

FACTORS DETERMINING DENGUE IN VIET NAM AND VECTOR CONTROL STRATEGY: A LITERATURE REVIEW

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VrijeUniversiteit Amsterdam

**Factors determining dengue in Viet Nam and vector control strategy:
A literature review**

A thesis submitted in partial fulfilment of the requirement for the degree of
Master of Public Health

by

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Viet Nam

Declaration:

Where other people's work has been used (either from a printed source, internet or any other source) this has been carefully acknowledged and referenced in accordance with departmental requirements.

The thesis **Factors determining dengue in Viet Nam and vector control strategy: A literature review** is my own work.

Signature:



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List of Abbreviations

CFR	:Case Facility Rates
DF	:Dengue Fever
DHF	:Dengue Hemogarrhic Fever
DSS	:Dengue Shock Syndrome
GDP	:Gross Domestic Population
EBS	:Event Based Surveillance
ECDs	:Electronic Communicable Disease software
GDPM	:General Department of Preventive Medicine, Ministry of Health
GNI	:Gross National Income
HIV/AIDS	:Human immunodeficiency virus infection/acquired immunodeficiency syndrome
HSPH	:Ha Noi School of Public Health
IVM	:Integrate Vector Management
KIT	:Royal Tropical Institute, Netherlands
MOH	:Ministry of Health
NDCP	:National Dengue Control Program
RRT	:Rapid Response Team
PPMC	:Provincial Preventive Medicine Center
WB	:World Bank
WHO	:World Health Organization

Glossary

Dengue: According to World Health Organization (WHO), “Dengue is a mosquito-borne viral disease”. The disease is transmitted by female mosquitoes with 2 main species, including *Aedes aegypti* and *Aedes albopictus*. There are 4 serotypes of dengue virus, including DEN-1, DEN-2, DEN-3 and DEN-4(1).

Dengue Haemorrhagic Fever: Dengue Haemorrhagic Fever (DHF) or severe dengue is a complication of dengue infections which can lead to serious illness and death for patients(1). There are 4 criteria for DHF diagnosis, including: “Fever or recent history of fever lasting 2–7 days; Any hemorrhagic manifestation; Thrombocytopenia (platelet count of $<100,000/\text{mm}^3$); and Evidence of increased vascular permeability”(2).

Dengue Shock Syndrome: Dengue Shock Syndrome (DSS) included all criteria for DHF plus circulatory failure(3).

Dengue outbreak: According to guideline on dengue fever surveillance and control which has been promulgated by Ministry of Health of Viet Nam (MOH): the identification of dengue fever outbreak was “A place/village/hamlet, (population groups or equivalent) is defined as dengue fever outbreak when clinical cases occur within 7 days or dengue fever cases are diagnosed room tests, simultaneous detection of wriggling/or mosquito larvae within a radius of 200 meters”(4).

Integrated Vector Management: According to WHO, IVM approach is a “rational decision-making process” in which emphasize role of multisectoral collaboration, evidence based in decision making, capacity building for human resources, integrate vector control methods, and social mobilisation and community empowerment(5).

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Abstracts

Background: Since 2005, Viet Nam has gained success in reducing mortality of dengue with less of 1 death per 1,000 cases. However, the number of dengue cases has been on an increasing trend and it always has potential risks to become outbreaks. Besides, there are varieties of issues which influence to the implementation of dengue prevention and control in Viet Nam in general and vector control strategy in particular.

Objectives: To identify determinants of dengue and to review vector control strategies in order to recommend appropriate solutions for the successful prevention and control of dengue in Viet Nam.

Methods: Literature review and Social Model of Health conceptual framework of Dahlgren & Whitehead have been used for this thesis.

Findings: Dengue fever occurs at all age groups and there was an increasing trend of ages among dengue cases. This is strongly influenced by living conditions, urbanization, water storage habits of community and climate conditions. In addition, community based vector control is the most important strategy in dengue vector control in Viet Nam.

Recommendations: Increasing effective and resources for dengue prevention and control by empowerment for local level, engagement of private sector, prioritize resources for high risk areas, intersectoral collaboration; applying information technology; and implementing further researches.

Key words: Dengue, *Aedes aegypti*, community based vector control, urbanization, water storage, strategy, Viet Nam.

Word count: 11,281

Introduction

I graduated from Medical Technical College in 2006 as a nurse. In 2007, I decided to further my studies by training in public health. I studied at the Ha Noi School of Public Health from 2007 to 2011. During this time, I also was an intern in the Department of Entomology and Zoology at the National Institute of Hygiene and Epidemiology and took part in activities of the National Dengue Control Program (NDCP). Since my graduation from the Ha Noi School of Public Health, I have worked in the General Department of Preventive Medicine at the Ministry of Health for 2 years in Division of Planning and Finance and 2 years in Division of Communicable Disease Control.

As above-mentioned, my background is public health and working as a planning officer and an epidemiological program officer. I am really interested in dengue fever in Viet Nam. Through the thesis, I would like to determine determinants of dengue and review vector control strategies in order to recommend solutions to resolve the health problem in the future.

This thesis included 6 chapters. The first chapter is background of Viet Nam and Health system related dengue prevention and control. Next, the second chapter is overview of the study, including problem statement and justification, objectives of study and methodology. The third chapter is determinant of dengue in Viet Nam and next to chapter on dengue vector control strategies in Viet Nam. The fifth chapter is international vector control strategies compare to Viet Nam. Final chapter is discussion, conclusion and recommendation through this paper.

CHAPTER 1: BACKGROUND

This chapter briefly describes background of Viet Nam which includes natural conditions, characteristic of health system related to dengue fever in Viet Nam.

1.1. Country at a glance

1.1.1 Geography

Viet Nam locates in Southeast Asia (Figure 1). The country has joint borders with China in the North, Laos and Cambodia in the West and the East is South China Sea (under Pacific Ocean). On the map, the country has latitude stretching from 23°23' North to 8°27' North with total lengths is about 1,650 kilometres(6).



Figure 1: Map of Viet Nam

Source: Website: worldatlas.com(7)

Viet Nam has a variety of topography, including: mountains, hills, coastlines and islands. Approximately third quarters of the country area is mountainous area in which low mountains and hills are major. Other areas are deltas included Red River delta in the North and Mekong delta in the South. In addition, Viet Nam also has a widely rivers network in which over 2,000 rivers with length for each river is over 10 kilometers. The Red River in the North and the Mekong River in the South are the two main river networks of Viet Nam(6).

1.1.2 Climate

Viet Nam has clarity tropical monsoon climate. The annual average temperature ranges from 21°C to 27°C. The average sunshine hours are ranging from 1,400 to 3,000 hours and the average air humidity is around 80%(6).

In addition, Viet Nam has diverse different climate according to geographical features and monsoons' impacts. There is a marked difference on climate between the northern and the southern region. The northern region is influenced by the northeast and the southeast monsoons so that Northern climate is characterized with four seasons (spring, summer,

autumn and winter). Temperature in the North has a high fluctuation with about 10⁰C between summer and winter(6). The Southern region is less influenced by the monsoons, hence it has a stable climate. The average temperature is around 27⁰C annually. Additionally, the region has low temperature fluctuations (from 3- 5⁰C). The weather in the South is divided into two distinct seasons, rainy season from May to October and the other months are dry season(6).

1.1.3 Population

According to the statistics in 2014, Viet Nam had a population of about 90 million people. This ranked 13th of the world's and 3rd of Southeast Asia countries(8). The population density was 274 people per 1 km² in which Ha Noi capital and Ho Chi Minh city were the highest density of population among 63 provinces(9). The population growth rate average was 1.06% per year. Total fertility rate was 2.09 children per woman in period of 5 years from 2009 to 2014 and the sex ratio was 112.2 boys/100 girls(8).

In addition, the statistics on labour force by age group revealed that there was 14.9% of the population that are in 15-24 years age group, 59.9% and 25.2% in 25-49 years and over 50 years age groups respectively(10). Besides, unemployment rate of labour force in urban areas was 3.59% in 2013(11).

1.1.4 Urbanization

Viet Nam has high speed of urbanization since "Doi Moi" reforms in 1986(12). According to the World Bank (WB), the population in the urban areas were 30% in 2011 and it has increased 3.4% per year. Urbanization is strongly presented in Ha Noi and Ho Chi Minh city, which are the two largest cities in Viet Nam with rapidly economic development(12). Population and census report in 2009 showed that there was 6.5 million labors from rural to urban. They concentrated mainly in Ha Noi and Ho Chi Minh city with 10% and 31% of total the population respectively(13).

Urbanization led to the expansion of urban areas at all regions in which the Red River Delta and the Mekong River Delta had the highest urban growth of 8.4% and 9.8% respectively from 1999 to 2009 (see Annex 1). Besides, urbanization also led to an increase of industrial activities, especially in manufacturing sector and construction sector with double and triple activities increasing from 1999 to 2009(12).

1.1.5 Socioeconomic situation

According to WB, Viet Nam is ranked in lower middle-income country with following socioeconomic indicators as table below:

Table 1: Viet Nam's socioeconomic indicators

Total of population (million, 2014)*	90.73
Gross Domestic Population (GDP) at market prices (billion, 2014)*	US\$186.2
Gross National Income (GNI) per capita, 2014*	US\$ 1,890
GDP Growth in 2014 (%)*	6.0

Poverty headcount ratio at national poverty lines (% of population, 2014)*	13.5
Total expenditure on health per capita, 2013**	US\$ 308
Total expenditure on health as % of GDP, 2013**	6.0

Source: *World Bank(14); ** World Health Organization(15).

1.2. Health system and dengue surveillance system

1.2.1 Health status

In recent years, Viet Nam has achieved successes in strengthening health status. In 2013, Viet Nam life expectancy was the highest among developing countries in Asia with 73.1 years. This life expectancy was higher than that of China, Malaysia and Thailand although these countries had higher income than Viet Nam. The Maternal Mortality Ratio was 49 per 100,000 live births; Infant Mortality Rate was 15.3 deaths per 1,000 live births; the malnutrition rate such as underweight and stunting in children under 5 were 15.3% and 25.9% respectively. These numbers were relatively low compared to those of other developing countries in Asia and in the world(16).

However, the country has to face with double burden of diseases included Non-Communicable Diseases and Communicable Diseases. Dengue fever is one of the public health concern in Communicable Diseases with the incidence was from 80.4 to 148.1 per 100,000 population in the period from 2010 to 2013(16).

1.2.2. Health system

Viet Nam's health care system is organized with a wide network, from central to local level (Figure 2). The central level includes MOH and regional technical institutes, general and specialized hospitals and medical universities. At provincial level, there are 63 Provincial Departments of Health in 63 provinces which belong to Provincial People's Committees. Provincial Departments of Health manage hospitals, Preventive Medicine Centers and Medical Schools in provincial level. District level includes Health Administrative Unit belongs to District People's Committee, District Health Centers, District General Hospitals. Commune Health Centers and a networks of village health workers are at communal level (17).

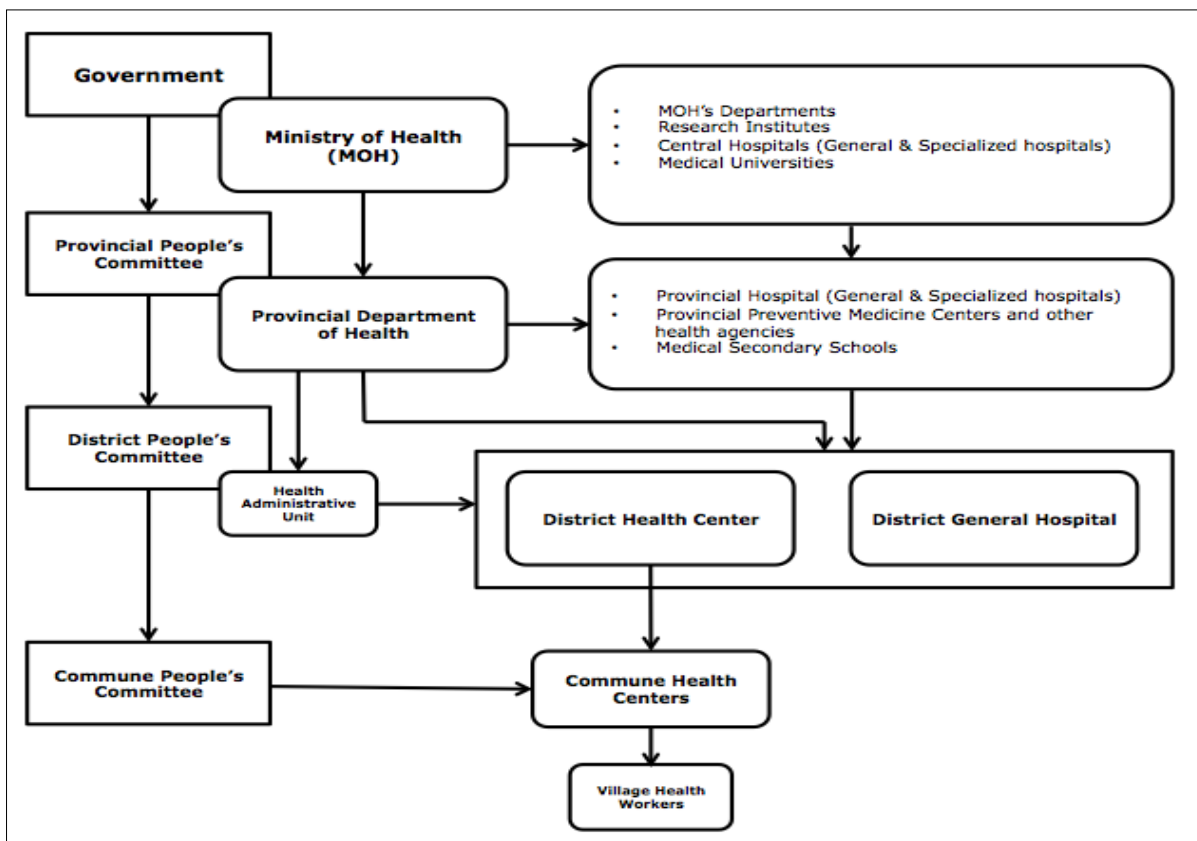


Figure 2: Viet Nam health care system network.
Source: Viet Nam Ministry of Health(18)

1.2.3. Dengue surveillance system

In Viet Nam, dengue surveillance system has been organized with 3 types of surveillance includes passive surveillance, sentinel sites surveillance and evidence – based surveillance (EBS). In term of passive surveillance, dengue fever is an infectious disease of group A which must be reported weekly under the regulation of Circular No.54/2015/ TT-BYT of MOH dated December 28, 2015(19) (the circular replaced for Circular No.48/2010/ TT-BYT of MOH dated December 31, 2010(20)). The surveillance system has been organized in all health agencies of the whole country, from local to central level (Figure 3). Dengue fever cases have been detected in community, which have to be reported to Commune Health Centers. District Health Centers are required to collect the information from Commune Health Centers and District hospitals then report to Provincial Preventive Medicine Center (PPMC). After that PPMC will report to Regional Institutes and General Department of Preventive Medicine (GDPM). Currently, Viet Nam has applied Electronic Communicable Diseases software (ECDs) for infectious disease report. The software was implemented pilot in 2013 with the participation of 45 provinces. Since July 2014, the software has been implemented in all 63 provinces.

