

Technical Report

*City health system preparedness for changes
in dengue fever reasonably attributable to
climate change:
an exploratory case study of Bangkok*



2009

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Abstract

Health system preparedness for changes in dengue fever attributable to climate change was explored in this collaborative study by Imperial College London and WHO Kobe Centre. A new toolkit was developed and an exploratory case study in Bangkok, Thailand was undertaken in 2008. The study found out that one, there is a clear lack of research in this area as most research has been looking upstream at impacts and not on immediate response and preparedness for effective response; and two, there is a clear need to develop and/or scale up national-capital city efforts to assess and address the implications of climate change for health systems. It recommends further case studies to validate the toolkit and generate guidelines on how to develop effective response plans.

1. INTRODUCTION

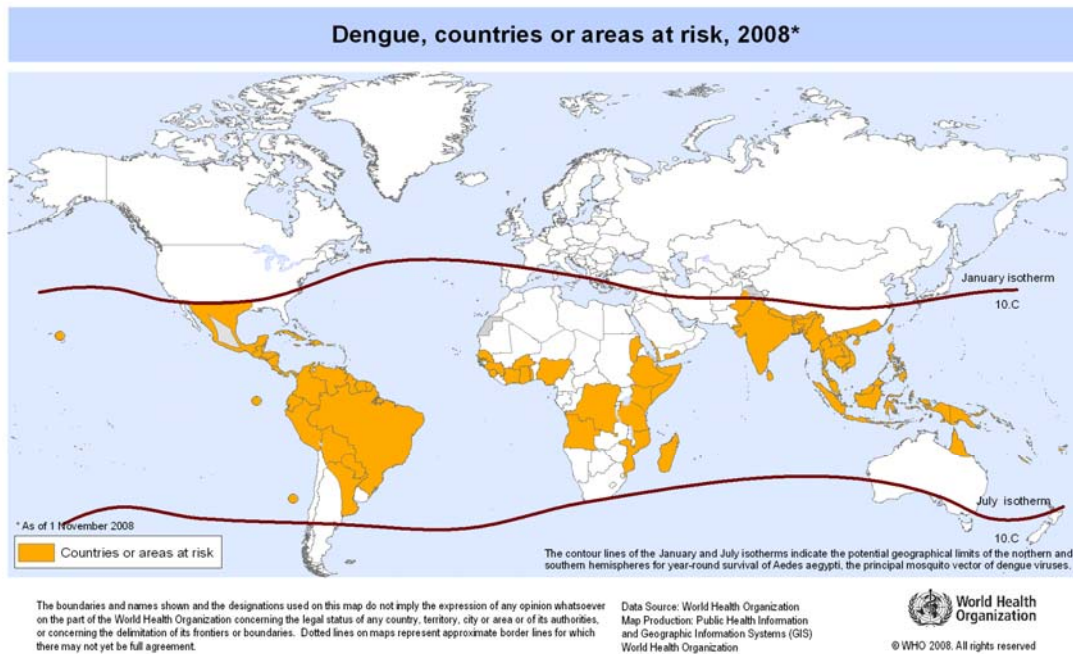
1.1 Background

1.1.1 Dengue fever and dengue haemorrhagic fever

Dengue fever, also known as breakbone fever, causes a flu-like illness (WHO, 2008). There are four serotypes of dengue fever. Most patients survive and have immunity for life from the serotype of flavivirus they have caught. However, patients who are infected with a second serotype are more likely to develop dengue haemorrhagic fever (DHF), possibly because of immune enhancement (WHO, 2008). Dengue haemorrhagic fever is a more virulent form of dengue fever, and is a potentially lethal complication (WHO, 2008). Dengue infects approximately 50 million people worldwide per year (WHO, 2008).

Dengue is a vector-borne disease, with its main vectors being the *Aedes aegypti* mosquito. Dengue persists mostly in the tropical and subtropical regions of the world where the temperature and rainfall are adequate for the mosquitoes to thrive and breed. It is an urban disease, with the vectors breeding mainly in water located in containers such as pots or tires (Gubler DJ et al., 2001).

Figure 1.1 Worldwide distribution of dengue (WHO, 2008)



Dengue fever is cyclical, with seasonal variations as well as bigger, epidemic cycles every 2-3 years (WHO, 2008, WHO, 2004a, Rodriguez-Tan RS & Weir MR, 1998, Lifson AR, 1996).

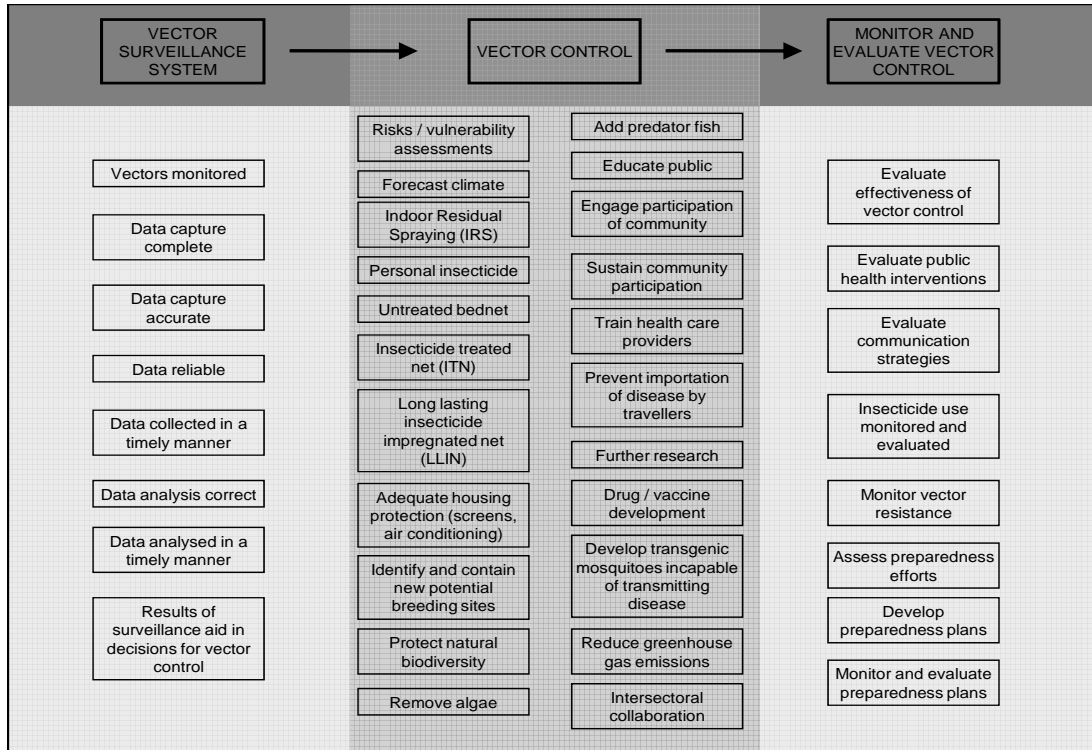
It is difficult to estimate the exact prevalence and incidence of dengue fever since only 30% of cases are symptomatic (Chen LH & Wilson ME, 2005). The remaining 70% are either asymptomatic or produce only mild symptoms such as a mild fever (Chen LH & Wilson ME, 2005). Moreover, there are no rapid diagnostic tools, rather a laboratory test (i.e., IgM ELISA) is required which can detect current or recent infection, 6-7 days after infection. As a result, doctors must treat patients for dengue fever symptoms without having a confirmed diagnosis. Dengue haemorrhagic fever (DHF) prevalence and incidence is easier to estimate since all cases require hospitalization.

