Dengue and chikungunya virus infection in Southeast Asia: active governmental intervention in Republic of Singapore

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Summary. This paper discusses countermeasures of Republic of Singapore towards mosquito-borne infectious diseases, particularly, dengue and chikungunya virus infection to identify an essential factor in controlling emergence of infectious diseases. In spite of expanding areas affected by and upsurge of these diseases in the region, the tropical urban country is known to have sustained an effective vector control, which often resulted in moderate prevalence and/or quick control of domestic outbreaks. This research has adopted an inter-disciplinary review of previous studies combined with field studies: interviewing at the Ministry of Health, Singapore and the National Environment Agency, Singapore; visiting a laboratory and hospitals; and observing on-site vector mosquito surveillance operations conducted by the agency. The findings have pointed out the national vector surveillance and control system implemented by 1970s, followed by improved countermeasures like vector and virus surveillance which have incorporated science and technology especially in the last two decades. The analysis produces an influential role of a government in promoting and supporting public health measures, which have been typically demonstrated through inter-ministry collaboration, public-private cooperation, and community involvement. In light of increasing transnational nature of emerging infectious diseases, Singapore's contribution in the region like sharing its knowledge of and experiences in dengue and chikungunya virus infection is illustrated. The resilient model of Singapore's vector control and governmental action warrants a further study to investigate transferability in other parts of the region.

Keywords: Singapore, governmental intervention, *Aedes* mosquitoes, dengue, chikungunya

1 Background

One can find in Singapore a government that desires to protect health of the people while preserving economic and trade activities in the ages of globalization. Singapore has maintained an impressive track record in responding to emerging and re-emerging infectious diseases (hereinafter expressed as emerging infectious diseases). For example, it was the year of 2003 when the country attracted waves of praise as a successful country in handling the outbreak of severe acute respiratory syndrome (SARS). Also, Singapore's resilient vector control management for mosquito-borne infectious diseases is noteworthy. The "energetically sustained" dengue control program is acclaimed as "a model for the rest of the world" [1]. Although a considerable number of studies on its outbreak response, surveillance, prevention, and disease management have been conducted by the medical and science community, others often attribute Singapore's outstanding infectious disease control to the small territory and economic affluence alone. Medicine and science-oriented studies, too, tend to pay little attention to factors that are not scientifically proven. What seems to be lacking is an inter-disciplinary investigation of emerging infectious disease countermeasures. This paper attempts to elucidate an active role of the Singapore Government in facilitating and sustaining satisfactory response to emergence of infectious diseases. The government here refers to the governing body consisting of politicians and the public servants engaged in the service of the supreme authority. This paper limits the discussion to Singapore's action against dengue fever (DF), dengue hemorrhagic fever (DHF)/dengue shock syndrome (DSS) (hereinafter abbreviated as dengue infection) and chikungunya viral infectious diseases. We will first review how the young nation, having become an independent state only in 1965, came to establish its national vector surveillance and control system by 1970's. Next, elaborating Singapore's measures in the recent decades, we reveal the heavy emphasis placed on the scientific research in public health tools in the country, which has been remarkably evident since 1990's. Finally, we will devote some space to the discussion of Singapore's role and capacity in a regional effort to control dengue infection.

1.1 Singapore: tropical city-state in Southeast Asia

Situated 137km north of the equator, highly populated Singapore is often referred as a tropical city-state. Population density was 6,814/km^2, heterogeneous Singapore citizens and permanent residents represented 75% of 4.84 million total population (mid-year estimates, 2008) [2]. Besides frequent travels of residents, mobility of people in Singapore is marked by transnational movements, especially considerable influx of foreign labor and overseas travel. In fact, residents recorded just 65.6% of labor force participation [2]. About 10.12 million tourist arrivals (excluding Malaysians arriving by land) show as high as 72% come from Asia, one-half of which are from ASEAN member countries [2]. Being a regional hub of frequent movements of people as well as trades and economy, the congested urban country pays careful attention to mosquito-borne infectious diseases spreading in the region. With constant import potential of viraemic humans, its hot and humid tropical climate of Singapore permits another threat: propagation of mosquitoes throughout the year including *Aedes aegypti* and *Ae. albopictus* that serve as vectors of dengue and chikungunya viruses.