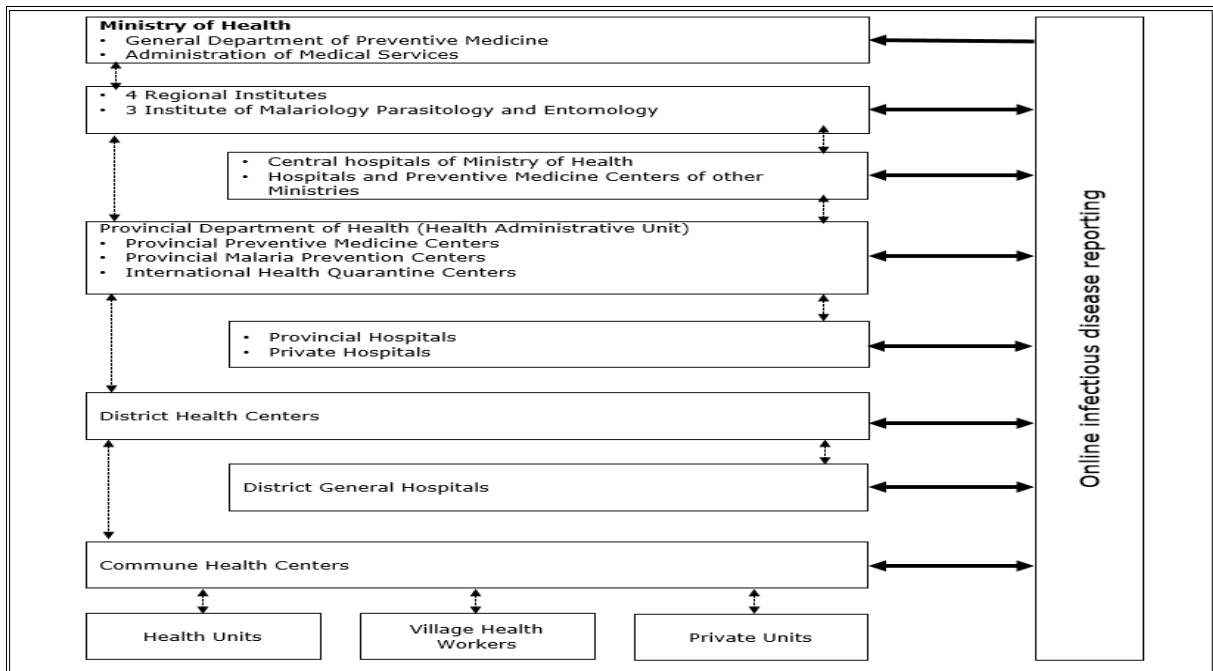


Figure 3: Organizational structure of infectious diseases reporting

Source: Viet Nam Ministry of Health(19)

In addition, dengue fever is one of the six infectious diseases which have sentinel sites surveillance in Viet Nam. There are 46 sentinel sites whole country, including: 11 sites in Northern region, 11 sites in Central region, 20 sites in Southern region and 4 sites in Highland Central. Besides, EBS has been implemented since 2012 at GDPM and 4 Regional Institutes. Dengue information has been collected through media such as online papers, newspapers, radios, televisions, and other reports. This surveillance aims to collect updated information and provide administrators with information timely so that early warning and responses are given.

1.2.4. Dengue legislation

In Viet Nam, dengue legislation includes law, circulars and guidelines (see Annex 2). Dengue has clearly been mentioned in the Law of Infectious Disease Prevention and Control(21). This law fully mentioned on principles, priority policies, and responsibilities of state organization in infectious diseases prevention and control in general as well as dengue fever in particular. In addition, MOH also has issued the Circulars (No.48 and No.54) on guiding for reporting and declaration of infectious disease, in which Dengue fever belongs to group A infectious diseases that must be reported within 24 hours since the first case detected(20)(19). These circulars aim to describe more details on the regulations which have been mentioned in the Law and guiding related agencies for implementation. Besides, MOH also established technical guidelines on dengue surveillance and diagnosis and treatment of DF/DHF in order to provide health facilities with technical documents and basic legislation(4)(22).

CHAPTER 2: STUDY OVERVIEW

This chapter describe situation of dengue fever and dengue vector control strategy and justifying why the topic was chosen for the thesis. Besides, this chapter also provided thesis objectives and methodology which have been used in this paper.

2.1. Problem statement and Justification

Dengue fever is one of public health challenges over the world. According to WHO, there are over 100 countries that endemic with the disease currently. In addition, WHO estimated that number of dengue cases is about 390 million each year and 3.9 billion people are living at risk of dengue infections(1).

In Viet Nam, dengue was first recorded in 1959. Since then to present, the disease has become an endemic disease in the country(23). Viet Nam has gained notable achievements in control dengue mortality with less than 1 per 1.000 cases since 2005. However, dengue morbidity still has an increasing trend and the epidemics occur with cycles from 3 to 5 years (Figure 4)(24). In addition, there was 90% of deaths that were children under 15 years old. Besides, the South was the most severely affected by dengue fever with 90% number of deaths and 85% number of cases whole country(24).

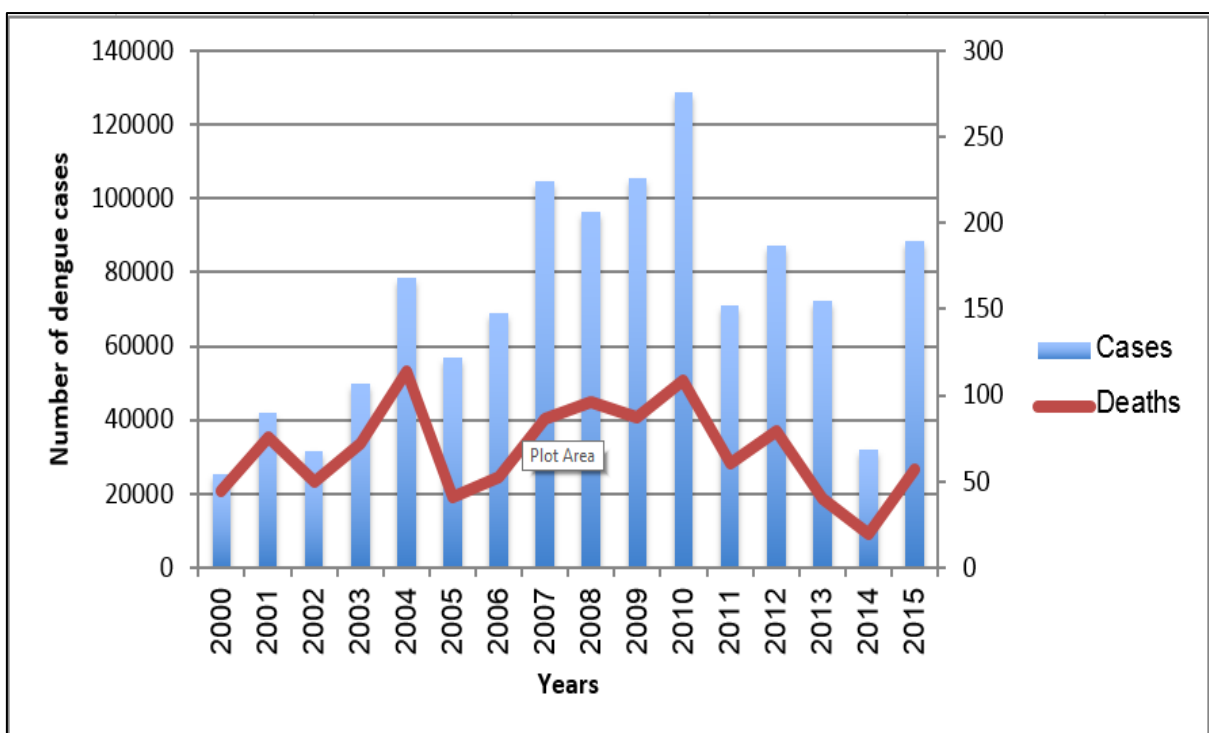


Figure 4: Number of cases and deaths by dengue in Viet Nam, 2000-2015
Source: Viet Nam Ministry of Health(25)(26).

Since 1999 to 2015, Viet Nam Government has invested in NDCP with total budget from \$1 million to \$5 million US dollar each year (exception with 2006)(24). In addition, there were variety of technical programs with international organizations in order to control dengue spreading. Nevertheless, dengue situation in Viet Nam is still a huge challenge currently. From 2016 onwards, NDCP will stops running by the decision of the Government(27). The funding for activities of dengue prevention and control

will be from Provincial People's Committee support directly. This situation will lead to challenges to Dengue prevention and control. Moreover, under regulation of Viet Nam National Assembly in the resolution No.18/2008/QH12(28), each province has to ensure supporting funding to preventive medicine programs with at least 30% of total health funding. However, almost no province have ensured this funding proportion(29). Meanwhile, existing many risk factors for developing of dengue fever such as climate change, urbanization, population growth and changing in serotypes of dengue virus (30)(31). In addition, the health system failed to control and to prevent the spread of *Aedes aegypti*(24). These factors will lead to difficulties in dengue prevention and control in the years to come.

In facts, the NDCP was interrupted financial support by the Government in 2006. The Government said that dengue fever has been controlled. However, the reality had proven to be difficult to control dengue without sustaining funding for implementation of prevention and control activities. Then, MOH had to explain with Viet Nam National Assembly on necessary of the NDCP to refund in 2007.

In Viet Nam, dengue prevention and control strategies include diagnosis and treatment, vaccine research and vector control. Currently, there is not specific treatment for DF/DHF. In addition, dengue vaccine is still being researched and the vaccine is still ongoing pilot in the fields(32). Thus, vector control is still the most important strategy in Viet Nam. This strategy aims at all the different stages in the life cycle of the mosquito in order to reduce the density of population and possibility of human-mosquito contact. Even when dengue vaccine has been successful pilot and applying in the fields, vector control is still the most significant strategy due to using vaccine depends on many factors such as affordability and acceptability of community as well as government.

In order to understand determinants of dengue in Viet Nam and to provide evidences to policy makers and administrative managements, this literature review will describe and analyze dengue vector control strategy in context of Viet Nam.

2.2. Objectives

2.2.1. General objective: To identify determinants of dengue and to review vector control strategies in order to recommend appropriate solutions for the successful prevention and control of dengue in Viet Nam.

2.2.2. Specific objectives:

- To identify risk factors of dengue in Viet Nam.
- To describe and analyse dengue vector control strategy which have been implemented in Viet Nam.
- To identify international dengue vector control strategy and compare to Viet Nam.
- To recommend appropriate solutions to Ministry of Health for the successful prevention and control of dengue in Viet Nam.

2.3. Methodology

Literature review is used in this thesis to give an overview on dengue fever.

Besides, the Social Model of Health conceptual framework of Dahlgren & Whitehead also has been referred to determine determinants of Dengue in Viet Nam.

2.3.1. Conceptual framework

The Social Model of Health - Dahlgren & Whitehead (Figure 5) is used in this literature review. Several conceptual frameworks have been considered using for the literature such as Conceptual frame work for community based interventions for infectious diseases of poverty; Wilcox and Gubler (2005) (see Annex 3)(33)(34). While, Conceptual frame work for community based interventions for infectious diseases of poverty model more specifics for HIV/AIDS, Tuberculosis and Malaria; Wilcox and Gubler (2005) model just mentioned about urbanization and environmental change which affect to vector bone diseases so that it is lack of factors related to individual as well as other factors(33)(35).

The Social Model of Health - Dahlgren & Whitehead is the most suitable for determine determinant of dengue than the other models due to the model could explain determinants of dengue in Viet Nam and the relationships between human, the environment and the disease. All layers of the model is suitable for explain determinant of dengue in Viet Nam. In facts that determinant of dengue is the interaction between factor of individual, community, sociocultural and environmental conditions, so that the model framework is the most suitable for describe determinant of dengue as well as risk factors which affected to dengue fever in Viet Nam.

Layers have been applied in determinants of dengue in Viet Nam with following details.

- The 1st layer, including: Age, genetic and sex.
- The 2nd layer, including: Individual lifestyle factors.
- The 3rd layer, including: Social and community networks.
- The 4th layer, including: Living conditions, housing, health care services, education, work environment and water and sanitation.
- The 5th layer, including: Urbanization, Water storage habits and rainwater using, climate change and seasonal features.

