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Understanding dengue solution and larval indices surveillance system among village health volunteers in high- and low-risk dengue villages in southern Thailand

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ABSTRACT

Background: Successful dengue solutions require community collaboration between agencies engaged in human health, vector control and the environment. In Thailand, village health volunteers emphasize the need for a health working group to interact, collaborate, and coordinate actions. The objectives of this study were to acquire an understanding of dengue solutions, as well as the larval indices surveillance system of village health volunteers in high- and low-risk dengue villages.
Methods: After 12 months of training in dengue prevention and setting larval indices surveillance systems, an analytical cross-sectional survey was conducted. A total of 117 villages were included in the 18 primary care facilities within one district in southern Thailand, and they were divided into 71 high-risk and 46 low-risk dengue villages. Sample size was determined using the G*power formula. The content validity index and reliability values of Cronbach's alpha coefficient for the questionnaires were 0.91 and 0.83, respectively. A random sampling approach was used to acquire data. The chi-square test, *t*-test, and odds ratio were used to assess the sample's level of understanding.
Results: The study included 1302 village health volunteers, including 895 and 407 from high- and low-risk dengue communities, respectively. In total, 87.9% were female, 51.6% were 20–35 years old, 48.8% had worked as a village health volunteer for 11–20 years, 27.1% had an upper elementary education, and 59.1% had dengue in the previous 12 months. Understanding of the dengue solution and larval indices surveillance system varied across high- and low-risk dengue villages. Village health volunteers with a high level of understanding of the dengue solution and larval indies surveillance system were 1.064 and 1.504 times more likely to stay in high-risk dengue villages, respectively (odds ratio [OR] = 1.064, 95% confidence interval [CI]:0.798–1.419, $p = 0.672$ and OR = 1.504, 95% CI:1.044–2.167, $p = 0.028$).
Conclusions: Village health volunteers require ongoing training to understand the prevention and control of dengue and larval indices surveillance systems, promote awareness, and monitor dengue in both high- and low-risk dengue villages.

Abbreviations: BI, Breteau index; CI, container index; DCD, division control disease; HI, house index; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; OR, odds ratio; PCU, primary care unit; UDS, understanding dengue solution; ULISS, understanding larval indices surveillance system; VHV, village health volunteer; WHO, World Health Organization.

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1. Introduction

Dengue is a complicated illness with several presentations, including dengue fever, dengue hemorrhagic fever, and dengue shock syndrome/expanded dengue syndrome [1,2]. This disease is of significant concern in tropical and subtropical areas, especially in Southeast Asia [3,4]. Between 2001 and 2010, 12 countries in Southeast Asia recorded morbidity of 2.9 million people due to dengue and had a mortality rate of 5906 patients per year, resulting in a yearly loss of USD 950 million [5]. In Thailand, dengue has been endemic for >60 years, with an unpredictable outbreak pattern [6]. A retrospective study of dengue outbreaks in 2014, 2015, 2016, 2017, and 2018 reported morbidity rates of 63.25, 222.58, 96.76, 79.55, and 128.41 cases/100,000 inhabitants and mortality rates of 0.10%, 0.10%, 0.10%, 0.12%, and 0.13%, respectively [7].

Previous dengue solutions that aid in combating dengue required updates. Therefore, the World Health Organization has proposed strategies to ensure appropriate modifications to prior solutions in the context of new advances. The global strategy for dengue prevention and control from 2012 to 2020 aimed to address the following five focus areas:1) diagnosis and case management, 2) integrated surveillance, 3) sustainable vector control, 4) future vaccine implementation, and 5) basic operation and research implementation [2,8–9]. To realize these opportunities, focus areas need to be implemented, coordinated, and adequately resourced, especially by building the capacity of key stakeholders, such as VHVs [10] and primary healthcare providers [11], within communities.

In Thailand, VHVs emphasize the need for a health working group to interact, collaborate, and coordinate actions in the primary care system. They are an important group of people who facilitate effective health activities that increase awareness, motivation, and involvement and monitor the health status within a community [12,13]. VHVs within local villages and PCUs are the first point of contact with primary care and the broader health system.

Almost all studies on dengue have been conducted based on knowledge, attitudes, and practices. A systematic review of 17 articles related to knowledge, attitude, and practice in Malaysia found that a high level of knowledge influences positive attitudes as well as optimal practices in dengue prevention and control [14]. