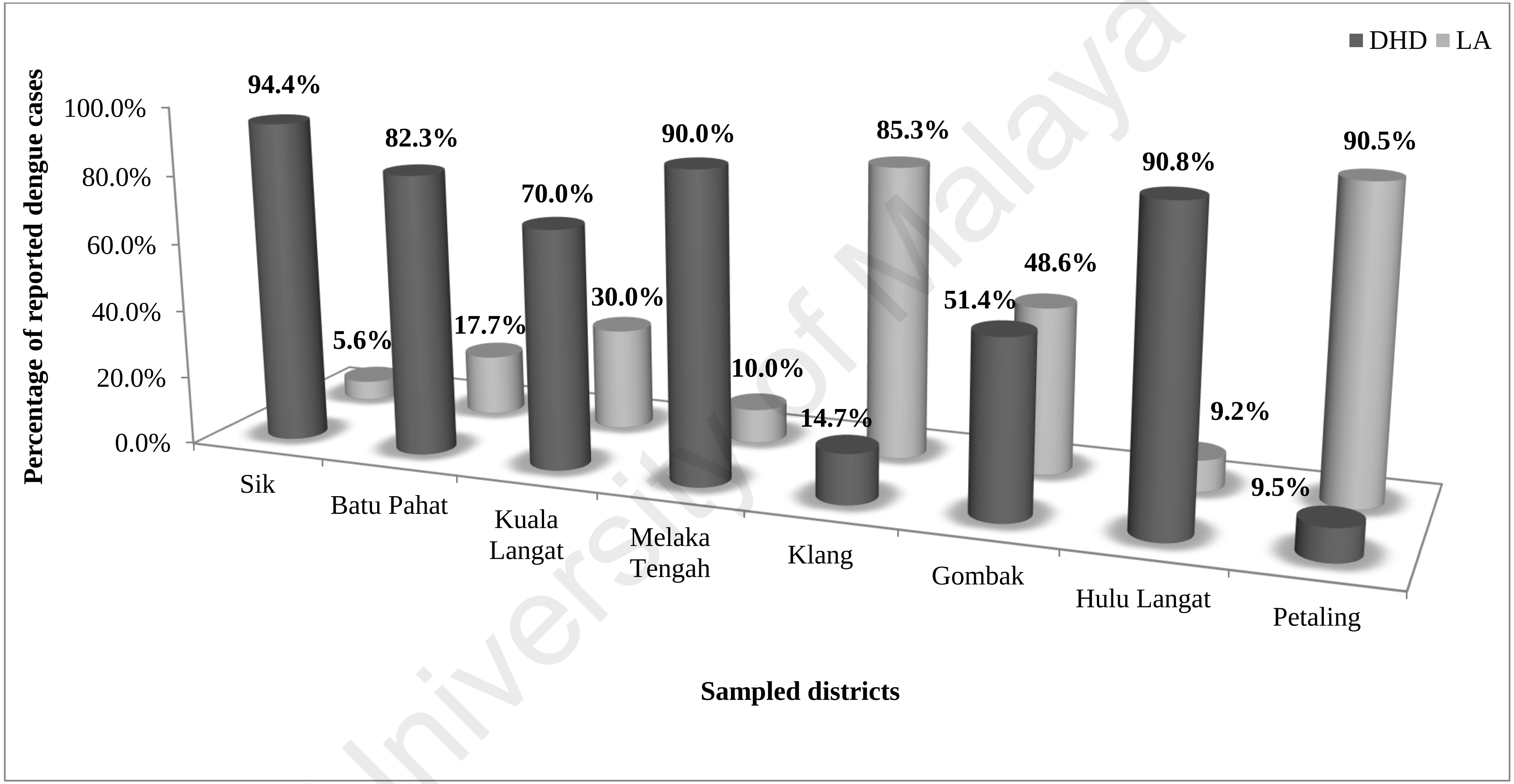

Figure 6.1: Percentage of cases responded by DHD and LA at sampled districts

6.3 Costs and Resources Use by DHDs and LAs

The sum of the dengue vector control and prevention costs of the DHDs at the sampled districts were MYR 22.20 mil (US$ 6.94 mil), and the LAs were MYR 13.98 mil (US$ 4.37 mil). The average costs for a DHD were MYR 2.77 mil (US$ 0.87 mil) and for the LA was MYR 1.17 mil (US$ 0.36 mil). The cost per reported dengue case for DHD was MYR 2,683 (US$ 838) and for LA was MYR 1,664 (US$ 520). Both DHD and LA spent highest cost percentage, 54.2%, and 58.3%, from their total costs in personnel human resources. For the DHDs, the next largest cost percentage was for the pesticides being 21.8% and for the LAs it was for the buildings. The LAs spent MYR 1.33 mil (US$ 0.41 mil) to outsource fogging and larviciding activities while the DHDs used their in-house team entirely to perform those activities in the sampled districts. Both DHDs and LAs spent largest cost percentage in fogging activities being 33.1% and 34.6% respectively. Premise inspection activities formed the second largest cost percentage for both DHDs (24.4%) and LAs (23.4%). The cost characteristics by line items and functions of the DHDs and LAs at sampled districts are summarized in Table 6.2 and Table 6.3.

The cost of capital items for DHDs was MYR 1.33 mil (US$ 0.42 mil) and for the LAs was MYR 1.80 mil (US$ 0.56 mil). The average cost of capital items was MYR 0.17 mil (US$ 0.05 mil) for the DHDs and MYR 0.15 mil (US$ 0.05 mil) for the LAs. The cost of buildings formed the largest cost percentage for both DHDs (42.2%) and LAs (65.9%). The cost of recurrent items for DHDs was MYR 20.87 mil (US$ 6.52 mil) and for the LAs was MYR 12.18 mil (US$ 3.81 mil). The mean cost of recurrent items was MYR 2.61 mil (US$ 0.82 mil) for the DHDs and MYR 1.01 mil (US$ 0.32 mil) for the LAs. The costs for human personnel formed the largest cost percentage for DHDs

(57.7%) and the LAs (66.9%). The cost characteristics by capital and recurrent items of the DHDs and LAs are summarized in Table 6.4 and Table 6.5. The costs and resources specific information by service providers at the each sampled districts is listed in Appendices BB-II.

A standard linear regression was performed to assess the ability of reported dengue cases to predict the total cost of dengue vector control and prevention by DHDs and LAs. Preliminary analyses were performed to ensure there was no violation of the assumption of normality, linearity, and homoscedasticity in the dataset. For the DHDs, a significant regression equation was found: DHD cost (in MYR) = -MYR 2.62 mil + Log(DHD cases) X MYR 2.01 mil or DHD cost (in US$) = -US$ 0.82 mil + Log(DHD cases) X US$ 0.63 mil (R^2=0.722, N=8, p=0.043) (Appendix JJ). For the LAs, a significant regression equation was found: LA cost (in MYR) = MYR 0.51 mil + LA case X MYR 940 or LA cost (in US$) = US$ 0.16 mil + LA case X US$ 294 (R^2=0.802, N=12, p=0.002) (Appendix KK).

The government staff that contributed to dengue vector control and prevention activities in the sampled district were 465 staff for the DHDs, and the LAs were 362 staff. The LAs had a lower median staff of 30 people as compared to the DHDs that had 58 people. From the total number of personnel, only 427 FTE staff (91.8%) of the DHDs and 255 FTE staff (70.4%) of the LA were dedicated to dengue-related activities. The DHDs had technical officers such as public health physicians and entomologists giving technical inputs for dengue vector control and prevention while the LAs had none of such civil servants. There were 64 vehicles allocated for dengue vector control units of the DHDs and 57 vehicles for the LAs. Among those vehicles allocated, an average of 93.4% and 76.3% were dedicated for dengue-related activities at the DHDs and LAs respectively. The DHDs had 280 fogging and larviciding equipment while the LAs had 135 equipment. For their annual servicing and maintenance purpose, the DHDs spent MYR 0.42 mil (US$ 0.13 mil), and the LAs spent MYR 0.11 mil (US$ 0.03 mil). The DHDs consumed higher liquid-based and powder-based pesticides usage than the LAs in their dengue vector control and prevention activities. Similar to pesticide, the DHDs had approximately four times greater consumption of diesel for pesticide dilution. The resources characteristics of DHDs and LAs were summarized in Table 6.6 and Table 6.7.

Table 6.2: Costs characteristics of the DHDs (n=8) at sampled districts

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported	
	MYR	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**
Human personnel	12,042,009	3,763,128	1,505,251	470,391	652,269	203,834	1,455	455
Buildings	848,574	265,179	106,072	33,147	74,490	23,278	103	32
Vehicles	1,918,573	599,554	239,822	74,944	226,124	70,664	232	72
Equipment	2,191448	684,829	273,931	85,604	394,132	123,166	265	83
Pesticides	4,848,187	1,515,059	606,023	189,382	657,017	205,318	586	183
PPE[a]	350,440	109,513	43,805	13,689	27,968	8,740	42	13
Outsourcing[b]	0	0	0	0	0	0	0	0
TOTAL[c]	**22,199,233**	**6,937,260**	**2,774,904**	**867,158**	**1,622,461**	**507,019**	**2,683**	**838**
Premise inspection	5,406,310	1,689,472	675,789	211,184	491,060	153,456	653	204
Entomological surveillance	2,303,092	719,718	287,887	89,965	185,812	58,066	278	87
Fogging	7,340,567	2,293,927	917,571	286,741	577,463	180,457	887	277
Larviciding	3,453,311	1,079,160	431,664	134,895	334,677	104,586	417	130
Health education	3,695,953	1,154,985	461,994	144,373	292,350	91,359	447	140

[a]PPE denoted Personal protective equipment; [b]Fogging and larviciding activities sub-contracted to private companies; [c]Sum of line items costs

Table 6.3: Costs characteristics of the LAs (n=12) at sampled districts

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported	
	MYR	US$	MYR	US$	MYR	US$	MYR	US$
Human personnel	8,149,877	2,546,836	679,156	212,236	469,933	146,854	970	303
Buildings	1,445,179	451,617	120,432	37,635	182,762	57,113	172	54
Vehicles	1,377,364	430,428	114,780	35,869	114,307	35,721	164	51
Equipment	671,863	209,957	55,989	17,496	34,764	10,864	80	25
Pesticides	738,583	230,808	61,549	19,234	58,770	18,365	88	27
PPE[a]	273,810	85,564	22,818	7,130	17,220	5,381	33	10
Outsourcing[b]	1,325,528	414,227	110,461	34,519	144,805	45,252	158	49
TOTAL[c]	**13,982,207**	**4,369,438**	**1,165,184**	**364,120**	**818,230**	**255,697**	**1,664**	**520**
Premise inspection	3,275,987	1,023,746	272,999	85,312	248,499	77,656	390	122
Entomological surveillance	836,284	261,339	69,690	21,778	100,748	31,484	100	31
Fogging	4,839,413	1,512,317	403,284	126,026	262,003	81,876	576	180
Larviciding	3,133,519	979,223	261,127	81,602	232,834	72,761	373	117
Health education	1,897,005	592,814	158,084	49,401	109,715	34,286	226	71

[a]PPE denoted Personal protective equipment; [b]Fogging and larviciding activities sub-contracted to private companies; [c]Sum of line items costs

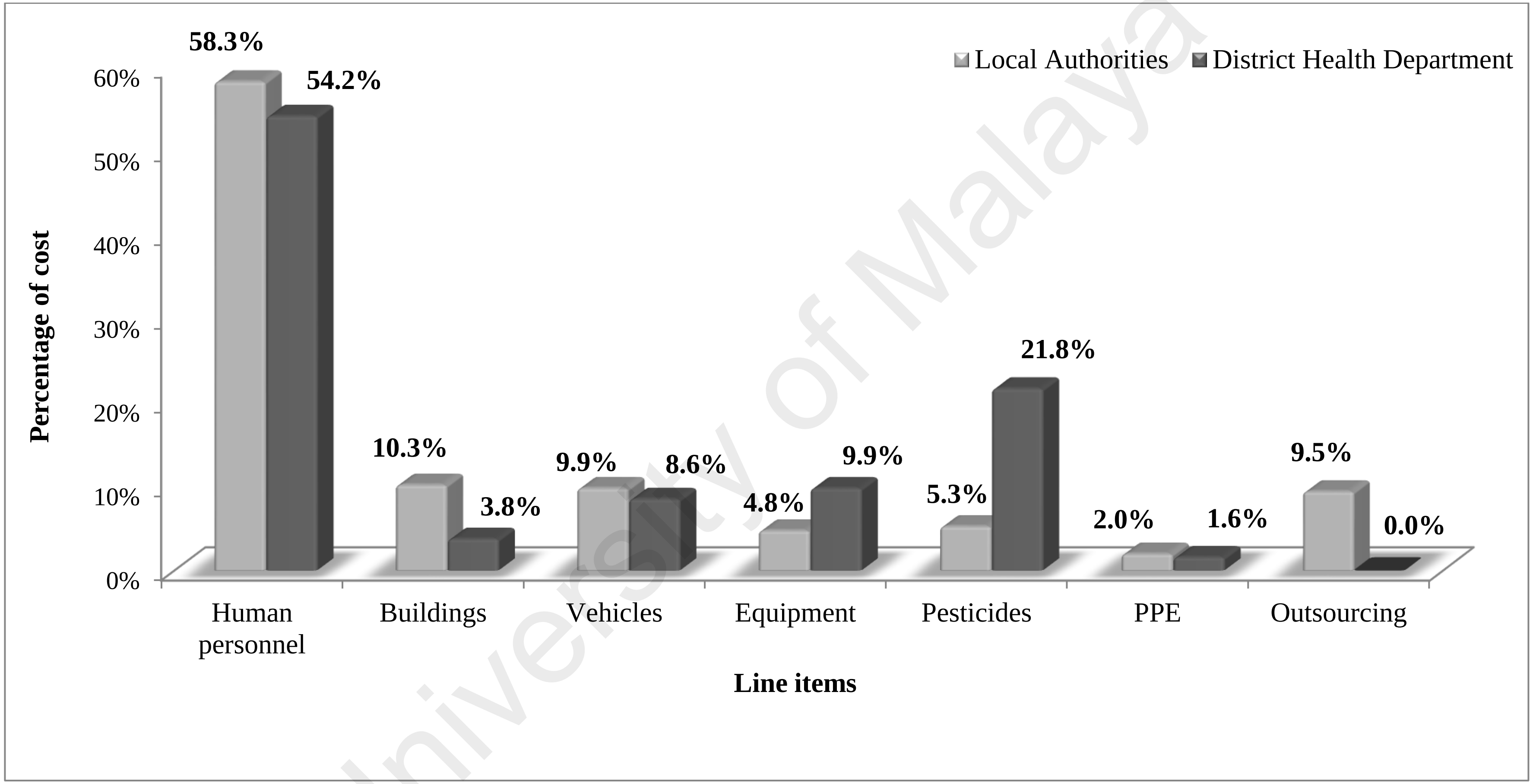

Figure 6.2: Cost percentage by service providers at sampled districts by line items

