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Risk factors related to dengue infections in primary school students: Exploring students' basic knowledge of dengue and examining the larval indices in southern Thailand

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Summary Dengue is a major problem in southern Thailand.
Objectives: (1) To determine students' basic knowledge of dengue and (2) to examine the larval indices in primary schools and in the students' households.
Methods: This study employed a cross-sectional quantitative and qualitative approach involving meetings with students, discussions with groups of teachers, a questionnaire investigating students' basic knowledge of dengue, and a survey of the larval indices in primary schools and in the students' households. The study consisted of three stages: (1) community preparation, (2) data collection and analysis, and (3) feedback.
Results: A total of 306 students (from primary education levels 4—6) from five primary schools in the community were included in the study. Of a total of 15 items on the basic dengue questionnaire, only five were answered correctly by more than 80% of the students. Most of the knowledge items showed statistically significantly different distributions of correct, incorrect, and unknown answers ($P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$). The larval indices surveyed in the five schools and in 302 student households showed a high risk of dengue, with high indices in the five schools (Breteau Index: BI = 200; House Index: HI = 60; and Container Index: CI = 7.94) and in the students' households (BI = 754; HI = 77; and CI = 35).

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Conclusion: Risk factors for dengue were related to the students' basic knowledge of dengue and to the larval indices in both the schools and the students' households. Additionally, a coordinated effort will be required to eliminate *Aedes aegypti* mosquito breeding sites in the community.

Introduction

Dengue is one of the most important arthropod-borne viral infections affecting humans. Worldwide, an estimated 2.5 billion people are at risk of dengue infection. Of those, approximately 975 million live in tropical and sub-tropical countries [1]. In Thailand, dengue has been a significant public health problem for the past fifty years [2]. Although the mortality rate of hospitalized patients has decreased, the morbidity rate has increased in all areas from 1998 to 2009. Dengue is problematic in southern Thailand due to the high morbidity rate and high larval indices. The dengue incidence may be higher in southern Thailand than in other areas due to factors such as its greater number of rainy days, more rainfall, higher relative humidity, and warmer temperatures [3].

There are many risk factors that must be understood by all stakeholders before the community can reduce the incidence of dengue. Eco-bio-social, climatic, and environmental factors must be considered in conjunction with human behaviors that impact vector breeding in peridomestic and intradomestic areas, which are more important infection sites than schools and public areas. In particular, breeding sites such as outdoor water containers, water supplies, and waste disposal sites are associated with *Aedes aegypti* breeding and dengue illness [4—6]. Vulnerable populations, including those with poor educations, low incomes, irregular water service, and overcrowded housing [6], as well as those in rural communities in which lakes serve as the water supply, are all at a enhanced risk of dengue [7]. Moreover, all risk factors are closely related to mitigation strategies based on multiple interventions [4].

The Kamphaeng Sao sub-district is a rural and semi-rural area of the Nakhon Si Thammarat province in southern Thailand. This sub-district has been implementing dengue prevention and control measures since 2009. This community has been the subject of several studies aiming to identify successful approaches to reducing the incidence of dengue, such as the training of village health volunteers, the use of high school-based programs, and the development of a community network for dengue prevention and control [8,9]. However, the primary schools in the sub-district lack an intervention program for dengue prevention and control. The community did not report any dengue morbidity in the past two years (2010 and 2011), but there was a dengue outbreak in April 2012 [8]. The first child diagnosed with dengue was considered the index case for the outbreak. The natural route of dengue transmission includes humans, mosquitos, and the environment. However, the morbidity rate within this sub-district (5 per 100,000 populations) was lower than the Thai Ministry of Public Health disease standard (<20 per 100,000 populations). The results of the dengue study showed that continuing community activities are needed to empower citizens in this region [10]. The morbidity rate indicated a high risk of a dengue epidemic, as almost all the student households were in the Kamphaeng Sao sub-district. Primary school students were considered a vulnerable group due to the lack of protection from and prevention of mosquito bites.

Community-based educational interventions are considered to be valuable methods for reducing the incidence of dengue because they are associated with decreases in larval breeding sites [11]. The larval index is the classical index used in the study of dengue [11,12]. A study carried out in primary schools investigated the impacts of a community-based project for children on knowledge, behavior, and residential mosquito infestation. This research showed that children and their parents require effective knowledge about dengue to change their behaviors regarding dengue prevention and control. Moreover, school programs increase parental knowledge about dengue through directed messages [13]. A dengue prevention and control attitude survey in nine primary schools in Thailand showed that the education program successfully impacted all stakeholders [14]. However, the schools need a clear model for activities and an integration program that is suitable for a primary school. The results of the study were compared with those of a qualitative study of community and school-based education programs. This study showed that there were many factors involved in developing an effective dengue knowledge program for children, such as equipment, content (i.e., information about dengue),

the teacher's commitment, and the budget [15]. Another study of a dengue education program for primary students in grades 7—9 consisted of one week of training for every eight weeks, health education to prevent dengue transmission [16], and student participation within the school context. The goal was to implementation of dengue prevention and control in student group activities [9]. Moreover, a study on the basic knowledge and activities of children in Islamic religious schools that are open only on Saturday and Sunday showed that the activities used in successful dengue reduction programs are based on age and the development of all children in the program [9]. The reviews concluded that school-based education and activities were important for increasing the students' knowledge and participation in dengue eradication [15,17—19].

Dengue is a community problem that must be addressed by all community participants, in this case, including the teachers of the five primary schools in the community. After the meeting, it was concluded that the students' knowledge of dengue and their participation were needed to reduce the incidence of dengue. Thus, the present study aims to describe the students' basic knowledge of dengue and to examine the larval indices of the students' households.

Materials and methods

This study was a part of a larger study known as ''The development of a school-based program for dengue prevention and control: a study in Kamphaeng Sao sub-district, Nakhon Si Thammarat province, Thailand''. The study was approved by the International Review Board (IRB), the Ethical Review Committee for Research Subjects, and the Health Science Group at Walailak University, Thailand. The researcher provided the objectives of the study to the five primary schools and obtained informed consent from each student's parents before collecting data at the school and in the household survey.

Study area and participants

The study was carried out in five primary schools and in student households in the Kamphaeng Sao sub-district of southern Thailand, from April to September 2012. The participants of the study included 306 students (primary education level 4—6), teachers, and representatives of all teachers from five primary schools and the Local Administrative Organization in the sub-district.

Methods

A cross sectional quantitative and qualitative approach was applied for the community participation portion of the study, which included a meeting with the students, a discussion with the teacher group, a basic dengue knowledge questionnaire answered by all participants, and the students' household environments. There were three steps of the study: (1) community preparation, (2) data collection and analysis, and (3) feedback.

Community preparation step

This step involved representatives from each group, which included a teacher from each of the five primary schools, community stakeholders, and the research team. The research team discussed the dengue problem in the sub-district with representatives of all stakeholder groups, including community leaders, health education teachers, the director of the primary school, the sub-district administrative organization, the health promotion hospital of the sub-district and a representative of the Medical Health office in the district.

Data exploration step

The data exploration step was performed to better understand the diversity of the dengue problem among the students. This step consisted of a situation assessment (based on the student's basic knowledge assessment), a primary school survey, and student household surveys.

Basic dengue knowledge testing. The students' basic knowledge of dengue was assessed by the research team in a meeting of students at each primary school.

