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Systemic Investigation of Dengue Incidence and Control Measures in Surin, Thailand, 2018

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Abstract

This study aimed to explore the situation of dengue outbreak in Surin, a province in the Northeast of Thailand, and its control measures, and determine the association between entomological indices and dengue incidence in 2018. A cross-sectional mixed-methods design was used. Document review, primary survey and in-depth interviews were performed. A survey was conducted in 17 subdistricts. Descriptive statistics and multivariable Poisson regression were exercised in quantitative data. Thematic coding was applied in qualitative data. The attack rate between 1 January 2018 and 28 July 2018 was 72.3 cases per 100,000 population. The outbreak was pronounced during June-July 2018, with no reported deaths. Most cases were children aged below 15 years. Dengue fever was the most common diagnosis. The survey found positive association between Breteau index and attack rate. Regarding control measures, most fogging used a single chemical instead of mixed chemicals. Some local providers flagged difficulties in operationalizing the control measures, resulted from resource-mobilization constraints and opposition from some local inhabitants. Intensifying larva elimination campaigns and switching the fogging method from single chemical to mixed chemicals were recommended. A participatory public policy process should be initiated to identify effective vector-control strategies that are in line with the inhabitants' living norms.

Keywords: Dengue, system investigation, Breteau index, house index, container index, integrated vector management

Introduction

Dengue has been one of the key global public health threats for years.[1,2] It is caused by any of four dengue virus serotypes (DENV 1, 2, 3 and 4) and transmitted by *Aedes* mosquitoes. The most prevalent vector is *Aedes aegypti*, which is usually found in urban environment.[3] The spectrum of illness ranges from a mild non-specific febrile syndrome to classic dengue fever (DF), to more severe forms like dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS).[4] The World Health Organization (WHO) estimated that about 100 million dengue infections occurred annually.[5]

For Thailand, the first case of dengue was reported in 1949. The reported cases increased enormously, varying around 50,000-150,000 each year.[6] With the increasing trend, dengue surveillance was later incorporated into the national surveillance system led by the Bureau of Epidemiology (BOE), the Ministry of Public Health (MOPH). Providers in public facilities are obliged to report all suspected and confirmed cases to the national R506 surveillance system.[7]

One of the most widely recognized dengue-control strategies is the '3/3/1 measures', proclaimed by the MOPH in 2013.[8] The term '3/3/1' denotes timely notification to local providers within 'three hours' after diagnosis, early elimination of sources within 'three hours' after notification, and cutting transmission by various means within 'one day' after notification. Moreover, currently, it is recommended that all control measures should be in line with the integrated vector management (IVM), proposed by the WHO in 2001, which focuses on optimal use of resources on the bases of social mobilization and mutual participation amongst stakeholders.[9]

The success of larva control can be assessed by several indicators. House index (HI) and Breteau index (BI) have been the most widely used indices worldwide.[10] Some literature recommends container index (CI) to assess transmission risk.[11] In Thailand, CI and HI are more recognized than BI in the wider public. The Thai MOPH sets the cutoffs at 10% for HI and 50 for BI to identify high risk areas, and recommends the cut-off at 0% for CI in highly populated areas, such as schools and temples.[12,13]

In 2018, Thailand faced dengue outbreaks in many provinces. As of July 2018, total number of cases nationwide was 37,793 (attack rate 57.8 cases per 100,000 population).[14] Surin, a province in the northeast, is one of the most affected areas. The outbreak was pronounced in six districts (Buachet, Chumpolburi, Kapchoeng, Prasart, Samrongthap and Thatum), especially during June-July 2018 (epidemiological weeks 23-30). The Office of Disease Prevention and Control Region 9 (ODPC 9) reported the BOE about the uncontrolled dengue epidemic in Surin. The BOE then initiated the investigation for dengue outbreak in Surin. This investigation was not performed on a case-by-case basis. In contrast, the study performed as a systemic investigation over the whole province. Hence, the objectives of this study were to describe the situation of dengue epidemic and its control measures in Surin, determine association between larva indices and dengue epidemic, and identify challenges in implementing dengue control measures through local providers' perspectives.

Methods

A cross-sectional mixed-methods design (comprising qualitative and quantitative approaches) was used. The study was conducted in Surin between 30 Jul and 4 Aug 2018 by the joint investigation team, comprising staff from the BOE, the District Health Office, the Provincial Health Office, and the ODPC 9.