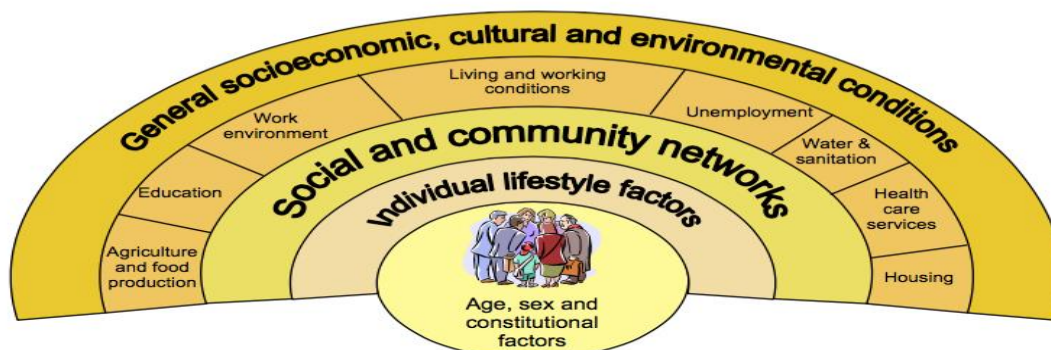


Figure 5: Social Model of Health- Dahlgren & Whitehead
Source: Dahlgren & Whitehead(36)

2.3.2. Search strategy

The authors of this literature review has searched and referred materials, including scientific literature and grey literature. This literature not only reviewed English materials, but also collected Vietnamese materials to make variety and extend as well as update for related information and data. In addition, Google and Google Scholar were tools to collect information and data.

Based on the thesis objectives, keywords used to identify title of articles, reports, newspapers, webpages and other sources (Table 2). Keywords could be searched with a combination or separately to find the most appropriate materials. Keywords also included Vietnamese due to the source of materials in both English and Vietnamese. Then abstracts will be reviewed and downloading contents if relevant with topics (only documents related to dengue and strategies). Besides, contacting by phone and email to collect reports and documents, which were not available on Internet from Ministry of Health (General Department of Preventive Medicine- GDPM) and other agencies such as National Institute of Hygiene and Epidemiology and Pasteur Institute of Ho Chi Minh city.

Keywords (Table 2): *Dengue, age, sex, children, adults, genetic, education, water storage, culture, risk factors, climate change, rainy season, socioeconomic, housing, family income, urbanization, population density, human mobility, economic, working conditions, living conditions, water and sanitation, health system, regions, outbreaks, life styles, factors, immigration, migrant, water storage, seasons, vector, strategy, community, chemical, biological, environmental, health education, responses, Wolbachia, Mesocyclops, guppy fish, collaborator, national dengue control program, dengue vaccine, funding, resources, challenges, Southeast Asian, Western Pacific Region, Singapore, Thailand, Malaysia, Indonesia, Philippines, Cambodia, Laos, Brunei, Myanmar, integrated vector management, mobilisation, campaign, Intersectoral, health education, biological control, chemical control, communication, increase, decrease successful, lesson learnt, integrate vector management and Viet Nam.*

There are total of 140 documents have been used in this paper in which included 65 journal articles, other documents are webpages, newspapers, reports, books, legislation and PhD thesis. In addition, there are 30 out of 140 documents which have been written by Vietnamese, including: report, legislation documents, online newspaper and Vietnamese journals.

Table 2: Search strategy

Objective	Key word	Source
To identify risk factors of dengue in Viet Nam	Dengue, age, children, adults, sex, genetic, education, water storage, culture, risk factors, climate change, rainy season, socioeconomic, housing, family income, urbanization, population density, human mobility, economic, working conditions, living conditions, water and sanitation, health system, regions, outbreaks, life styles, factors, immigration, migrant, water storage, seasons and Viet Nam.	<p>Google and Google scholar have been used to find out various websites and research articles. The results are described with following details:</p> <ul style="list-style-type: none"> - Websites: World Health Organization (WHO), World Bank (WB), Viet Nam Government Portal, Viet Nam Ministry of Health, General Statistic Office of Viet Nam, National Institute of Hygiene and Epidemiology, Maastricht University (Netherlands) - Journals: American Society of Tropical Medicine and Hygiene, PLOS Neglected Tropical Diseases, Nature Genetics, Cambridge Journal of Epidemiology and Infection, The Southeast Asian Journal of Tropical Medicine and Public Health, Tropical Medicine and Health, Journal of the American Mosquito Control Association, Tropical biomedicine, PLOS Pathogens, Emerging Infectious Diseases journal, BMC Infectious Diseases, PLOS Neglected Tropical Diseases, Journal of International Health, Viet Nam Journal of Preventive Medicine. - Reference number: 16,24,30,31,37-78
To describe and analyse dengue vector control strategy which have been implemented in Viet Nam	Dengue, vector, strategy, community, chemical, biological, environmental, health education, responses, Wolbachia, Mesocyclops, fish, collaborator, national dengue control program, fish, pilot, dengue vaccine, funding, resources and Viet Nam.	<p>Google and Google scholar have been used to find out various websites and research articles. The results are described with following details:</p> <ul style="list-style-type: none"> - Websites: World Health Organization (WHO), National Institute of Hygiene and Epidemiology, Vietnamese Labour Online Paper, Eliminate Dengue Program Website, National Institute of Hygiene and Epidemiology, Pasteur Institute of Ho Chi Minh city, Viet Nam Government

Objective	Key word	Source
		<p>Portal, Viet Nam Ministry of Health.</p> <ul style="list-style-type: none"> - Journals: The Lancet, Dengue Bull, Tropical Medicine International Health, The American Journal of Tropical Medicine and Hygiene, Acta Tropical, The American Journal of Tropical Medicine and Hygiene, Asian Pacific Journal of Tropical Medicine, Viet Nam Journal of Preventive Medicine, Western Pacific Surveillance and Response Journal, Transactions of the Royal Society of Tropical Medicine and Hygiene, Journal of the American Mosquito Control Association. - Reference number: 4,23,25,30-32,57,79-103
<p>To identify international dengue vector control strategy compare to Viet Nam</p>	<p>Southeast Asian, Western Pacific Region, Americas, Singapore, Thailand, Malaysia, Indonesia, Philippines, Cambodia, Laos, Brunei, Myanmar, dengue, vector, strategy, challenges, integrated vector management, mobilisation, campaign, intersectoral, national dengue control program, legislation, health education, biological control, chemical control, communication, community, increase, decrease successful and Viet Nam.</p>	<p>Google and Google scholar have been used to find out websites and research articles. Besides, contact to colleagues from GDPM, NIHE and PI-HCMC to collect reports of MOH and international workshop materials related to dengue. The results are described with following details:</p> <ul style="list-style-type: none"> - Websites: World Health Organization (WHO), Singapore National Environment Agency. - Journals: Western Pacific Surveillance and Response Journal, Indo American Journal of Pharmaceutical Research, Journal of the American Mosquito Control Association, Pathogens and Global Health, PLOS Neglected Tropical Diseases, PLOS one, Emerging Infectious Diseases, Pathogens and global health, The International Medical Journal of Malaysia, The Southeast Asian Journal of Tropical Medicine and Public Health. - Reports from ASEAN Dengue Conference 2016 - Reference number: 1,90,104-135

2.3.3. Limitations of the thesis

Reflection on the conceptual framework:

This framework is very useful for describe and analysis determinant of dengue in Viet Nam. Besides, it also shows relationship between risk factors. Nevertheless, it is more specific for side of human than on side of dengue virus and vectors.

Collection of data and information:

There are information which have not been uploaded on Internet such as internal reports and documents of Viet Nam Ministry of Health so that it is difficult to approach and collect them, especially in data and information on logistic activities.

Additionally, there are researches which did not implemented whole country so that it affects to overview of the literature results in chapter 3 (Determinant of dengue in Viet Nam)

Besides, this literature only reviews documents which are presented by English and Vietnamese so that it affected to comprehensive of data and information, especially in content of chapter 5 (International dengue vector control strategies). Besides, there is limitation on dengue fever information and data related to Brunei and Myanmar so that it affected to comprehensive as well as critical analysis on dengue vector control strategy in this chapter for the 2 countries.

CHAPTER 3: DETERMINANTS OF DENGUE IN VIET NAM

This chapter describe and analyse determinants of dengue through that identify influence factors to dengue situation in Viet Nam.

3.1. Individual characteristics

3.1.1. Age

In Viet Nam, dengue fever occurred in all age groups. People who do not have immune with Dengue virus could be infected with dengue fever(37). According to WHO, 90% of number of deaths by dengue was in children under 15 years old in Viet Nam(24).

According to MOH, there was a significant increasing age of dengue cases with 58% of total cases in over 15 years old group in 2015 compared to 52% in average of the period of 5 years, from 2010 to 2014. Besides, all regions had higher dengue cases in over 15 years old group than under 15 years old group, exception with Southern region. In Northern and Central Highlands region, proportion of dengue cases in over 15 years old group was very high, from 78% to 88% of all cases in the period from 2010 to 2015 (Figure 6)(38). However, It is likelihood affected by migration so that in central highland and central region number of dengue cases in over 15 years old group went down from 83% to 78% and from 64% to 62% respectively.

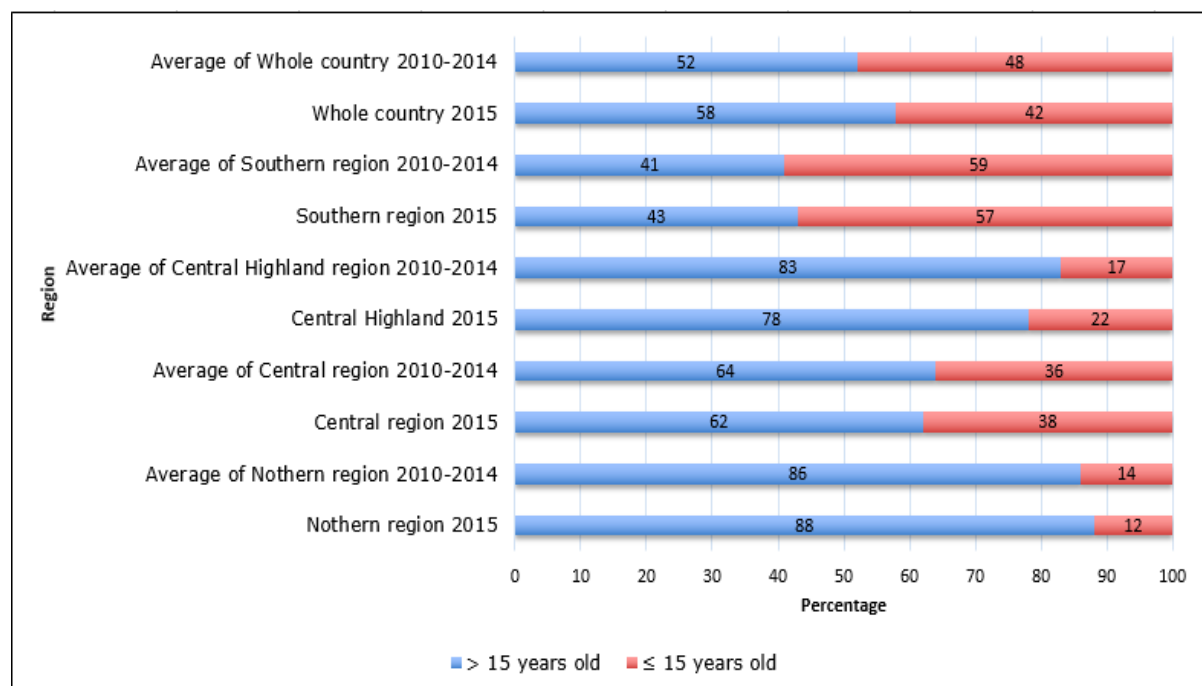


Figure 6: Distribution of dengue cases by age in 2015 and average of the period 2011-2014.

Source: Viet Nam Ministry of Health(38)

In Southern Viet Nam where has over 85% of cases and 90% of deaths(24), there was an trend to increase in the age of dengue infection from 1999 to 2014. Dengue morbidity in over 15 years old groups was increasing compared with under 15 years old group, from 18% in 1999 to 44% in 2014(Figure 7). It could be explained by changing in population structure and labours migration from rural to urban(39).

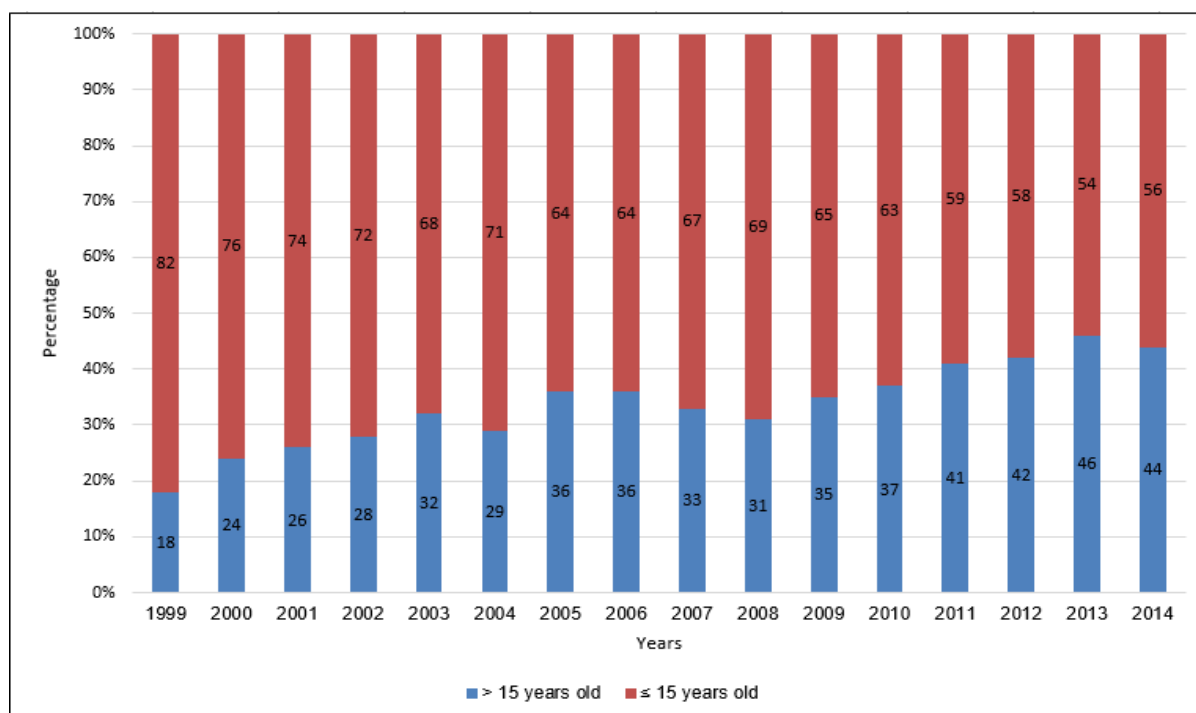


Figure 7: Proportion of dengue cases in Southern Viet Nam in two age groups, 1999-2014.

Sources: Quang LC, Quoc DK, Ngoc PTT et al (39)

Research in Ho Chi Minh from 1996 to 2009 revealed that dengue mortality was the highest in children aged 1-5 years(40). In addition, risk of death in children aged 1-5 years was higher than children aged 11-15 years with about four times(40). Besides, children aged 6-10 were the highest risk of DSS. Another research in Hospital of Tropical Disease in Ho Chi Minh reported that there were some different clinical features between children and adults. DSS such as sock and plasma leakage were more common in children, while bleeding and organ dysfunction were popular in adults. These syndromes are due to different number of platelets between children and adults. Platelets have a significant in control bleeding, while number of platelets in adults is lower than children(41).

3.1.2. Genetic

Evidences showed that human genes influence to dengue virus infection. It is explained to reasons why people have different symptoms and level of infection when infected with dengue virus(42). A research in 2004 revealed that there was different human immune response among races such as Vietnamese, Thai, Cuban and Mexicans when they were infected with dengue virus. The immune response included susceptibility, protective and resistance with severity of dengue virus infections(42) (Figure 8). In addition, two researches which have been implemented in Viet Nam also showed evidences on relationship between Vietnamese genes with DHF and DSS (43)(44).

Alleles	Class	Effect	Population	Reference
HLA alleles	Class I			
	A1	Susceptibility	Cubans	20
	A2	Susceptibility	Thai	19, 22
	A*0203	Protective	Thai	22
	A*0207	Susceptibility	Thai	22
	A24	Susceptibility	Vietnamese	21
	A29	Protective	Cubans	20
	A33	Protective	Vietnamese	21
	B blank	Susceptibility	Cubans/Thai	19, 20
	B13	Protective	Thai	19
	B14	Protective	Cubans	20
	B44	Protective	Thai	22
	B46	Susceptibility	Thai	22
	B51	Susceptibility	Thai	22
	B52	Protective	Thai	22
	B62	Protective	Thai	22
	B76	Protective	Thai	22
	B77	Protective	Thai	22
		Class II		
	DRB1*04	Resistance	Mexicans	29
Non-HLA alleles	Fc gamma-receptor	Resistance	Vietnamese	30
	Vitamin D receptor	Resistance	Vietnamese	30

Figure 8: Effect of Human Leukocyte Antigens (HLAs) on dengue infection
Source: Wagenaar JFP, Mairuhu ATA, van Gorp ECM (42)

Additionally, researches revealed that there is an interaction between human genetics, dengue virus serotypes and the severity of dengue infection(45)(46). Accordingly, the interaction of human genetics and dengue virus serotypes will lead to different levels of dengue infection such as DHF or DSS. While, there was a circulating of 4 dengue serotypes in different periods in Viet Nam. Research in the South showed that there was a changing on 4 dengue serotypes virus. In the period from 1999-2000 and 2003-2005, DEN 2 was the highest proportion among 4 the serotypes. In 2001, DEN 1 and DEN 4 were the highest proportion among 4 the serotypes. From 2007 to 2014, DEN 1 was the highest proportion among 4 the serotypes and this proportion was follow by DEN 4, and DEN 3 always have low proportion with under 3% annually(39). Another research in the South from 2005 to 2014 showed that DEN 2 led to the most severity dengue infections in this region(47).

3.1.3. Sex

There was some researches on association between sex and dengue infections, however the researches findings was confliction so that it is difficult to make a conclusion for the association. Research in Ho Chi Minh city at Children Hospital No.1 in 2005 showed that risk in developing of DF/DHF between male and female was equal(48). However, another research at 3 hospitals included Children’s Hospital No.1, Children Hospital No.2 and Hospital of Tropical Diseases from 1996 to 2009 showed that girls have higher in developing of DSS and death than boy(40). It can be clearly seen that above researches implemented in hospitals. It is not present for all patients at population. However, findings of these researches may suggest on influence of human biological to dengue infections.

3.2. Individual lifestyles

In Viet Nam, limited researches on influencing of individual lifestyle factors to Dengue. However, a research in Ha Noi in 2004 which suggested that individual behaviours such as sleeping without bed nets and time spent outdoor place where near vectors could be lead to more risk of dengue infection(49) due to mosquitoes will have more opportunity to bite human.

3.3. Social and community networks

In Viet Nam, social and community networks have important role in implementation of dengue prevention and control activities. Researches in using *Mesocyclops* and *Wolbachia* showed that involvement of local authorities, civil society organizations such as Farmer, Youth and Women Associations, and collaborators had significant role in implementation of these activities(50)(51). With the engagement of the stakeholders and community, applying *Mesocyclops* and *Wolbachia* in Viet Nam has achieved significant results(52). Through that contributing in reducing risk of dengue infections in high risk areas. In facts, most of dengue prevention and control implemented at community so that it is difficult to get success if programs do not develop strongly community networks as well as supporting by social groups.

3.4. Living conditions

Researches on influence of living conditions to dengue infection showed that there was a relationship between poor living conditions and dengue infection. A research in Ha Noi in 2014 revealed that people who lived in rented houses or houses near uncovered sewers and houses with discharging sewage directly into ponds were at significant higher risks of DF/DHF. People who lived in rented houses were at 2.2 times higher risk of DF/DHF than owned houses' owners. Living near uncovered sewers and houses with discharging sewage directly into to ponds were 3.4 times and 4.3 times more risk of DF/DHF respectively than others(49). In addition, report of Ha Noi PPMC showed that 24% dengue cases were migrant labors and 21% were students who often lived in rented houses with poor living conditions(53). Because of making more breeding sites and living places for mosquitoes(49).

3.5. Housing

Housing type also is one of risk factors which related to dengue infection due to increase shelter and resting places, and making a favourable conditions for development of dengue. Researches in Viet Nam showed that houses with more outdoor spaces, more rooms, large roof, near gardens and animal shelters will have more risk of dengue infections. While, house with air conditioners will has less risk of dengue infection(54)(55).

The isolated and row houses types were higher infestation of mosquito (*Aedes aegypti*) compared to apartments or dormitory rooms. It can be explained by more rest places for this mosquito than apartments or dormitory rooms(54). Housing with outdoor space was also favorite conditions for mosquitoes' resting and breeding sites. This space often has various discards and other types of unused containers(54). Otherwise, housing with air conditioners contributed to the decreased density of dengue mosquitoes because this type of house often had closed door hence it had fewer chance for mosquitoes to enter into house as well as blood feeding and residents(54). In addition, housing has four or more rooms had higher risk of occurring *Aedes albopictus* due to it often has large roof and lobby so that may be lead to increase number of outdoor containers(54). Another research in Binh

Thuan province proved living in a house which near gardens, near animal shelters and rubbish around house were significant risk factors in high incidence group(55). These factors are favorite conditions for dengue mosquitoes resting and shelter.

3.6. Health care services

According to WHO, one of reasons leading to current dengue situation in Viet Nam was the limitation of health system in controlling the spread of *Aedes aegypti*(24). Lack of funding in implementation of dengue prevention and control activities was the significant reason that the NCPD only covered about 10% of communes in the country in the period from 2011 to 2015(30). In addition, implementation of actively diseases prevention also has many problems due to limited in finance of the government and local authorities. Report from MOH showed that only 76.3% of PPMC developed annual disease prevention plan from 2011 to 2015(56). Besides, funding allocation for NDCP often was late about half a year, which only be allocate for health facilities in May or June. So that, most of health facilities do not have enough funding for implementation of activities in the first five months. This leads to limited implementation of regular dengue surveillance and prevention.

3.7. Education

Researches in Viet Nam revealed that population with higher education level will have higher knowledge of dengue prevention(49)(57). However, these researches also showed that there was not a significant relationship between education level and practicing dengue prevention measures. It means that there are a space to transfer from knowledge and practicing in dengue prevention measures so that need to more health education for community to behavior change in implementation of dengue prevention measures.

3.8. Work environment

Work environment such as construction sites and open markets have more risk of dengue infections due to more favorable conditions for development of mosquitoes(58)(59). These places have various water containers, which are breeding sites for mosquitoes. Research in 2012 showed that water tanks and toilet tanks in open markets were key breeding sites of *Aedes* mosquitoes in open markets(59). In addition, there was dengue outbreaks with a lot of cases in construction sites(58).

3.9. Water and sanitation

Water and sanitation also risk factors influence to dengue fever in Viet Nam. Researches showed that human living near water sources such as ponds and rivers had higher rate of dengue infection. Because these places lead to more breeding sites for mosquitoes(49)(60). Besides, research in the South showed that water sources such as piped water, rain water and river water were not related to dengue infection, it was related to water storage behaviors(61). Although community has been provided piped water however they were still storage with many containers around their house so that make more breeding sites for mosquitoes. In addition, research in Ha Noi revealed that people living in a house with sewage discharging to ponds directly had higher risk of dengue infections from 3.4 to 4.3 times if compare to house

with completely sanitary sewage(49).

3.10.General socioeconomic, cultural and environmental conditions

In Viet Nam, dengue fever has been strongly impacted by urbanization, habit of community in water storage and using rainwater. Besides, the disease also has been impacted by environmental conditions included climate change and seasonal features.

3.10.1. Urbanization

According to WHO, urbanization has strongly impacted to increase vector borne diseases included dengue fever(62). In Viet Nam, research showed that increasing urbanization combine with other factors such as seasons and regions influence to distribution of dengue vectors, especially increasing distribution of *Aedes albopictus*(63). Additionally, the urbanization led to increase urban and sub-urban areas, while the government’s capacity for management of water supply and housing was not fully response with requirements. This, in turn, led to the increased density of dengue mosquitoes and the increased risk of DF/DHF(16).

Research in the South showed that there was a different in number of dengue cases between Southeast and Southwest regions due to affect by urbanization. Southeast region included 67.4% industry zones of the South and 31.8% of whole country. The number of factories increased to over 3.5 times from 2005 to 2012 in this region. Increasing of factories led to increase number of immigrants from other areas so that increased number of dengue cases compared to Southwest region (Figure 9)(39). This situation could be explained by increasing number of immigrant leads to increasing of poor living conditions so that make more breeding sites for mosquitoes.

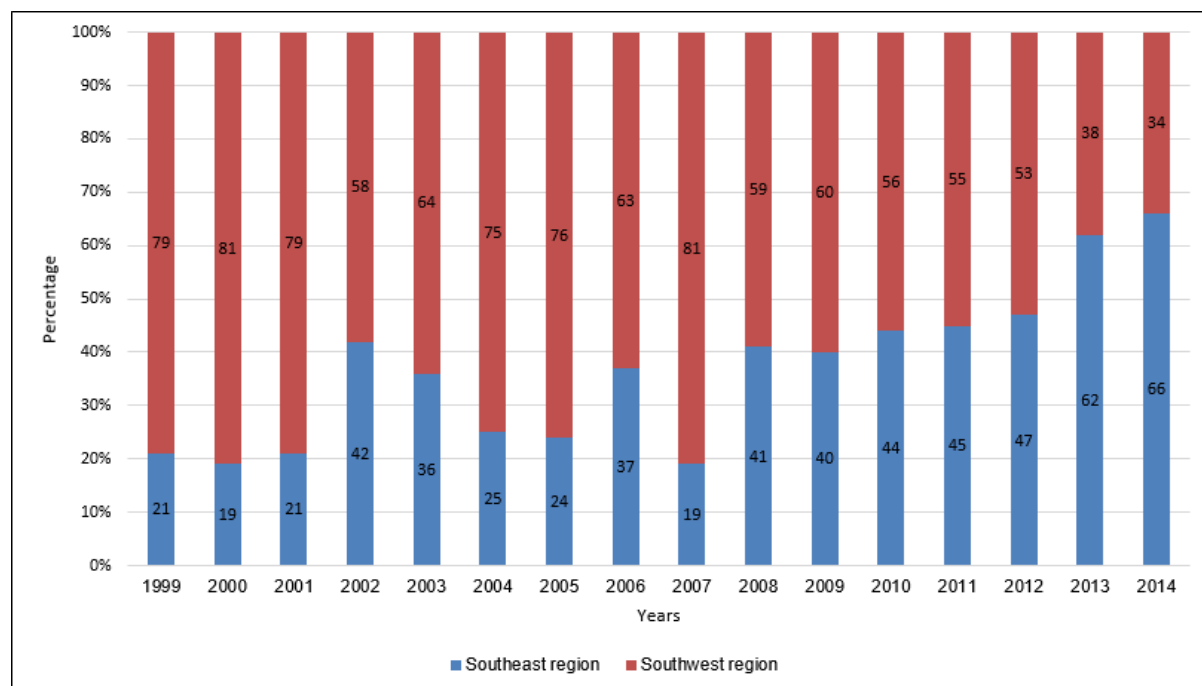


Figure 9: The proportion of dengue cases in Southeast and Southwest region, 1999-2014.

Source: Quang LC, Quoc DK, Ngoc PTT et al (39)

3.10.2. Water storage habits and rainwater using

In Viet Nam, people often keep water around their house with various types of containers. Even when being supplied with piped water, people still store water in containers(64). This situation has become a habit and could be explained by worrying of water scarcity in dry season and a fear of limited water supply (Table 2) (65). A research in the South showed that 98% households store water around their house at clays jugs (42%), plastic barrels, tanks, flasks (51%) and other kind of containers(66). A research in Ho Chi Minh city revealed only a range from 51% to 62% water containers were appropriately covered. In addition, there was a significant relationship between increasing number of pre-adult *Aedes aegypti* and inappropriately or no cover of water containers(57). Accordingly, there was a range of 30.8 -57.1% number of inappropriately covered and no covered containers which had pre-adults mosquitoes(57).

Besides, using rainwater is popular in both rural and urban areas, especially in rural area. People prefer rainwater than water purchased from vendors, well water and surface water, even as piped water(65)(67). They supposed that quality of rainwater is better than others due to smell, taste and colour. It was often use for drinking and cooking (Table 3)(65). Using rainwater beside other water sources also means that people have to prepare more containers types. Water storage abundance will lead to increase convenient environment for reproductive and development of mosquitoes(64),thus, increasing risk of dengue infection in their community.