(1) Basic dengue knowledge questionnaires

The self-reporting questionnaires were developed and tested by the researcher. The questionnaires consisted of two parts. Part I assessed the general characteristics of the population and Part II focused on the children's basic dengue knowledge. The content was validated by three experts in dengue prevention and control. The reliability was tested in 30 students, and the questionnaire was shown to have a Cronbach's alpha coefficient of 0.83. The survey required approximately 15 min to complete and consisted of 15 items testing the participants' dengue knowledge. The questions could be answered as 'yes', 'no', or 'don't know'. The questions focused on the cause of dengue, major

signs of dengue, *A. aegypti* mosquito-bite prevention, dangers of dengue, the mosquito life cycle, and methods for mosquito elimination.

(2) Participants and sample size of the basic knowledge tests

The parties responsible for the dengue prevention and control program in the five primary schools and the community were all considered stakeholders in the community [20—22]. In the study, all students in primary education grades 4—6 were asked to complete the self-report questionnaire described above, a school survey, and household survey. The students were studying health education according to the standard Thai primary school course.

(3) Collection of basic dengue knowledge data

The researcher introduced herself and presented the objectives of the study to the community and to the representatives of the organizations in the community. The research team obtained consent from the children's parents at the first session and began the data collection process. The questionnaire was administered during the meeting in each primary school and took approximately 15 min to complete. The principal researchers described the study objective and explained the questionnaire. The researcher read each of the 15 items of the questionnaires to the students and recorded their answers.

(4) Data analysis

The student's basic knowledge of dengue was assessed. The participant information was summarized using descriptive statistics (percentage, mean, and standard deviation). The basic knowledge of dengue was analyzed with descriptive statistics. The frequency and percentage of correct (yes), incorrect (no), and unknown (do not know) answer for each item were analyzed, and then the answer percentages were compared using a Chi-square (χ^2) test at the 0.05 level of statistical significance. Items for which $\geq$80% of participants responded with the correct answer indicated a good level of basic dengue knowledge.

Dengue reduction methods proposed in the student meeting. A 10—15 minute meeting was held after the participants took the basic dengue knowledge questionnaires. The researcher asked the students about dengue prevention methods. The students then discussed and wrote down their ideas. A participating teacher in each primary school helped the research team conduct the meeting. The students' suggestions were analyzed and grouped by category.

Primary school and student household survey. As an epidemiological indicator of dengue transmission, the standard larval index survey [12] should be viewed with caution. In an entomological survey involving a large community of more than 300 households, a sample size of approximately 10%, or at least 100 households, should be taken [21]. In this study, all student households (306 households) and all five schools were surveyed. The research team explained the survey and trained students in techniques for surveying their households. The survey focused on the larval indices in the five primary schools and in the students' households.

(1) Primary school survey

The health education teacher of each primary school and student representatives surveyed various aspects of the school's environment and buildings, such as drinking water containers, used water containers, the water containers in the bathroom and toilet, cupboard saucers in the cafeteria, vases, plant-related containers, and other discarded containers around the school.

(2) Student household surveys

The format of the student household surveys and the method for the mosquito breeding site surveys were described by the principal researcher in a student meeting in each primary school. The researcher provided a list of the breeding sites of *A. aegypti* mosquitoes, which include drinking water containers, used water containers, water containers in the bathroom and toilet, cupboard saucers in the kitchen, vases, plant-related containers, and other discarded containers around the household. The students were shown the survey format and gave the informed consent form to their parents. The students then surveyed the mosquito breeding sites. The students sent the results of their surveys to their assigned classroom teacher and to the research team.

(3) Larval index analysis

The following larval indices were analyzed: the House Index (HI), the Container Index (CI), and the Breteau Index (BI). The HI was defined as the percentage of houses infested with larvae and/or pupae. The CI was defined as the percentage of water-holding containers infested with larvae and/or pupae. The BI was defined as the number of positive containers per 100 houses inspected [21]. The frequency and percentage of each type of containers were also calculated.

Data feedback
The feedback to the school was provided in group discussions with the primary schools based on the results of the preparation and exploration steps. The group discussions were structured as a series of workshops attended by the researcher and the teachers who were involved in dengue prevention and control in each primary school. The contents of the feedback data were used to develop a program to enhance dengue prevention and control in the primary school.