1.1.2 Dengue fever and DHF control

The potential control measures for dengue can be categorized into surveillance of the vector, control of the vector, and monitoring and evaluation of vector control (Figure 1.2), based on the WHO guidelines for dengue fever and DHF control ((WHO, 2003)).

Surveillance of the vector includes monitoring, data capture, data analysis and data reporting to evaluate and choose vector control methods. Vector control involves risk assessments, climate forecasting, indoor residual spraying (IRS), personal insecticide, untreated bednets, insecticide treated nets (ITN), long lasting insecticide impregnated nets (LLIN), adequate housing protection (screens, airconditioning), identifying new potential breeding sites, protecting natural biodiversity, removing algae, adding predator fish, engaging community participation, sustaining community participation, educating health care providers, preventing importation of disease by travelers, further research, drugs/vaccine development, development of transgenic mosquitoes, reducing greenhouse gas emissions, and intersectoral collaboration. Monitoring and evaluating vector control helps to evaluate the effectiveness of certain measures and to monitor resistance.

Figure 1.2 Vector control for dengue fever



1.1.3 Impacts of climate change on dengue fever

Climate change will affect the prevalence and distribution of vector-borne diseases such as dengue fever, and potentially has already (Lifson AR, 1996, Khasnis, 2005, Gubler, 2001, Sutherst, 2004, Ye, 2007). Dengue prevalence is likely to be affected by climate change due to the fact that the mosquito vector is cold-blooded and therefore greatly affected by changes in temperature, humidity or precipitation (Lifson AR, 1996, Khasnis, 2005, Lindsay, 1996, Tanser FC, 2003, Martens, 1995, Hales S, 2002). The four flavivirus serotypes are associated with temperature. The abundance and bite rate of *Aedes aegypti* mosquitoes, which transmit dengue fever by feeding during the day, are also affected by temperature, humidity and precipitation (Lifson AR, 1996, Hales S, 2002, Hales S et al., 1999).

1.1.4 Responses to health impacts

In history, several response plans have been created by policy-makers after disasters, as unexpected health impacts are not seen as a priority until after the events have occurred.

A Thailand disaster plan on response to tsunamis was only created after the tsunami of December 2004, even though a former chief of the Meteorological Department predicted such an event in 1998 (Lott S, 2007). At the time, Thammasaraj's prediction was not believed or prioritised. The United Nations created a Tsunami Warning and Mitigation System for the Indian Ocean during a UNESCO meeting in March 2005 (UNESCO, 2005).

The French Heat-Wave National Plan was developed straight after the August 2003 heat wave which killed over 14 000 people in the country (Vandentorren S & Empereur-Bissonnet P, 2005, Pascal M, 2006).

Brazil had a dengue outbreak in 2007 which infected over 110 000 people and killed over 95. It was finally controlled by the lack of new susceptible individuals rather than by effective vector control programmes (Chiaravalloti Neto F, 2007, Medronho, 2008).

Describing the future of the environment and health process in Europe, the Fourth Ministerial Conference on Environment and Health stated "health aspects are still not well integrated into international and national initiatives, strategies and action plans on sustainable development" (WHO, 2004b) and that "A comprehensive strategy to support a public health response is conspicuously lacking" (Campbell-Lendrum D & Woodruff R, 2007). This is an important issue and has been propelled forward on the agenda recently as a result of WHO World Health Day 2008, WHO reports on protecting health from climate change (WHO 2003a, WHO 2008, Matthies F et al., 2008) and the World Bank writing a practical guide, *How to climate-proof our cities* (The World Bank, 2008).

1.1.5 Systematic review of response and preparedness to changes in dengue fever epidemic associated with climate change

A systematic review was carried out to assess the health system responses to changes in dengue fever as a result of climate change.

1.1.5.1 Methods

The systematic review followed the Cochrane criteria: to create a clear, structured report, with repeatable results (*The Cochrane Collaboration*). These were carried out to emphasize the importance of the context, and to aid in the development of the toolkit. The data sources used were EBSCO Business Source Complete with Business Searching Interface, Factiva, GreenFILE, Health Management Information Consortium International (HMIC) July 2008, JSTOR, Ovid Journals@Ovid Full Text June 09, 2008, and PubMed.

To help ensure the quality of the data, only peer-reviewed publications were explored. All types of studies were included, and not just randomized control trials but also studies looking at the response and preparedness to changes in dengue fever associated with climate change.

Keyword logic:

("climate change" OR "global warming") AND (health OR "health impact" OR "health impacts") AND (assessment OR assessments OR initiative OR initiatives OR intervention OR interventions OR plan OR plans OR preparedness OR programme OR response OR responses OR strategy OR strategies OR surveillance OR "sustainable development" OR system OR systems) AND ("dengue fever" OR "dengue hemorrhagic fever" OR DHF) AND (control OR distribution OR dynamic OR dynamics OR epidemic OR epidemics OR impact OR "infectious disease" OR "infectious diseases" OR insecticide OR insecticides OR intervention OR interventions OR larvicide OR mosquito OR mosquitoes OR net OR nets OR outbreak OR outbreaks OR parasite OR parasites OR prevention OR repellent OR surveillance OR transmission OR vaccine OR vaccines OR vaccination OR vector)

1.1.5.2 Results

The number of studies identified at each sift are outlined in Table 1.1. For the first sift, abstracts were read and articles removed that had no abstracts or were not peer reviewed. For the second sift, non-relevant articles were discarded (those not focused on health system responses to dengue fever). For the third sift, duplicates were removed, all papers were read and high quality ensured.

Table 1.1 Number of eligible studies whilst sifting

Databases	Number of papers at each stage			
	All results	First sift	Second sift	Third sift
EBSCO Business Source Complete with Business Searching Interface	2	2	2	
Factiva	857	18	4	
GreenFILE	2	2	1	
Health Management Information Consortium International (HMIC) July 2008	0	0	0	
JSTOR	73	32	5	
Ovid Journals@Ovid Full Text June 09, 2008	3	3	0	
PubMed	13	13	8	
Total	950	70	20	12

The characteristics of the included studies can be seen in Table 1.2. Only 12 studies met the inclusion criteria (Gubler DJ et al., 2001, Rodriguez-Tan RS & Weir MR, 1998, Lifson AR, 1996, Hales S et al., 1999, Bultó PL et al., 2006, Campbell-Lendrum D & Woodruff R, 2006, Frumkin H et al., 2008, Patz JA & Kovats RS, 2002, Patz JA et al., 2000, Rawlins SC et al., 2007, Sutherst RW, 2004, Woodruff R, 2006). Out of the 12 studies identified, there were eight reviews (Gubler DJ et al., 2001, Rodriguez-Tan RS & Weir MR, 1998, Hales S et al., 1999, Campbell-Lendrum D & Woodruff R, 2006, Frumkin H et al., 2008, Patz JA & Kovats RS, 2002, Patz JA et al., 2000, Sutherst RW, 2004).