Table 3: Community opinions on water storage and water sources

<i>"We have to store tap water in two cylindrical tanks and one jar as the tap water supply can be intermittent and we need water for bathing and washing"</i>
<i>"When it's raining heavily, I store rain water in case the tap water supply is cut. Every time there is power cut, tap water is cut as well"</i>
<i>"I never think of getting rid of my old containers. I use them to store rain/river/tap water in case tap water is cut".</i>
<i>"I use rain water for drinking and cooking and river water for washing. In the wet season, I use rain water for everything while in the dry season, I use river water for washing and rain water for drinking"</i>
<i>"I use rain water for drinking and cooking and river water for washing. In the wet season, I use rain water for everything while in the dry season, I use river water for washing and rain water for drinking"</i>
<i>"I think rain water is the best source, because it looks clearer and tastes better than river water".</i>

Source: Tran HP, Adams J, Jeffery JAL et al(65).

3.10.3. Climate change

It is evidenced that Viet Nam will be severely impacted by climate change

conditions by increasing temperature and rainfall(68). The country will be one of the most vulnerable countries over the next 30 years(68). It is expected that annual temperature and rainfall will increase with a range from 1.6°C-2.8°C and a range from 1.4%-7.9% in 2100 respectively for all regions of Viet Nam (Table 4). A research showed that feeding behaviours of mosquitoes is closely related to temperature. Incidence of female mosquitoes' blood feeding increase accordingly with higher temperature(69). Besides, increasing of rainfall will lead to potential increasing of breeding sites for mosquitoes. So that it leads to increase risks to mosquitoes contact with people.

In addition, statistic of MOH also showed that there was an increasing number of dengue outbreaks in 1987, 1998 and 2009 with increasing influencing of El Nino and La Nina in Viet Nam in given years if compared to other years(70).

Table 4: Forecast of changing on temperature and rainfall among climatic zones in Viet Nam.

Climatic zone	2020		2040		2060		2080		2100	
	°C	%	°C	%	°C	%	°C	%	°C	%
North West	0.5	1.4	1.0	3.0	1.6	4.6	2.1	6.1	2.6	7.4
North East	0.5	1.4	1.0	3.0	1.6	4.7	2.1	6.1	2.5	7.3
North Delta	0.5	1.6	0.9	3.2	1.5	5.0	2.0	6.6	2.4	7.9
North Central	0.5	1.5	1.1	3.1	1.8	4.9	2.4	6.4	2.8	7.7
South Central	0.4	0.7	0.7	1.3	1.2	2.1	1.6	2.7	1.9	3.2
Highland Central	0.3	0.7	0.6	0.5	1.0	0.9	1.4	1.2	1.6	1.4
Southern	0.4	0.3	0.8	0.6	1.3	1.0	1.8	1.2	2.0	1.5

Source: Toan DTT(60).

Besides, researches in Viet Nam showed that under impact of climate change with increasing of temperature and rainfall combine with urbanization also lead to expanding distribution of *Aedes albopictus*(63)(71)(72). The changing of dengue vectors distribution will affect to dengue prevention and control strategies in coming time as well as requesting suitable dengue outbreaks response.

3.10.4. Seasonal features

In Viet Nam, almost all dengue cases occurred in rainy season with high temperature and high humidity. This season with average temperature about 27°C and humidity about 80% are favourable conditions for development of mosquitoes(6). According to MOH in the period from 2010 to 2015, there was an increase in incidence of dengue cases from June to December each year. It is clearly seen that the incidence of dengue cases more pronounced in 2015 due to increase number of cases in the year if compare to other years (Figure 10)(38).

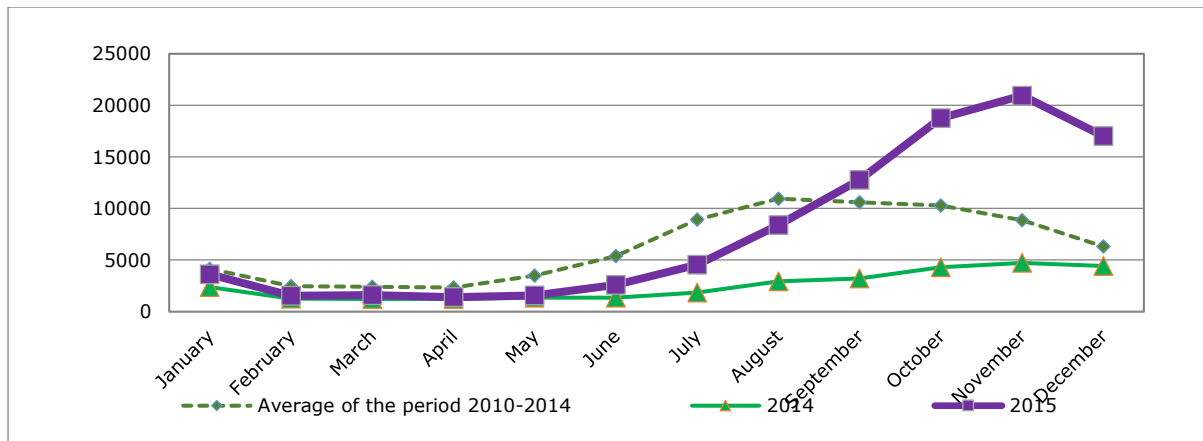


Figure 10: Monthly distribution of dengue cases in 2015 compared to 2014 and the average of the period 2010-2014.

Source: Viet Nam Ministry of Health(38)

A research in Hai Phong City (Northern region) revealed risk of DF infection was higher from September to December due to increasing of humidity and rainfall in these months(73). Research in Southern region in 10 years, from 2001 to 2010 showed that almost dengue cases (with a range from 74% to 92%) occurred in rainy seasons, from June to December(74). Additionally, research in Highland Central region also provided evidences on relationship between climatic factors and dengue cases with approximately 72% dengue cases occurred from July to October. Given months were higher temperature, rainfall and humidity compare with other months(75). Another research in 9 provinces also showed weather features such as temperature, humidity and sunshine impact to dengue incidence and this influence was different among regions(76).

Besides, seasonal features in Northern and Southern regions led to different in dengue status among the regions. Northern region has four seasons with winter has average temperature about 17⁰C and the lowest temperature can reduce to 2⁰C(77). In addition, a research revealed that temperature is one of factors, which affect to dengue outbreaks status between Northern and Southern region. Cool winter in the North lead to a reduction of mosquito population and limiting the virus replication(78).

Statistic of MOH showed that *Aedes aegypti* is primary dengue vector in Viet Nam with 94% outbreaks which related to this mosquito(31). A research revealed that *Aedes aegypti* mainly distributed in the South and the Central, while *Aedes albopictus* dominant distribution in the North(63). The vector distribution may be explained due to different in temperature and rainfall among regions. *Aedes albopictus* is more adaption with cool temperature than *Aedes aegypti*, while *Aedes aegypti* is better adaption with hot and dry climates. In the North, the temperature often is below 20⁰C from December to March, while average temperature in the South is above 24⁰C throughout the year. Additionally, the monthly rainfall average in the North is over 180mm, while other regions are about 160mm. Besides, dry season in the South also longer than the North. The dry season in the South is 3 months, from January to March, while in the North is only one month (January)(63).

CHAPTER 4: DENGUE VECTOR CONTROL STRATEGY IN VIET NAM

According to WHO, dengue vector control strategies aim to prevent and to reduce dengue virus transmission based on controlling mosquito vector or interrupting contact between human and vector(79). In Viet Nam, dengue vector control strategies include long-term and short-term strategies which aim to actively prevent and involvement of all stakeholders (80)(81).

4.1. Long-term strategies

Long-term strategies included community based vector control, health education and environmental improvement.

4.1.1. Community based vector control

In Viet Nam, community based vector control is the most important strategy in dengue prevention and control. This strategy has been clearly described in NDCP(81) which included 4 elements: vertical and horizontal approach, priority control based on key containers, using *Mesocyclops* and community activities(82).

4.1.1.a. Vertical and horizontal approaches

Vertical and horizontal approaches (see Annex 4) have been applied in 3 phase of using *Mesocyclops* programs in Viet Nam(82). Researches showed that the approaches have been proven important role in successful applying *Mesocyclops* in the fields(82)(83)(52). Besides, these approaches have been applied in many programs of NDCP such as health education and clean up campaigns. These programs based on direction from MOH, technical support from Regional institutes and the local authorities were responsible for cooperate with other stakeholder such as Women, Farmer, Youth Associations and school in order to implement activities at community level. Research showed that local authorities have significant role in implementation of collaborator network(84). Accordingly, the involvement of local authorities, school and collaborator have important role in implementation activities at community level.

However, these approaches also face with challenges due to it needs the involvement of many stakeholders, not only health facilities but also other agencies as well as authorities. So that depending on accountability as well as willingness from the stakeholders. In fact, the approaches had unsuccessful in several fields in the South due to lack of willingness of collaborators(85).

4.1.1.b. Priority control based on key container productivity

Identify key breeding sites of mosquitoes has important role in dengue prevention and control. Through determining key breeding sites, intervention programs will have appropriate methods in implementation of dengue prevention activities for each regions(86). Besides, targeting key containers will reduce implementation cost and improve cost-effective of activities(87). The breeding sites determined through vector survey which is implemented every 3 months in high risk areas(82)(30). In Viet Nam, the most important key breeding sites identified included larger tanks with capacity about 1,000 litters and middle jars with capacity about 100-200 litters(80)(86)(52).

4.1.1.c. Using *Mesocyclops* as biological agent

Mesocyclops has been developed and piloted in dengue prevention and control since 1995 with the support from WHO(88). Up to present, *Mesocyclops* has been applied at 10 provinces in three regions of the whole country(88)(85)(83). Entomological surveys implemented at communities to identify local *Mesocyclops* before releasing them to larger tanks and wells. Besides, training for collaborators and teachers on methods of using *Mesocyclops*, educating residents and teaching for pupils (82)(89). In research places, monthly vector surveillance will be implemented by collaborators to evaluate density of larvae and pupae in water containers.

Using *Mesocyclops* was cost effective method with only \$0.28 to \$0.89 per person each year (85)(52). In addition, reports showed that using *Mesocyclops* has achieved success in reducing dengue incidence as well as adults mosquitoes in research places(83)(52). However, this strategy also have to face with challenges such as sustainability funding for implementation of household vector surveillance as well as maintain collaborators(52)(85). Besides, applying *Mesocyclops* in the South also have more difficult than the North and Central due to geography with many rivers, different in languages so that affect to activities of collaborators(52).

4.1.1.d. Community activities

The participation of community is important in community based vector control strategy. Stakeholders in implementation of dengue programs at community level include local leaders, social organizations such as Youth, Farmers and Women Associations, health collaborators, teachers, pupil and residents(82). Accordingly, local authorities leaders have role in coordination and the other stakeholders are responsible for performance activities such as conducting larvae/pupae surveillance, organizing clean up campaigns and educating for population as well as pupil in schools(82).The involvement of the stakeholders have been proven by results in reducing morbidity of dengue in Viet Nam over past years(30)(23). However, it also has a lot of challenges which need to improve in coming time. Report of NDCP in the period from 2011 to 2015 showed that the cooperation between agencies at local level was still limited. Lack of direction from local leaders in implementation of dengue prevention and control activities so that it affected to effective of NDCP and sustainability of the dengue control programs(30). The reasons can be explained due to limited appropriate funding for implementation activities. In addition, lack of appropriate communication for local leaders on the important of dengue prevention to people health as well as burden of the disease. Besides, lack of awareness of community which leads to difficulty in changing behaviour of community in practicing measures of dengue prevention(31).

4.1.2. Health education

Health education is one significant strategy in dengue prevention and control in Viet Nam. This element aims to change behaviour and enhance practice of community in dengue prevention and control by providing

people with knowledge and skills(4). Through media such as television, radio, etc. the communities have been approached with necessary information on dengue prevention such as prevent mosquitoes bite and reducing breeding sites of mosquitoes(4). In addition, health education for community has been implemented through activities of collaborators by educating residents in dengue prevention such as elimination of discards and water container management(82). Besides, Viet Nam also implement dengue prevention and control by educating for pupil at school. Teachers and pupils will participate in lessons on dengue prevention, conducting extracurricular activities and competitions on dengue prevention and control(80).

This strategy has been implemented regularly in Viet Nam through implementation of NDCP and integrated with other programs such as using *Mesocyclops*(90)(91). With the implementation of health education, people have been provided knowledge on dengue fever and approaching with measures to prevention mosquitoes(30)(91). Although improved knowledgeable, however practicing with mosquitoes preventive measures was still limitation in community(57).

4.1.3. Environmental improvement

Environmental improvement aims to reduce breeding sites of mosquitoes. Annual sanitation campaign is a program funded and encouraged by the Government. This program aims to provide dengue prevention information to households, guide community to remove water containers have larvae/pupae and how to control them. Though that increasing public awareness, enhancing participation of authorities and other social agencies at all levels. According to report of MOH in 2013, there were 60 per 63 provinces, which have implemented environmental sanitation. These campaigns had participation of social agencies and schools(25). However, effective of these campaigns were limited due to lack of follow-up plans after conducting kick off campaigns. After these campaigns, health facilities were responsibilities for implementation almost of activities and involvement of other sectors were limited(30). The situation could be explained by lack of funding for implement follow up plans and other sectors did not fully understanding on role of environmental improvement in dengue prevention and control as well as affecting of dengue to people health.

4.2. Short-term strategies

Short-term strategies included pilot intervention, collaborator network and emergency response(80).

4.2.1. Pilot intervention

4.2.1.a. Environmental intervention

Environmental interventions aim reduce contacts between human and mosquitoes and development of mosquitoes(92). In Viet Nam, since 2005 the interventions have been applied such as mosquito-proof water containers and application of new water infrastructure(61)(93)(94). These activities, including provision of new water containers with nets or lids and water supply

for studied communities. However, effective of these interventions were limited due to people removed lids of provided water containers. In addition, although providing new water supply infrastructure such as pipe water however they still storage water with many containers so that it was still increasing breeding sites for mosquitoes(61).