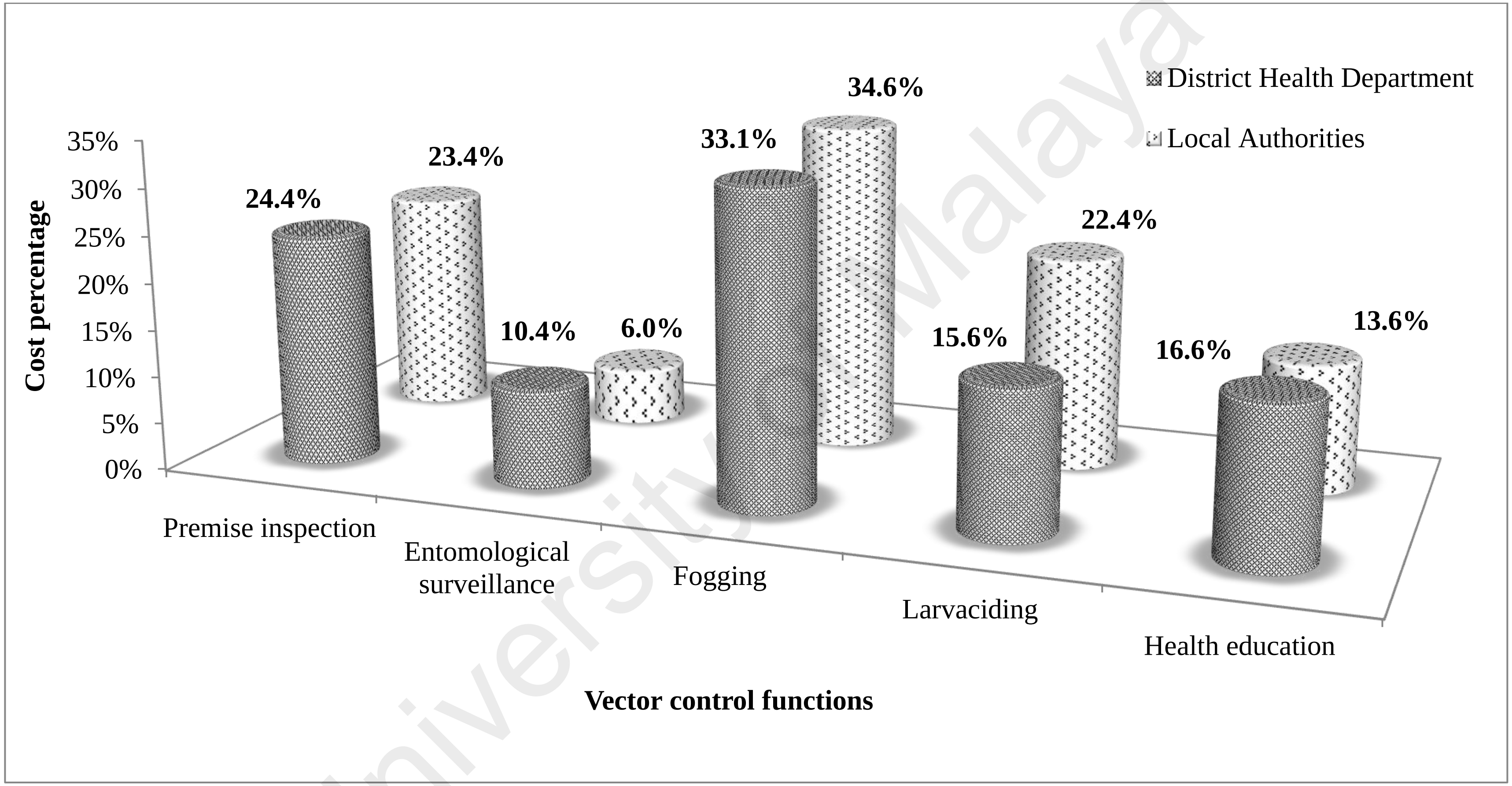

Figure 6.3: Cost percentage by service providers at sampled districts by functions

Table 6.4: Capital and recurrent items costs of the DHDs (n=8) at sampled districts

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported	
	MYR	**US$**	**MYR**	**US$**	**MYR**	**US$**	**MYR**	**US$**
Buildings	561,096	175,343	70,137	21,918	63,445	19,827	68	21
Vehicles	408,598	127,686	51,075	15,961	21,771	6,804	49	15
Equipment	360,774	112,743	45,097	14,093	46,296	14,468	44	14
TOTAL[a]	**1,330,469**	**415,772**	**166,309**	**51,972**	**100,346**	**31,358**	**161**	**50**
Human personnel	12,042,009	3,763,128	1,505,251	470,391	652,269	203,834	1,455	455
Buildings	287,478	89,837	35,935	11,230	22,436	7,011	35	11
Vehicles	1,509,976	471,867	188,747	58,983	215,134	67,229	182	57
Equipment	1,830,674	572,087	228,834	71,511	362,516	113,287	221	69
Pesticides	4,848,187	1,515,059	606,023	189,382	657,017	205,317	586	183
PPE[b]	350,440	109,513	43,805	13,689	27,968	8,740	42	13
Outsourcing[c]	0	0	0	0	0	0	0	0
TOTAL[d]	**20,868,765**	**6,521,489**	**2,608,595**	**815,186**	**1,564,985**	**489,058**	**2,522**	**788**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

Table 6.5: Capital and recurrent items costs of the LAs (n=12) at sampled districts

Parameters	Sum of cost		Mean		Standard deviation		Cost per case reported	
	MYR	US$	MYR	US$	MYR	US$	MYR	US$
Buildings	1,188,402	371,376	99,034	30,948	170,058	53,143	141	44
Vehicles	500,411	156,379	41,701	13,032	49,246	15,389	60	19
Equipment	114,561	35,800	9,547	2,983	12,021	3,757	14	4
TOTAL[a]	**1,803,371**	**563,555**	**150,281**	**46,963**	**183,060**	**57,206**	**215**	**67**
Human personnel	8,149,877	2,546,836	679,156	212,236	469,933	146,854	970	303
Buildings	256,778	80,245	21,398	6,687	15,614	4,879	31	10
Vehicles	876,954	274,049	73,080	22,837	98,487	30,777	104	33
Equipment	557,303	174,157	46,442	14,513	33,570	10,491	66	21
Pesticides	738,583	230,808	61,549	19,234	58,770	18,365	88	27
PPE[b]	273,810	85,564	22,818	7,130	17,220	5,381	33	10
Outsourcing[c]	1,325,528	414,227	110,461	34,519	144,805	45,252	158	49
TOTAL[d]	**12,178,833**	**3,805,886**	**1,014,903**	**317,157**	**719,612**	**224,879**	**1,450**	**453**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

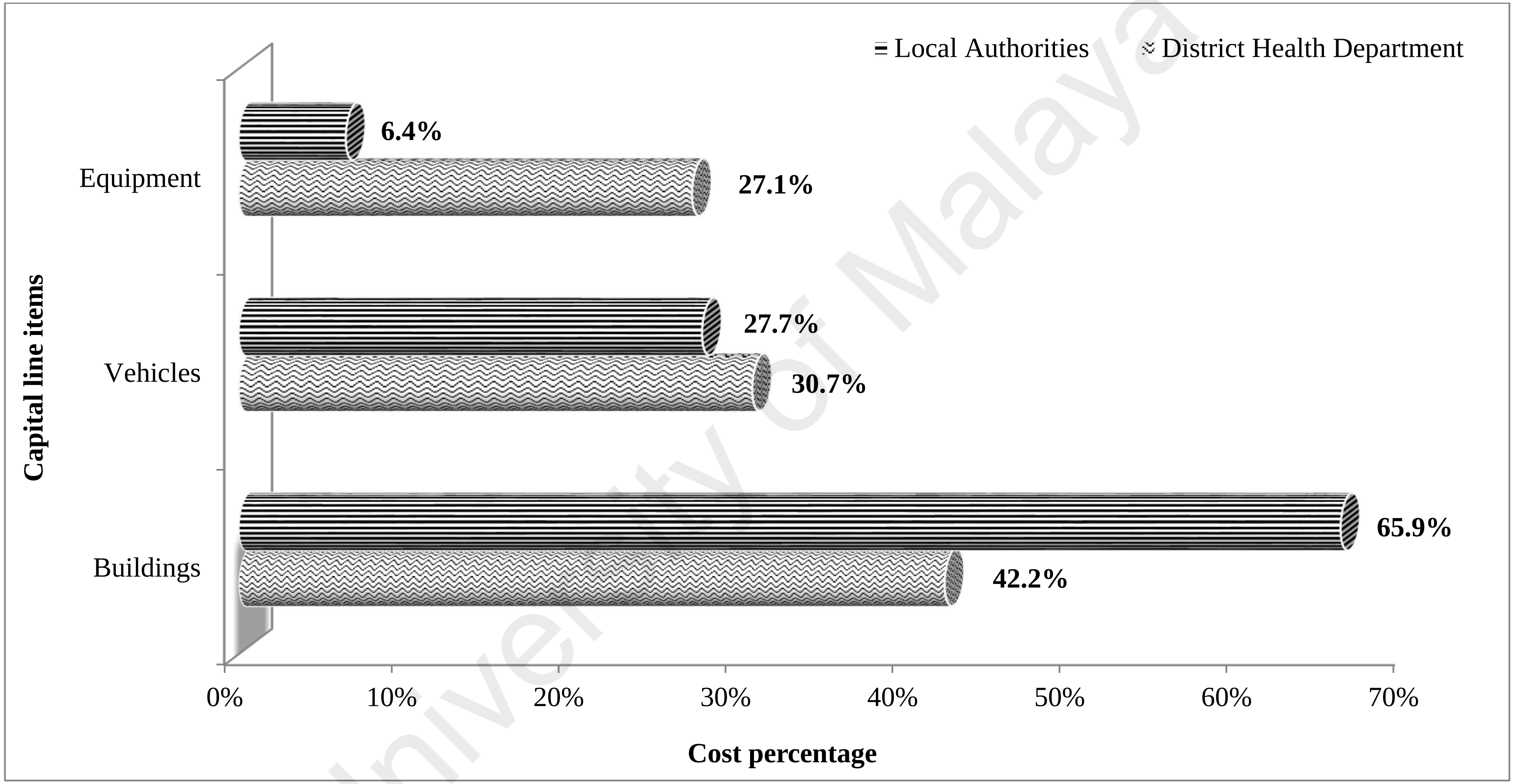

Figure 6.4: Cost percentage by service providers at sampled district by capital line items

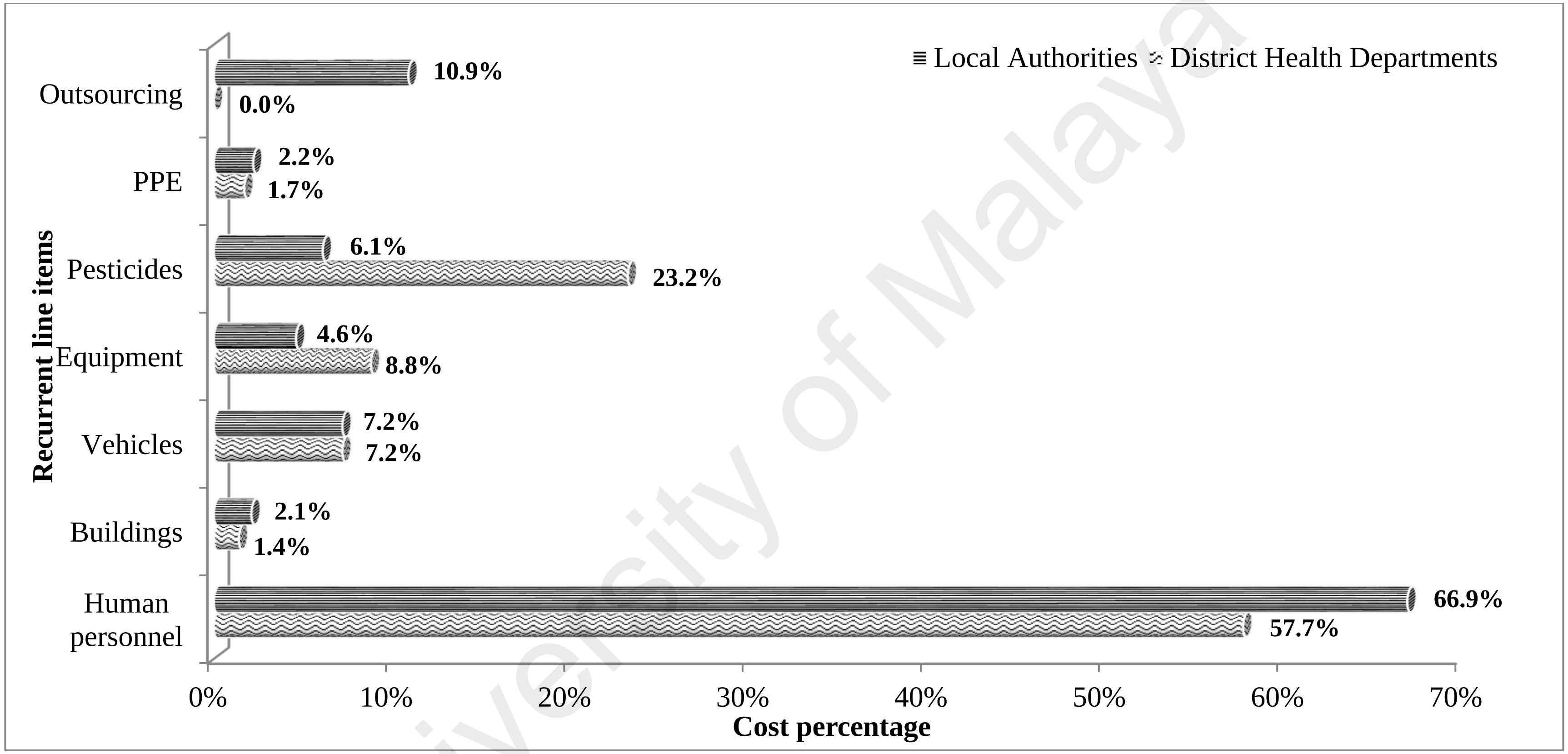

Figure 6.5: Cost percentage by service providers at sampled district by recurrent line items

Table 6.6: Resources characteristics of DHDs (n=8) at sampled districts

Resources	Sum	Mean	Median	Std deviation
Total number of staff	465	58	62	27
-Medical officer	15	2	2	1
-Public health physician	12	2	2	1
-Entomologist	2	0	0	0
-Percentage of professional staff[a]	91.0	91.4	96.8	NA
-Percentage of administrative staff[b]	9.0	8.6	3.2	NA
-Percentage of FTE[c] for dengue vector control	91.8	91.8	92.5	NA
Vehicles	64	8	9	4
-Percentage dedicated to dengue vector control	NA	93.4	99.0	NA
-Percentage more than five years old	28.1	28.1	23.5	NA
-Annual servicing and maintenance costs (in millions)	MYR 178,503 / US$ 55,783	MYR 22,313 / US$ 6,973	MYR 17,173 / US$ 5,367	MYR 11,295 / US$ 3,530
Equipment (fogging & larviciding)	280	35	33	15
-Annual servicing and maintenance costs (in millions)	MYR 417,130 / US$ 130,355	MYR 52,141 / US$ 16,294	MYR 32, 250 / US$ 10,078	MYR 58,984 / US$ 18,433
Pesticides				
-Liquid-based pesticides (litres)	47,273	5,909	4,404	6,965
-Powder based pesticides (kg)	4,045	506	422	497
-Diesel[#] (litres)	676,166	84,521	21,132	172,569

[a]Professional staff is persons trained for dengue vector control, surveillance and prevention activities and they include doctors, entomologist, public health inspectors; [b]Administrative staff is persons performing administrative or general duties such as clerks, drivers, cleaners; [c]FTE refers to full-time equivalent; [#]Refers to diesel used to dilute oil-based pesticides for fogging activities; NA denotes not applicable

Table 6.7: Resources characteristics of LAs (n=12) at sampled districts

Resources	Sum		Mean		Median		Std. deviation	
Total number of staff	362		30		30		21	
-Medical officer	5		0		0		1	
-Public health physician	0		0		0		0	
-Entomologist	0		0		0		0	
-Percentage of professional staff[a]	87.6		88.1		95.0		NA	
-Percentage of administrative staff[b]	12.4		11.9		5.0		NA	
-Percentage of FTE[c] for dengue vector control	70.4		64.2		64.0		NA	
Vehicles	57		5		5		3	
-Percentage dedicated to dengue vector control	NA		76.33		93.0		NA	
-Percentage more than five years old	38.6		38.5		33.3		NA	
-Annual servicing and maintenance costs (in millions)	MYR 234,951	US$ 73,422	MYR 19,579	US$ 6,119	MYR 16,195	US$ 5,061	MYR 16,535	US$ 5,167
Equipment (fogging & larviciding)	135		11		10		6	
-Annual servicing and maintenance costs (in millions)	MYR 108,323	US$ 33,853	MYR 9,027	US$ 2,821	MYR 8,673	US$ 2,711	MYR 7,343	US$ 2,295
Pesticides								
-Liquid-based pesticides (litres)	6,679		557		531		480	
-Powder based pesticides (kg)	677		56		61		48	
-Diesel[#] (litres)	175,282		14,607		10,842		14,289	

[a]Professional staff is persons trained for dengue vector control, surveillance and prevention activities and they include doctors, entomologist, public health inspectors; [b]Administrative staff is persons performing administrative or general duties such as clerks, drivers, cleaners; [c]FTE refers to full-time equivalent; [#]Refers to diesel used to dilute oil-based pesticides for fogging activities; NA denotes not applicable

6.4 National Costs at District-Level by Service Providers

The average cost for DHDs at each district was MYR 1.23 mil (US$ 0.38 mil) and for the LAs were MYR 0.35 mil (US$ 0.11 mil). Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) are summarized in Table 6.8 (in MYR) and Table 6.9 (in US$).

The average cost of capital items for the DHDs was MYR 0.08 mil (US$ 0.03 mil) and for the LAs were MYR 0.05 mil (US$ 0.02 mil). The average cost of recurrent items for the DHDs was MYR 1.14 mil (US$ 0.36 mil) and for the LAs were MYR 0.29 mil (US$ 0.09 mil). Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items are summarized in Table 6.10 (in MYR) and Table 6.11 (in US$).

Table 6.8: Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) (MYR)

Parameters	DHD				LA			
	Mean Costs	Standard error	95% Confidence Interval		Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*			*Lower*	*Upper*
LINE ITEMS								
Human personnel	835,704	47,042	746,603	929,502	194,006	33,567	132,984	264,396
Buildings	47,638	3,220	41,761	54,137	42,055	8,986	26,428	60,904
Vehicles	94,374	6,779	82,525	108,880	25,035	6,820	13,164	39,748
Equipment	66,919	13,002	44,882	94,625	23,350	2,996	17,753	29,472
Pesticides	152,485	24,094	110,136	203,078	33,431	4,267	25,302	42,197
PPE[a]	28,398	1,653	25,234	31,767	14,059	1,269	11,679	16,664
Out-sourcing[b]	0	0	0	0	13,183	7,818	0	29,943
TOTAL[c]	**1,225,519**	**81,454**	**1,071,335**	**1,391,633**	**345,118**	**58,737**	**238,092**	**467,124**
FUNCTIONS								
Premise inspection	344,725	19,797	307,959	386,067	61,716	14,243	36,760	92,954
Entomological surveillance	114,132	12,917	88,898	139,388	11,894	4,944	3,536	22,605
Fogging	390,295	24,538	344,278	440,694	126,264	19,831	90,389	168,315
Larviciding	219,604	16,957	18,6840	253,454	82,087	15,611	53,332	114,779
Health education	156,763	13,998	130,655	185,333	63,157	7,942	48,570	79,902

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

Table 6.9: Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) (US$)

Parameters	DHD				LA			
	Mean Costs	Standard error	95% Confidence Interval		Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*			*Lower*	*Upper*
LINE ITEMS								
Human personnel	261,158	14,700	233,822	290,093	60,627	10,490	41,858	82,821
Buildings	14,887	1,006	13,054	16,935	13,142	2,808	8,285	19,169
Vehicles	29,492	2,118	25,932	34,012	7,823	2,131	4,289	12,419
Equipment	20,913	4,063	14,234	29,904	7,297	936	5,554	9,190
Pesticides	47,652	7,529	34,888	63,803	10,447	1,334	7,991	13,163
PPE[a]	8,875	517	7,910	9,894	4,393	397	3,659	5,185
Out-sourcing[b]	0	0	0	0	4,120	2,443	0	9,771
TOTAL[c]	**382,975**	**25,454**	**336,115**	**434,412**	**107,849**	**18,355**	**75,079**	**146,756**
FUNCTIONS								
Premise inspection	107,726	14,700	96,385	120,456	19,286	10,490	11,434	28,605
Entomological surveillance	35,666	4,037	27,884	43,601	3,717	1,545	1,105	7,032
Fogging	121,967	7,668	107,443	137,953	39,458	6,197	28,147	52,376
Larviciding	68,626	5,299	58,560	79,262	25,652	4,878	16,689	35,956
Health education	48,989	4,374	40,769	58,056	19,737	2,482	15,167	24,919

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

Table 6.10: Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items (MYR)

Parameters	DHD				LA			
	Mean Costs	Standard error	95% Confidence Interval		Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*			*Lower*	*Upper*
CAPITAL ITEMS								
Buildings	30,815	2,622	25,962	36,196	28,730	7,972	15,155	46,172
Vehicles	43,901	686	42,628	45,284	8,461	1,412	5,898	11,396
Equipment	8,373	1,626	5,492	11,748	10,419	1,209	8,100	12,839
TOTAL[a]	**83,089**	**3,836**	**76,281**	**91,096**	**50,581**	**9,470**	**33,908**	**70,849**
RECURRENT ITEMS								
Human personnel	835,704	47,042	745,829	930,142	194,006	33,567	134,037	264,792
Buildings	16,823	1,639	13,694	20,167	11,930	1,411	9,261	14,810
Vehicles	50,473	6,457	39,292	64,465	14,997	5,423	6,117	27,179
Equipment	58,546	11,668	39,243	84,652	12,931	2,477	8,455	18,150
Pesticides	152,485	24,094	110,672	204,269	32,870	4,242	24,890	41,640
PPE[b]	28,398	1,653	25,286	31,684	14,059	1,269	11,693	16,654
Out-sourcing[c]	0	0	0	0	13,183	7,818	0	29,943
TOTAL[d]	**1,142,430**	**79,191**	**995,013**	**1,300,479**	**294,537**	**51,934**	**202,623**	**404,563**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

Table 6.11: Average district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items (US$)

Parameters	DHD				LA			
	Mean Costs	Standard error	95% Confidence Interval		Mean Costs	Standard error	95% Confidence Interval	
			Lower	*Upper*			*Lower*	*Upper*
CAPITAL ITEMS								
Buildings	9,630	819	8,105	11,334	8,978	2,491	4,697	14,514
Vehicles	13,719	214	13,320	14,172	2,644	441	1,831	3,575
Equipment	2,617	508	1,731	3,688	3,256	378	2,542	4,017
TOTAL[a]	**25,966**	**1,199**	**23,781**	**28,512**	**15,807**	**2,959**	**10,626**	**22,370**
RECURRENT ITEMS								
Human personnel	261,158	14,700	232,808	290,875	60,627	10,490	41,704	82,648
Buildings	5,257	512	4,294	6,285	3,728	441	2,888	4,617
Vehicles	15,773	2,018	12,325	20,087	4,687	1,695	1,926	8,409
Equipment	18,296	3,646	12,256	26,335	4,041	774	2,639	5,673
Pesticides	47,652	7,529	34,541	63,832	10,272	1,326	7,755	12,959
PPE[b]	8,875	517	7,887	9,909	4,393	397	3,646	5,202
Out-sourcing[c]	0	0	0	0	4,120	2,443	0	9,357
TOTAL[d]	**357,009**	**24,747**	**309,562**	**407,331**	**92,043**	**16,229**	**62,980**	**126,112**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

The national economic costs at district-level by service providers were extrapolated from the costs of the DHDs and LAs of the sampled districts. The national costs for the DHDs were MYR 169.12 mil (US$ 52.85 mil) and for the LAs were MYR 47.63 mil (US$ 14.88 mil). For both service providers, the cost for human personnel formed the largest cost expenditure with 68.2% for the DHDs and 69.7% for the LAs. The cost for pesticides formed the next highest cost expenditure for DHDs (12.4%) and LAs (10.3%).

Looking from the activities perspective, the cost for fogging activities formed the highest cost component for both service providers. The DHDs spent MYR 53.86 mil (US$ 16.83 mil) or 31.8% of their total cost while the LAs spent MYR 17.42 mil (US$ 5.45 mil) or 36.6% of their full cost. Among the DHDs, the costs for premise inspections formed the second largest cost component (28.1%) from the total cost. The costs of premise inspections for the DHDs were MYR 47.57 mil (US$ 14.87 mil). However, among the LAs, the costs for larviciding activities formed the second largest cost component (23.8%) from the total cost. The costs of larviciding for the LAs were MYR 11.33 mil (US$ 3.54 mil). The estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by line items and functions are summarized in Table 6.12 (in MYR) and Table 6.13 (in US$). The cost percentage of line items is shown in Figure 6.6 and by functions is depicted in Figure 6.7.

The national costs of capital items for the DHDs were MYR 11.47 mil (US$ 3.58 mil) and for the LAs were MYR 6.98 mil (US$ 2.18 mil). The DHDs recorded highest capital item cost expenditure for vehicles forming 52.8% from the total cost of capital items and for the LAs, it was the capital cost for buildings forming 56.8%.

The national costs of recurrent items for the DHDs were MYR 157.66 mil (US$ 49.27 mil) and for the LAs were MYR 40.65 mil (US$ 12.70 mil). The largest recurrent item cost expenditure for both service providers was the human personnel component forming 73.2% for the DHDs and 65.9% for the LAs. The estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items are summarized in Table 6.14 (in MYR) and Table 6.15 (in US$). The cost percentage of capital and recurrent items by service providers are shown in Figure 6.8 and Figure 6.9.

The DHDs appears to have larger expenditure roles in dengue vector control and prevention activities in Malaysia. The greater role is evident from the total national costs at district-level whereby, the DHDs had contributed 78.0%, and the LAs spent about 22.0% of the national expenditure (Figure 6.10).