Most of the reviews explored general health impacts of climate change (Campbell-Lendrum D & Woodruff R, 2006, Frumkin H et al., 2008, Patz JA & Kovats RS, 2002, Patz JA et al., 2000) or concentrated on vector-borne diseases (Gubler DJ et al., 2001, Hales S et al., 1999, Sutherst RW, 2004)). Only two reviews concentrated specifically on dengue fever, however both only mentioned climate change in passing ((Rodriguez-Tan RS & Weir MR, 1998, Lifson AR, 1996).

Out of the four studies that collected data, three collected weather and climate data, two collected dengue data, two mosquito data, two socioeconomic data and one collected response/adaptation data (Rodriguez-Tan RS & Weir MR, 1998, Lifson AR, 1996, Hales S et al., 1999, Bultó PL et al., 2006, Rawlins SC et al., 2007, Woodruff R, 2006).

Bulto *et al.* (2006), explored climate variability and *Aedes aegypti*, predicting “more frequent epidemic outbreaks and a change in the season and spatial pattern of dengue fever” in Cuba. As a result of this they suggest the use of climate projections to inform policy decisions in the development of vector control programs.

Hales *et al.* (1999), investigated the relationship between the El Niño southern oscillation (ENSO) and dengue fever, and concluded that ENSO may trigger dengue fever outbreaks on large populated islands.

Woodruff *et al.*, estimated the spread of dengue in Australia as a result of increased temperatures on the basis of “no policy action” to reduce greenhouse gas emissions (Woodruff R,

2006). Their conclusions were that strong policy action to reduce emissions would prevent expansion of dengue fever (Woodruff R, 2006).

The paper that collected response data explored community knowledge of climate change issues and community willingness to help control dengue fever in the Caribbean (Table 1.3). Understanding and awareness of these issues were found to be high, but involvement would only occur with more community persuasion (Rawlins SC et al., 2007).

There is an awareness of vector control methods (Table 1.4). However, there is a clear gap in the literature on responding to changes in dengue fever as a result of climate change, let alone monitoring of evaluations.

Table 1.2 Characteristics of studies included in dengue fever review

Authors	Year	Specific Countries or Regions	Weather and climate data	Epidemiologic data	Ecologic data	Socio-economic data	Response / Adaptation data
Bulto et al.	2006	Cuba	Collected	None	Aedes aegypti collected	Collected	None
Campbell-Lendrum and Woodruff	2006		None	None	None	None	None
Frumkin et al.	2008		None	None	None	None	None
Gubler et al.	2001		None	None	None	None	None
Hales et al.	1999	South Pacific	Collected	Dengue fever cases	None	None	None
Lifson	1996	United States	None	None	None	None	None
Patz and Kovats	2002		None	None	None	None	None
Patz et al.	2000		None	None	None	None	None
Rawlins et al.	2007	Caribbean	None	None	Vector population and habitats	Collected	Community knowledge and willingness
Rodriguez-Tan and Weir	1998	United States	None	None	None	None	None
Sutherst	2004		None	None	None	None	None
Woodruff et al.	2006	Australia	Collected	Dengue transmission regions	None	None	None

Table 1.3 Vector control methods discussed in included studies of dengue fever review

Authors	Year	Develop preparedness plans	Assess preparedness efforts	Evaluate communication strategies	Evaluate public health interventions	Intersectoral collaboration	Reduce greenhouse gas emissions	Drug / vaccine development	Further research	Prevent/importation of disease by travellers	Train health care providers	Educate Public	Protect natural biodiversity	Forecast climate	Improve data collection	Surveillance
Bulto et al.	2006				Yes								Yes			Yes
Campbell-Lendrum and Woodruff	2006															
Frumkin et al.	2008	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes		Yes	Yes	Yes
Gubler et al.	2001				Yes			Yes	Yes		Yes	Yes		Yes		Yes
Hales et al.	1999															
Lifson	1996											Yes				Yes
Patz and Kovats	2002	Yes						Yes			Yes			Yes		Yes
Patz et al.	2000	Yes						Yes	Yes	Yes	Yes			Yes		Yes
Rawlins et al.	2007			Yes	Yes	Yes			Yes			Yes				
Rodriguez-Tan and Weir	1998							Yes			Yes					Yes
Sutherst	2004	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Woodruff et al.	2006						Yes					Yes				Yes

Table 1.4 Response data

Authors	Year	Specific countries or regions	Response/Adaptation data	Strategies	Summary of findings
Rawlins, et al.	2007	Caribbean	Community knowledge and willingness	Environmental sanitation	Knowledge of environmental sanitation and source reduction (removing water dwellings) was high. A lower proportion of respondents were applying these strategies for dengue fever prevention.

1.1.5.3 Discussion

No studies were captured that had explored health system responsiveness to changes in dengue fever as a result of climate change with this search criteria. The included studies either focused on the impact of climate change on dengue fever outbreaks and patterns (Hales S et al., 1999, Bultó PL et al., 2006) or the impact of climate change policies on dengue fever distribution (Woodruff R, 2006) or community knowledge and willingness to participate in vector control methods (Rawlins SC et al., 2007).

There is a clear lack of research in this area as most of the research is looking upstream at impacts and not at response. This is a globally important issue which needs to be addressed.

According to Bultó (2006), “Anticipatory prevention is better than reacting once a disease outbreak has occurred”.

This systematic review of the response and preparedness to changes in dengue fever epidemic associated with climate change illustrates gaps in the literature and highlights the importance of this study.

1.2 Aim and objectives of the study

Aim:

- To understand the complexities behind assessing the preparedness of health systems and plans to changes in dengue fever

Objectives:

- To review what research has been carried out on assessing the preparedness of health plans to changes in dengue fever;
- To develop a toolkit to assess preparedness; and
- To undertake a case study in Bangkok, Thailand.

2. METHODOLOGY

2.1 Methods

This study was carried out in collaboration with the World Health Organization Centre for Health Development (WHO Kobe Centre – WKC), Japan, which is interested in urban health and recently hosted a World Health Day Symposium on climate change and health impacts (*Climate refugees, dengue mosquitoes and killer heat - top scientists speak out at WHO Kobe Centre's World Health Day Symposium, 2008*) and a WHO workshop on research priorities for climate change and health in urban settings, 27-28 November 2008.

There is a need for a tool that assesses the preparedness of health systems for changes in dengue fever prevalence and distribution, for instance, as a result of global warming, but no such comprehensive tool exists. This study looks at the preparedness of health systems for changes in dengue fever with reference to the following three components:

- Systematic review for the preparedness of health plans for changes in dengue fever reasonably attributable to climate change
- Development of toolkit to assess preparedness
- Bangkok case study

This study is considered important because it is vital to understand and explore any gaps or bottlenecks in the preparedness of national-capital city health systems for changes in dengue fever, then to be able to advise or guide countries on improving preparedness.