Results

The results of the study included: (1) the basic level of dengue knowledge; (2) larval indices and the types of water containers at the primary schools and students' households; and (3) the reflections of the meeting in preparation and exploratory step.

The level of basic knowledge of dengue

The basic level of dengue knowledge was evaluated based on the questionnaire results. The results were divided into four sections: (1) personal information; (2) sources of dengue information; (3) experiences with dengue illness; and (4) basic knowledge of dengue.

Personal information
We analyzed five groups of students (306 total students) from five primary schools: Touratsongkou school (136 students), Watchan school (71 students), Bantal school (43 students), Sounpon school (30 students), and Banyansou (26 students). The cohort included nearly equal numbers of boys and girls (51.6% and 48.4%, respectively). Most of the children were 10 years old ($n = 115$, 37.6%), the most common education level was primary education grade four ($n = 114$, 37.3%) and the most common family occupation was farming ($n = 126$, 41.2%). The primary dengue information sources for the 306 children were television ($n = 224$, 73.2%), family ($n = 176$, 57.5%), teachers ($n = 87$, 28.4%), village health volunteers ($n = 86$, 28.1%), neighbors ($n = 77$, 25.2%), information dome in the community ($n = 54$, 17.6%), health providers ($n = 49$, 16%); a community dengue project ($n = 28$, 9.2%), and the hospital ($n = 8$, 2.6%). Fifty of the students had contracted dengue at least once (16.3%). Of these 50 students, 41 students had contracted dengue once (13.4%), eight students reported having dengue twice (2.6%), and one student had been ill with dengue four times (0.3%).

Basic knowledge of dengue
Five questions were answered correctly by more than 80% of the students: (1) Item number 14, ''Sleep in a net to prevent mosquito bites'' ($n = 290$, 94.8%); (2) Item number 10, ''Coconut shells, broken water jars, and garbage with stagnant water surrounding the household are *Aedes aegypti* breeding sites'' ($n = 273$, 89.2%); (3) Item number nine, ''*Aedes aegypti* like breeding in clean water containers such as water containers in the bathroom and water jars'' ($n = 258$, 84.3%); (4) Item number two ''All members of the community are at a high risk of dengue fever'' ($n = 252$, 82.4%); and (5) Item number 15, ''Citronella is an herb that can be used to expel mosquitoes'' ($n = 252$, 82.4%).

Three items were mostly incorrect answer: (1) Item number eight, ''*Aedes aegypti* habitually bite in the daytime'' ($n = 158$, 51.6%); (2) Item number one, ''*Aedes aegypti* is a vector of dengue fever'' ($n = 128$, 41.8%); and (3) Item number six, ''Dengue treatment must address only the signs and symptoms because there is no specific drug for the disease'' ($n = 118$, 38.6%).

Most students did not know the answers to four items: (1) Item number three, ''*Aedes aegypti* can fly from one house to another house 50—100 meters away'' ($n = 152$, 49.7%); (2) Item number 13, ''Dry red lime can be added to a water container to inhibit mosquito breeding'' ($n = 109$, 35.6%); (3) Item number six, ''Dengue treatment must address only the signs and symptoms because there is no specific drug for the disease'' ($n = 83$, 27.1%); and (4) Item number eight, ''*Aedes aegypti* habitually bite in the daytime'' ($n = 83$, 27.1%).

The χ^2 test was used to identify significant differences among correct, incorrect, and unknown answers for each item. For 13 of all items, the answers were significantly different (χ^2 test, $P \leq 0.001$). Only item number one, which read, ''*Aedes aegypti* is a conductor of dengue fever'' had significantly different answers ($\chi^2 = 6.915$; $P \leq 0.01$). Item number six, which read, ''Dry red lime can be added to a water container to inhibit mosquito breeding'', exhibited significant differences among all answers ($\chi^2 = 6.137$; $P \leq 0.05$) (Table 1).