The first objective was achieved through document review and secondary data analysis. The analysis was divided into outbreak situation and control measures. For outbreak investigation, individual records diagnosed with dengue (either DF, DHF or DSS) since 1 Jan 2018 were obtained from the R506 report. The case definition followed the reporting guideline of BOE.[15] Demographic data were analyzed by descriptive statistics. For control measures, the main data collection technique was document review on prior reports of the Vector Borne Diseases Control Center (VBDC), ODPC 9. The report was part of the routine operations in VBDC, comprising control-measures data in 16 target subdistricts. The target subdistricts were areas where cases within a week outnumbered the last 5-year median; and when counted back to the past four consecutive weeks, there was no any single week containing the case volume smaller than the last 5-year median. Moreover, Mueang (headquarter) district was used as a case study to assess the relationship between IVM and the outbreak. Of 21 subdistricts in Mueang district, four of them implemented IVM. Univariable Poisson regression was applied to determine the effect of IVM on the outbreak. Attack rate during June-July 2018 served as a dependent variable. The presence of IVM served as independent variable. Incidence rate ratio (IRR) and 95% confidence interval (95% CI) were presented.

The second objective involved both primary and secondary data collections. The fieldwork was conducted in six epidemic districts. The term epidemic was defined as the number of cases during epidemiological weeks 27-30 larger than the last 5-year median. Unit of analysis was subdistrict. The number of selected subdistricts was basically set at 17 based on feasibility of human resources and time. Within these six districts, there were 59 subdistricts. Thirty five of them met the epidemic definition. Then simple random sampling with probability proportional to size was applied. As a result, 11 out of 35 epidemic subdistricts and six out of 24 non-epidemic subdistricts were randomly selected. In each subdistrict, reports of dengue cases at the health center and prior larva survey by village health volunteers were explored.

The research team also conducted on-site survey on larva indices in 20 randomly selected households per subdistrict. The survey started from the subdistrict center. Then the team performed a random walk towards the edge of each subdistrict. The households were selected in alternate fashion. Descriptive statistics and multivariable Poisson regression were applied. The dependent variable was attack rate between 1 and 30 Jul 2018, while the independent variables were BI reported a month earlier (3-30 Jun 2018) and BI from the fieldwork (spot survey). BI was used instead of CI and HI because it captures information from containers and households altogether.[16] The analysis was adjusted for prior attack rate, one month before the survey. Adjusted IRR and 95% CI were displayed.

For the third objective, unstructured informal interviews with local health staff in each subdistrict were performed plus in-depth interviews with two local providers from two epidemic subdistricts. Each interview lasted around 30 minutes and took place at the Surin Provicial Health Office. The question guides focused on challenges and experiences in implementing control measures from providers' experiences. The interviews were analyzed by inductive thematic coding. Summary of the methods is demonstrated in figure 1.

As this study was part of the regular operation of the BOE, it did not require approval from the Ethics Committees of the MOPH and consent to participate was not needed. However, the study had strictly followed confidential requirement as per conventional ethical standards.

Results

Situation of Dengue Epidemic and Control Measures

A total of 1,009 cases were diagnosed with dengue in Surin, between 1 Jan and 28 Jul 2018 (attack rate 72.3 cases per 100,000 population). Dengue cases were distributed all over Surin and especially in Meung District (Figure 2). No patients passed away from dengue.