This multidisciplinary, multi-method cutting-edge approach to evaluation was primarily validated in a cross-sectional, cross-cultural setting. This work will inform WHO on the application of this new toolkit which has been successfully applied in Thailand and will assist in the evaluation of other countries' and cities' preparedness for changes in dengue fever as a result of global warming.

2.2 Toolkit development

There are no current approaches for identifying the preparedness of national health systems for changes in dengue fever as a result of global warming. The toolkit was developed after carrying out systematic reviews and is based on the Systemic Rapid Assessment (SYSRA) toolkits and Systemic Rapid Assessment and Monitoring (SYSRAM) toolkits for tuberculosis and influenza developed by Professor Rifat Atun and his colleagues (Atun RA, 2005, Atun RA, 2004, Coker R, 2004, Coker, 2006, Coker R, 2007). Other frameworks for evaluating public health systems were also used, including responses to disasters such as bioterrorism and heatwaves (Landesman LY et al. 2005, Bravata 2004,

Bravata DM 2005, WHO 2005, Kovats RS 2006, Buehler 2004). The toolkit created is robust and has been developed from a strong theoretical basis.

Although a number of guidelines and manuals exist for assessment, monitoring and evaluation of vector control methods, these lack well developed tools to enable a response to climate-led variation in dengue fever (WHO 2003b, WHO 2005, WHO 2006b, WHO 2006a).

Despite the importance of a response to increasing incidence of dengue fever, no formally validated tool exists to undertake a detailed assessment of preparedness. There is a need for a systemic as well as a programmatic approach to analysing preparedness to changes in dengue fever.

2.2.1 Aim of toolkit

- To analyse the organizational arrangements around dengue fever
- To investigate to what extent health systems are able to respond to changes in dengue fever as a result of climate change
- To identify the barriers and enablers to effective response

2.2.2 Development of the analytical framework to analyse an optimal response plan for vector-borne diseases

The toolkit framework was developed in collaboration with WHO Centre for Health Development. This toolkit has been created after reviewing dengue fever control guidelines (WHO 2003b, WHO 2005, WHO 2006b, WHO 2006a, LLoyd LS 2003), and reviewing:

- approaches for evaluating public health systems or programs (CDC 2001)
- public health responses to disasters (Landesman LY et al., 2005), such as bioterrorism (Bravata 2004, Bravata DM 2005), influenza pandemics (WHO 2005, Mounier-Jack 2006), and heatwaves (Matthies F et al., 2008, Kovats RS 2006)
- methods for early detection of outbreaks (Buehler 2004)
- a Systemic Rapid Assessment Toolkit (SYSRA) (Atun RA 2004)

Since the topic is broad, and involves many key players in different settings, an optimal response plan for vector-borne diseases was created to help guide the interviewer during the meetings and aid in the recognition of gaps in response plans.

2.3 Elements of the toolkit

The toolkit involves recording relevant information from national documents, exploring routine epidemiological and weather data, and conducting key informant interviews.

2.3.1 National documents

Key documents pertaining to climate change in the country; ministry of health plans in relation to responses to health impacts of climate change.

2.3.2 Routine epidemiological and weather data

National and regional data and trends for incidence and prevalence, as well as mortality, will be sought and analysed for changes and variances. Long-term weather data will also be analysed to ascertain any changes and trends.

2.3.3 Key informant interviews

The questions for the interview were developed using the published toolkits and response plans. The structure is based on the optimal response plan for vector-borne diseases (Figure 2.1). These questions are more a guide for the interviewer than obligatory, and the questions asked will depend firstly on the knowledge and expertise of the person being interviewed, and the questions will be adapted depending on the answers given.

2.3.4 Interview preparation

A contact in the host country will aid in obtaining information on potential respondents. The point of the toolkit is to purposefully sample key actors involved with the different health system functions outlined in the framework at different administrative levels (e.g. national vs. regional). A mix of respondents from different levels and specialties is required for a robust qualitative response.

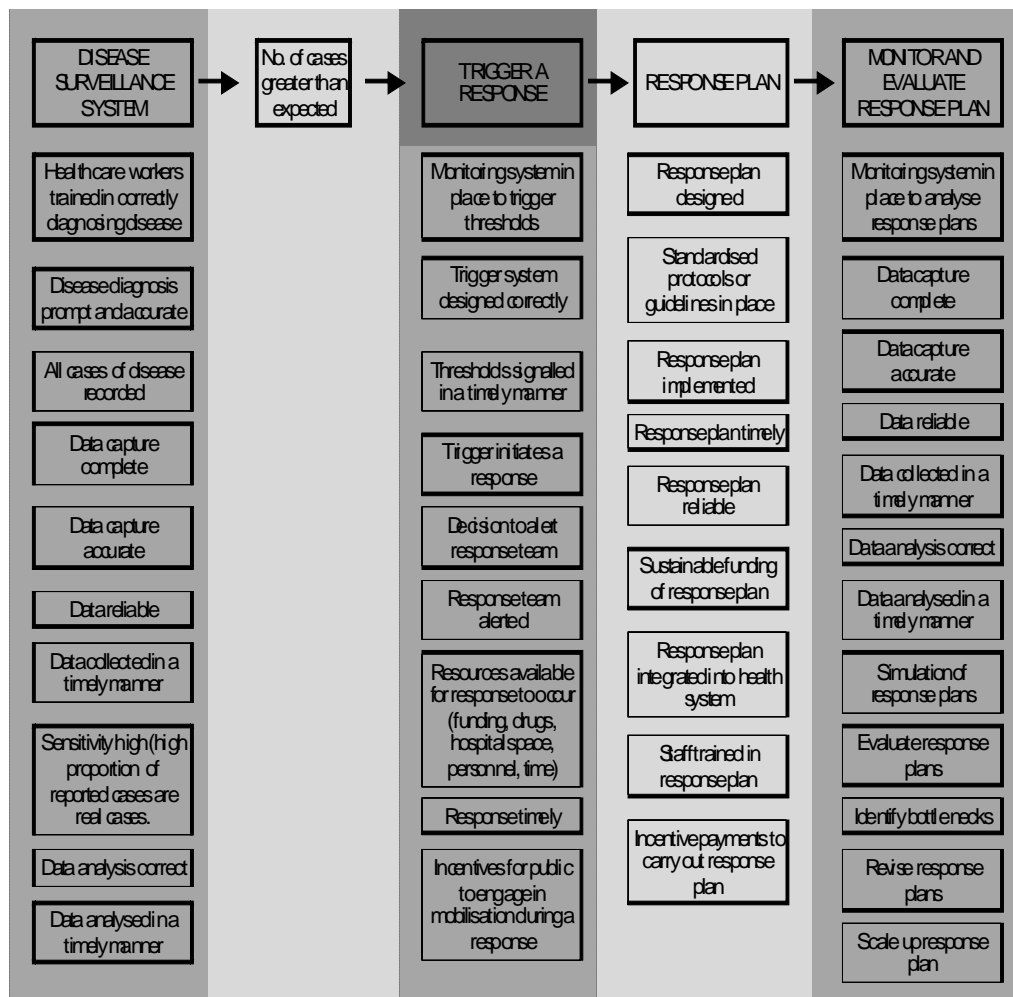
All information provided by interviewees is confidential and non-attributable. The interviews may be recorded in writing or on audiotape with the permission of the interviewee and transcribed verbatim for detailed thematic analysis.