1.2 Chikungunya and dengue infectious diseases

Chikungunya virus (CHIKV) is a single-stranded RNA virus (family *Togaviridae*, genus *Alphavirus*) and is known to be transmitted by the same vector species causing dengue infection. As of March 2008, 35 countries have reported domestic CHIKV infection and the list includes almost all Southeast Asian countries including Singapore [3]. Section 4.5 summerises Singapore's response to the first and subsequent domestic outbreaks in 2008.

The agent of dengue infection is also a small single-stranded RNA virus (family *Flaviviridae*, genus *Flavivirus*). A dengue infection cycle starts when a female *Aedes* mosquito bites an infected human, acquires competence to mediate, and then bites another person(s). There are four serotypes of dengue virus, DEN-1, -2, -3, and -4 and infection with one serotype could provide a lifetime protection to the particular serotype. Cautions are, therefore, required against the subsequent infection with other serotypes.

The World Health Organization (WHO) has analyzed factors contributing to the global burden of dengue infection. Examples are rapid population growth, migration between rural and urban locations, and transnational travel by infected persons and goods [4, 5]. The international health authority often cites that the vector control is the sole preventative tool currently available and maintains that "[d]espite the availability of effective tools to control dengue, efforts to prevent and control dengue have been constrained due to lack of sustained political commitment, inadequate resources and lack of coordinated effort" [6].

2 Method

The present study has benefited from inter-disciplinary research of previous studies and 10 fieldworks between September 2006 and August 2009. Research activities during the field trips to Singapore included: document collection; interviews with ministry personnel from the Ministry of Health (MOH), Health Promotion Board under the MOH, and the National Environment Agency (NEA) under the Ministry of the Environment and Water Resources; visits to the NEA's laboratory called Environmental Health Institute (EHI) as well as public and private hospitals; and observing two on-site inspections of the NEA. Particularly insightful were the larval surveillance and adult trapping operations performed by the South East Regional Office of the agency. The operations covered private houses, public high-rise residential buildings (known locally as HDB flats, Figure 1), and a construction site of a condominium (Figure 2) in September 2008 and March 2009 [7,8]. In addition, the author attended the inaugural Asia-Pacific Dengue Program Managers Meeting convened by Western Pacific Regional Office of the WHO (WPRO) and co-sponsored by the NEA in May 2008 [9]. In August 2007, the author visited the regional office of the WPRO in Manila, the Philippines to learn views and activities of the international health authority.

3 Result: Singapore's resolute efforts to fight against dengue infection

3.1. Establishment and improvement of vector surveillance and control system in 1960s to 1970s

Known as breakbone fever, DF has been prevalent for centuries and DHF first occurred in the Philippines in 1953 [10]. The first DHF outbreak struck Singapore in 1960, one year after it attained a self-government status ahead of the country's birth as an independent state in 1965. The Vector Control Unit (VCU) was formed in 1966 initially under the MOH and was later transferred to the Ministry of the Environment in 1972 [11].

Fig. 1 An example of public high-rise residential buildings (HDB flats). The NEA's vector control strategies are modified depending on different structures and characteristics of buildings.

Fig. 2 A construction site of a condominium; inspecting construction sites is an important vector control effort in Singapore.

Goh KT (1983) elaborated activities of the VCU: it gathered ecological and biological data such as vector distribution and density, location of breeding habitats, and seasonal fluctuations in vector population. Chan KL (1985) pointed out that several entomological surveys of slum areas around that time suggested the evidence of huge *Ae. aegypti* inhabitants, supporting a close correlation between DHF and poverty [10]. Evidently, this finding led the young government to address the environmental issue, including replacement of slum houses and cleaning of residential areas. To deal with a challenging task to transform human behavior, the Singapore Government decided to use law enforcement and health education: the Destruction of Disease Bearing Insects Act was enacted and the "Keep Singapore Clean and Mosquito-free Campaign" was designed to motivate the community to participate in the countrywide vector control program in 1969 [10].