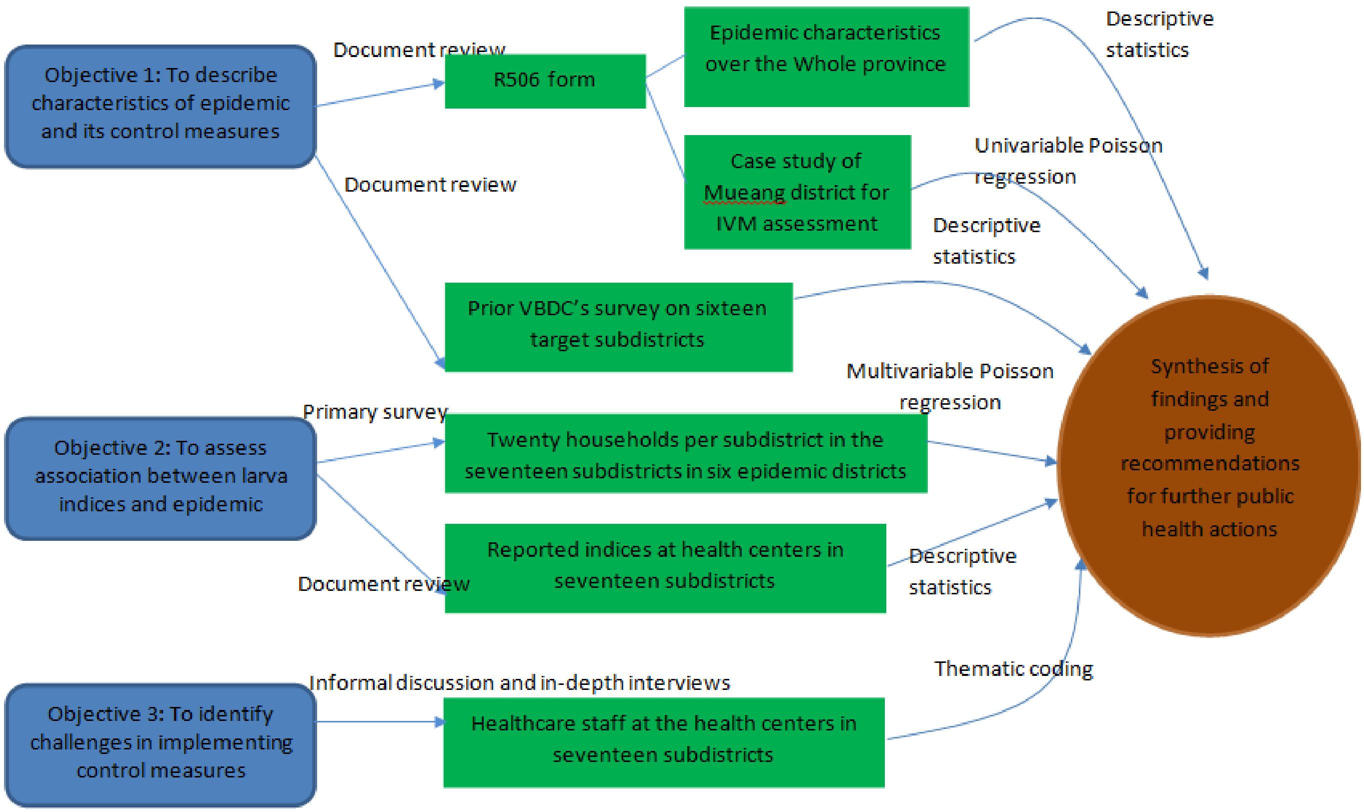

Figure 1. Summary diagram of the data collection techniques and data analysis

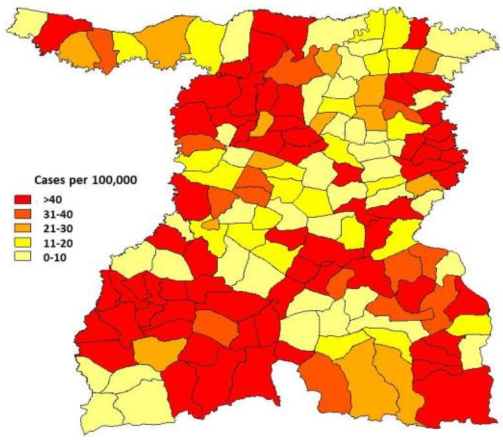

Figure 2. Distribution of dengue cases in subdistricts of Meuang District, Surin Province, Thailand, June-July 2018

The outbreak was pronounced during June-July 2018. That period accounted for about 67.1% (677/1,009) of the total cases (Figure 3).

About three-quarters (757/1,009) of the cases were diagnosed with DF. Inpatient care was the most common treatment type. Almost all (1,007/1,009) cases were Thai. Males slightly outnumbered females. Mean age and median age of the cases were 15 years and 11 years respectively (range 6 months - 89 years). The majority of cases (707/1,009) were below 16 years old. Students and children under guardian accounted for over 82.5% (832/1,009) of total cases. Gap between onset date and treatment date was three days on overage (Table 1).

Control Measures

The recent survey by the VBDC, ODPC 9 found a great variation in the completeness of each action listed in the '3/3/1 measures'. After excluding one health center with missing information, only nine (56.3%) from 16 health centers received a timely notification and performed mosquito spraying within three hours. The action completeness reduced by time as reflected by the decline of health centers performing fogging, from 75.0% (12/16) to 62.5% (10/16) in days 3 and 7 respectively. There appeared difficulty in assessing the completeness of community education. Some providers insisted that they did provide community education. However, this was done informally, instead of mass public campaign—and this was assessed as 'undetermined'. The assessment of health centers' performance in reaching CI and HI targets on day 7 also faced much difficulty due to data incompleteness and contradiction between data reported by the health centers and those reported by the VBDC (Table 2).