An optimal response plan was created with key questions to assess the preparedness of health to changes in dengue fever as a result of climate change. Having

developed the toolkit, it was tested in the Bangkok case study, with Professor Rifat Atun (Section 6). The toolkit has since been reviewed and revised.

Creation of this toolkit is especially important in the light of the change in the patterns of these infectious diseases as a result of or reasonably attributable to climate change, increasing the need for a coordinated and integrated approach to vector control.

Figure 2.1 Optimal response plan for vector-borne diseases



3. BANGKOK CASE STUDY

3.1 Background

The developed toolkit (Please see 6.1 Toolkit topic guide) was tested on the Thai health system. Thailand was chosen since it is globally renowned for its well-functioning health system. Thailand is a middle-income developing country with an integrated health system and it is also being affected by climate change. Since Thailand has integrated a number of health programmes into its health systems, it should be well-positioned to respond to changes in dengue fever reasonably attributable to climate change.

Through the WHO Centre for Health Development, the WHO Regional Office for South-East Asia (WHO SEARO) and the WHO Country Office Thailand, meetings were organized with key staff at the Ministry of Public Health, Bangkok Metropolitan Administration (BMA), Faculty of Tropical Medicine and Faculty of Science of Mahidol University and various Health Offices in Ayutthaya province. Mahidol University was chosen since it is one of the leading universities in tropical medicine in Thailand, is the Regional Centre for Tropical Medicine for Southeast Asian Ministers of Education Organization (SEAMEO) and has several WHO Collaborating Centres in its fold.

The primary research was inherently difficult since it consisted of a new territory and a new field. The interviews were at multiple levels and involved multiple stakeholders. This qualitative work was robust since Prof Rifat Atun and Dr Pauline Brocard, principal investigators, both attended the meetings, enabling better facilitation and observation. The researchers followed a triangulation and inductive approach as they were constantly discussing findings between meetings.

In addition to understanding how a health system might be able to respond to changes in dengue fever reasonably attributable to or as a result of climate change, the aim of this exploratory case study is to identify how a response might be mounted in the Thai health system as a result of perceived changes in the environment. Other key questions are: What systems are in place to cope with possible increases in incidence of dengue fever as a result of climate change? What are the thresholds? Who will make the decisions? To what extent is climate change associated with changes in incidence?

To mount a response the competencies needed are to have vigilance and respond rapidly. With health systems, the appropriate strategy is organizational effectiveness rather than competitiveness or profit maximisation as seen with commercial organisations.

The researchers organised meetings with key people at the Ministry of Health, Mahidol University, and Health Offices in and around Bangkok. The visit was mainly focused on how Thailand is mounting a response to increased incidence of dengue fever as a result of climate change. Meetings were organised with provincial health offices to explore the understanding and awareness of these issues in the field.

The meetings were sound recorded with permission, and later transcribed. The interview notes are not included here due to confidentiality but are available on request. Direct quotes will be referenced by name of institution, to keep interviewees pseudo-anonymised.

3.2 Changing climate and perceived impact on dengue

3.2.1 Views from various bodies

“Rain and dengue fever are highly correlated” (Mahidol University Faculty of Tropical Medicine). “Dengue incidence increases and decreases every 1-3 years” (Faculty of Tropical Medicine, WHO Thailand Office). “This could be due to population immunity or different serotypes that cause more cases” (Ayutthaya Provincial Office). “In 2008, the Ministry of Health reported that the number of cases increased by 40% compared to 2007. The Ministry has been issuing warnings about this since February, as this is the dry season and usually very quiet” (Faculty of Tropical Medicine).

“Temperature has increased. It is difficult to say if this has affected the number of cases. Scientific evidence shows that an increase in temperature shortens the incubation period, increasing the period that infection can occur. Research also shows that the parasite develops more quickly in mosquitoes. In addition, the mosquito itself develops faster” (Bureau of Vector-borne Diseases).

“The alert for dengue may now last all year, because it is becoming less seasonal. This year the alert started in January, which is very unusual” (WHO Thailand Office).

“Researchers do not have the information which can determine whether this trend is due to climate change or not, but they have started thinking about it” (Faculty of Tropical Medicine). “Researchers have never touched on this issue” (Sena District Health Office).

“Our difficulty is that we cannot predict. We have not tried to collect the information to see what is the component contributed by the weather change” (Faculty of Tropical Medicine). “We do not know about decomposition analysis - controlling for seasonal cycles and longer term 2-3 year cycles” (Bureau of Vector-borne Diseases).

3.3 Health system preparedness

3.3.1 Disease surveillance system

“All diseases apart from malaria are integrated into the health system” (Bureau of Vector-borne Diseases) (WHO Thailand Office).

“Not all cases of dengue fever are reported, since only 10% of patients in Thailand have symptoms and go to a health centre. The other 90% of patients do not go to a health centre since they have only mild or no symptoms” (Bureau of Vector-borne Diseases). “100% of dengue haemorrhagic fever (DHF) cases are recorded since all the patients go to hospital” (Faculty of Tropical Medicine). “There are no resources for active case detection at Sena District Health Office. The Faculty of Tropical Medicine has done a serum survey of schoolchildren, identifying the presence of immunoglobulin G (IgG) antibodies. In schools, 80% of children had IgG present, which shows that a high proportion were either immune, ill and asymptomatic, or had only mild symptoms” (Faculty of Tropical Medicine).

3.3.2 Triggers for response

What is the threshold for a response to a dengue fever outbreak?

“If the number of cases for cold season (November to January) is high, as it was in 2008, then there is likely to be a problem in the following hot season (April to August). With more mosquitoes, there are more larvae. If this happens and the implementers cannot control the number of larvae, then the number of cases in hot season will be high” (Bureau of Vector-borne Diseases).

“Warnings should be announced every year for dengue when rainy season starts. There are no specific thresholds” (WHO Thailand Office).

“The threshold is the 5-year median +/- two standard deviations” (Bureau of Vector-borne Diseases).

“The warning system was developed maybe 6-7 years ago. Now we are trying to modify it for better detection. It stopped working because the sensitivity and specificity need to be adjusted. We use the concept of a very simple Poisson” (Faculty of Tropical Medicine).

What is the response?

“SRRT is Surveillance Rapid Response Team – responding to all diseases including dengue fever” (Bureau of Vector-borne Diseases).

“When there is one case, we send a team to control by spraying to reduce the number of infected mosquitoes within 100 m. We control the larvae by emptying containers, education, and re-dipping bednets” (Bureau of Vector-borne Diseases).

“For every single case, we use all available resources” (Ayutthaya Provincial Office).

“When we reached 15 cases of dengue fever in September (2007), we held a war room meeting, and continued with monthly war room meetings as the trend continued increasing. We sent extra teams to help regions, had more cooperation with volunteers, more health education, but the disease was still increasing. We did not understand why it happened. We put all of our efforts in. We think there was not enough participation by the community” (Sena District Health Office).

“If one district has a greater number of cases, increase the number of teams in that area. Have a campaign. If more problems emerge, mobilize other health workers. We have a very flexible system in place” (Ayutthaya Provincial Office).

“We divide teams and use nurses. We get Disease Control Division of BMA to help; ask the Ministry of Public Health and mobilize support from communities” (Chatuchak District Health Office).

3.3.3 Response plans

Do you have a response plan for an increase in dengue as a result of climate change?

“Dengue has to be visible to gain public attention and the collaboration of health workers and the public. There are competing priorities. Communication is not a problem. People are aware. But the difficulty is changing behaviour” (Ayutthaya Provincial Office).

“No. Not at all. It has to be Ministry policy. I think they prepare disaster management plans for climate change and national disaster management plans for other diseases. Now they recognize

disasters like storms. They are aware of climate change. But for dengue they have no system. Policy-makers at the Ministry of Health do not recognize climate change as important. It is still at the research stage” (Faculty of Tropical Medicine).

Do you have a response plan for other diseases or disasters?

“For heat waves, we asked a disease expert ‘What should we do?’ We have learnt a lot. We have a protocol and response team” (Bureau of Vector-borne Diseases).

“From the Severe Acute Respiratory Syndrome (SARS) experience, we trained every district team, regional office and provincial team. We have also done simulations. For sub-districts we have smaller teams that gather health volunteers and staff from other ministries – agriculture, education” (Bureau of Vector-borne Diseases).

“Simulations are held once a year. We have evaluated simulations for avian flu and plane crashes. We have to budget for this, and funding for every province, and for capacity building. However, the quality depends on the capacity of people, which is affected by them moving to higher positions or to other sectors” (Bureau of Vector-borne Diseases).

“After the tsunami, we held a table-top exercise” (Faculty of Tropical Medicine).

“Yes for floods, bird flu, fires and collapsed buildings. But not for dengue” (Chatuchak District Health Office).

3.3.4 Monitoring and evaluation of response effectiveness

There are no response plans for increases in dengue fever as a result of climate change, and so no questions were asked about this.

3.3.5 Suggested improvements

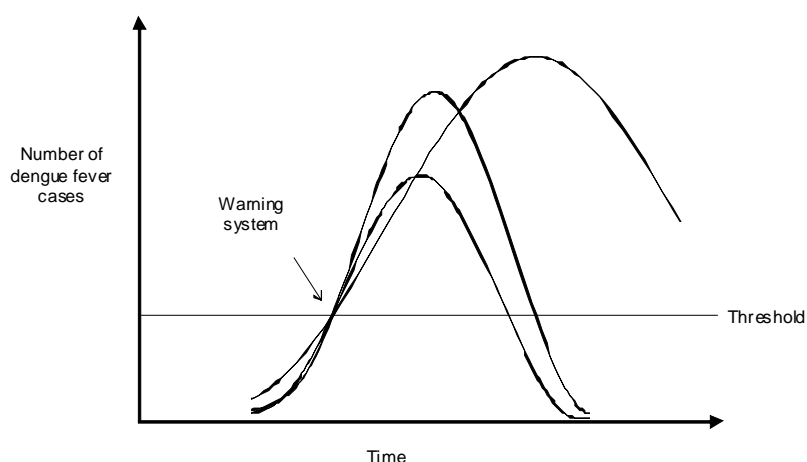
The incidence and prevalence of dengue fever is currently underestimated due to patients with mild or no symptoms not going to hospital. This is an issue that needs to be addressed via mobilization of resources for active case detection. If the ratio of reported versus unreported cases was estimated then it would be possible to have a better estimate of dengue fever incidence. It is difficult to manage something that is not accurately measured. Many places, including Sena District Health Office and Chatuchak District Health Office, record DF and DHF combined. It would be better to report these separately, especially since dengue is extremely under-reported compared to almost 100% recording of DHF.

The data analysis of disease surveillance is extremely simple with only basic descriptive statistics, making it difficult to understand the underlying trends of dengue fever. Dengue fever needs more complex statistical analysis such as decomposition analysis, Conditional Autoregressive model, Age-Period-Cohort (APC) model, geostatistical model, or Silawan Seasonal autoregressive integrated moving average (ARIMA) model (Altizer, 2004, Smith, 1995, Fukuda, 2008, Gemperli, 2006, Silawan, 2008).

There are response teams in place but since they respond to every single case, the health workers believe that they are doing everything they can. This is considered a very reactive system and not a proactive one. If cases increase dramatically, there is no plan to rapidly respond.

As a result of climate change, not only is the number of cases increasing, but the curve of dengue incidence may be changing (Figure 3.1). If the Thai health system continues as it is, it will continue to respond, but the response mode will not change. At some point the Thai health system will need to mount a large-scale response instead of increasing incrementally with each case.

Figure 3.1 Projected scenarios of dengue incidence



There are several bottlenecks of triggering a response that have been identified, from resilience, to decision-making, to drug supply issues. The Thai health system can currently cope with a 10-20% increase in cases. It would need to develop flexible resources to respond to an increase in cases of greater than 20%. It is not clear who makes the decision to respond. This may lead to communication issues.

Ministry of Health and health offices seem to be not aware of the potential of climate change to alter the disease patterns of dengue fever dramatically. There are other priorities. As a result there are currently no response plans in place for this.

“We can take care of problem. It is a question of prioritisation. If it is a threat or not. It is not thought of as urgent.” (Faculty of Tropical Medicine)

The Thai health system has protocols and simulations for heat waves and SARS, and so there are systems in place, and there are resources and capabilities to develop response plans. However, as can be seen from the French heat wave in 2003 and the Brazil dengue outbreak in 2007, although these were very good health systems, they had a high mortality rate as no plans were in place. It took longer for decisions to be made and for resources to reach the disaster areas (Vandentorren S & Empereur-Bissonnet P 2005, Pascal M 2006, Chiaravalloti Neto F 2007, Medronho 2008). The Thai health system needs to translate the organizational learning from other disasters and from other settings to dengue fever.

The response plans would need to be assessed once they were in place.

4. DISCUSSION

There are many peer-reviewed papers reflecting awareness of the potential changes in dengue fever as a result of climate change. However, there are no such papers looking specifically at the preparedness of health systems and plans to respond to changes in dengue fever reasonably attributable to climate change.

A toolkit was developed to assess the preparedness of health systems to changes in dengue fever reasonably attributable to climate change.

Thailand has a system for monitoring and responding to dengue fever. Response to cases is greater than expected, with a specific response team being sent out to the site of every case reported. However, with this reactive vector control strategy there is no system in place to identify long-term changes in dengue fever, and no response plan for changes as a result of a warmer climate.