Larval indices and types of water container

Larval indices in the primary schools and student households
The five primary schools were had BI, HI, and CI ratios (%) of 200, 60 and 7.94, respectively. The household surveys were completed for 302 of the 306 student households (98.69%). The household BI,

Table 1 Number and percentage (*n*, %) of correct, incorrect, and unknown answers to the basic dengue knowledge questionnaire.

Item	Number (percentage)		
	Correct	Incorrect	Unknown
1. *Aedes aegypti* is a conductor of dengue fever[b]	176(57.5)	130(42.5)**	–
2. All members of the community are at a high risk of dengue fever[a]	252(82.4)	54(17.6)***	–
3. *Aedes aegypti* can fly from one house to another house 50–100 meters away[c]	113(36.9)	41(13.4)	152(49.7)***
4. A very high fever sustained for 2–7 days is usually a sign of dengue fever	200(65.4)	24(7.8)	82(26.8)***
5. Dengue fever usually results in a red face and skin bleeding (arm and leg) after a fever for 2–3 days	229(74.8)	29(9.5)	48(15.7)***
6. Dengue treatment must address only the signs and symptoms because there is no specific drug for this disease[b,c]	105(34.3)	118(38.6)	83(27.1)*
7. Patients with dengue fever may die	222(72.5)	39(12.7)	45(14.7)***
8. *Aedes aegypti* habitually bite in the daytime[b,c]	65(21.2)	158(51.6)	83(27.1)***
9. *Aedes aegypti* like breeding in clean water containers such as water containers in the bathroom and water jars[a]	258(84.3)	29(9.5)	19(6.2)***
10. Coconut shells, broken water jars, and garbage with stagnant water surrounding the household are *Aedes aegypti* breeding sites[a]	273(89.2)	11(3.6)	22(7.2)***
11. Closed water jars and water containers can be used to prevent mosquito breeding	217(70.9)	55(18)	34(11.1)***
12. Eliminate mosquito breeding sources by using clean containers and change the water every 7 days	206(67.3)	22(7.2)	78(25.5)***
13. Dry red lime can be added to water containers to inhibit mosquito breeding[c]	128(41.8)	69(22.5)	109(35.6)***
14. Sleep in a net to prevent mosquito bites[a]	290(94.8)	10(3.3)	6(2)***
15. Citronella is herb that can be used to expel mosquitoes[a]	252(82.4)	8(2.6)	24(15)***

Chi-square test (χ^2).
[a] Items answered correctly by >80% of respondents (5 items).
[b] Answered mostly incorrectly (3 items).
[c] Most unknown items (4 items).
* $P \leq 0.05$.
** $P \leq 0.05$.
*** $P \leq 0.001$.

Table 2 Larval indices (%) of the primary schools and student households.

Larval indices	Percentage of larval indices (%)	
	Primary schools	Student households
The number of positive containers per 100 schools inspected: BI (BI < 50)	200	754
Percentage of schools (or homes) infested with larvae and/or pupae: HI (HI < 10)	60	77
Percentage of water-holding containers infested with larvae and/or pupae: CI (CI < 1)	7.94	35

Table 3 Types of containers, number of inspected containers, positive containers, and the percentage of positive containers at the primary schools and student households.

Types of containers in the primary school surveys and student households	Number of containers inspected (Pieces):number of positive containers (Pieces):percentage of positive containers (%)	
	Primary schools	Student households
1. Drinking water containers	25:0:0	525:51:10
2. Water containers in the bathroom and toilet	52:4:8	557:93:17
3. Used water containers	7:0:0	630:175:28
4. Cupboard saucers	0:0:0	314:58:18
5. Vases	4:1:25	185:43:23
6. Plant-related containers	18:1:6	442:127:29
7. Discarded containers	20:4:20	1,360:860:63
Total	126:10:8	4,013:1407:35

HI, and CI ratios (%) were 754, 77, and 35, respectively (Table 2).

Types of water containers at the five primary schools and student households

The total number of water containers inspected (Pieces), the number of positive containers (Pieces), and the percentage of positive containers (%) at the schools were 126, 10, and 8, respectively. The three most common types of containers surveyed were ''vases'' (4, 1, and 25, respectively), ''Discarded containers are surrounding the school building'' (20, 4, and 20, respectively), and ''Water containers in the bathroom and toilet (52, 4, and 8, respectively). The overall percentage of positive containers per container inspected was 7.94%.

The total number of containers inspected (Pieces), number of positive containers (Pieces), and the percentage of positive containers (%) in the 302 student households surveyed were 4,013, 1407, and 35, respectively. The three most common types of container inspected were ''Discarded containers surrounding the household'' (1,360, 860, and 63, respectively), ''Plant answered-related containers'' (442, 127, and 29, respectively), and ''Used water containers'' (630, 175, and 28, respectively). The overall percentage of positive containers was 35% (Table 3).

Three themes and three sub-themes from the meetings and group discussions

''Primary school students had a high risk of dengue''

This theme was generated based on two meetings of all stakeholders during the study preparation and planning. During the first meeting, 11 teachers from the five primary schools and the research team discussed the state of the dengue problem in the community as it related to the students attending the five primary schools. After the principal researcher explained the project, the teachers' indicated their availability for participation in the study and agreed to the objectives of the study. The second meeting was attended by 18 representatives of all community stakeholders, including the research team. These representatives included community leaders, health education teachers, the director of the primary school, representatives of the sub-district administrative organization, a health promotion hospital, a representative of the district Medical Health office, and eight representatives of the Health Fund of Kamphaeng Sao sub-district.

''Students at different levels of education and ages require different methods for dengue prevention and control''

This theme was developed according to several points from all students in three education levels. The important points are related to the level of education and student age. The suggestions were grouped according to grade level: level four (114 students), level five (95 students), and level six (97 students).

There were 114 students at level four. They emphasized two solutions. Namely, (1) Personal protection from mosquito bites, such as sleeping in a mosquito net, wearing repellent lotion, wearing long sleeved clothes, and slapping mosquitoes and (2) Eliminating *A. aegypti* mosquito breeding sites, for example, by taking out the garbage, closing the covers of water containers, and keeping fish in water jars. For example, one student from this grade suggested ''sleep in a mosquito net, and wear clothes with long arms and long pants''.

The 95 students in education level five suggested three methods to help prevent mosquito bites. The first method was to use personal protection, similar to the responses from children of primary education level four. The second method was to eliminate *A. aegypti* mosquito breeding sites by closing the covers of water containers, changing the water in jars every seven days, and scrubbing water containers to eradicate mosquito eggs. Their final point was to use biological and physiological methods, such as herbs (e.g., citronella or orange peels), to eliminate the *A. aegypti*. Other suggestions included the addition of red lime to water containers and keeping fish in water jars. For example, one student of primary education level five suggested the following: ''We must cover water jars after using them because if the cover is left open, the mosquitoes will breed and spread dengue, and we may be killed by dengue.''

The 97 students studying at primary education level six suggested the same methods for reducing mosquito bites as did the students in level five. However, they provided more specific details than did students at lower education levels. Their suggestions included using herbs to eliminate mosquitos, adding Kaffir lime to water containers in the bathroom or toilet, use citronella oil, or using mosquito repellent when going into the garden. One sample response from a level six student was ''sleep in mosquito net, change the water container, scrub the water container every day, remove the water from discarded containers round the house, and use herbs such as orange rind or citronella to expel *Aedes aegypti* mosquitoes.''