Concerning mosquito fogging, only three (18.8%) from 16 health centers used mixed chemicals such as deltamethrine 0.5% and piperonyl butoxide 10% while other 13 applied a single chemical. Deltamethrine 0.5% was the most commonly used (Figure 4).

Table 1. Characteristics of dengue cases in Surin Province, Thailand, January-July 2018 (n=1,009)

Characteristic	Number	Percent
Diagnosis		
Dengue fever	757	75.0
Dengue hemorrhagic fever	250	24.8
Dengue shock syndrome	2	0.2
Treatment type		
In-patient	650	64.4
Out-patient	358	35.5
Unknown	1	0.1
Race		
Thai	1,007	99.8
Non-Thai	2	0.2
Gender		
Male	510	50.5
Female	499	49.5
Occupation		
Student	676	67.0
Under guardian	156	15.5
Agriculturist	75	7.4
Manual labor	56	5.5
Others	46	4.6
Age group (year)		
Under 16	707	70.1
16-30	195	19.3
31-45	50	4.9
46-60	37	3.7
Above 60	20	2.0
Gap between dates of onset and treatment (day)		
≤1	280	27.8
>1-2	107	10.6
>2-3	223	22.1
>3-4	196	19.4
>4-5	126	12.5
>5	77	7.6

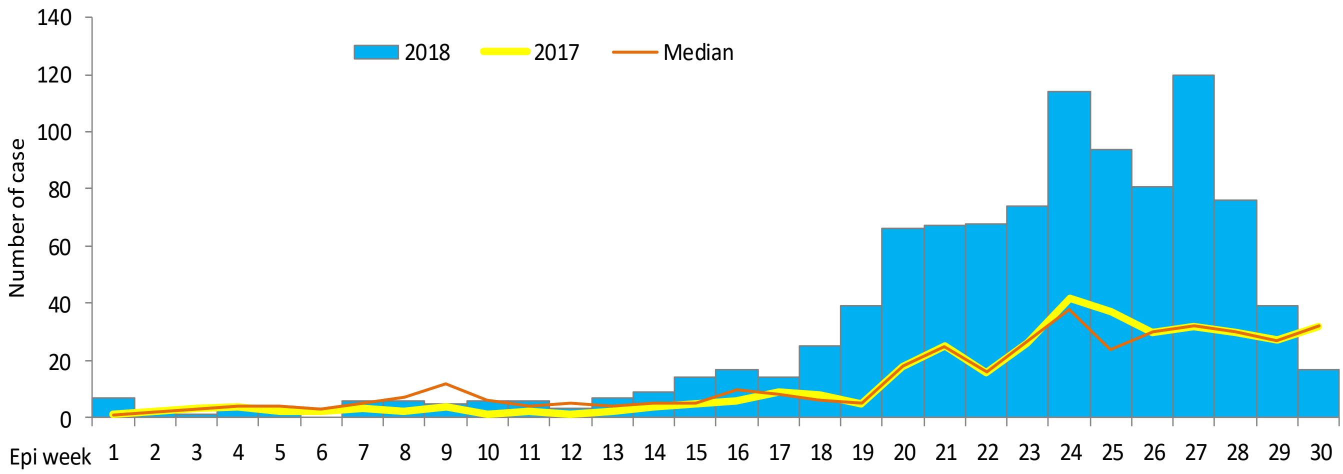

Figure 3. Epidemic curve of dengue cases in Surin Province, Thailand, January-July 2018

Table 2. Completeness of each action in the '3/3/1 measures' from the survey on 16 dengue-epidemic subdistricts, Meuang District, Surin Province, Thailand (n=16)