4.2.1.b. Biological intervention

Using predatory copepods of mosquitoes in order to reduce density of larvae and pupae(90). In Viet Nam, fish, *Mesocyclops* and *Wolbachia* bacteria have been applied to control dengue vectors in the fields. Research on using fish to control larvae has been implemented since 1983 in Viet Nam(95). This research showed effective in larvae control in Viet Nam. In the NDCP, using fish for larvae control was also an activity mentioned and encourage implement in community annually. In addition, using *Wolbachia* bacteria aims to reduce dengue mosquito population though limiting reproductive of *Aedes aegypti* population. Since 2006, MOH has cooperated with Oxford University Clinical Research Unit and Monash University to implement laboratory research on using *Wolbachia* in dengue prevention and control. After that, a field trial has been taken in Tri Nguyen Island (Khanh Hoa province) from April 2013 to identify the possible effectiveness of the method. In 2015, the method has implemented in Nha Trang city (Khanh Hoa province). The researchers hope that through results of fields trial, the method will be applied in other areas of Viet Nam in the coming time(96).

4.2.1.c. Chemical intervention

Using chemical in order to impact to larvae habitats (larvicides) and adults mosquitoes (adulticides) to reduce density of larvae/pupae and mosquitoes(97). Under guideline on dengue surveillance which issued by MOH, preventive medicine health facilities develop annual plan on chemical and spray equipment to reverse for dengue prevention and control activities(4). In high-risk areas and outbreak areas, chemical has been sprayed actively from 2 to 3 times depending on the level of outbreaks. Besides, chemicals also have been used in eliminating larvae, pupae in water containers such as flower vases, aquariums and other water containers(4).

In facts, chemical intervention has been used commonly in dengue prevention and control in Viet Nam. However, the country also has to face with chemical resistance situation of mosquitoes. Report of chemical resistance situation of the South in 2016 with common chemical which have been used in NDCP showed that 17/17 provinces were resistance with Permethrin 0.75%, 16/16 provinces were resistance with Deltamethrin 0.05%, 17/18 provinces were resistance with Cyfluthrin 0.15%, 18/18 provinces were resistance with Lambdacyhalothrin 0,05% and 1/17 provinces were resistance with Malathion 5%(98).

In recent years, new chemical such as *Bacillus thuringiensis* has implemented pilots in cooperation with Cuba and Japan respectively. Results of the pilot with *Bacillus thuringiensis* in the fields showed that the chemical has high effectiveness to *Aedes* larvae up to 98% killed after 12 weeks(99). It suggests to scale up in using the chemical in Viet Nam in coming time.

4.2.1.d. Dengue vaccine

Viet Nam has cooperated with WHO in implementing dengue vaccine pilots. Currently, the vaccine pilots have been in Phase III clinically. Phase III clinical trial of dengue vaccine is conducted in five Asian countries included Thailand, Malaysia, Indonesia, the Philippines and Viet Nam. This study has been implemented in 10,275 children from 2 to 14 years old in the 5 countries(100). In Vietnam vaccine trials is carried out in two sites, including Long Xuyen in An Giang province and My Tho in Tien Giang province with the participation of about 2,300 children(101).Results from Phase III clinically in the 5 Asia countries included Viet Nam showed that efficiency of dengue vaccine in age group 9 years or over was 65.6%, while the proportion with age group under 9 years was 44%(32). Currently, the vaccine is still in progress of trial in Viet Nam.

4.2.2. Collaborator network

In Viet Nam, collaborator network has been established since 1999 in high-risk areas under NDCP. Collaborators are responsible for monthly household inspection to detect larvae and pupae at water containers, health education for household members on the way to kill larvae, pupae and mosquitoes and cleaning risk containers and detecting suspect cases to report to health facilities to early treatment and prevention. Each collaborator is responsible for implementation of dengue prevention activities with maximum 100 households. Collaborators network aims to ensure control all households, water containers and breeding sites at their responsible area(81)(80). In facts, collaborators network in dengue prevention and control have achieved many successful. Research on applying *Mesocyclops* in Viet Nam also showed significant role of collaborators in implementation of the programs with working as a bridge between health facilities and community. This is important factor to ensure successful and sustainability of this program(82).

However, Viet Nam has faced with declining coverage of collaborators network because of weakness in management of local authorities as well as health agencies and limited in financial support for health collaborators(30). According to report of MOH in 2013, collaborator network had been implemented in 46 provinces (596 communes) of whole country with total of nearly 18,500 collaborators. They were responsible for about 1,300,000 households. The report also showed that the proportion of collaborator implemented monthly household inspection from 87.5% to 99.06% in 4 regions(25).

4.2.3. Emergency response

To implement Law of Infectious Disease Prevention and Control, Viet Nam established the Infectious Disease Prevention and Control Steering Committee at province and district levels. The Steering Committees are responsible for technical and logistic activities in dengue prevention and control to ensure regular activities and emergency response with dengue outbreaks. In addition, Rapid Response Teams (RRTs) have been established at 4 regional institutes, 63 provinces and districts. The teams

implement activities when occurring dengue outbreaks such as investigate, early detect, patient transportation and other performance technical activities in order to early response with dengue outbreaks and other disease outbreaks(102). According to Ministry of Health, Viet Nam has achieved successes in emerging infectious diseases prevention and control such as SARS, influenza (H7N9), MERS-CoV and Ebola in general and dengue outbreaks in particular(103). There was a lot of dengue outbreaks which have been controlled timely and prevent to spread widely. However, RRTs also have some challenges such as staff turnover, lack of equipment and lack of appropriate funding for activities as well as low remuneration. These challenges affected to motivate of RRTs staffs as well as effective of works.

CHAPTER 5: INTERNATIONAL DENGUE VECTOR CONTROL STRATEGY AND COMPARE TO VIET NAM

This chapter identify dengue vector control strategies in Southeast Asia countries where is one of the most severely affected areas by Dengue in the world(1). In addition, the chapter also compares the international strategies and the Vietnamese strategies that was presented in the previous chapter.

Southeast Asia countries have different in using strategies in dengue prevention and control as well as dengue vector control. There are 8 out of 10 countries in Southeast Asia region, which established NDCP (see Annex 5). However, all countries focus on Integrate Management Vector (IVM) approach and emphasize on roles of social mobilization and communication activities in order to improving awareness and behaviors change of community such as long term and sustainable strategy in dengue vector control(104). In addition, the approach also guide to apply variety of interventions including environmental, biological and chemical methods and improving role of multi-sectorial and agencies collaboration in coordination and implementation of dengue activities. Research of WHO in Southeast Asia and Western Pacific Region also showed that depending on available resources, burden of the disease, and cultural context so that each countries have proper approaches in dengue vector control strategies (Figure 11) (90).

Country/areas	Space spraying (outbreak)	Larviciding (chemical & biological larvicide)	Biological control	Environmental management (source reduction)	Health education and community mobilization)	Legislation	Intersectoral and agency collaboration
Australia (North Queensland)	++	++		++	++	+	+
Australia (Northern Territory)	++	++		++	++		
Cambodia	+	++	+ (guppy fish as operational research)	+	+ (school based)	-	+
China	+	-	-	+	+	-	+
Hong Kong (China) & Macau (China)	+	-	-	+	+	+	+
Lao People's Democratic Republic	+	+	+ (guppy fish as operational research)	+	++	-	+
Fiji	+	+	-	+	+	-	-
Malaysia	+	+	-	+	+	++	+
Philippines	+	+	+ (guppy fish as operational research)	+	+	-	+
Solomon Islands	+	-	-	-	+	-	-
Singapore	+	+	-	+	+	++	++
Vanuatu	+	+	-	+	+	-	+
Viet Nam	+	+	+ (<i>Mesocyclops</i>)	+	++	+	+

++ Exists and is a regular/core programme activity
+ Exists but irregular, only used under field research condition
- Does not exist
Source: Country Reports, 2008, World Health Organization Western Pacific Region.

Figure 11: Dengue vector control strategies in Southeast Asia countries and Western Pacific Region

Source: Chang MS, Christophel EM, Gopinath D et al(90)

Singapore

Dengue incidence has significantly increased over the past 40 years in this country (Figure 12)(105). Number of dengue cases increased about 13% each year for each 100,000 people(105).

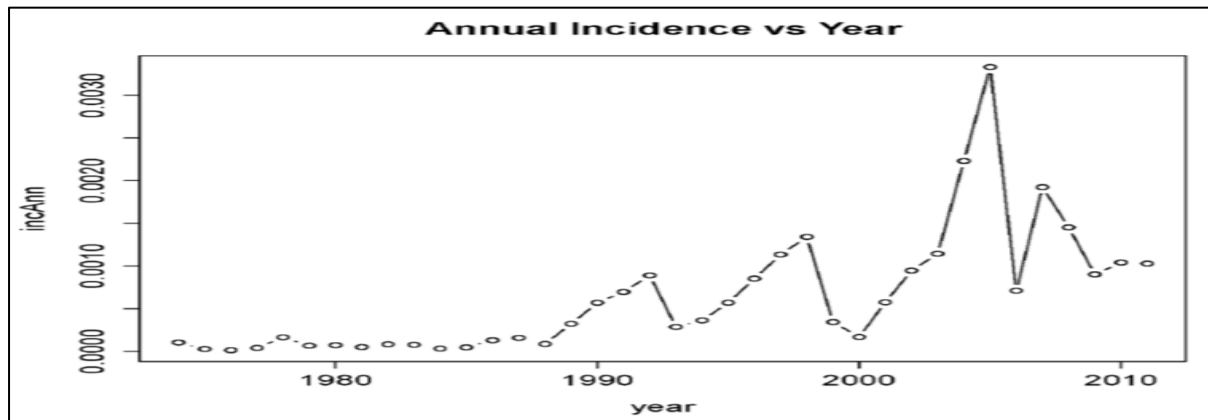


Figure 12: Annual dengue incidence in Singapore, 1974-2011.

Source: Struchiner CJ, Rocklöv J, Wilder-Smith A (105)

Singapore has strongly experienced in applying inter-sectorial and agency cooperation in dengue vector control. There is closely cooperation between public and private sector in dengue vector control. MOH and The National Environment Agency are responsible for cases management and early detect as well as regularly monitoring and surveillance dengue at community. Local authorities has significant role in implementation activities to eliminate mosquitoes breeding sites at homes. While private sectors also take part in activities of surveillance and providing insecticides for community(90). Besides, the country emphasize role of public communication in order to enhance awareness of community and other partners(106). Public communication programs have implemented through online and digital media such as facebook, blogs, online banner advertisement, mobile, and traditional media such as television, radio and outdoor advertisement(106). Besides, community engagement through a national dengue campaign called "Do the Mozzie Wipeout" has been conducted since 2013(104). The campaign has been started before peak and involvement of community, preschool and school, corporate organization, special interest group and construction sites and dormitories(107).

However, dengue prevention and control strategy also existed issues. Lack of leadership in the dengue programs was the biggest challenge identified. So that it affected to effective of technical activities such as coordination, communication as well as sharing data surveillance among related agencies. In addition, lack of experts who has experience in dengue vector surveillance at regional level was also problem. Besides, biological control did not apply in urban areas, and adulticidal fogging did not prove its effective, exception with during outbreaks(108). While, the country also have to face with many risk factors such as urbanization, climate change which also impacted to dengue fever(105).

Thailand

Average of annual dengue incidence was about 115 cases per 100,000 population from 2000 to 2011 and the country also had the highest of cases in Southeast Asia before 2004 (Figure 13)(109).

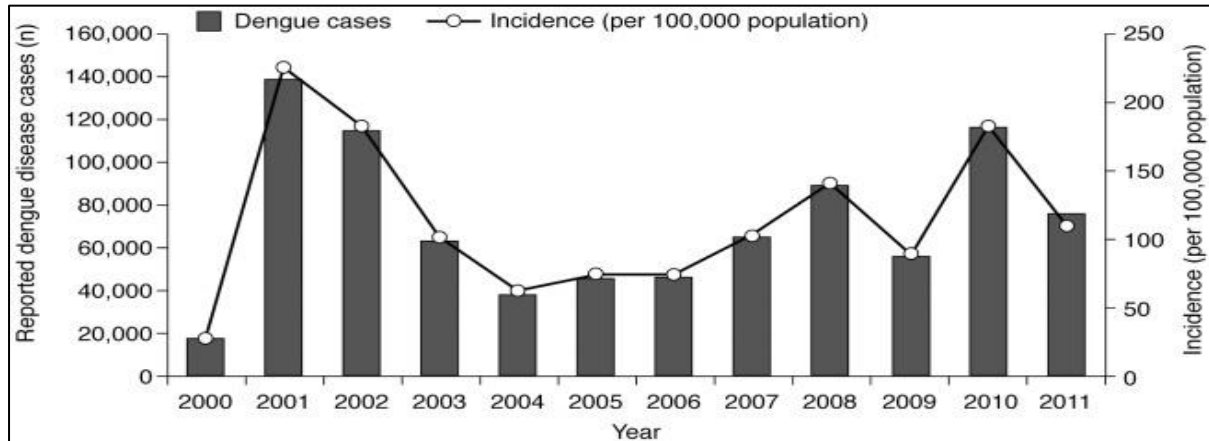


Figure 13: Number of dengue incidence and dengue cases in Thailand, 2000-2011.

Source: Limkittikul K, Brett J (109)

In Thailand, community based vector control through using horizontal and vertical approach has been applied since 2006(104). Similar with Viet Nam, the strategy has participation of local leader authorities, public health organizations and school(110). Many interventions have been conducted with participation of community, including: clean-up campaigns before rainy season, covered water containers and using copepods as biological control(110). In term of health education, school children have been presented symptoms of dengue fever, biological of mosquitoes and how to prevention and control dengue vector at community(110). The country established Memorandum of Understanding between 8 Government organizations in organizing dengue campaigns which called "Big Clean Day Campaign" annually(111)(112). With the cooperation between health sector and educational sector, health education program has been implemented at school and community level(104). Other methods such as environmental, chemical and biological controls also applied in dengue prevention and control (104). In addition, Thailand have implemented dengue vaccine trial which was conducted with 4,002 children and other strategies such as eco-bio-social strategies in urban and sub urban areas(104)(113). However, report from MOH revealed that dengue morbidity was affected by risk factors, including: climate change, dengue serotypes change, ineffective of community participation in dengue prevention, lack of cooperation between agencies in risk communication and insufficient outbreak preparedness and responses(112).