In addition to the adult mosquito surveillance began in 1966, a weekly *Aedes* larval routine survey in premises became operational in June 1971. Subsequently, the incident rate of DHF dropped; morbidity rate per 100,000 was 42.15 in 1968 [12] and remained between 3 and 10 for the period from 1969 to 1972 [13]. However, optism resulting from low level of incidence might have translated into 1,187 cases with 27 deaths in 1973[13]. The vector surveillance became even more crucial to establish the knowledge of "the normal level" of vector density, which enabled the VCU to calculate a premise index (PI) or a percentage of premises positive for *Aedes* breeding to estimate dengue virus transmission risks. Wherever a PI exceeded 5%, the VCU fogged the area with insecticides to eradicate the adult mosquitoes. As priorities of breeding habitats kept shifting owing to the vector behavioral change, the breeding sites elimination task became difficult in a cat-and-mouse game. To address the issue, the repeated evaluation and feedback system was used in1960s and 1970s, which became useful to review and amend strategies (Figure 3). In addition, the regulatory requirement made dengue infection legally notifiable in 1977 under the Infectious Diseases Act of 1976 while DHF had been already made administratively notifiable in 1966 [11,12,13].While the rest of the Southeast Asian region experienced epidemics in 1976 and 1977, the vector control system contributed to low frequency of DHF in Singapore [10]. Singapore benefited from the reduced vectors for a period of almost 15 years after recording 384 cases in 1978. Its vulnerabilities to importation of dengue infection, however, existed as long as the disease was endemic in the region [11,12].

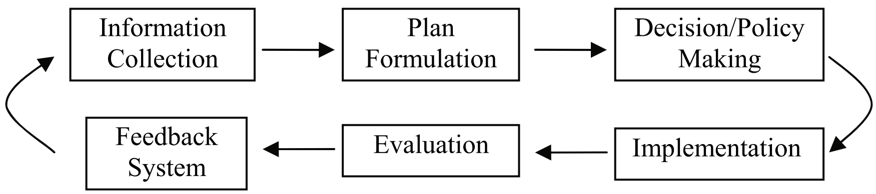

Fig. 3 Basic steps in DHF vector control in Singapore in 1960s and 1970s.
Source: Reconstructed by the author from Chan KL (1985).

3.2 Emphasis on scientific researches in 1990s and 2000s

By the 1990s, the city-state saw the resurgence of dengue infection. In addition to the expansion and escalation of the diseases in the region, the previous diligent vector control possibly fueled the situation as the low prevalence of the disease generated the large susceptible human populations due to reduced herd immunity [14]. There was, however, another contributing factor: by then, the labor intensive vector control had been changed to respond to human cases instead of a higher PI in response to a call for efficient usage of public resources [14]. Areas “at risk” may not be sufficiently discovered by case detection [15] as Ooi EE et al. (2006) has illustrated: this shift inevitably overlooked risks that were hidden by subclinical cases [14]. Seeing the dengue infection increase from 3,128 cases in 1996 to 4,300 in 1997, and to 5,258 in 1998, the government set up in 1998 an educational program and launched volunteer groups. Active persuasion of the community began. A political leader’s involvement was evident in the following quotation:

> The best way to protect yourself and your family from dengue fever is to make sure that the mosquitoes do not have a chance to multiply in your homes and neighborhood. Unfortunately not enough residents make the special effort necessary to prevent *Aedes* mosquitoes from breeding…Residents should therefore come together as a community to get rid of the mosquitoes, and keep the estate free from dengue fever.

The above speech was delivered by then Deputy Prime Minister and current Prime Minister Lee Hsien Loong at the launch of an educational program and volunteer groups in May, 1998[16]. From this passage, we can infer the political will to solve the problem by influencing the residents to become more responsible and cooperative towards governmental intervention. Subsequently, the number of cases declined to 1,355 in 1999, 673 in 2000, 2,372 in 2001, and 3,945 in 2002 [17]. Singapore was able to transform human behavior towards *Aedes* mosquito breeding [15].