''Education program for dengue prevention and control in primary school''

This theme was developed based on five group discussions (26 total teachers) in the data feedback step, with one meeting at each primary school, including Touratsongkou school (6 teachers), Sounpon school (4 teachers), Bantal school (4 teachers), Watchan school (6 teachers), and Banyansou school (6 teachers). The discussions with the teachers produced three sub-themes: (1) ''Previous dengue education programs did not teach obvious methods of prevention''; (2) ''Schools should provide basic dengue knowledge''; and (3) ''New methods of dengue prevention and control must involve the school and the student's parents''.

''Previous dengue education programs did not teach obvious methods of prevention''. Although the education program in Thai primary schools provides basic health education, dengue is not emphasized in the hygiene education course and is divided according to the education level of curriculum. The assigned classroom teacher teaches all of the courses in the classroom, and differences in student knowledge may be attributed to differences in classrooms. The textbook used could also differ. However, the teachers point out note that the basic knowledge of dengue was obtained from other sources and was not a major part of their education curriculum:

''... the assigned classroom teachers already have full workloads ... in the past, we taught about dengue based on the standard of Thai Ministry of Education ... however, all of the infections come from the student's households ... the school environment did not have any mosquito breeding sites ...'' (An assigned classroom teacher)

''Schools should provide basic dengue knowledge''. The teachers in each primary school felt that the students' risk of dengue infection was related to their household environments. They indicated that the primary school environment, including a clean bathroom, fish in water containers, and an herbal garden, was not likely to breed mosquitoes. The points raised at the meeting include:

''...although the primary school health education program included disease education, the basic dengue knowledge was less extensive than that in the questionnaire in this study ... the school needs to teach more details ... schools can make time available for researchers or health officials from the health promotion hospital ... maybe one day per term ...'' (A primary school administrator)

''New methods of dengue prevention and control must involve the schools and student's parents''. The meetings with all teachers in the five primary schools suggested that the schools should teach methods to prevent mosquito bites and dengue transmission, including an education program for primary students, the use of media or technology, and continued household surveys. An example of this reflection:

''... dengue prevention and control should be taught for students and their parents once per term ... I think that on the first day of a term, there should be a meeting of parents in the school ... and I think that all teachers (Especially health education teachers and assigned classroom teachers) need to know about dengue ...'' (A primary school administrator)

Discussion

The dengue morbidity rate was 45/100,000 people during the study period (April—September, 2012). Although this ratio was lower than the 50/100,000 morbidity rate index set by the Thai Ministry of Public Health [2], it confirmed that there are early signs of the dengue case index predicting a dengue outbreak and that there is a need for interventions for dengue prevention and control. The results of study confirmed that risk factors related to the dengue problem in the student population consisted of little basic dengue knowledge and a high level of dengue indices in schools and households.

The basic knowledge of dengue for the students in the five primary schools (306 students) included the five most correctly answered items in the survey (>80% of students) which included ''Sleep in a net to prevent mosquito bites''; ''Coconut shells, broken water jars, and garbage with stagnant water surrounding the household are *Aedes aegypti* breeding sites''; ''*Aedes aegypti* like breeding in clean water containers such as water containers in the bathroom and water jars''; ''All members of the community are at a high risk of dengue fever'', and ''Citronella is an herb for expelling mosquitoes''. The correct items were common knowledge acquired from information sources such as ''television'' (73.2%) and ''family'' (57.5%). Direct sources of dengue information that were reported at a lower percentage were a ''teacher at school'' (28.4%, ''Health provider (16.0%) and ''community dengue project'' (9.2%). Moreover, the basic dengue knowledge of students was not generally related to their own dengue illness experience, as only 50 of 306 students reported having at least one dengue infection (16.3%). Three items of the questionnaires that were most often incorrectly answered were ''*Aedes aegypti* habitually bite in the daytime'', ''*Aedes aegypti* is a vector of dengue fever'', and ''Dengue treatment must address only the signs and symptoms because there is no specific drug for this disease''. The questions that were most likely to be answered as ''don't know'' were ''*Aedes aegypti* can fly from one house to another house 50—100 meters away'', ''Dry red lime can be added to a water container to inhibit mosquito breeding'', ''Dengue treatment must address only the signs and symptoms because there is no specific drug for this disease'', and ''*Aedes aegypti* habitually bite in the daytime''.