Malaysia

This country has significant increasing of mortality and morbidity of dengue in recent years (Figure 14). The statistic showed that incidence rate was 396.4 per 100,000 population and 336 deaths in 2015(114). Due to failure

in early detect cases which leads to increase mortality in this country(115). Besides, the country also was impacted by risk factors such as urbanization growth, climate change so that leading to unsuccessful in dengue control(116).

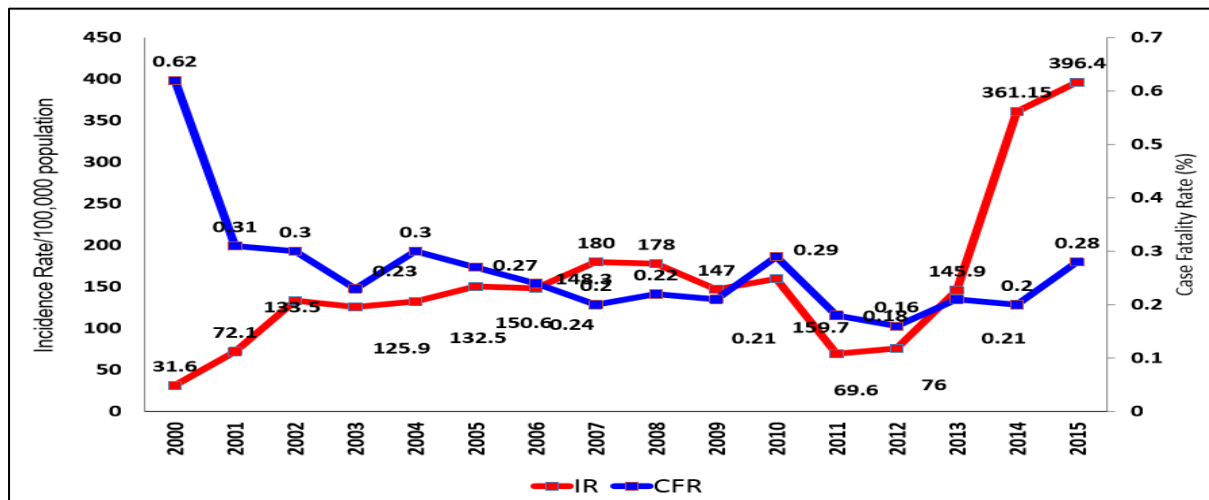


Figure 14: Dengue incidence rate and Case Fatality Rate in Malaysia, 2000-2015

Source: Ministry of Health of Malaysia(114)

In Malaysia, there are significant in cooperation between government organization, including MOH and Ministry of Local Government and Housing in which both the Ministers have similar power in dengue prevention and control. Besides, other Ministries and community organization groups also involved in dengue prevention and control(90)(117). Malaysia also focuses on implementation of vector surveillance regularly at high-risk areas in order to reducing breeding sites of mosquitoes. In addition, the country has applied in using *Bacillus thuringiensis* in dengue vector control at high risk areas(104). Information and technology also has been applied in dengue outbreaks such as “iDengue Website” and “iDengue mobile apps”(118).However, dengue vector control in this country still have to face with challenges such as chemical resistance of mosquitoes with Permethrine (a popular insecticide in vector control program). Besides, participation of community in practicing dengue prevention and control measures was limited. The dengue vector control programs almost depended on efforts of health facilities(119). Additionally, the circulating of 4 dengue serotypes also impacted to effective of vector control programs in Malaysia(120)

Indonesia

In Indonesia, the first dengue cases was reported in 1968. Up to now, the disease has occurred in 34 provinces of this country. In the period 2000-2015, number of cases from 65,725 to 156,086 per year, and number of death from 597 to 1.358 per year(121).

Similar with Viet Nam, Indonesia focuses on enhancing role of community participation in dengue vector control. Community empowerment through a program which called “Jumantik”(121). The program is managed by District

Health Center and there is participation of local resident person and health volunteers. The program activities have been implemented at village, neighborhood group and family level with larvae monitoring and surveillance, and providing community with knowledge on dengue prevention and control (121)(122). Besides, the country also emphasizes on IVM approach by using various methods such as biological control with *Bacillus thuringiensis*, *Wolbachia* bacterium and fishes; chemical control through larvaciding, chemical spraying; and environmental methods by source reduction(123)(121)(104). In addition, the country also implemented dengue vaccine trial similar to Thailand, Viet Nam, Philippines and Malaysia(104). However, this country also have to face with many challenges in implementation of dengue prevention and control due to limited on capacity of human resources, funding and implement surveillance at district level(123).

Philippines

Statistic in 2010 showed that dengue incidence in Philippines was 144.55 per 100,000 population and there was 793 deaths. This incidence was higher than several countries at Southeast Asia such as Singapore, Cambodia and Brunei(120).

In Philippines, community based programs focus on enhancing awareness of community and conducting surveillance at high-risk areas. These programs have involvement of government organizations and health facilities(104)(124). In addition, the country also focus on reduction of mosquitoes breeding sites, using chemical for outdoor and indoor spraying and changing behavior of community through improving awareness(104). Similar to Viet Nam, the country also face with challenge due to water storage of population, which affects to implement activities to reducing breeding sites at community(104). However, implementation of dengue vector control in this country have many challenges such as participation of private sector was limited, lack of funding and human resources for implementation of activities(125). In addition, there were some failures in implementation of chemical control such as chemical spraying due to mistake in determine key breeding sites, lack of appropriate combination of interventions(126).

Cambodia

According to statistic of WHO, number of dengue cases and deaths in this country was 12,500 and 38 respectively in 2010. The incidence was 83.10 per 100,000 population in this year(120).

In Cambodia, health education and source reduction with involvement of community are key strategies in dengue vector control(127)(104). Besides, Cambodia, Myanmar and Laos also cooperated with WHO in successful implementation of guppy fishes project with participation of related stakeholders from central to local levels(128). In term of health education, primary school level is priority in implementation of dengue education programs. Besides, health education through media such as television, radio, flipchart, banners also applied in order to enhance awareness of

community(129). However, dengue vector control in this country also have to face with problem due to lack of proper budget to implement NDCP so that it affected to regular in implementation of activities(130)

Laos

According to statistic from 2007-2012, number of cases and deaths was the highest in 2010 with 22, 890 and 46 respectively(131). The country applied strategies such as health education and environmental improvement, biological control and chemical control. The country also implemented other strategies, which includes using curtains for windows, water container covered and targeting in adults mosquitoes(132). Laos NDCP focus on 4 traditional methods for dengue vector control, including: communication for community and conducting clean up campaigns; applying chemical control; using biological control such as guppy fishes and indoor spraying insecticides to reducing adults mosquitoes(132). However, applying dengue vector control strategy in this country have challenges, including: weakness in agencies collaboration and water storage habit of community as well as irregularly cleaning water containers(128)

Brunei

Research in Brunei showed that there was 398 dengue cases in the period from 1992 to 2006, in which the highest cases was recorded in 2003 with 163 cases(133). In 2010, statistic showed that case fatality rate was 0.67% in this country which was higher than Viet Nam, Philippines, Malaysia, Laos and Cambodia(120).

In Brunei, the government and MOH emphasizes role of health education and clean-up campaign through enhancing awareness of community in dengue prevention and control. These strategies have been implemented in schools and rural areas with participation of stakeholders such as government organizations and private sectors(104).

Myanmar

In Myanmar, the first cases was detected in 1970s(104). Since this year, number of DHF cases gradually increased with about 28,000 cases in the period 1970-1979 to 123,000 cases from 2010-2014(134).

Similar with many countries in Southeast Asia Region, health education and clean up campaigns have been implemented at community level. In addition, using chemical as Malathion by fogging also implemented regularly. However, government organizations cooperation and financial resources for dengue vector control was not sustainability(135).

CHAPTER 6: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter discusses major determinant of dengue in Viet Nam and challenges and gaps in implementation of dengue vector control activities in the context of Viet Nam when stop running NDCP from 2016 onwards. Based on that making conclusions and giving appropriate solution in order to improving effective of dengue vector control in the coming time.

6.1. Discussion

From the above findings, it could be seen that age, living conditions, urbanization, water storage habits and using rainwater, climate change and seasonal features different among regions are main determinant of dengue in Viet Nam.

In Viet Nam, there was an increasing trend of age in dengue cases(38). This trend is similar with Asia countries such as Singapore, Indonesia, Bangladesh and Thailand(136). This shifting also was similar with Nepal where most of dengue cases in 16-45 age groups; Sri Lanka where most of dengue cases in 15-34 age groups(136).

In addition, there are strongly interaction among risk factors which leading to dengue situation in Viet Nam. Urbanization led to increasing urban and sub-urban areas. Urbanization also led to increase immigration of population from rural to urban area so that increasing density of population in urban areas. Accordingly, increasing of number of rented house with poor living conditions so that increasing favorable conditions for development of Aedes mosquitoes. Besides, water storage habits of population with many water containers around their house also is significant risk factors leading to increase breeding sites of mosquitoes. Although the government also provided pipe water to households but the situation is still exist even in urban areas. Additionally, the increasing urbanization combine with climate change such as increasing of temperature and rainfall in regions also impacted to mosquitoes distribution and frequent occurrence(63). These conditions made more variety of distribution of dengue vector (63).

Over past year, Viet Nam has achieved successes in dengue prevention and control by reducing mortality and mobility of dengue(30). However, the country has to face with many challenges including: Unsustainable finance, weakness in agencies collaboration and implementation of dengue surveillance.

In the context of Viet Nam, the NDCP will be stopped financial investing from the Government in 2016 onward. Besides, financial support from international donors also reduced. This situation will increase risk of lacking funding for implementation dengue prevention and control activities such as maintain collaborator networks and regular dengue surveillance.

Implementation of dengue prevention activities was almost depending on MOH. The involvement of other ministries and stakeholders were limitation. Besides, lack of appropriate mechanism with involvement of private sector in dengue prevention and control. Although the country has implemented

vertical and horizontal approach in dengue prevention, however it seems very top down or vertical way, lack of effective interaction between health facilities and other sectors as well as local agencies.

Viet Nam has comprehensive in dengue legislation and widely surveillance networks at all levels. However, lately reporting and existing many limitation in vector, virus and patient surveillance included lack of vector surveillance data in local levels, limitation in vector surveillance of construction sites, lack of data on virus surveillance(31). Besides, the ECDs has been applied from central to district level. However, limitation in computer skills of health staffs as well as lack of equipment for data import so that it led to lack of dengue surveillance information and lately reporting. In addition, the implementation of passive surveillance and EBS also had many difficulties. This situation due to limitation of capacity of health facilities at local levels, lack of funding for implementation activities and low remuneration for health workers.

Since 2004, IVM approach has been promoted by WHO(137)(5). This strategy has been mentioned in Global Strategy for Dengue Prevention and Control, Dengue Strategic Plan of Asia Western Pacific Region and State of the Art in the Prevention and Control Dengue in Americas(138)(139). In addition, the trend in dengue vector control has been shifted from depend chemical method such as using insecticides to more applying biological and environmental control with participation of community(90). Besides, using integrated approaches with combination of many methods are commonly in countries at Western Pacific Region(90). In the context of Viet Nam, community based vector control is still the most important strategy for dengue prevention and control. However, new interventions and lesson learnt from other countries should be applied in order to improve effective of dengue vector control strategy in Viet Nam.

Singapore has experiences in intersectoral collaboration which included private sector in dengue vector control. The participation of private sector improved effective as well as resources for implementation of activities at community level. It suggests that involvement of private sector may be solution for increasing resources for dengue vector control in Viet Nam.

Besides, Singapore and Malaysia also applied information technology as mentioned above for early detection and health communication through that rapid response with outbreaks and providing knowledge as well as information with community timely. In facts, Viet Nam has about 40% of population using smart phone so that it is very well to apply information technology such as mobile apps, facebook as Singapore and Malaysia(140).

Experiences in Thailand also showed that empowerment for district level was one of important factor leading to reduce dengue mortality in the country, from 11% to 0.1% of dengue cases(112). As above mentioned, Viet Nam also implemented vertical and horizontal approaches with involvement of multisectors at local level. However, it seems depending on vertical approach a lot. Most of decision as well as intervention need to approve by MOH and provincial agencies. Thus, empowerment in dengue surveillance and vector

control for local level will help giving appropriate solution which suitable with specific context through that enhance effective of dengue prevention and control in Viet Nam. In addition, experiences from Mexico and Brazil showed that decentralization for local levels and improving intersectoral were the keys for successful of IVM approach(139).

6.2. Conclusions

Determinant of dengue in Viet Nam is very broad and being influences by various factors. The disease has been strongly impacted by living conditions, urbanization, water storage habits and using rainwater, climate change and seasonal features different among regions .

Community based vector control is the most important strategy in dengue vector control in Viet Nam. Besides, the country also applied variety of interventions in order to control *Aedes* mosquitoes. However, this country also have to face with many challenges due to limitation of funding, urbanization, climate change, and ineffective intersectoral and agencies collaboration in implementation of dengue vector control.

Integrated approach in dengue vector control is popular in countries. In which applying many interventions with participation of community. Besides, emphasizing role of intesectoral and agencies collaboration in implementation of activities in dengue vector control.

6.3. Recommendations

From findings and conclusion have been above mentioned. The appropriate solutions have been proposed to MOH for the successful prevention and control of dengue in Viet Nam with following contents:

6.3.1. Recommendations on Policy

- MOH should increase empowerment for health facilities at commune and district level in implementation of dengue surveillance, vector control and health communication in order to improve effective of community based strategy.
- MOH should encourage involvement of private sector in order to enhance resources as well as effective of dengue prevention and control strategy.
- MOH should prioritize resources in implementation of dengue prevention and control for migrants and the South where has high risks of dengue infection.
- MOH should improve effective of vertical and horizontal approaches in dengue prevention and control in combination with other vector borne diseases and enhancing collaboration with other sectors.