However, as transmission outside home premises like construction sites emerged [14], the number of cases jumped to 4,788 in 2003 and 9,459 in 2004 [17]. The large outbreak in 2005 occurred concurrently with the region-wide epidemic [14]. By then, Singapore was even more congested, experiencing nearly doubled population density from 3,245/ km^2 in 1965 to 6,208/ km^2 in 2005 [18]. Replacement of dominant dengue serotypes over the years, “a contributory role” of the rising temperature [19] as well as cumulative precipitation in years 2004-2007 [20] had been also documented. Laboratory confirmed cases amounted to 14,209 comprising 13,816 DF and 393 DHF; 27 fatalities represented the third largest among all notified infectious diseases in Singapore in 2005. Several initiatives deployed and countermeasures reinforced in response are detailed in section 4.1. When the city-state achieved lowering the cases significantly in 2006, the WHO referred Singapore as "a good example of a country that has successfully controlled the mosquito population…" [21]. Reported cases of 3,127 (3,051 DF and 76 DHF) in 2006 represented a decline of 78 % from 2005 [22] and all cases were confirmed by laboratories with one or more tests like anti-dengue IgM antibody, enzyme linked immunosorbent assay (ELISA), and polymerase chain reactions (PCR) [22]. The figure included 2,844 indigenous, 103 imported, and 180 cases suffered by foreigners of whom the majority is patients having acquired the diseases overseas and sought medical treatment in Singapore [22]. Although the territory wide anxiety was heightened in Singapore when the weekly reported cases indicated as high as 432 during July 1-7th, 2007, the weekly number in 2008 and 2009 remained below both the epidemic threshold of 339 weekly cases and the warning level of 244 [23].

4 Analysis: characteristics of recent countermeasures in Singapore

4.1. Active organizations and mobilization of resources

For dengue infection, Communicable Disease Surveillance Branch at the MOH handles surveillance of human cases while the NEA is responsible for environmental surveillance. In response to an alarming upsurge, the MOH formed an Expert Panel in September 2005. Local and international experts of the panel reached a conclusion that the regular importation of dengue viruses into Singapore was likely to continue "because dengue is a re-emerging disease globally and is endemic in the surrounding regions" [24]. Furthermore, the Inter-agency Task Force was formed around the same time to enhance the communication and coordination among various agencies with the aim to strengthen the countermeasures in the areas of investigation, audit, and infrastructure [25].

Environment Heath Department of the Environmental Public Health Division of the NEA is in charge of vector surveillance, control, prevention, and research operations. As many as 70,000 residential and 3,000 non-residential premises on average are inspected each month [17]. Devices known as ovitraps are deployed across the city-state; an ovitrap is a black plastic container designed to attract female mosquitoes to lay eggs and then trap the emerging adults within the containers. The weekly checks of the ovitraps enable the NEA to detect the presence and types of mosquitoes early and proactively remove mosquito breeding habitats [7]. The department has compiled examples of common and potential mosquito breeding places by types of premises and sites to draw further attention from residents and visitors [26]. In Situation Room at the Head Office, the NEA uses a geographical information system (GIS) implemented in 2003 for the analysis of the distribution of both vectors and infection cases. In December 2005, the agency reinforced its vector surveillance and control system; about 500 officers were conducting routine ground surveillance across the island especially in dengue-prone areas (e.g. construction sites, compounds of landed housing properties, and schools) for the purpose of detection and removal of breeding sites [17]. In 2006, the NEA carried out inspections of approximately 1.5 million premises in addition to over 40,000 ground surveys. Furthermore, the NEA led two intensive source reduction exercises in April-May and July-September [25].

4.2 Information disclosure

The Singapore authorities make the emergence of infectious diseases in the territory known in a timely manner. As for dengue infection, locations of cases and the results of outbreak investigations are made transparent. The MOH also periodically communicates: MOH MedAlert reports outbreaks; MOH Weekly Infectious Disease Bulletin reveals weekly data; Epidemiological News Bulletin analyzes quarterly trends and special topics; and Communicable Diseases Surveillance provides annual overviews and comprehensive data. Additionally, news and updates of the outbreaks are often issued as press releases. All these materials mentioned above are made available on-line. As for the accuracy of the number of reported cases, the following section will clarify. Both residents and visitors often see posters and other warning materials throughout the country especially when dengue cases are on the rise (Figure 4). Thus, it is reasonable to say that Singapore's information is kept widely open to both local and international community.

4.3 Emphasis on science and technology capabilities

While many Southeast Asian countries tend to report only the manifested cases based on clinical diagnoses in general, Singapore is known to report dengue infection inclusively (DF/DHF/DSS). Thus, the variance in reporting system makes it difficult to compare the reported dengue cases for evaluation among countries in the region. This problem may be partly

Fig. 4. A highly visible dengue alert poster at a bus stop.

attributable to underdeveloped costly technology in the region. As for Singapore, there is enough evidence to identify dedication of the government to science and technology development, especially following National Science and Technology Plan 2000 announced in September 1996. The Singapore Government prioritized its policy to make Singapore "the hub for life-science research in Southeast Asia" [27]. The political commitment can be seen as embodied in the grand establishment in 2003: a complex of seven buildings named Biopolis houses the biomedical industry including the EHI, the NEA's laboratory.

Singapore regards laboratory-based virus surveillance as an integral part of the dengue countermeasures. It is important since identification of the antigen and four serotypes could produce scientific data that have significant relevance to epidemiological investigation and disease surveillance. In other words, the findings could suggest or predict potential shift of dominant serotype, which would cause large outbreaks. The EHI adopted a new economical method in 2005 called the multiplex RT-PCR technique with high throughput capability for the screening of dengue viruses [28]. The technology can also facilitate rapid and reliable diagnosis to administer proper clinical treatments [28] even when patients present undifferentiating febrile illnesses. Moreover, an EHI researcher revealed faster and greater horizontal and vertical flight ranges of the dengue vector mosquitoes by conducting "mark-release-recapture" studies at three different locations in the city-state [29], which supplied useful information for vector control operations. In 2008, researchers in Singapore published a diagnostic algorithm allowing early diagnosis or differentiation of dengue infection with an accuracy of almost 85% from other febrile diseases [30]. It can be said that each achievement is a product of government-driven investments in science for health, which Singapore has been active since 1990s. One recent addition was the S$25 million grant announced in October 2009; the Government of Singapore will make available over five years to researches on dengue infection. The research efforts are expected to focus on the development of evidence-based case management and disease prevention and pursue to fill in gaps between bedside and “bench research” [8,31].

4.4 Social management

The battle against dengue infection of the NEA is constituted of not only the vector control and virus surveillance, but also law enforcement and community involvement. Legal compliance of dengue control measures is facilitated through the Environmental Public Health Act and the Control of Vectors and Pesticide Act. The former consolidates and defines the law pertaining to environmental public health and the latter makes it illegal to breed mosquitoes through the section of prohibition on creating conditions favorable to vectors. Examples were (as of February 2007): S$100 fine for the 1st and S$200 for the subsequent offences committed in residential premises; heavier penalties are applied to construction sites as S$1,000 for the 1st, S$2,000 for the 2nd, followed by court appearance and maximum S$10,000 and/or six months imprisonment. The agency can ultimately order the construction companies to stop the work. [32].

Community involvement, on the other hand, is encouraged through various social activities and a series of campaigns. In 2007 when the author visited Singapore for almost two months, an educational community outreach promotion or the indoor “10-minute mozzie wipe-out” initiative which had been implemented in 2005 was actively seen. The community outreach effort by the agency appeared to ensure that knowledge was translated into practice: for example, it reminded the households to check and remove stagnant water at homes like water in flower vases [33]. The educational materials prepared by the NEA included pamphlets, booklets, posters, and audio-visual items in all four official languages of English, Chinese, Tamil and Malay to reach residents, domestic help workers, and so on. Materials addressing construction sites and shipyards showed additional three foreign languages as Singapore has abundant influx of foreign labor as has been pointed out earlier.