The students' answers reflected their knowledge of the details of dengue transmission and mosquito habits, which is important for the students and their parents, and reflected their information sources, as seen in this study of a primary school education program and in previous studies of the impacts of dengue prevention education programs in the community [7,11,13,16,19]. The acquisition of basic dengue knowledge in primary school requires a formal dengue education program for students [23]. As one of the assigned classroom teachers reflected:

''... teaching primary students, I think that dengue education requires basic knowledge ... because teachers did not know certain points about dengue and mosquito habits such as the mosquito life cycle and ... mosquito biting and breeding habits for ... moreover, some teachers did not know that red lime can be added to the water container to eliminate larvae ...''

Both the morbidity rate and students' knowledge of dengue were correlated to the high larval indices. The student household surveys showed a BI = 754, HI = 77, and CI = 35. In the school survey, the ratios were BI = 200; HI = 60; and CI = 7.94. These levels were higher than the standard level set by the Thai Ministry of Public Health (BI < 50; HI < 10; and CI < 1)[2,24]. These levels reflect a number of female *A. aegypti* mosquitoes between 300,000 and 900,000 mosquitoes/km^2, which is associated with a high risk of a dengue epidemic [24]. Larval indices were used as an indirect outcome of the students' basic dengue knowledge because they have been validated as primary measurement tools for monitoring larval populations and were easily used in this community. However, the environments of the five primary schools and of the students' households were risk factors for dengue outbreak among the students.

The types of water containers in the students' households included several potential mosquito breeding sites. The percentage of positive containers, such as discarded containers (63.24%), plant-related containers (28.73%), water containers in the bathroom and toilet (27.78%) and vases (23.24%), confirmed previous studies identifying water containers as breeding sites [25,26]. These larval indices and types of water containers were confirmed as environmental risk factors for dengue, and the population was considered at high risk based on the results of the students' household surveys (302 households of all 306 students; 98.69% with an appropriate sample size estimated at 300 households) [21].

The results of the study showed that the students' basic knowledge about dengue and their household environments are important factors for the dengue education program [9,10]. Through the meetings of the students, teachers, stakeholders, and research team, we determined that a

program aiming to reduce the incidence of dengue in the study area should incorporate an educational program, dengue prevention campaign, and coordination with the student's parents. A dengue education program in primary schools should integrate courses into the curriculum for the students, the teachers, and the students' parents, as dengue emerges from the households. If the education program can reach all the suggested groups, the prevalence of breeding sites at the school and in the community should decrease [14]. Moreover, the study highlighted the importance of dengue control in the community and confirmed previous studies of dengue in schools [9,16]. In particular, the communication of knowledge about dengue and the elimination of *A. aegypti* mosquito breeding sites need to be formally acknowledged as a part of the school's education program. One goal is to enhance the dengue knowledge of the health education teacher and the assigned classroom teacher.

However, the data collection depended on the growth and development of the students. The accuracy of the data would be compromised if students took the questionnaire forms back home to their parents and had help with the answers. Therefore, the basic dengue knowledge questionnaire was administered directly to the students by the principal researcher over 10—15 minutes at a student meeting. The students of each school were then shown how to conduct a larval survey at school and in their homes. Moreover, the questionnaire used in the study was designed to be simple to administer and answer. The results confirmed that students' lack of basic knowledge about dengue, the environment surrounding their primary school, and students' households were likely contributing to the incidence of dengue. The next step of the study will be to develop an age- and education level-appropriate school-based program appropriated with the student's age, education level, that is suited to the number of students in each classroom and number of classrooms for each primary school and reaches parents as well as students.

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