There is collaboration, innovation and enthusiasm at health centre level. However, there is an organizational issue in response, since the system is complex. There are good surveillance systems in place, but there are organizational issues in the field.

The current researchers are the first group ever to explore how the Thai health system would cope with a sudden increase in dengue fever reasonably attributable to climate change. This is a good initiative to encourage awareness of this issue and the need to create a response plan in the Ministry of Health.

As a result of this case study, the toolkit created has been evaluated and revised. This toolkit could be used in different countries as a rapid assessment test. Gaps in health systems could be identified, and then guidelines could be formulated to aid health system preparedness to changes in dengue fever reasonably attributable to climate change.

4.1 Strengths and weaknesses of the study

This study was carried out in collaboration and coordination with the World Health Organization. It explores a new territory, follows robust methodology, develops a new toolkit and evaluates it with a case study in Bangkok. Systematic reviews have been carried out to a high standard, following the Cochrane guidelines.

Meetings were held in Bangkok with many people (48), and included the following key people from the Thai health system: the Director of the Bureau of Vector-borne Diseases at the Ministry of Public Health, Directors of Disease Control Division at several District Health Offices, the Director of SEAMEO TROPMED and the Dean of Faculty of Tropical Medicine, and a National Professional Officer at the WHO Thailand Office. The meetings were facilitated by Professor Rifat Atun, a leader in rapid assessment toolkits and with knowledge of the Thai health system. Having two people interviewing improved the robustness, since one person could facilitate, whilst the other took notes and observed. The interviews were sound-recorded and transcribed. After the meetings, the principal investigators would discuss observations and identify key results, strengthening the case study.

Data on dengue fever for a district were given to us after the meetings. However, the dataset covered too small an area, and did not include climate data, so it was not possible to carry out complex statistical analysis to take account of seasonality and to identify an underlying trend. Unfortunately it was not possible to further explore the surveillance system. Efforts were made to meet with or discuss with Dr Supavadee Chonchom, the officer-in-charge of malaria statistics in the Bureau of Vector-borne Diseases of the DDC, who developed the surveillance system with warning signals. Unfortunately, she was unavailable for a meeting or to comment.

4.2 Possible implications for policy-makers

Policy-makers need to become aware of the risks of increases in dengue fever and change in its geographic range reasonably attributable to climate change and to then prioritise the development of response plans for this.

4.3 Further research

Recommendations for future work include the following:

- Collect disease and weather data from Thailand. Carry out decomposition analysis to identify the key underlying trends. The results can then be used to engage policy-makers.
- Analyse the health system preparedness of Thailand for changes in the malaria epidemic due to climate change.
- Carry out other case studies, which could further validate the toolkit. As a result of these assessments, guidelines could be written on how to develop response plans to increases in dengue fever reasonably attributable to climate change, and the importance of creating these.

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6. APPENDICES

6.1 Toolkit topic guide

Evaluation criteria for identifying the preparedness of national health systems to changes in dengue fever reasonably attributable to climate change

1. Disease surveillance system

- 1.1 Are health care workers trained in correctly diagnosing the disease?
- 1.2 Is diagnosis of the vector-borne disease prompt and accurate?
- 1.3 Are all cases of disease recorded? Why or why not?
- 1.4 Is data capture complete?
- 1.5 Is data capture accurate?
- 1.6 Are the data collected reliable?
- 1.7 Are data collected in a timely manner?
- 1.8 What is the sensitivity (the proportion of reported cases that are real cases)?
- 1.9 Are the data analysed?
 - 1.9.1 How have the data been analysed? Why?
 - 1.9.2 Who analyses the data?
 - 1.9.3 How often are the data analysed?
- 1.10 Are the data reported? In what format are the data reported? Why?
 - 1.10.1 Who sends the data reports?
 - 1.10.2 Who receives the data reports?
 - 1.10.3 How often are the data reports?

2. Triggering a response

- 2.1 Is there a monitoring system in place that triggers a response after the number of cases reach a threshold?
- 2.2 How does the monitoring system work?
- 2.3 What is the threshold?
- 2.4 How long does it take once the threshold has been reached to trigger a response?
- 2.5 Is a response initiated?
- 2.6 Who is notified if the threshold has been reached?
- 2.7 Who decides to alert a response team?
- 2.8 How long does this decision process take?
- 2.9 What does a response consist of?
- 2.10 Who is part of a response team?
- 2.11 How long does it take for a response team to act once they have been alerted?

- 2.12 What resources are in place to allow a response?
- 2.13 Is there adequate funding for a response to take place?
- 2.14 Are there adequate drugs for a response to take place?
- 2.15 Is there adequate hospital space for a rapid increase in cases?
- 2.16 Are there adequate personnel to respond?

3. Are there incentives for the public to engage in mobilization during a response?

4. Response plans

- 4.1 Are there response plans?
 - 4.1.1 Who decided to have response plans?
 - 4.1.2 Who designed the response plans?
 - 4.1.3 What are the response plans?
- 4.2 Are there standardised protocols or guidelines in place?
 - 4.2.1 What are the protocols or guidelines for the response plans?
 - 4.2.3 Have the standardised protocols or guidelines been adapted to the local context? If so, how?
- 4.3 Have the response plans been implemented?
- 4.4 What is the timeliness of the response plans?
- 4.5 What is the reliability of the response plans?
- 4.6 Are there adequate funds for the response plans to be sustainable?
- 4.7 Are the response plans integrated into the health system?
- 4.8 Are staff trained in the response plans?
 - 4.8.1 If yes, what are they trained? Who by?
- 4.9 Is the willingness to participate in the response plans high? Why or why not?
- 4.10 Can the response plans be scaled up and adapted to other environments?
- 4.11 Are there incentive payments for the key people carrying out the response plans?

5. Monitoring and evaluation of response plan

- 5.1 Have the response plans been evaluated?
 - 5.1.1 What were the results?
- 5.2 Is there a monitoring system in place to analyse the response plans?
 - 5.2.1 If so, what monitoring system is in place?
- 5.3 Which of the following have been used to evaluate performance of the response plans:
 - Mosquito numbers
 - Incidence (no. of new cases for a time period)
 - Prevalence (no. of total cases at a given time)
 - Mortality

- Number of ITNs being used
 - Knowledge of disease prevention and vector control by the community
 - Behaviour to prevent disease and control vectors by the community
- 5.4 How are the data captured?
- 5.4.1 Who collects the data?
- 5.4.2 How frequently are the data collected?
- 5.4.3 How complete are the data?
- 5.4.4 How accurate are the data collected?
- 5.4.5 Are the data reliable?
- 5.5 How are the data analysed?
- 5.5.1 Who analyses the data?
- 5.5.2 How often are the data analysed?
- 5.5.3 How long does data analysis take?
- 5.6 Have there been simulations of response plans?
- 5.7 Have bottlenecks been identified?
- 5.8 Have response plans been revised as a result of monitoring and evaluation?
- 5.8.1 If so, how?
- 5.9 Can the response plans be scaled up?