Table 6.12: Estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by line items and functions (MYR)

Parameters	DHD			LA		
	Costs	95% Confidence Interval		Costs	95% Confidence Interval	
		Lower	*Upper*		*Lower*	*Upper*
Human personnel	115,327,167	103,217,715	128,503,461	26,772,889	18,385,001	36,552,728
Buildings	6,574,051	5,773,506	7,484,444	5,803,551	3,653,709	8,419,945
Vehicles	13,023,654	11,409,042	15,052,653	3,454,866	1,819,928	5,495,150
Equipment	9,234,828	6,204,916	13,081,930	3,222,288	2,454,361	4,074,477
Pesticides	21,042,951	15,226,306	28,075,481	4,613,435	3,497,966	5,833,723
PPE[a]	3,918,973	3,488,623	4,391,846	1,940,096	1,614,553	2,303,838
Out-sourcing[b]	0	0	0	1,819,203	0	4,139,563
TOTAL[c]	**169,121,622**	**148,111,875**	**192,393,065**	**47,626,334**	**32,916,251**	**64,579,871**
Premise inspection	47,572,007	42,575,262	53,373,688	8,516,749	5,082,131	12,850,840
Entomological surveillance	15,750,153	12,290,174	19,270,380	1,641,374	488,866	3,125,156
Fogging	53,860,682	47,596,476	60,925,896	17,424,498	12,496,296	23,269,554
Larviciding	30,305,359	25,830,644	35,040,003	11,328,008	7,373,165	15,868,153
Health education	21,633,345	18,063,023	12,594,005	8,715,647	6,714,850	9,794,857

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

Table 6.13: Estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by line items and functions (US$)

Parameters	DHD			LA		
	Costs	95% Confidence Interval		Costs	95% Confidence Interval	
		Lower	*Upper*		*Lower*	*Upper*
Human personnel	36,039,749	32,325,814	40,105,263	8,366,546	5,786,871	11,449,960
Buildings	2,054,374	1,804,649	2,341,283	1,813,617	1,145,430	2,650,065
Vehicles	4,069,872	3,585,053	4,702,173	1,079,637	592,983	1,716,953
Equipment	2,885,927	1,967,865	4,134,273	1,006,968	767,794	1,270,558
Pesticides	6,575,925	4,823,248	8,820,717	1,441,731	1,104,707	1,819,765
PPE[a]	1,224,691	1,093,494	1,367,858	606,276	505,859	716,788
Out-sourcing[b]	0	0	0	568,502	0	1,350,805
TOTAL[c]	**52,850,526**	**46,467,851**	**60,057,375**	**14,883,196**	**10,379,646**	**20,288,947**
Premise inspection	14,866,235	13,325,160	16,653,076	2,661,479	1,580,739	3,954,615
Entomological surveillance	4,921,934	3,854,976	6,027,773	512,929	152,770	972,168
Fogging	16,831,468	14,853,977	19,071,957	5,445,206	3,891,351	7,241,018
Larviciding	9,470,431	8,095,977	10,958,013	3,540,007	2,307,317	4,970,937
Health education	6,760,435	5,636,366	8,026,276	2,723,653	2,096,873	3,445,014

[a]PPE denoted Personal protective equipment

[b]Fogging and larviciding activities sub-contracted to private companies

[c]Sum of line items costs

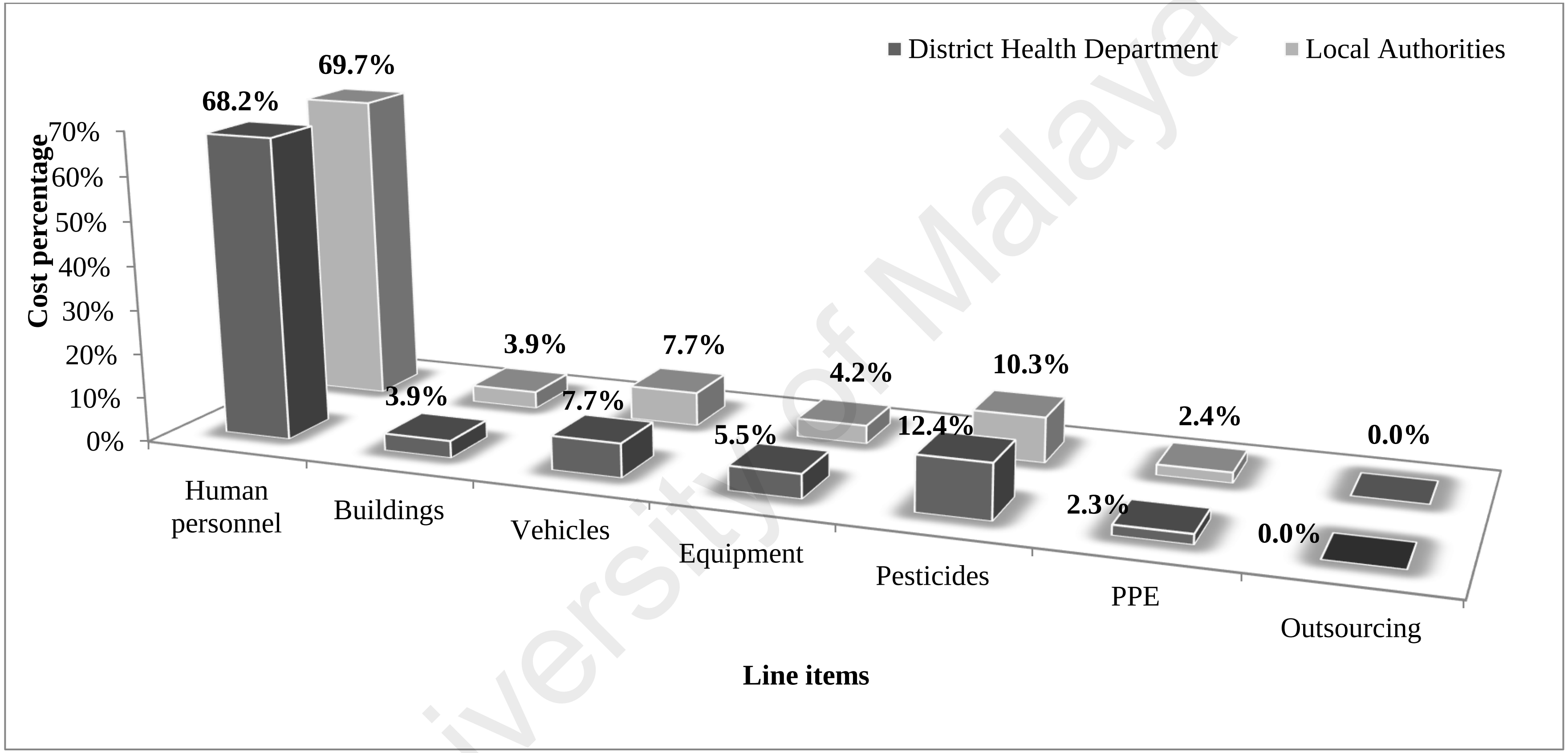

Figure 6.6: Cost percentage of line items by service providers for all districts in Malaysia (N=140)

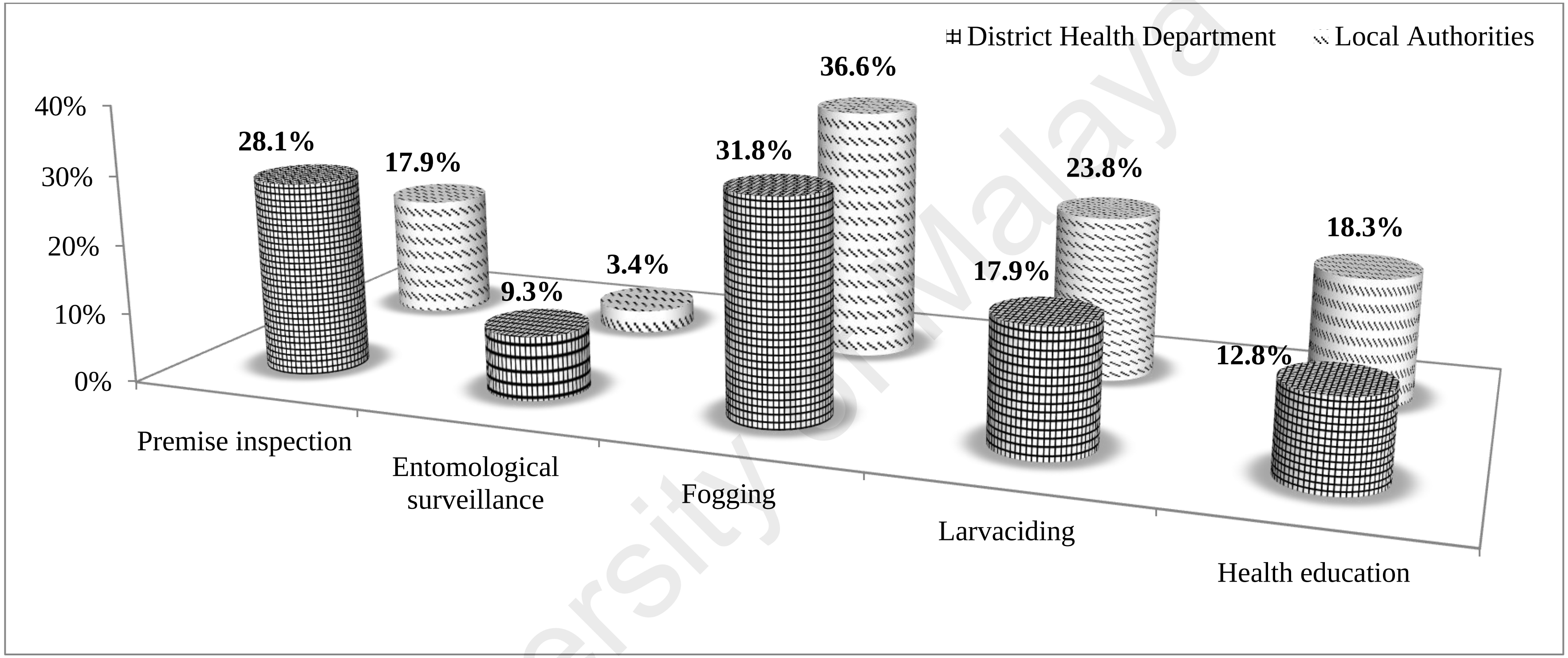

Figure 6.7: Cost percentage of functions by service providers for all districts in Malaysia (N=140)

Table 6.14: Estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items (MYR)

Parameters	DHD			LA		
	Costs	95% Confidence Interval		Costs	95% Confidence Interval	
		Lower	*Upper*		*Lower*	*Upper*
CAPITAL ITEMS						
Buildings	4,252,515	3,589,182	5,004,036	3,964,703	649,319	2,006,623
Vehicles	6,058,360	5,893,347	6,260,441	1,167,685	253,147	494,274
Equipment	1,155,422	759,258	1,624,100	1,437,771	351,446	555,373
TOTAL[a]	**11,466,303**	**10,545,819**	**12,594,005**	**6,980,155**	**1,468,982**	**3,092,600**
RECURRENT ITEMS						
Human personnel	115,327,167	103,110,815	128,591,972	26,772,889	5,765,592	11,426,082
Buildings	2,321,536	1,893,170	2,788,109	1,646,311	399,263	638,309
Vehicles	6,965,327	5,432,069	8,912,299	2,069,611	266,259	1,162,569
Equipment	8,079,407	5,425,356	11,703,192	1,784,517	364,829	784,291
Pesticides	21,042,951	15,300,353	28,240,149	4,536,085	1,072,059	1,791,569
PPE[b]	3,918,973	3,495,721	4,380,248	1,940,096	504,023	719,205
Out-sourcing[c]	0	0	0	1,819,203	0	1,293,616
TOTAL[d]	**157,655,352**	**137,560,469**	**179,790,998**	**40,646,091**	**8,707,032**	**17,434,910**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

Table 6.15: Estimated district level dengue vector control and prevention costs by service providers for all districts in Malaysia (N=140) by capital and recurrent items (US$)

Parameters	DHD			LA		
	Costs	95% Confidence Interval		Costs	95% Confidence Interval	
		Lower	*Upper*		*Lower*	*Upper*
CAPITAL ITEMS						
Buildings	1,328,872	1,120,447	1,566,954	1,238,992	649,319	2,006,623
Vehicles	1,893,221	1,841,506	1,959,301	364,908	253,147	494,274
Equipment	361,083	239,289	509,912	449,294	351,446	555,373
TOTAL[a]	**3,583,256**	**3,287,744**	**3,941,765**	**2,181,320**	**1,468,982**	**3,092,600**
RECURRENT ITEMS						
Human personnel	36,039,749	32,185,617	40,213,401	8,366,546	5,765,592	11,426,082
Buildings	725,504	593,616	868,903	514,471	399,263	638,309
Vehicles	2,176,649	1,703,979	2,776,977	646,740	266,259	1,162,569
Equipment	2,524,846	1,694,366	3,640,816	557,670	364,829	784,291
Pesticides	6,575,925	4,775,349	8,824,724	1,417,559	1,072,059	1,791,569
PPE[b]	1,224,691	1,090,326	1,369,958	606,276	504,023	719,205
Out-sourcing[c]	0	0	0	568,502	0	1,293,616
TOTAL[d]	**49,267,271**	**42,796,927**	**56,313,453**	**12,701,889**	**8,707,032**	**17,434,910**

[a]Sum of capital items costs; [b]PPE denoted Personal protective equipment; [c]Fogging and larviciding activities sub-contracted to private companies; [d]Sum of recurrent items costs

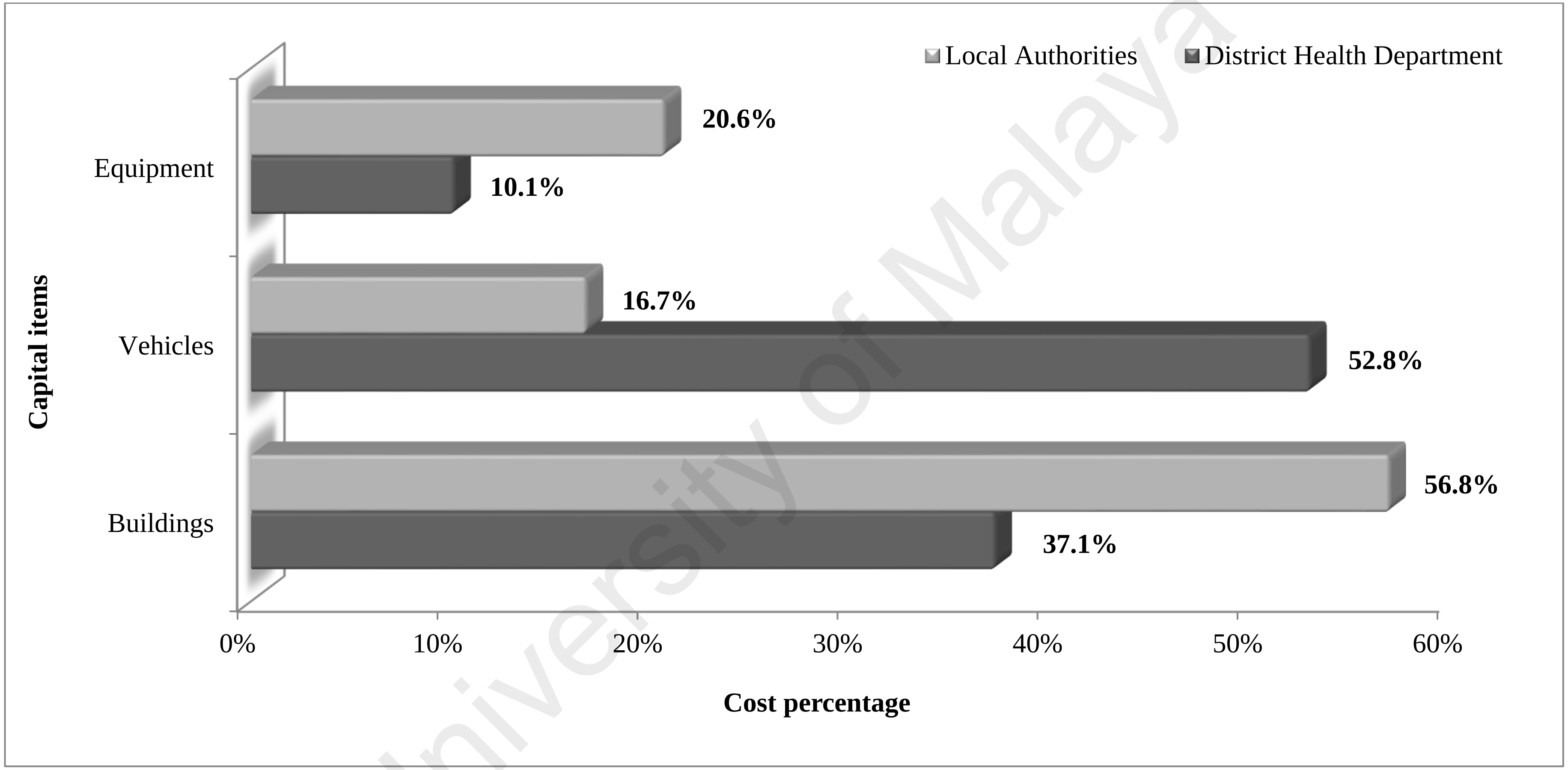

Figure 6.8: Cost percentage of capital items by service providers for all districts in Malaysia (N=140)

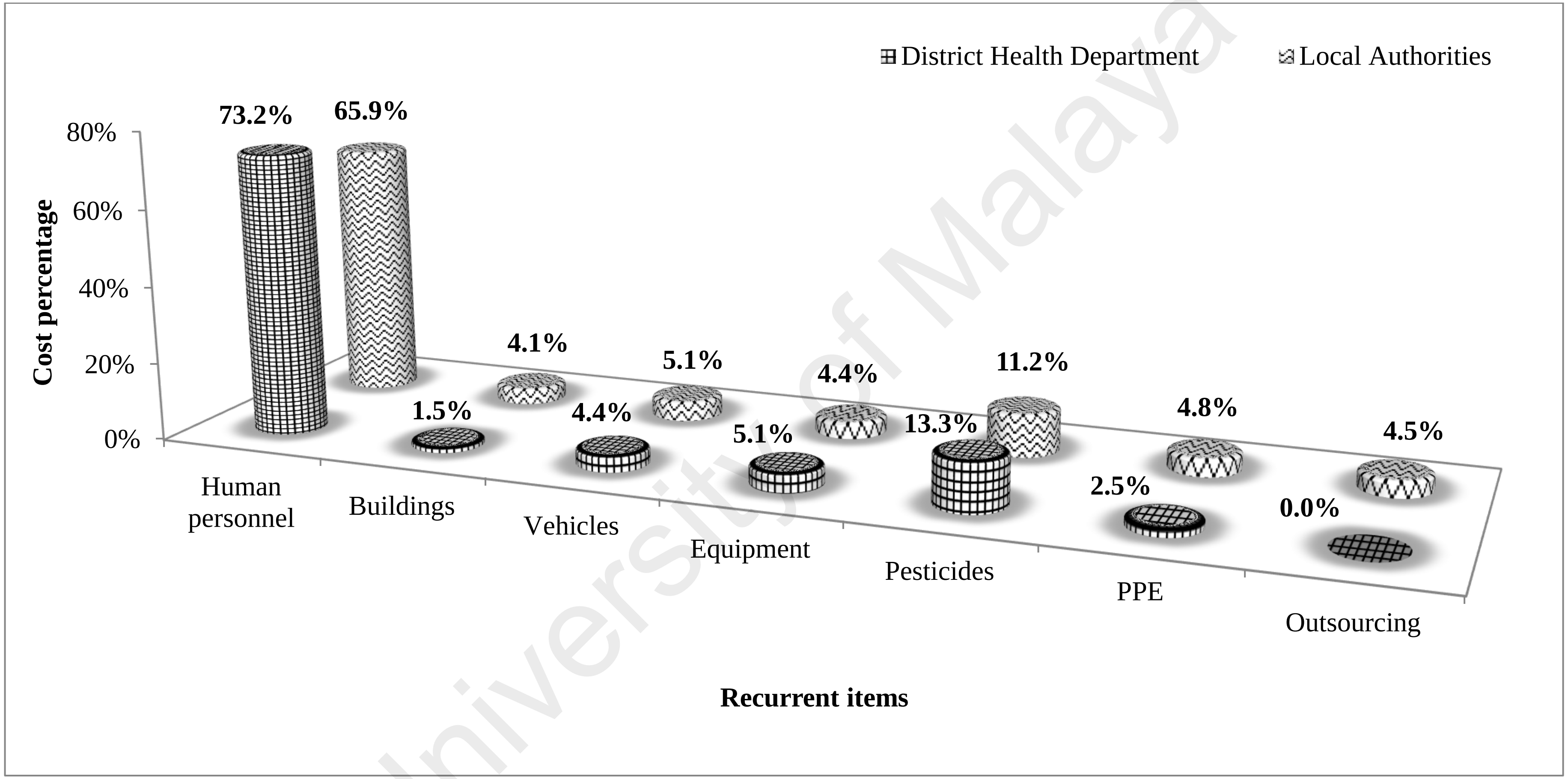

Figure 6.9: Cost percentage of recurrent items by service providers for all districts in Malaysia (N=140)

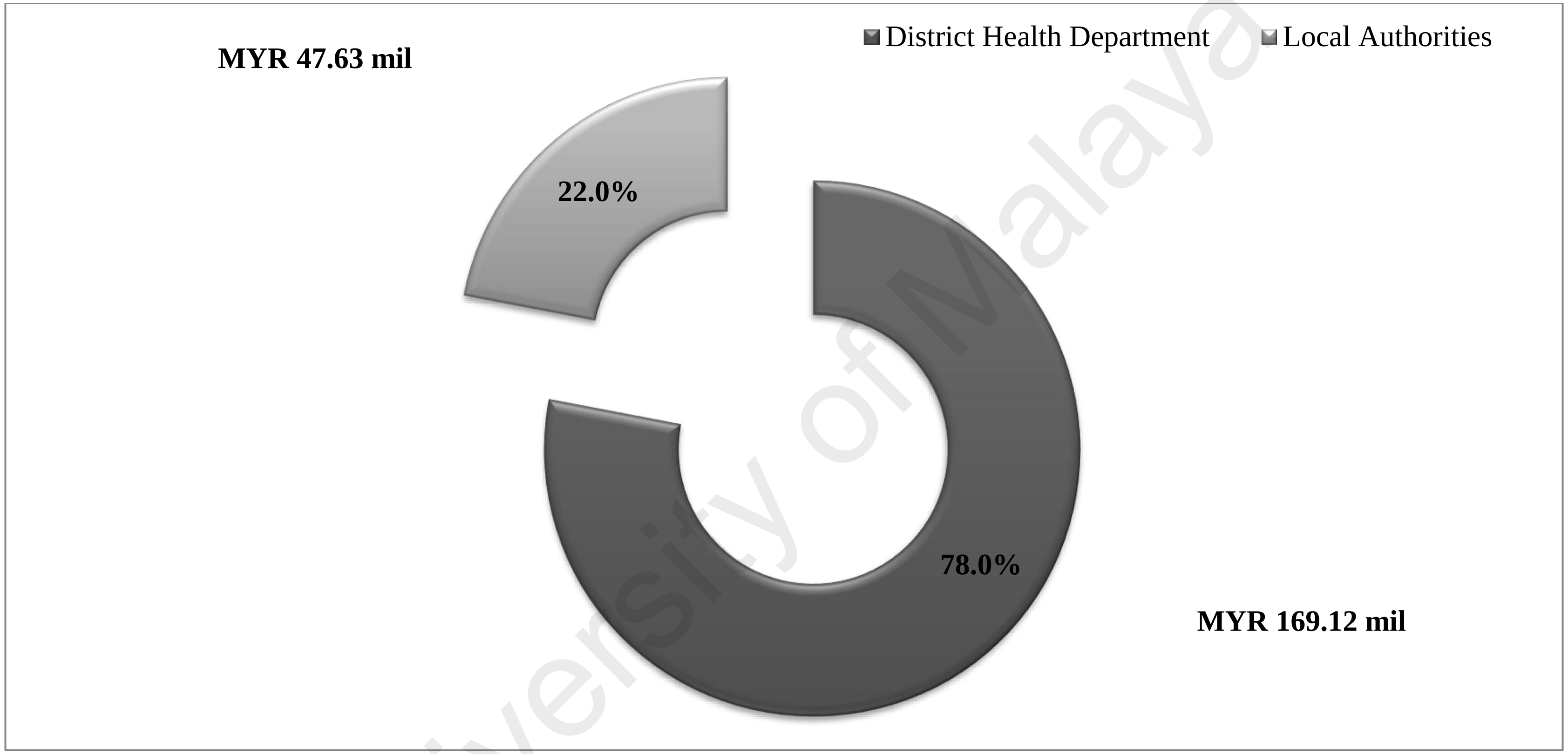

Figure 6.10: Costs by service providers in Malaysia, 2010

6.5 The Comparison of Sample Study Units Characteristics by DHD and LA

The eight DHDs and eight LAs compared in this study reported total 13,494 dengue cases or 29.2% of the national cases. The DHDs responded to a total of 8,275 or 17.9% of the national situation. The LAs responded to 5,219 cases or 11.3% of the national context. The average number of reported dengue cases responded by the DHDs were 1,034 cases per DHD, and the LAs were 652 cases per LA. From the total reported dengue cases among the sampled sites, 61% were responded by the DHDs and the LAs had responded to 39%. By looking at the distribution of dengue cases, in larger and more urbanized towns, the LAs appears to respond to a greater number of reported dengue cases than the DHDs. However, in smaller and less urbanized towns, the DHDs had responded to a larger proportion of reported dengue cases than the LAs. Table 6.16 summarizes the sample study site characteristics by DHD and LA.

6.6 The Costs and Cost per Case Comparison among the DHD and LA

The total dengue vector control costs for the three dengue vector control activities of premise inspection, fogging, and larviciding for the DHDs was MYR 17.98 mil (CI = MYR 10.98 mil – MYR 26.23 mil) and for the LAs were MYR 8.34 mil (CI = MYR 4.28 mil – MYR 12.39 mil) respectively. The corresponding cost in US Dollars were US$ 5.62 mil (CI = US$ 3.43 mil – US$ 8.20 mil) for the DHDs and US$ 2.61 mil (CI = US$ 1.34 mil – US$ 3.87 mil) for the LAs. The average total dengue control costs for the DHDs were MYR 2.25 mil (CI = MYR 1.37 mil – MYR 3.28 mil) and for the LAs were MYR 1.04 mil (CI = MYR 0.53 mil – MYR 1.55 mil). The average costs in US Dollars were US$ 0.70 mil (CI = US$ 0.43 mil – US$ 1.02 mil) for the DHDs and US$ 0.33 mil (CI = US$ 0.17 mil – US$ 0.48 mil). The costs and resources comparison by service providers at the each sampled districts is listed in Appendices LL-SS.

Table 6.16: The dengue cases responded by DHD and LA at the sampled districts

Sample district	Quantity		Reported dengue cases	
	DHD	LA	DHD	LA
Sik	1	1	67	4
Batu Pahat	1	1	144	22
Kuala Langat	1	1	367	157
Melaka Tengah	1	1	943	105
Klang	1	1	257	1,495
Gombak	1	1	1,598	1,033
Hulu Langat	1	1	4,408	444
Petaling	1	1	491	1,959
TOTAL	**8**	**8**	**8,275**	**5,219**
Mean (95% CI)			1,034 (305-2,125)	652 (205-1,161)
Median			429	301
Standard deviation (95% CI)			1,453 (252-2,091)	753 (324-924)

The number of reported dengue cases by DHDs and LAs were obtained directly from study sites

The data for population coverage by both service providers were not distinguishable due to unclear and overlapped geographic demarcation of operational areas

CI denotes Confidence Interval

The total costs for DHDs and LAs were then divided by the number of reported dengue cases responded by the respective service providers to derive the total cost per case. The total cost per case for DHDs was MYR 2,172 (CI = MYR 1,543 – MYR 4,507) and for the LAs were MYR 1,598 (CI = MYR 1,334 – MYR 2,604). The corresponding cost per case in US Dollars for the DHDs were US$ 679 (CI = US$ 415 – US$ 991) and for the LAs were US$ 499 (CI = US$ 256 – US$ 742). Table 6.17-6.22 shows the total costs (MYR and US$), average costs (MYR and US$) and cost per case of dengue vector control activities and costs of resource consumptions by DHDs and

LAs. Fogging was the highest activity cost for both service providers in the sampled districts. It made up 51.0% of the total costs for the DHDs and slightly a lower proportion of 45.8% for the LAs. Once adjusted by cost per case, the DHDs spent 51.1% more than the LAs in fogging activities. The total costs for the DHDs and LAs when combined the costs for human personnel and pesticides made up 75.2% of the total costs for DHDs and 63.5% for LAs. The DHDs had spent more on human personnel and pesticides resources even if outsourcing of services in the case of the LAs were taken into consideration.

Table 6.17: Costs of main vector control activities and the resources used by the DHD and LA (MYR) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Cost (MYR)	95% CI		Cost (MYR)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	8,275			5,219		
ACTIVITIES						
Premise inspection	3,583,512	2,443,351	4,640,191	1,914,701	651,644	3,199,705
Fogging	9,170,452	5,316,143	13,511,348	3,818,436	2,057,792	5,485,487
Larviciding	5,222,512	2,744,872	8,640,780	2,606,998	942,778	4,226,214
Overall[b]	**17,976,475**	**10,979,771**	**26,233,944**	**8,340,138**	**4,276,472**	**12,386,435**
RESOURCES						
Human personnel	8,673,814	6,135,486	10,948,975	4,700,704	2,416,884	6,816,520
Buildings	589,580	357,462	837,466	965,483	253,832	1,984,442
Vehicles	1,413,712	613,877	2,418,321	725,954	226,237	1,329,311
Equipment	2,191,448	747,394	4,505,588	497,401	282,858	689,824
Pesticides	4,848,187	2,134,037	8,744,819	598,628	277,761	965,535
PPE[c]	259,732	150,599	370,682	164,017	78,772	251,898
Outsourcing[d]	0	0	0	687,950	0	1,701,800
Overall[e]	**17,976,475**	**10,979,771**	**26,233,944**	**8,340,138**	**4,276,472**	**12,386,435**
CAPITAL ITEMS						
Buildings	388,539	181,840	603,672	815,545	174,425	1,776,008
Vehicles	295,942	225,322	378,583	241,570	40,355	489,141
Equipment	360,774	136,291	617,528	100,732	35,684	176,302
Overall[f]	**1,045,252**	**658,596**	**1,448,569**	**1,157,848**	**384,982**	**2,176,193**
RECURRENT ITEMS						
Human personnel	8,673,814	6,135,486	10,948,975	4,700,704	2,416,884	6,816,520
Buildings	201,044	130,612	279,825	149,936	77,279	223,918
Vehicles	1,117,770	344,828	2,047,330	484,386	134,233	1,034,533
Equipment	1,830,674	550,320	3,941,730	396,669	195,751	594,844
Pesticides	4,848,187	2,134,037	8,744,819	598,628	277,761	965,535
PPE[c]	259,732	150,599	370,682	164,017	78,772	251,898
Outsourcing[d]	0	0	0	687,950	0	1,701,800
Overall[g]	**16,931,223**	**10,175,485**	**24,930,035**	**7,182,289**	**3,670,237**	**10,831,464**

[a]Number of reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

Table 6.18: Costs of main vector control activities and the resources used by the DHD and LA (US$) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Cost (US$)	95% CI		Cost (US$)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	8,275			5,219		
ACTIVITIES						
Premise inspection	1,119,846	763,545	1,450,059	2,606,293	203,639	999,908
Fogging	2,865,766	1,661,295	4,222,296	1,193,262	643,060	1,714,215
Larviciding	1,632,036	857,772	2,700,246	814,687	294,619	1,320,693
Overall[b]	**5,617,648**	**3,431,177**	**8,198,108**	**2,606,293**	**1,336,397**	**3,870,762**
RESOURCES						
Human personnel	2,710,566	1,917,339	3,421,553	1,468,969	755,275	2,130,160
Buildings	184,244	111,707	261,708	301,713	79,322	620,137
Vehicles	441,785	191,836	755,726	226,861	70,699	415,409
Equipment	684,829	233,561	1,407,997	155,437	88,394	215,568
Pesticides	1,515,059	666,887	2,732,756	187,072	86,801	301,731
PPE[c]	81,165	47,062	115,836	51,257	24,618	78,720
Outsourcing[d]	0	0	0	214,984	0	531,811
Overall[e]	**5,617,648**	**3,431,177**	**8,198,108**	**2,606,293**	**1,336,397**	**3,870,762**
CAPITAL ITEMS						
Buildings	121,418	56,824	188,647	254,859	54,509	555,004
Vehicles	92,481	70,412	118,306	75,490	12,611	152,856
Equipment	112,743	42,592	192,977	31,479	11,150	55,095
Overall[f]	**326,641**	**205,809**	**452,678**	**361,827**	**120,307**	**680,060**
RECURRENT ITEMS						
Human personnel	2,710,566	1,917,339	3,421,553	1,468,969	755,275	2,130,160
Buildings	62,826	40,817	87,443	46,855	24,150	69,974
Vehicles	349,304	107,758	639,792	151,369	41,947	323,291
Equipment	572,087	171,977	1,231,792	123,959	61,170	185,890
Pesticides	1,515,059	666,887	2,732,756	187,072	86,801	301,731
PPE[c]	81,165	47,062	115,836	51,257	24,618	78,720
Outsourcing[d]	0	0	0	214,984	0	531,811
Overall[g]	**5,291,007**	**3,179,839**	**7,790,637**	**2,244,467**	**1,146,951**	**3,384,835**

[a]Number of reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

Table 6.19: Average costs of main vector control activities and the resources used by the DHD and LA (MYR) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Mean cost (MYR)	95% CI		Mean cost (MYR)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	1,034			652		
ACTIVITIES						
Premise inspection	447,939	305,419	580,024	239,338	81,456	399,963
Fogging	1,146,307	664,518	1,688,919	477,305	257,224	685,686
Larviciding	652,814	343,109	1,080,098	325,875	117,847	528,277
Overall[b]	**2,247,059**	**1,372,471**	**3,279,243**	**1,042,517**	**534,559**	**1,548,304**
RESOURCES						
Human personnel	1,084,227	766,936	1,368,622	587,588	302,111	852,065
Buildings	73,698	44,683	104,683	120,685	31,729	248,055
Vehicles	176,714	76,735	302,290	90,744	28,280	166,164
Equipment	273,931	93,424	563,199	62,175	35,357	86,228
Pesticides	606,023	266,755	1,093,102	74,829	34,720	120,692
PPE[c]	32,467	18,825	46,335	20,502	9,847	31,487
Outsourcing[d]	0	0	0	85,994	0	212,725
Overall[e]	**2,247,059**	**1,372,471**	**3,279,243**	**1,042,517**	**534,559**	**1,548,304**
CAPITAL ITEMS						
Buildings	48,567	22,730	75,459	101,943	21,803	222,001
Vehicles	36,993	28,165	47,323	30,196	5,044	61,143
Equipment	45,097	17,036	77,191	12,592	4,461	22,038
Overall[f]	**130,657**	**82,324**	**181,071**	**144,731**	**48,123**	**272,024**
RECURRENT ITEMS						
Human personnel	1,084,227	766,936	1,368,622	587,588	302,111	852,065
Buildings	25,131	16,327	34,978	18,742	9,660	27,990
Vehicles	139,721	43,103	255,916	60,548	16,779	129,317
Equipment	228,834	68,790	492,716	49,584	24,469	74,356
Pesticides	606,023	266,755	1,093,102	74,829	34,720	120,692
PPE[c]	32,467	18,825	46,335	20,502	9,847	31,487
Outsourcing[d]	0	0	0	85,994	0	212,725
Overall[g]	**2,116,403**	**1,271,936**	**3,116,254**	**897,786**	**458,780**	**1,353,933**

[a]Average reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

Table 6.20: Average costs of main vector control activities and the resources used by the DHD and LA (US$) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Mean cost (US$)	95% CI		Mean cost (US$)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	1,034			652		
ACTIVITIES						
Premise inspection	139,981	95,443	181,257	74,793	25,455	124,989
Fogging	358,221	207,662	527,787	149,158	80,382	214,277
Larviciding	204,005	107,222	337,531	101,836	36,827	165,087
Overall[b]	**702,206**	**428,897**	**1,024,763**	**325,787**	**167,050**	**483,845**
RESOURCES						
Human personnel	338,821	239,667	427,694	183,621	94,409	266,270
Buildings	23,031	13,963	32,714	37,714	9,915	77,517
Vehicles	55,223	23,980	94,466	28,358	8,837	51,926
Equipment	85,604	29,195	176,000	19,430	11,049	26,946
Pesticides	189,382	83,361	341,595	23,384	10,850	37,716
PPE[c]	10,146	5,883	14,480	6,407	3,077	9,840
Outsourcing[d]	0	0	0	26,873	0	66,476
Overall[e]	**702,206**	**428,897**	**1,024,763**	**325,787**	**167,050**	**483,845**
CAPITAL ITEMS						
Buildings	15,177	7,103	23,581	31,857	6,814	69,376
Vehicles	11,560	8,802	14,788	9,436	1,576	19,107
Equipment	14,093	5,324	24,122	3,935	1,394	6,887
Overall[f]	**40,830**	**25,726**	**56,585**	**45,228**	**15,038**	**85,008**
RECURRENT ITEMS						
Human personnel	338,821	239,667	427,694	183,621	94,409	266,270
Buildings	7,853	5,102	10,930	5,857	3,019	8,747
Vehicles	43,663	13,470	79,974	18,921	5,243	40,411
Equipment	71,511	21,497	153,974	15,495	7,646	23,236
Pesticides	189,382	83,361	341,595	23,384	10,850	37,716
PPE[c]	10,146	5,883	14,480	6,407	3,077	9,840
Outsourcing[d]	0	0	0	26,873	0	66,476
Overall[g]	**661,376**	**397,480**	**973,830**	**280,558**	**143,369**	**423,104**

[a]Average reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

Table 6.21: Cost per case of main vector control activities and the resources used by the DHD and LA (MYR) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Cost per case (MYR)	95% CI		Cost per case (MYR)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	8,275			5,219		
ACTIVITIES						
Premise inspection	433	273	1,003	367	344	397
Fogging	1,108	795	2,182	732	591	1,253
Larviciding	631	508	1,127	500	455	574
Overall[b]	**2,172**	**1,543**	**4,507**	**1,598**	**1,334**	**2,604**
RESOURCES						
Human personnel	1,048	644	2,519	901	734	1,472
Buildings	71	49	147	185	214	155
Vehicles	171	142	252	139	143	138
Equipment	265	265	307	95	74	172
Pesticides	586	514	876	115	104	169
PPE[c]	31	22	62	31	27	48
Outsourcing[d]	0	0	0	132	183	0
Overall[e]	**2,172**	**1,543**	**4,507**	**1,598**	**1,334**	**2,604**
CAPITAL ITEMS						
Buildings	47	36	75	156	106	191
Vehicles	36	22	92	46	25	53
Equipment	44	36	56	19	19	22
Overall[f]	**126**	**85**	**270**	**222**	**234**	**234**
RECURRENT ITEMS						
Human personnel	1,048	644	2,519	901	734	1,472
Buildings	24	16	54	29	24	47
Vehicles	135	120	142	93	82	111
Equipment	221	226	232	76	64	119
Pesticides	586	514	876	115	104	169
PPE[c]	31	22	62	31	27	48
Outsourcing[d]	0	0	0	132	0	183
Overall[g]	**2,046**	**1,467**	**4,177**	**1,376**	**1,166**	**2,235**

[a]Number of reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

Table 6.22: Cost per case of main vector control activities and the resources used by the DHD and LA (US$) at sampled districts

Parameters	DHD (n=8)			LA (n=8)		
	Cost per case (US$)	95% CI		Cost per case (US$)	95% CI	
		Lower	Upper		Lower	Upper
Cases[a]	8,275			5,219		
ACTIVITIES						
Premise inspection	135	92	175	499	39	192
Fogging	346	201	510	229	123	328
Larviciding	197	104	326	156	56	253
Overall[b]	**679**	**415**	**991**	**499**	**256**	**742**
RESOURCES						
Human personnel	328	232	413	281	145	408
Buildings	22	13	32	58	15	119
Vehicles	53	23	91	43	14	80
Equipment	83	28	170	30	17	41
Pesticides	183	81	330	36	17	58
PPE[c]	10	6	14	10	5	15
Outsourcing[d]	0	0	0	41	0	102
Overall[e]	**679**	**415**	**991**	**499**	**256**	**742**
CAPITAL ITEMS						
Buildings	15	7	23	49	10	106
Vehicles	11	9	14	14	2	29
Equipment	14	5	23	6	2	11
Overall[f]	**39**	**25**	**55**	**69**	**23**	**130**
RECURRENT ITEMS						
Human personnel	328	232	413	281	145	408
Buildings	8	5	11	9	5	13
Vehicles	42	13	77	29	8	62
Equipment	69	21	149	24	12	36
Pesticides	183	81	330	36	17	58
PPE[c]	10	6	14	10	5	15
Outsourcing[d]	0	0	0	41	0	102
Overall[g]	**639**	**384**	**941**	**430**	**220**	**649**

[a]Number of reported dengue cases responded by the service provider; [b]Sum of activities costs; [c]PPE denote personal protective equipment; [d]Fogging and larviciding activities sub-contracted to private companies; [e]Sum of line items costs; [f]Sum of capital items costs; [g]Sum of recurrent items costs

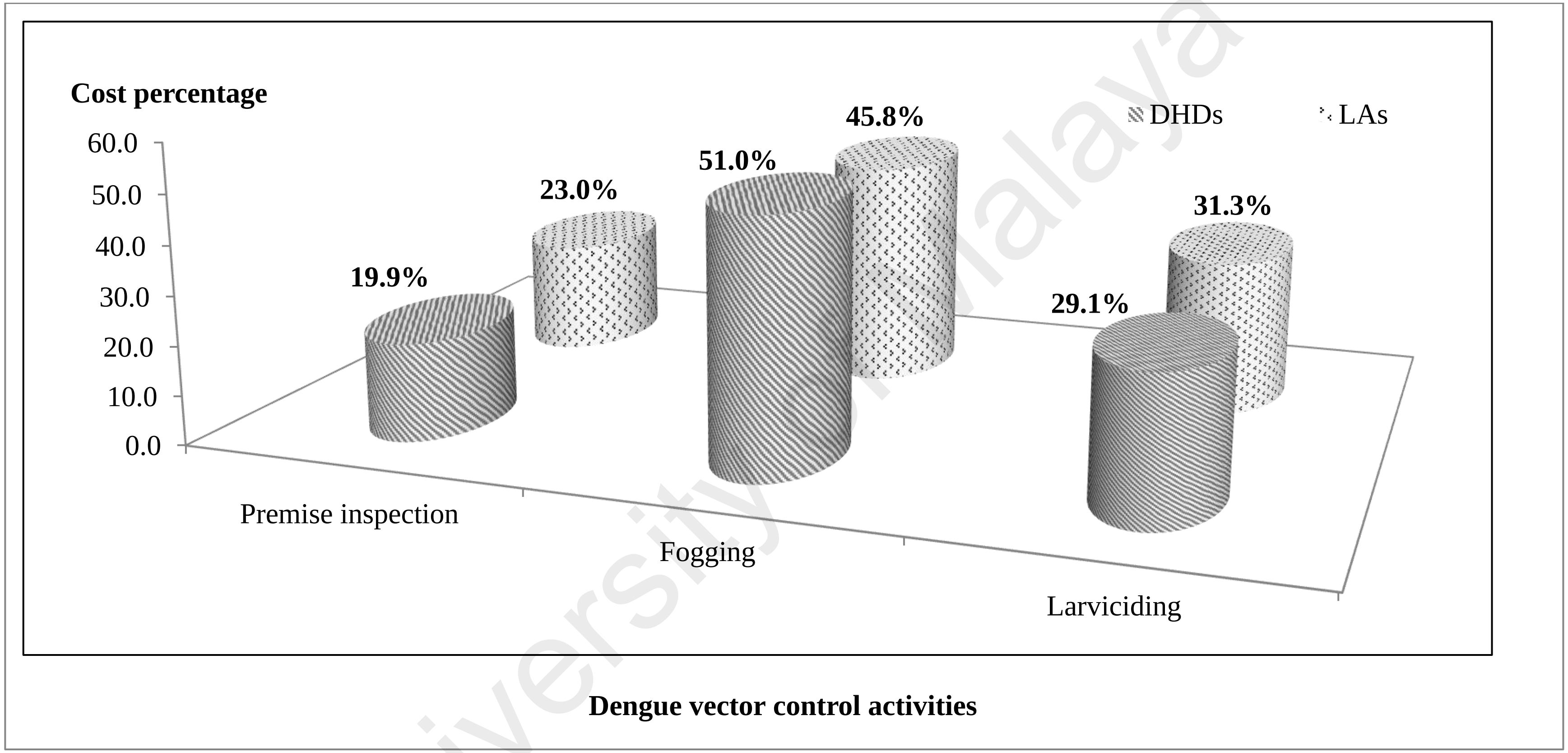

Figure 6.11: The cost per case comparison of dengue vector control activities by the DHDs and LAs

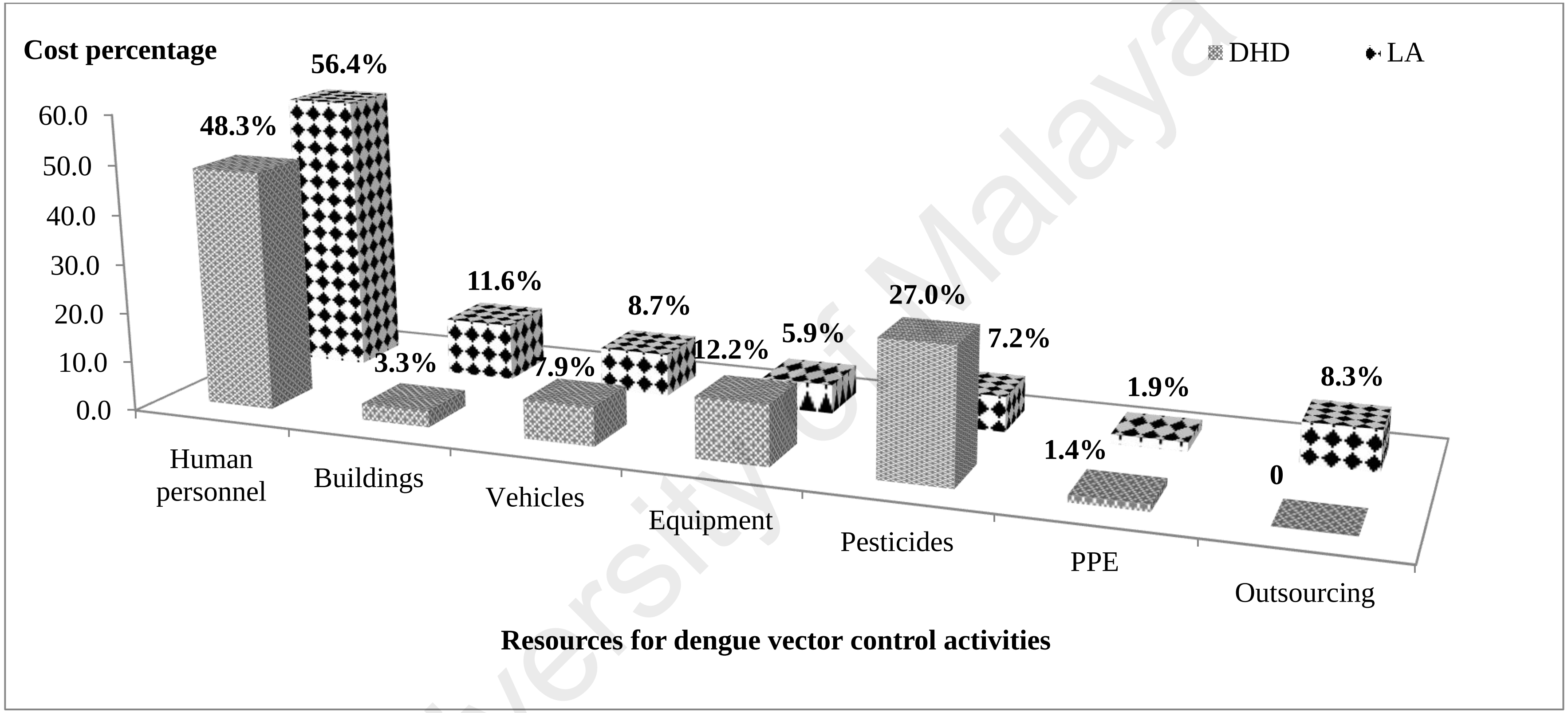

Figure 6.12: The cost per case comparison of resources for dengue vector control activities by the DHDs and LAs

6.7 Summary

Historically, the responsibility for maintaining hygiene, sanitation, and vector control in the towns falls under the purview of the LAs. However, the DHDs had taken over as the primary implementer of dengue vector control services in the country as a result of increasing dengue burden. Moreover, in the national dengue surveillance system, notification of dengue cases is received by the DHDs of MOH at each district and not to the LAs. Most often, the LAs will receive directions from the DHDs for dengue vector control activities, but the division of responsibilities between the two public sector agencies is usually arbitrarily decided. Such actions at times results in conflicts as the two public sector delivery agencies operate under two different government ministries. They receive their operating budgets and resources from their respective ministries that are MOH and MHLG. Differences in priorities by these public sector agencies had led the LAs to concentrate predominantly on three dengue vector control activities, namely the inspection of premises for mosquito breeding sites, larviciding that is the application of insecticides to potential breeding sites and water holding containers and fogging to destroy the adult mosquitoes. The extra activities that are entomological surveillance to collect data on mosquito vector densities and health education and clean environment promotion activities to raise awareness among the general public and communities are mostly left to the DHDs. The two public sector agencies also had different modus operandi. In the case of DHDs, all dengue control activities are performed by their in-house personnel. Some LAs had outsourced to private contractors primarily to perform the fogging and larviciding services at their operational housing areas in the community.

CHAPTER 7 : DISCUSSION

In 2010, there were 46,171 dengue cases with 134 deaths in Malaysia (Ministry of Health Malaysia, 2010a). These figures by far are much higher than those for other known vector-borne diseases in Malaysia. For example, there were 6,650 malaria cases with 33 deaths(Ministry of Health Malaysia, 2010c) and 804 chikungunya cases with no documented deaths(Director General of Health Malaysia, 2011).

7.1 National Cost Burden Of Dengue Vector Control

The Malaysian government has invested substantially in the national dengue control and prevention programme. It has been estimated MYR 235.05 mil (US$ 73.45 mil) in public funds was spent on dengue vector control and prevention programme in 2010. The total expenditure for dengue vector control and prevention services makes up 0.03% of Malaysia's Gross Domestic Product (GDP) (The World Bank, 2014), 0.64% of the total health expenditure, 1.22% of the total government funding for healthcare (Ministry of Health Malaysia, 2013) and 20.04% of the public sector expenditure for prevention and public health services in Malaysia for 2010 (Ministry of Health Malaysia, 2013). This has shown that dengue is the most important vector-borne disease in Malaysia in terms of disease and economic burdens.

7.2 Cost Comparison To Other Dengue-Endemic Countries In The Region

The financial commitment of Malaysia to dengue vector control and prevention is not unique in the region. Few dengue-endemic SEA countries that face substantial dengue case burdens have also invested significantly towards dengue vector control and prevention in their respective countries. The cost of dengue vector control and prevention in Malaysia is comparable to other dengue-endemic countries in the region. The World Bank (2014) has country-specific current GDP and population estimates for the relevant years. The fraction of the cost per capita of dengue vector control and prevention and the cost per capita GDP were then calculated. The dengue vector control and prevention costs reported in published studies would amount to 0.01% of the GDP of Cambodia for the period 2001 to 2008(Beauté & Vong, 2010; Suaya, Shepard, Moh-Seng, et al., 2007), a range of 0.01% to 0.04% of the GDP in Thailand for 2000-2005 (Kongsin et al., 2010; Lim et al., 2010) and 0.04% of the GDP of Singapore for 2000-2009 (Carrasco et al., 2011). The costs of dengue vector control and prevention in these countries ranged 0.01% to 0.04% of their GDPs and Malaysia is also committed in the similar range of cost investments in the programme.

7.3 Dengue Vector Control And Prevention Costs Adjusted To Under-Reporting

The true burden of dengue is higher than the officially reported dengue cases in the districts. A large proportion of dengue cases were not captured by the country's national surveillance system, and this situation is described as underreporting. Shepard et al. (2012) estimated the degree of underreporting and projected the true burden for Malaysia for the year 2009. The adjusted EF that was derived through Delphi's method was 3.79 for both public and private sector(Shepard et al., 2012). It will be a cautious presumption that the degree of underreporting will not have significant variation between the year 2009 and 2010. If the conservative EF were applied to the reported dengue cases for the year 2010 (46,171 cases), the true adjusted burden would approximately be 174,988 dengue cases.

The Malaysian public sector agencies for dengue vector control and prevention that is the MOH and LA would have initiated appropriate vector control measures similar to the reported cases. Hence, the true cost of dengue vector control and prevention activities in Malaysia could be higher if adjusted to the underreporting scenario. The resources consumption and costs for the FHD and SHDs will not be affected because these units handle macro-level administrative functions. However, the resources consumption and costs for DHDs and LAs will be implicated since these entities are directly responsible for providing dengue vector control and prevention services to the communities in each district.

The costs of the capital items and some recurrent items, for example, human personnel, buildings and vehicles would be constant because the vector control units would have functioned using the existent resources. The increase in resources consumption would be observed only in certain recurrent items such as the equipment, pesticides, and outsourcing. The costs per case of these recurrent items were then multiplied by the estimated true burden of dengue cases for 2010. The capital and recurrent costs of each line item were then combined. The summation of the line items yields the national cost of the district-level units. Once adjusted for underreporting, the national costs at district-level became MYR 320.92 mil (US$ 100.29 mil). The adjusted economic burden of dengue vector control and prevention activities in Malaysia for 2010 was MYR 339.23 mil (US$ 106.01 mil). The total adjusted expenditure for dengue vector control and prevention services constitutes 0.04% of Malaysia's GDP. It formed 0.92% of the country's total health expenditure and 1.75% of the total health expenditure by the public sector.

7.4 Effectiveness Of The Dengue Vector Control Interventions

Despite the staggering investment of Malaysia into dengue vector control and prevention activities, the effectiveness of the dengue vector control interventions practised under the national programme have not been fully evaluated. In fact, the effectiveness of any dengue vector control methods have not been fully evaluated and known(Bowman et al., 2016). The dengue vector control activities at the level of the districts were conducted predominantly to prevent the transmission of dengue from reported cases rather than to eliminate or prevent the disease. Public sector agencies in Malaysia have been performing integrated vector control interventions to combat the disease but no evidence is available to support that this is an effective combination of approaches. One-third of the costs for dengue prevention activities was incurred for the killing of adult mosquitoes through chemical fogging. This approach by the public sector agencies may be driven by public expectations of government's immediate reaction to dengue cases and outbreaks in the country rather than higher expectations of proactive actions to prevent the disease. This is despite lack of evidence from randomized controlled trials to evaluate the effectiveness of fogging(Bowman et al., 2016) to reduce dengue transmission or dengue incidence in Malaysia or any dengue-endemic countries. Fogging is not likely to be fully effective because Aedes aegypti being the main vector for dengue is an indoor resting mosquito and risk of transmission occurs when it bites the human host indoor. Many households in Malaysia refuse to allow vector control staff to spray the insecticide indoor and most of the time only outdoor residual spraying is carried out. Moreover, space spraying will only kill adult mosquitoes and does not kill the aquatic phase of mosquitoes (i.e. larvaes, pupaes). Having a short life cycle of less than seven days, the aquatic phase of mosquitoes will rapidly develop into adult mosquitoes and those harbouring the dengue virus will continue the disease transmission into susceptible human hosts.

Such overt dependence on chemical fogging has raised several concerns in relation to excessive use of insecticides in dengue prevention, namely the development of mosquito resistance, risks to the surrounding environment and the transient variable efficacy of peridomestic space spraying(Chan, Mustafa, & Zairi, 2011; Esu et al., 2010; Koenraadt et al., 2007; Shafie et al., 2012; Thammapalo et al., 2012). There is significant need in Malaysia for further studies that will examine the effectiveness and health impacts of chemical fogging and insecticide used for dengue vector control.

The national dengue vector control and prevention programme spent MYR 17.39 mil (US$ 5.43 mil) or 8% of the total costs for entomological surveillance. These are activities' to collect data for entomological indices, such as Aedes and Breteau indices. Single values of entomological indices are not reliable universal dengue transmission thresholds and there is little evidence of quantifiable associations between vector indices and disease transmission that would be reliable for outbreak prediction(Bowman, Runge-Ranzinger, & McCall, 2014). Since the entomological indices collected at the district-level units are found to have a weak evidence base and not effective, alternate options such as performing entomological studies (i.e. sentinel ovitrap surveillance, 48-hours ovitrap and sticky ovitraps) are evidence based that could contribute positively to dengue vector control activities(Hasnan, Dom, Rosly, & Tiong, 2016; Horstick & Morrison, 2014; Llagas et al., 2016; Mohiddin, Jaal, Lasim, Dieng, & Zuharah, 2015; Sairi, Dom, & Camalxaman, 2016).

The national dengue vector control and prevention programme spent MYR 30.35 mil (US$ 9.48 mil) or 14% of the total costs for health education related activities at the district level. Frequent social mobilization and continuous communication with the local communities form important measures that ensure sustainable dengue prevention and control activities can be implemented successfully (Lloyd, Winch, Ortega-Canto, & Kendall, 1994; Renganathan et al., 2003; Toledo et al., 2007; L. P. Wong & AbuBakar, 2013). As opposed to chemical fogging activities that specifically target adult mosquitoes, educational messages embedded in a community-based approach have shown to create a significant impact on reducing the larval breeding sites(Al-Muhandis & Hunter, 2011). The costs of such activities were found to be approximately three times less than the expenses of fogging and larviciding activities. Community-based partnership has demonstrated the capacity to resolve problems of mutual concern and has shown positive impact on reducing dengue transmission(Toledo et al., 2007). It will be a strategic move for Malaysia to invest further in social mobilization and communication activities. Randomized controlled trials may not be appropriate as a tool to evaluate the effectiveness of the community based intervention(Toledo et al., 2007). A qualitative based study can be used instead to measure behavioural change and the intended outcomes.

7.5 Resources For Dengue Vector Control

Dengue vector control and prevention activities as practiced in Malaysia are intensely human resource dependent. A large human workforce is required to perform the variety of dengue vector control, surveillance, and prevention activities at the district level. Trained allied health professionals conduct premise inspections, fogging and larviciding activities, the mainstay of the national vector control programme. Other public health professionals, including doctors and entomologists, provide technical support and are essential for monitoring and evaluation. The logistics of dengue outbreak response activities are very challenging and often require redistribution of staff, increase staffing levels(Silvia Runge-Ranzinger et al., 2016) through emergency hires and the extension of working times that lead to a high overtime claims. As a consequence, human resources' costs contribute the largest portion of the overall programme costs. Lack of service delivery effectiveness among the dengue vector control staff is a widespread issue in the districts. The national dengue vector control programme must look into capacity building and set operational standards for quality service delivery.

Capital items such as vehicles, fogging and larvaciding equipment has an average working life of five years. 34% of the capital items (i.e. vehicles and equipment) at the sampled districts were found to be significantly beyond the average working life. Such old equipment not only incurred high costs for maintenance and services but will experience frequent breakdowns. These issues influence the optimal function of the equipment and may result in less effective machine performance. It will lead to a situation where the fogging equipment will deliver inconsistent droplet sizes during fogging and impair the effectiveness of the space spraying activity.

Another resource that was found to have high consumption in the sampled districts was diesel usage (0.85 mil litres). Majority of the dengue vector control units were using oil-based pesticides that required diesel for dilution prior fogging activity. The usage of oil-based pesticides also resulted in poor compliance among households to allow vector control staff to perform indoor residual spraying. The fogging activity will lead to unpleasant oil staining of the premises especially the floor, furniture's and curtains. If the dengue vector control programme instead uses water-based pesticides, significant cost savings could be achieved by reducing diesel purchases. A water-based pesticide may allow greater compliance among households for indoor residual spraying since there will absence of oil staining. The cost effectiveness of using a water-based pesticide as compared to an oil-based pesticide will be required as an evidence base to support this suggestion

7.6 Rationalization Of Dengue Vector Control Service Delivery

The dengue vector control and prevention services in Malaysia are delivered by two public sector agencies, namely the MOH through the DHDs and the MLGH through the LAs. The DHDs national expenditure for 2010 was MYR 169.12 mil (US$ 52.85 mil), and the LA's was MYR 47.63 mil (US$ 14.88 mil). Based on these cost data, the MOH is shouldering 78.1% of the operational cost at the districts as compared to the LAs, which was 21.9%. The distribution of reported dengue cases responded by respective service providers at the sampled districts was observed to be almost equal. However, the precise national case distribution and population coverage by respective service providers at district-level were ambiguous due to unclear and overlapped operational geographic demarcations. The available data at the federal level does not reflect the actual operational situation observed in the districts.

The majority of dengue breeding sites detected at the districts were associated with poor environmental sanitation, the presence of man-made artificial containers disposed of indiscriminately, the dissatisfactory implementation of solid waste disposal system resulting in many illegal dumpsites, ill-maintained drainage system, and poorly sloped storm drains(K. Mulligan, S.J.Elliott, & C.Schuster-Wallace, 2012). All these issues are under the purview of urban services delivered by the LAs. Hence, the LAs need to play a greater role in dengue vector control and prevention services at the national level since many dengue breeding sites are related to urban planning and municipal services. The LAs must intensify inspection and enforcement of mosquito breeding sites and potential water stagnation areas at housing areas, commercial premises and construction sites. The vector control units of the LAs ought to be systematically included in mainstream urban planning and governance.

This study has found that the LAs appear to be more cost-efficient than DHDs in providing premise inspection services, fogging, and larviciding targeted for dengue vector control in Malaysia. Since the LAs have been found to be cost efficient, one possible option would be for the LAs to fully take over dengue vector control services namely premise inspections, fogging and larviciding activities in the urban and semi-urban towns. The DHDs, on the other hand, can perform those activities at the rural town areas. The role of MOH should be focussed towards dengue surveillance, health education and health promotive activities and overall monitoring and evaluation of the dengue vector control and prevention programme. However, this study focused only on costs of providing services and not the effectiveness of services rendered. The higher DHD vector control costs are related to the mix of health care personnel providing such services. While the vector control staff in DHDs includes highly trained technical experts such as public health physicians, entomologists, and health inspectors, LAs do not have such staff to guide and monitor the performance of their workers. This situation may also impact the effectiveness of services provided. A further evaluation of the effectiveness of dengue vector control services provided by the respective public sector agency is required to aid the final decision-making process.

The largest share of the vector control costs for both the DHDs and LAs was for fogging activities which destroy adult mosquitoes rather than environmental control to eliminate potential breeding sites. The higher pesticides cost for DHDs suggests higher pesticides use among DHDs. This is despite the existence of several issues related to insecticide use in dengue vector control which was discussed earlier. Meanwhile, it is apparent that the LAs have not given sufficient priority to health education activities as it can have a large impact on reducing mosquito breeding sites as compared to fogging activities.

7.7 Strenghs And Limitations Of The Study

The major strength of this study comes from the use of micro-costing to estimate dengue vector control costs through a bottom-up approach in which all vector control resources were identified. Inputs and cost data was obtained directly from the vector control units from a representative selection of public agencies. This study is believed as the first attempt to use systematic and comprehensive cost methods to estimate dengue vector control and prevention in Malaysia.

There are several limitations to this study. The cost perspective is limited to the public sector only. The cost of dengue vector activities paid for by private corporations (e.g., fogging activities surrounding hotels, factories, and warehouses) and private households (e.g., fogging conducted in areas surrounding private condominiums and residential apartments) were not included in this study. These services are conducted at regular intervals by private pest control companies. Although such services are primarily aimed at prevention of DF, they are only carried out in a small proportion of workplaces and residential apartments. The private household expenditures for the purchase of mosquito coils, insecticide spray cans, and mosquito window nettings were not included as well. However, these items are mainly used to deter nuisance mosquitoes rather than prevention of DF. Community mosquito prevention activities conducted by nongovernmental organizations, which are mostly performed on an ad hoc basis, were not included. On the other hand, the costs of pesticides estimated may have included some products used against Aedes albopictus for chikungunya control. However, this amount would have been small, as reported chikungunya cases were fewer than 2% of the reported dengue cases(Director General of Health Malaysia, 2011).

The total cost of dengue vector control of each service providers was divided by the number of reported dengue cases responded by respective providers to derive the cost per case. Many dengue endemic countries inclusive Malaysia adopted the system of passive surveillance of cases. Once a suspected dengue case is notified by a health practitioner, the dengue vector control units will perform a series of vector control activities. Hence, it is a reactive cost rather than a preventive cost. The cost per case for LAs appears to be lower than the DHDs. Although the LAs were portrayed to be cost efficient, the dengue vector control protocols and effectiveness(Azil, Li, & Williams, 2011) between the DHDs and LAs is fundamental and should be a research priority. The data for population coverage by both service providers were not distinguishable due to unclear and overlapped geographic demarcation of operational areas. Hence, the costs of respective service providers by per capita population could not be estimated.

This study provides some evidence to inform decision making as to the future roles of DHDs and LAs in the provision of dengue vector control activities in Malaysia. Since LAs have been found to be cost efficient, one possible option would be for these agencies to take over premise inspection, fogging, and larviciding activities in the towns leaving the DHDs to perform such activities in rural areas as well as to concentrate on monitoring and evaluation of dengue control programme. The ultimate decision would require further evaluation into the effectiveness of services provided by these public sector agencies.

The study estimated the resources consumptions and associated costs of dengue vector control and prevention for Malaysia as well as the costs of providing dengue vector control services by two public sector service providers. This study was not aimed at nor was designed to examine the effectiveness of any single dengue vector control intervention or combination of integrated vector control interventions. The available data of activities done at the district-level were predominantly process indicators that list the number of activities performed by respective dengue vector control units. Data to assess effectiveness of any specific intervention need to be outcome based. Since the conventional dengue vector control interventions are aimed to keep the mosquito density low and reduce risk of transmission of disease, the outcome indicators must be based upon entomological indices and parameters. The use of dengue incidences or duration of outbreak days will not be appropriate as other factors (i.e. environmental factors, natural history) could influence the outcome and confound the results.

7.8 The Role Of Dengue Vaccine

Recently there was the introduction of a dengue vaccine in the market by Sanofi Pasteur and it was adopted in several dengue endemic countries(Sanofi Pasteur, 2015a, 2015b, 2015c, 2015d). The WHO has recommended that dengue-endemic countries consider immunization of individuals aged 9-45 years in the population(World Health Organization, 2016a). Clinical trials done in several countries have shown the vaccine to be less efficacious towards DENV1 and DENV2 and more efficacious towards DENV3 and DENV4 (Capeding et al., 2014; Arunee Sabchareon et al., 2012). Additonally, during the third year after vaccination, the protective efficacy were found to be reduced and asymmetrically protective(Scott B. Halstead, 2016). The trial also noted higher rate of hospitalizations and complications among children less than five years old(Scott B. Halstead & Russell, 2016) hence the reason for Sanofi's recommendation for those aged nine years and above to be a candidate for vaccine administration. Another factor that requires serious consideration is the observation of preconditions related to developments of antibody dependent enhancements (ADEs)(Scott B. Halstead, 2016). ADE will result in more severe dengue infection that requires hospitalizations and associated with increased complications. Further studies, and post-marketing surveillance have to be conducted to assess the long-term efficacy of the vaccine(Guy et al., 2011).

The option of vaccination can be seriously considered by Malaysia provided if it is found to be cost-effective. A country specific cost effectiveness analysis will be required as an aid for decision making among policymakers. Currently there is none available yet for Malaysia. The WHO Scientific Advisory Group of Experts on Immunization (SAGE) recommends that vaccination should be considered as an integrated strategy together with a communication strategy, well-executed and sustained vector control, the best evidence-based clinical care for all patients with dengue, and robust dengue surveillance(World Health Organization, 2016a). The integration of conventional dengue vector control and vaccination as recommended by SAGE will incur additional vector control cost implications for Malaysia. The vaccine is argued to be able to reduce the curative cost (cost of treatment and complications) of dengue and thereby will lead to reduction of the overall economic burden of dengue in the country. Hence, in the long run, possible cost savings can be predicted if Malaysia decides to adopt this strategy. The challenge will be for Malaysia on the negotiation table to obtain the best pricing of the vaccine from the pharmaceutical company.

7.9 Re-emergence Of Zika Virus Infection

Recently, there was the emergence of Zika virus infection and it has spread rapidly affecting many countries worldwide(Harris, 2016). The vector responsible for transmission of Zika infection is Aedes species and it is a matter of time before an epidemic of Zika infection occurs among the local population in Malaysia due to globalization, population mobility and international commerce(Marchette et al., 1969; Musso et al., 2014). The Zika virus epidemic was declared as Public Health Emergency of International Concern (PHEIC) by WHO in view of occurrence of high incidence of microcephaly and neurological illness(Barreto et al., 2016; World Health Organization, 2016c, 2016d). Currently there is no definitive treatment or effective vaccine yet available for Zika infection and primary method of disease control is through Aedes vector control which is very much similar to dengue(World Health Organization, 2016b). The control and preventive method is universal for Zika infection, dengue, chikungunya and other vector-borne diseases where the primary vector responsible is the Aedes mosquitoes. Initially there were suggestions of cost savings concept in the long term for Malaysia through the availability of a dengue vaccine. A lowered dengue incidence will lead to fewer case reporting and subsequently reduced vector control and prevention activities. However, the emergence of Zika infection has radically changed the scenario for Aedes vector control and prevention. Malaysia should step up and sustain its vector control and prevention activities to reduce the Aedes mosquito density. It is imperative for Malaysia to continue and preserve its expenditure in vector control and prevention activities.

CHAPTER 8 : CONCLUSION

In conclusion, Malaysia is an upper-middle-income country that spends annually approximately 5% of total GDP on health overall and 0.03% specifically on dengue vector control. Dengue poses a significant economic burden to the country, with a combined annual cost for prevention and illness of MYR 594.84 mil (US$ 175.71 mil). Malaysia has been reliant on a government funded integrated dengue vector control programme, which includes efforts to garner community support through health education activities.

These approaches have not been able to prevent dengue outbreaks in the country. Innovative control technologies against this disease include the Toxorhynchites larvae (Nathan, 2013; Nyamah, Sulaiman, & Omar, 2011), genetically modified sterile mosquitoes (Alphey, Alphey, & Bonsall, 2011; Lacroix et al., 2012), Wolbachia inserted into mosquitoes (Hoffmann et al., 2011) and the dengue vaccine (Capeding et al., 2014; Coller & Clements, 2011) are available but evidence of intervention effectiveness remains weak. Cost effectiveness analysis of conventional and innovative vector control interventions is important and should be made as research priority. This study's quantification of the disease's economic burden informs policy makers and stakeholders regarding the implementation of existing and new technologies for controlling dengue.

This study also highlighted the significant differences in costs and resource consumption of the two public sector agencies responsible for the provision of dengue vector control services in Malaysia. The effectiveness of service delivery must be determined prior to the rationalization of service delivery among the public sector agencies. The cost data are useful for operational and managerial enhancement to the dual delivery system adopted by the country and subsequently provide evidence for informed policy discussions on the rationalization of dengue vector control and prevention services in Malaysia. Steps for the improvement of dengue vector control and prevention in Malaysia has been discussed.

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LIST OF PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

1. Packierisamy PR, Ng CW, Dahlui M, Venugopalan B, Halasa YA, Shepard DS (2015). The cost of dengue vector control activities in Malaysia by different service providers. Asia Pac J Public Health, 27(8 suppl), pg. 73S-78S. doi:10.1177/1010539515589339

2. Packierisamy PR, Ng CW, Dahlui M, Inbaraj J, Balan V K, Halasa YA, Shepard DS (2015). Cost of dengue vector control activities in Malaysia. Am J Trop Med Hyg, 93(5), pg. 1020-1027. doi:10.4269/ajtmh.14-0667

ORAL PRESENTATION

1. Packierisamy PR, Ng CW, Dahlui M, Venugopalan B, Halasa YA, Shepard DS (2013). Comparing cost of dengue vector control services between different delivery agencies in Malaysia. The Third International Conference on Dengue and Dengue Haemorrhagic Fever, 21st-23rd October 2013, The Imperial Queen's Park Hotel, Bangkok, Thailand.

POSTER PRESENTATIONS

1. P. Raviwharmman, C.W. Ng, M. Dahlui, B. Venugopalan, Y.A. Halasa, D.S. Shepard, (2013). Economic cost of dengue vector control in Malaysia. American Society of Tropical Medicine & Hygiene (ASTMH) 62nd Annual Meeting, 13th-17th November 2013, Marriott Wardman Park, Washington, DC, USA.

2. P. Raviwharmman Packierisamy, Chiu-Wan Ng, Maznah Dahlui, B. Venugopalan, Yara A. Halasa, Donald S. Shepard (2014). The cost of dengue vector control activities in Malaysia by different service providers. Asia-Pacific Academic Consortium for Public Health (APACPH) 46th Annual Conference, 17th-19th October 2014, Hilton Kuala Lumpur, Kuala Lumpur, Malaysia.