6.3.2. Recommendations to intervention and further research

- MOH should apply information technology in early detect and health education for dengue prevention and control by using mobile apps and social networks. Researches on impacting of urbanization and climate change to dengue vectors and virus serotypes; chemical resistance; and applying dengue vaccine in order to establish appropriate strategy as well as effective interventions in coming time.

- Research on cost effectiveness and sustainability of interventions, which have been applied in Viet Nam in order to improve effective of dengue prevention and control strategy in coming time.

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ANNEXES

Annex 1. Urbanization change in land areas and city population from 1999 to 2009 in Viet Nam.

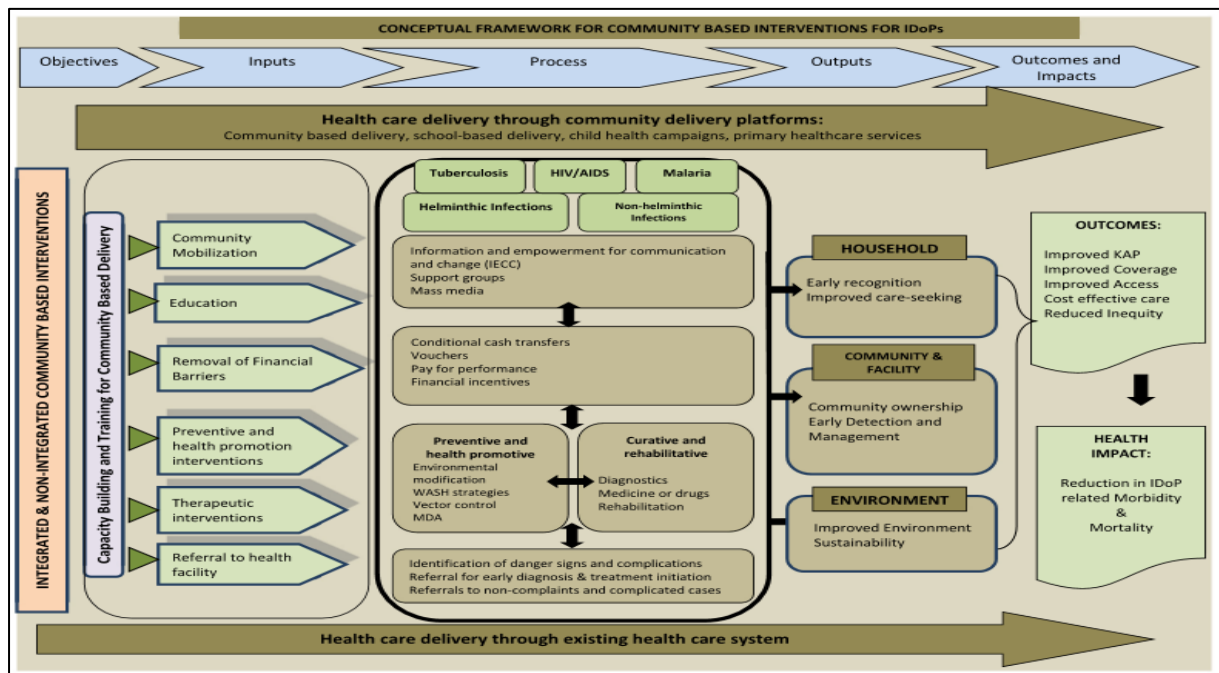
Region	Northern Midlands	Red River Delta	North Central/ Central Coast	Central Highlands	Southeast	Mekong River Delta	Total
City population density, total, 2009, persons/ha	10.3	19.2	18.5	5.7	33.6	12.1	21.3
Urban density (a)	28.5	70.4	33.0	16.7	96.6	27.2	62.5
Rural density (b)	5.0	11.7	10.8	2.3	9.1	5.7	9.2
(a/b), %	572.3%	599.7%	306.8%	716.7%	1059.1%	474.1%	679.3%
Annualized growth rates over the period 1999 - 2009							
Total city population density	3.1%	1.1%	2.0%	1.6%	3.5%	1.4%	2.1%
Urban density growth	-1.6%	-1.9%	0.9%	-2.4%	2.6%	-2.9%	-0.4%
Rural density growth	3.4%	0.3%	-0.3%	0.5%	3.8%	0.1%	1.4%
Annualized growth rates over the period 1999 - 2009							
Total city population	3.7%	2.6%	1.1%	1.4%	3.3%	1.2%	2.4%
Urban growth	3.4%	4.4%	3.3%	2.5%	3.7%	5.4%	4.1%
Rural growth	3.1%	1.2%	-3.6%	0.0%	3.2%	-1.8%	0.8%
Annualized growth rates over the period 1999 - 2009							
Total city land area	-0.3%	1.2%	-1.8%	-1.5%	-0.8%	-0.1%	-0.3%
Urban growth	3.2%	8.4%	2.4%	3.4%	0.9%	9.8%	5.6%
Rural growth	-1.0%	0.2%	-3.4%	-1.9%	-1.2%	-1.4%	-1.2%

Source: World Bank(12)

Annex 2. Dengue legislation documents in Viet Nam

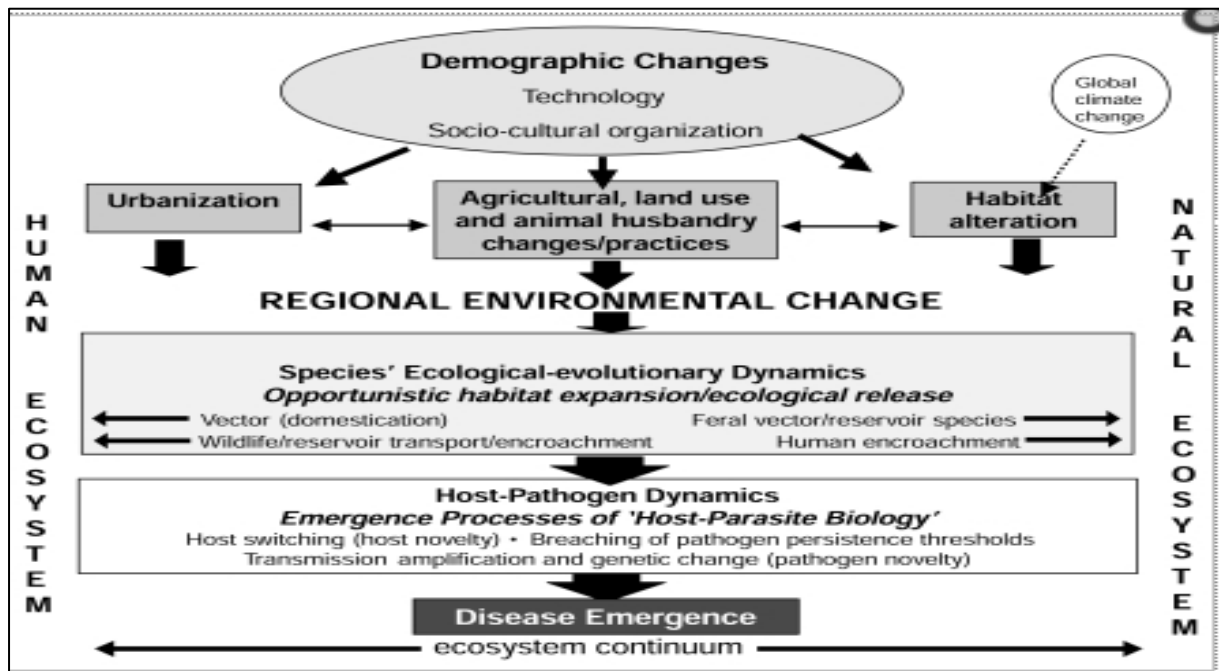
#	Document	Issued by organization	Year
1	Law of Infectious Disease Prevention and Control	Viet Nam National Assembly	2007
2	Circular on Guiding for reporting and declaration of infectious disease	Ministry of Health	2010
3	Circular on Guiding for reporting and declaration of infectious disease (replace for the circular in 2010)	Ministry of Health	2015
4	Guideline on diagnosis and treatment of DF/DHF	Ministry of Health	2011
5	Guideline on Dengue fever surveillance	Ministry of Health	2014

Annex 3. Models of Conceptual Framework



Community based interventions for infectious diseases of poverty conceptual framework

Source: Lassi, Z S; Salam, R A; Das, J K et al.(33)



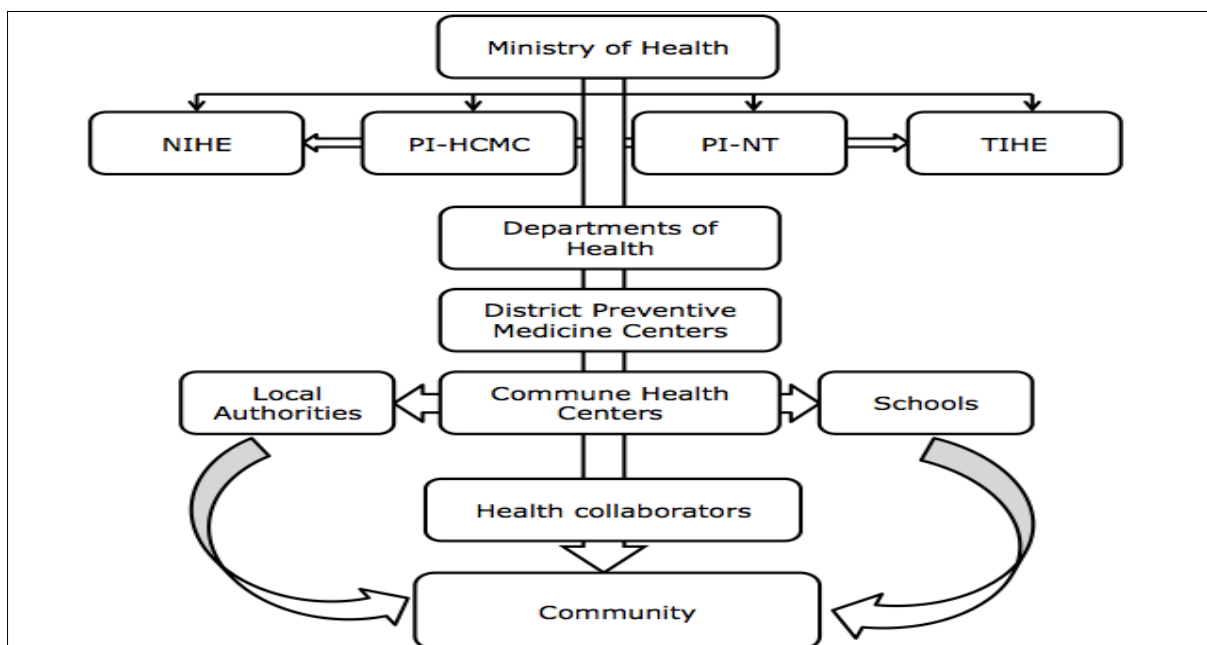
Social Framework model: Wilcox and Gubler (2005)

Source: Institute of Medicine (US) Forum on Microbial Threats. Washington (DC)(35)

Annex 4. Vertical and horizontal approach in community based vector control

In community based vector control, vertical approach or top-down approach means health facilities providing community with plan and technical guiding in dengue prevention and control such as providing knowledge and skills for community to detect key container, productivity of mosquitoes and methods to control mosquitoes at household level. MOH is responsible for coordinating all activities. Under the coordination of MOH, 4 regional institutes are responsible for technical advice and training. These institutes will direct and cooperate with health facilities in provinces such as Department of Health and Provincial Preventive Medicine Centre at provincial level, District Health Centre at district level and Commune Health Centre at commune level(80)(81).

With horizontal approach or bottom-up approach, local authorities, health collaborators and school teachers will cooperate in implementation of activities at community level. Local authorities have an important role in creating favorable conditions for the implementation of dengue prevention and control activities in their areas and monitoring the implementation of activities. Besides, health collaborators and school teachers will be trained and participation in implementing activities such as health education, environmental control at community level. Though that, it is expected that the community will understand the effectiveness and the importance of dengue prevention and control to their health. After that, results and challenges as well as recommendations will be reported for higher levels(81)(82).



Vertical and Horizontal approach model of Dengue community based vector control in Viet Nam

Source: Vu Sinh Nam et al (82)(80).

Annex 5. National Dengue Control Programs in Southeast Asia countries

#	Countries	NDCP strategies
1	Singapore	<ol style="list-style-type: none"> 1. Dengue surveillance for dengue cases, virus and vectors 2. Inter-sectoral collaboration, risk stratification and inspections 3. Communication and outreach 4. Cluster management
2	Thailand	<ol style="list-style-type: none"> 1. Empowerment for individuals and communities 2. Applying IVM to control breeding sites of Aedes vectors 3. Enhancing capacity of staffs at all level 4. Strengthening networking for dengue prevention and control 5. Enhancing surveillance and outbreak response 6. Technical support for dengue prevention and treatment
3	Malaysia	<ol style="list-style-type: none"> 1. Dengue surveillance 2. National Cleanliness policy and Integrated Vector Management 3. Dengue fever cases management 4. Social Mobilization and Communication 5. Outbreak Response 6. Research 7. Reduce burden of dengue fever in the Klang Valley
4	Indonesia	<ol style="list-style-type: none"> 1. Source reduction or sanitation to reduce the breeding places 2. Improving water supplies 3. Biological control 4. Insecticide control 5. Health education and community empowerment 6. Partnership 7. Regulation 8. Research
5	Philippines	<ol style="list-style-type: none"> 1. Integrated vector control approach 2. Case diagnosis, management and reporting 3. Surveillance
6	Cambodia	<ol style="list-style-type: none"> 1. Surveillance and outbreak response 2. Vector control and coordination 3. Case's clinical and management 4. Health education 5. Study and research.
7	Laos	<ol style="list-style-type: none"> 1. Health education and container clean up 2. Chemical control 3. Biological control 4. Indoor and Outdoor spraying of insecticides
8	Viet Nam	<ol style="list-style-type: none"> 1. Increasing dengue surveillance system for dengue

#	Countries	NDCP strategies
		<p>cases, dengue virus and dengue vector.</p> <ol style="list-style-type: none"> 2. Enhancing dengue diagnosis and treatment at health facilities 3. Enhancing awareness of community in dengue prevention and control