Day	Hour	Action	Number of health center (%)		
			With actions	Without actions	Undetermined
0	3	Reporting the presence of new case(s) to local health center's staff	9 (56.3)	1 (6.2)	6 (37.4)
0	3	Mosquito spraying at patient's house	9 (56.3)	4 (25.0)	3 (18.7)
1	-	Larva control within 100 meters from the patient's house	15 (93.8)	1 (6.2)	0 (0)
1	-	Mosquito fogging within 100 meters from the patient's house	15 (93.8)	1 (6.2)	0 (0)
1	-	Summoning villagers to undertake health education	0 (0)	0 (0)	16 (100)
3	-	Mosquito fogging within 100 meters from the patient's house	12 (75.0)	1 (6.2)	3 (18.8)
3	-	Summoning villagers to undertake health education	16 (100)	0 (0)	0 (0)
7	-	Mosquito fogging within 100 meters from the patient's house	10 (62.5)	6 (37.5)	0 (0)
7	-	Assessing CI and HI (target HI = 0 and target CI = 0)	0 (0)	0 (0)	16 (100)

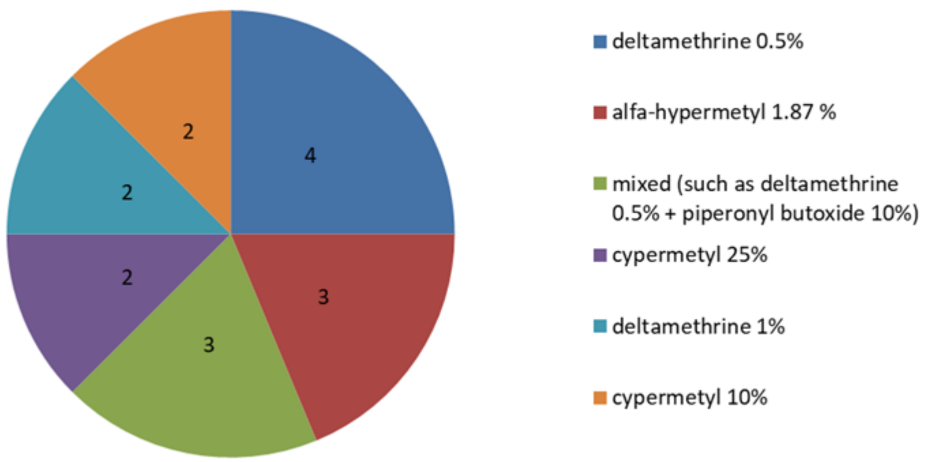

Figure 4. Number of health centers tallied by fogging chemicals in Mueang District, Surin Province, Thailand, June-July 2018 (n=16)

The case study of Mueang District revealed that smaller attack rate was found in IVM-implemented subdistricts than non-IVM subdistricts. Univariate Poisson regression showed that the presence of IVM was significantly associated with lower dengue incidence by around 28% (IRR = 0.720, 95% CI = 0.569-0.912) (Table 3).

Larva Indices and Association with Dengue Epidemic

According to the survey in 17 subdistricts, amongst all indoor containers, tile fragments had the largest CI (CI = 40.4%). For outdoor containers, garden pot saucers had the largest CI (CI = 40.0%), followed by non-specific containers and water jars (Figure 5).

Table 1. Attack rate of dengue and integrated vector management (IVM) implementation in Mueang District, Surin Province, Thailand, June-July 2018

Case per 100,000 population	IVM implemented (n=4)	Non-IVM implemented (n=17)
Mean (Standard deviation)	20.1 (15.2)	28.0 (40.6)
Median (Interquartile range)	15.2 (19.4)	13.0 (24.1)
Minimum-Maximum	8.0-42.1	0-154.0
Incidence rate ratio (95% CI) Ref = Non-IVM	0.720 (0.569- 0.912)*	

** P-value = 0.006*

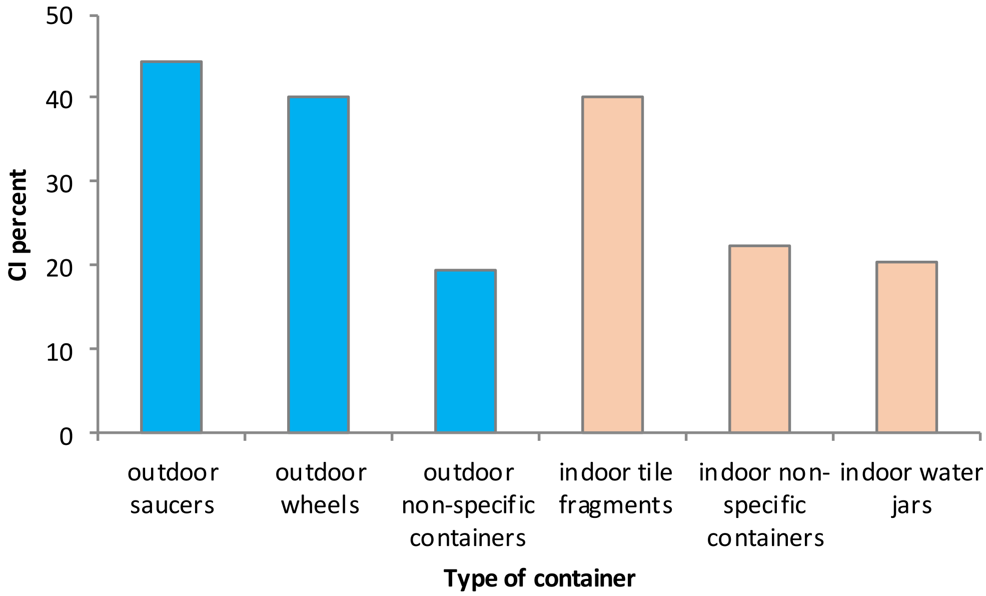

Figure 1. Top 3 containers with largest container index from the spot survey in 17 subdistricts from 6 epidemic districts, Surin Province, Thailand, July 2018

Concerning larva indices, the indices from spot survey were larger than those reported by village health volunteers. For instance, the mean spot BI was 113.1 while the mean reported BI was 25.6. The multivariable Poisson regression suggested that every unit increase in prior BI tended to enlarge the incidence in the following month by 0.4% with statistical significance (adjusted IRR = 1.004, 95% CI = 1.002-1.007). The spot BI also yielded nearly the same effect size (adjusted IRR = 1.005, 95% CI = 1.004-1.006) (Tables 4 and 5).

Challenges in Implementing Control Measures

Two main themes emerged from the interviews: resources constraints, and dissonance between control measures and living norms of inhabitants. In the first theme, most health care staff voiced their concerns towards resources mobilization and human resources constraint. Some health centers had only one professional nurse, plus few public health officers responsible for a wide range of task (not only dengue control). In addition, materials and budget are amongst the crucial issues. At present, there existed the District Health Board, serving as the main policy platform in the communities. The Board members consisted of representatives from all relevant authorities, including health facilities. This also meant a pooling of resources, including budget. Thus, the mobilization of budget to buy fogging chemicals and temephos (organophosphate larvicide) did not solely depend on the discretion of health staff. In practice, budget mobilization required approval from the Board. Thus, at times, the fogging could not be done promptly. This was because staff who initiated the fogging was local government officers whom the health sector did not have authority over.

"When there were new cases during weekend, sometimes we could not force them (local government officers) to do the fogging immediately..." a male provider in a health center, 40-50 years old

Table 4. Entomological indices (June 2018 and on-site survey) in 17 subdistricts from 6 epidemic districts, Surin Province, Thailand, July 2018 (n=17)

Index	Mean percentage (Standard deviation)	Median percentage (Interquartile range)	Range
From prior report (June 2018)			
Container index	4.5 (3.3)	4.0 (4.4)	0.7-12.0
House index	14.1 (8.7)	12.9 (12.2)	3.0-31.5
Breteau index	25.5 (23.1)	17.4 (33.4)	0.0-76.0
From spot survey			
Container index	16.2 (6.7)	16.1 (9.7)	3.2-26.9
House index	51.8 (20.0)	50.0 (30.0)	15.0-95.0
Breteau index	113.1 (57.1)	107.5 (80.0)	25.0-250.0

Table 5. Multivariable Poisson regression on the association between entomological indices and dengue attack rate in 17 subdistricts from 6 epidemic districts, Surin Province, Thailand, July 2018

Variable	Adjusted incidence rate ratio (95% CI)	P-value
Prior Breteau index (June 2018)	1.004 (1.002-1.007)	0.001
Spot Breteau index	1.005 (1.004-1.006)	<0.001
Previous attack rate (June 2018)	1.012 (1.011-1.014)	<0.001

In the second theme, the interviewees voiced that they experienced opposition from some local villagers against fogging or temephos addition. One of the key reasons flagged by local inhabitants was fogging might harm their silkworms. Some households gained revenue from raising silkworms. Thus, those villagers feared that fogging might jeopardize the worms. Moreover, some subdistricts were promoted to be 'green/organic' tourism spots. This made some villagers reluctant to accept the use of temephos and fogging.

"There are households raising silkworms for living. And the district is promoted for green tourism. So some people deny fogging for fear that this might harm the silkworms." a female provider in a health center, 40-50 years old

Discussion

This study confirmed the presence and magnitude of dengue outbreak in Surin. The majority of cases were students aged less than 15 years. This finding corresponds with previous study by Chareonsook et al[19] and Nagao et al[20], suggesting that since late 1990s the mean age of dengue cases shifted from early childhood (0-4 years) to late childhood (10-14 years). Nevertheless, some positive sides from this event were noted. First, no deaths were reported; and second, most patients received care in a timely manner (within three days after disease onset).[17]

Another potential factor of the burgeoning trend of dengue in Surin was the use of single-chemical fogging in some subdistricts. The mixed chemicals mostly contain piperonyl butoxide, which provides synergistic toxicity effect on mosquitos. The use of single pyrethroid agent likely creates pyrethroid resistance.[18] Chuaycharoensuk et al reported a wide degree of physiological response (~4-5.6%) to permethrin in *Ae. aegypti* in different regions of Thailand.[19]

Moreover, positive relationship between entomological indices and dengue attack rate was highlighted. Every unit increase in BI tended to magnify dengue incidence in the following month by 0.4%.

From public health point of view, this discovery warrants prompt public health actions. Larva eliminating campaigns should focus on containers that appeared to have high CI, which are likely to be overlooked, such as saucers, wheels and tile fragments. At present, the MOPH recommended the BI-cutoff at 50.[12,13] Yet, some international literature suggested different cutoffs, varying around 4-50[20,21] Thus, the MOPH's recommendation for BI-cutoff should be revisited.[21]

Another worth-mentioning point is the reported indices seemed to be lower than those from on-site survey. This phenomenon likely leads to complacency in dengue control. Stringent measurement and close supervision during routine larva controls are recommended. Nevertheless, monitoring local health staff's performance in larva control is not straightforward as their performance did not necessarily conform to every detail written in the guideline. Further discussions between local providers, academics and policy formulators should be initiated to fine-tune appropriate assessment methods and implementation details.

Qualitative findings also confirmed difficulty in exercising the 3/3/1-measure, especially in terms of fogging and temephos introduction in light of resource pooling under the District Health Board. Though in principle this approach aims at seamless collaboration among all sectors, it de facto creates difficulty to local health staff as they did not have absolute authority in resource mobilization. It does not mean that the Board is to be blamed. The bottom line is the function of each authority should be streamlined to allow timely mobilization of resources. Collaboration among authorities should be strengthened. Besides, local villagers should be included in the participatory public policy process. This will help raise awareness towards dengue situation and in the same time help increase compliance to the control measures, particularly among those with negative views towards fogging. All of these notions are indeed in line with the IVM concept and evidence shows that areas with IVM (which includes 3/3/1 measures) appeared to have better protection against dengue.[9,22,23] However it seems that this concept has not been fully utilized amongst all relevant stakeholders.

Limitations

This study encountered some limitations. Firstly, the fieldwork was confined to only one province. In addition, the number of subdistricts in the primary survey was quite limited. There were also other unobserved factors that might affect the incidence of dengue; for instance, seasonal influence, entomological indices in public places, and populations' immunity. Nevertheless, influence from those factors was, to some degree, captured by adding attack rate in the month prior as a variable in the model. Lastly, views of other stakeholders were still lacking.

Public Health Actions and Recommendations

Health care providers were advised to change their fogging method, from single-chemical fogging to mixed-chemicals fogging. Campaigns to get rid of larva sources in communities, especially areas with high entomological indices, should be promoted. A participatory public policy process that engages all stakeholders, including policy makers, health care providers, and local inhabitants, should be initiated to identify effective vector-control strategies that are suitable to the living norms of the inhabitants. Processes to mobilize dengue-control resources should be simplified and streamlined among different authorities to ensure a timely response towards the incidence.

Conclusion

During June-July 2018, Surin faced severe dengue outbreak. The use of single-chemical fogging was probably a contributory factor, coupled with inadequate larva control as reflected by high entomological indices. Dissonance between chemical-use strategies and living norms of the inhabitants and resource-mobilization constraints were noted. Intensifying larva-elimination campaigns and shifting fogging means were recommended. A participatory public policy process should be initiated to identify vector-control strategies that are effective and in the same time acceptable to the living norms of the inhabitants. Processes to mobilize dengue-control resources should be simplified and streamlined among different authorities.

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Suggested Citation

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