In addition, the standard operating procedures (SOPs) reveal Singapore’s action plans for 3Ps, i.e. three sectors of People, Private, and Public (government). The People sector covers grassroots organizations, residential clubs, NGOs, and NPOs while the Private sector means private businesses, associations, etc. The Public could include government ministries and agencies listed in the Singapore Government Directory but the particular dengue SOPs make more direct references to the NEA in terms of source reduction and ULV/outdoor fogging. The SOPs have seven steps of action plans depending on the number of cases: 1, 2, 3-10, 11-20, 21-30, 31-40, and >41 cases [17]. For instance, procedures adhered when two cases of human infection are identified in a particular area: a team of two NEA officers gets deployed for vector control tasks; a member of parliament from the particular constituency and a community leader are informed to take actions; the MOH warns doctors in the affected area; dengue alert poster/banner at the premises are displayed; grassroots organizations are engaged to speak to residents; grassroots members assist with distribution of dengue prevention pamphlets and alert letters to residents; and so on [17]. An excess of 6,000 volunteers from the 3Ps joined the outdoor "carpet-combing" exercise from September 17 to October 22, 2005 and more than 1,000 *Aedes* mosquito breeding and 8,400 potential sites were removed [25,34]. About 10,000 volunteers sacrificed their weekends to distribute the "10-minutes mozzie wipe-out" pamphlets to nearly 888,000 homes [25,34], indicating the community involvement in the governmental initiative. Thus, the 3Ps mechanism of human resource mobilization in Singapore has proven effective; the national dengue response of the Singapore virtually involves the whole nation.

4.5 Application of dengue strategies to CHIKV containment

The year 2008 brought Singapore a new challenge as the first domestic outbreak of chikungunya fever arrived in January. Impressively, Singapore terminated the transmission within 18 days. According to interviews conducted at the MOH and the NEA in March and May 2008, a collaboration of the clinical network consisting of general practitioners and the reference laboratory, the EHI, had been implemented; an active surveillance on chikungunya fever started as early as in 2006. In fact, blood samples tested negative for dengue virus by PCR were then tested for CHIKV. The careful and thorough preparation, partly in response to the outbreaks in other countries, may explain why Singapore was able to react quickly in January 2008 (Yoshikawa M.J. et al., manuscript in press). Shortly after the first domestic case of chikungunya fever was identified owing to the collaboration, the authorities collected a total of 2,626 blood samples within 150 meter radius in the area where the index case worked/resided and discovered additional 12 cases [35,36]. As for the vector control, the NEA destroyed over 4,800 mosquito breeding sites [35].

However, subsequent domestic outbreaks started in June 2008. Interviews at the NEA in March and August 2009 revealed that the previous control measures were not sufficient to address the new situation. As a phylogenetic analysis of CHIKV envelope 1 (E1) gene by the EHI revealed, L.C. Ng et al. (2009) confirmed that subsequent domestic outbreaks were much more complicated with importation of multiple CHIKV strains [37]. Furthermore, vector surveillance and control operations proved the new vector competence acquired by additional vector, *Ae. albopictus* [38]. The first domestic outbreak was mediated by *Ae. aegypti* mosquitoes [36]. Whereas *Ae. aegypti* tend to stay in and around residential premises and buildings, *Ae. albopictus* breed in outdoor environments. Thus, lowering the vector population quickly was a real challenge. Indeed, the subsequent domestic outbreaks were located in the rural and sub-urban areas of the city-state [38]. The revised vector control strategy incorporated these scientific findings; the agency increasingly utilized outdoor thermal fogging to kill adult mosquitoes, expanded target area to remove breeding sources, and intensified operations at areas with vegetation. Clearly, the city-state benefited from its past and present dengue infection control experiences; the similar governmental intervention was carried out through the inter-ministry collaboration and public-private cooperation during the course of chikungunya fever domestic outbreaks (Yoshikawa, M.J. et al., manuscript in press). The weekly number of reported cases declined significantly by the 6th week in 2009 and remained 10 or below throughout the year [23].