6.2 List of meetings

Attended by Dr Pauline Brocard, MBA Student, and Prof Rifat Atun, Professor of International Health Management (principal investigators), both representing Imperial College London and WHO Centre for Health Development.

Meetings with the Bureau of Vector-borne Diseases, Ministry of Public Health

1. Date: 21 August 2008 (am)

Duration: 00:56

Meeting attended by:

Wichai Satimai, Director, Bureau of Vector-borne Diseases, Ministry of Public Health

satimai@health.moph.go.th

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

2. Date: 21 August (am)

Duration: 01:27

Meeting attended by:

Miss Saowanit Vijaykadga, Chief, Malaria Cluster, Bureau of Vector-borne Diseases, Ministry of Public Health saowanit@health.moph.go.th

Mr Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with WHO Thailand Office

3. Date: 21 August (am) and 22 August (am) **Duration:** 01:30

Meeting attended by:

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

chawalit@searo.who.int

Meeting with Faculty of Tropical Medicine, Mahidol University

4. Date: 21 August (pm)

Duration: 01:17

Meeting attended by:

Pratap Singhasivanon, Director, SEAMEO TROPMED, Dean, Faculty of Tropical Medicine, Mahidol University tmpsh@mahidol.ac.th

Wijitr Fungladda, Associate Professor, Faculty of Tropical Medicine, Mahidol University

Phanorsri Attanath, Deputy Dean for International Relations, Faculty of Tropical Medicine, Mahidol University

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with Ayutthaya Provincial Office

5. Date: 22 August (am)

Duration: 01:41

Meeting attended by:

Prasit Kongkaoropdham, Deputy Provincial Chief Medical Officer, Ayutthaya Provincial Health Office pskkrt206@hotmail.com

Chaeweevon Sathienchok, Head of Health Promotion Section, Ayutthaya Provincial Health Office numhom@gmail.com

Podjane Chomvicha, Head of Disease Control Section, Ayutthaya Provincial Health Office

Saowaluk Vijitbunjung, Responsible for TB Control, Ayutthaya Provincial Health Office

Songwut Krajangyao, Responsible for DHF Control, Ayutthaya Provincial Health Office

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with Sena District Health Office

6. Date: 22 August (pm)

Duration: 01:40

Meeting attended by:

Anan Jantararat, Head, Sena District Health Office

Suthat Toloi, Public Health Technical, Sena Hospital suthat_ron@hotmail.com

Tanatchai Pattanavasit, District Health Officer, Sena District Health Office

Manop Wattanaphan, Public Health Technical Officer, Sena District Health Office

Korkiat Pongmuang, Public Health Officer, Sena District Health Office

Chaeweewon Sathienchok, Head of Health Promotion Section, Ayutthaya Provincial Health Office

Saowaluk Vijitbunjung, Responsible for TB Control, Ayutthaya Provincial Health Office

Songwut Krajangyao, Responsible for DHF Control, Ayutthaya Provincial Health Office

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with Samkhor Health Centre, Sena District, Ayutthaya Province

7. Date: 22 August (pm)

Duration: 00:30

Meeting attended by:

Pattaranan Meesema, Head, Samkhor Health Centre

Rerk-artit Popangpum, Nurse Practitioner, Samkhor Health Centre

Suthat Toloi, Public Health Technical, Sena Hospital

Tanatchai Pattanavasit, District Health Officer, Sena District Health Office

Wattanaphan, Public Health Technical Officer, Sena District Health Office

Korkiat Pongmuang, Public Health Officer, Sena District Health Office

Chaeweewon Sathienchok, Head of Health Promotion Section, Ayutthaya Provincial Health Office

Saowaluk Vijitbunjung, Responsible for TB Control, Ayutthaya Provincial Health Office

Songwut Krajangyao, Responsible for DHF Control, Ayutthaya Provincial Health Office

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with London School of Hygiene & Tropical Medicine

8. Date: 22 August (pm)

Duration: 01:00

Meeting attended by:

Richard Coker, Reader (Communicable Diseases Policy Research), LSHTM richard.coker@lshtm.ac.uk

Meeting with Chatuchak District Health Office, BMA

9. Date: 23 August (am)

Duration: 02:08

Meeting attended by:

Parnrudee Manomaipiboon, Director of Disease Control Division, Health Department, BMA

parn2507@yahoo.co.th

Pornpimol Kijnitinan, Disease Control Technical Officer, Vector Control Sub-division

Kanyarat Sirinai, Environmental Sanitation, Chatuchak District

Somporn Dumrongsin, Disease Control Technical Officer, Dengue control and Prevention Centre

Anehitta Wilaiwas, Health Volunteer, Nakorn Laung community

Montha Buakird, Chief Nurse of Public Health Centre 51

Kanjana Khongartvanit, Nurse, Health Centre

Titiporn Han-Idhikul, Nurse, Health Centre

Wera Pusuwan, Chief of Environment and Sanitation, Chatuchak district

Aree Pimgate, Sanitation Technical Officer, Chatuchak district

Renu Suesattaya, Sanitation Technical Officer, Chatuchak district

Sompis Oatwaree, Chief of Vector Control Section, Disease Control Division

Kasinee Tongjunjuar, Sanitation Technical Officer, Chatuchak district

Jitrudee Taingchaiyaphum, Sanitation Technical Officer, Chatuchak district

Jongjai Jongaramraung, Sanitation Technical Officer, Chatuchak district

Kassawan Chamchoy, Sanitation Technical Officer, Chatuchak district

4 student nurses, Ramathibodi Hospital

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

Meeting with Research Centre, Faculty of Science, Mahidol University, Nakhon Pathom Province, Salaya District

10.Date: 23 August (pm)

Duration: 01:37

Meeting attended by:

Patamavadee Kittayapong, Associate Professor, Mahidol University

grpkt@mahidol.ac.th, pkittayapong@msn.com

Yves Charpak, Director International Affairs, Institut Pasteur, Paris, France

Abdo Malak, Attaché de Coopération Scientifique et Universitaire, French Embassy, Bangkok, Thailand

Somwang Kurusartra, PhD Student, Bangkok joe_somwang@hotmail.com

Amy Henry, PhD student, Hawaii

Chawalit Tantinimitkul, National Professional Officer (CDS), WHO Thailand Office

6.3 List of acronyms and abbreviations

BMA	Bangkok Metropolitan Administration
CDC	Centres for Disease Control and Prevention
CDS	Communicable Disease Surveillance
DDC	Department of Disease Control
DF	Dengue fever
DHF	Dengue haemorrhagic fever
IRS	Indoor residual spraying
ITN	Insecticide treated net
LLIN	Long lasting insecticide impregnated nets
MOH	Ministry of Health
MoPH	Ministry of Public Health
SEAMEO	Southeast Asian Ministers of Education Organization
SRT	Special Response Team
SRRT	Surveillance and Rapid Response Team
SYSRA	Systemic Rapid Assessment Toolkit
WHO	World Health Organization
WKC	WHO Kobe Centre

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