5. Discussion: Singapore's contribution to transnational approach

Global warming and the expansion of affected areas of mosquito-borne infection do not seem to be reversing anytime soon; the northern limit of dengue infection appears moving upward. *Ae. albopictus* in Japan raises concern. Although its reported cases of dengue and chikungunya virus infection have been all imported for now, DF epidemics broke out in the western Japan between 1942 and 1945 [39,40,41,42,43]. Approximately 70% of 214 imported cases during 2004-2007 period were traced to India, Indonesia, the Philippines, Thailand, and Malaysia [43]. As of December 4, 2009, 14 imported cases of chikungunya fever were recorded in Japan arriving from (the patient numbers in parenthesis): Sri Lanka (2), India (3)

Indonesia (6), Malaysia (2), and Thailand (1) [44].

As Reiter (1998) claimed a decade ago that Singapore was "situated in the world's major region of dengue transmission" [1], the city-state is at constant risk, given the significant number of tourist arrivals from the regional countries. In fact, situation in the ASEAN countries deteriorated further in this century [9,45]. With the global expansion of the infected areas, the Asia-Pacific Dengue Partnership was set up in March 2006 under the WPRO and the South-East Asia Regional Office of the WHO (SEARO). The WHO has estimated that 1.8 billion populations residing in these two regions are at risk, bearing about 75% of the global burden of the disease [6,46]. Although lower case fatality rates owing to better case management is recently observed in several member states, the disease is spreading not only to more countries but also from urban to rural areas [46]. Dengue infection, therefore, is unlikely to remain just an "urban problem".

The WPRO and the NEA co-hosted the inaugural Asia-Pacific Dengue Program Managers Meeting in Singapore in May 2008. The event was attended by 17 member states from the WPRO and five from the SEARO in addition to temporary advisors, partner agencies, and observers [9,45]. The bi-regional initiative can be beneficial for the ASEAN countries to work *vis-à-vis* the public health threat in the region as they belong to the two separate WHO regions. During the meeting, Singapore presented informative analysis of the historical and current situation of dengue infection and integrated approach on vector control and virus surveillance. Several participants praised its unique and outstanding Inter-Agency Dengue Task Force as having enabled good resource mobilization [9]. The first Asia-Pacific Dengue Workshop was also organized in Singapore by the WHO and co-hosted by the Ministry of Foreign Affairs, Singapore and the NEA in March 2009. Sharing field surveillance technique and laboratory research findings in the week-long capacity building workshop, Singapore joined the WHO in offering expertise on mosquito-borne infectious disease control. In addition, the city-state is said to have provided assistance to cover training and material costs, medical insurance for the participants during the workshop, and accommodation for the entire duration of the workshop [47].

We recall that community-based approach and program have been emphasized in various global issues of concern in the recent decades, including public health. It is indeed difficult to control infectious diseases without community involvement. However, in light of inherent transnational nature of emerging infectious diseases today, public health professionals are expected to apply effective control measures without seriously disrupting movements of people and goods, coordinate effort regionally and/or globally, and make the use of limited resources. It is necessary to keep in mind that curving mosquito-borne epidemics like dengue infection and chikungunya fever require capacities such as laboratory-based surveillance and territory-wide vector control program as well as regional collaboration. Thus, the community-oriented approach is unlikely to accomplish the mission in the absence of respective government involvement. In this respect, as we have examined, Singapore has the committed policymakers and the dedicated public servants who strive to sustain and improve infectious disease countermeasures. While there are occasional criticisms towards Singapore's strict law enforcement as well as concerns for the dominant party rule, this paper has attempted to deduct an important role of a government in appropriate and successful intervention in emerging infectious diseases of global concern. From what has been seen in Singapore's response to dengue and chikungunya domestic outbreaks, we can conclude that the strong governmental intervention of the city-state often manages to achieve support from the community. On the "neglected tropical disease" battlefield of dengue infection, it is inspiring to see the small tropical city-state remain undefeated and laudably accept the continuous challenges from the emerging infectious diseases. However difficult it is to reproduce dedication of the government, some of the country's specific actions can be illuminating subjects for a case study in strategy formation against mosquito-borne infectious diseases, especially in urbanizing areas with rapid population mobility, a phenomenon on the rise in Southeast Asia. The potential leaves room for further research on applicability of Singapore's countermeasures.

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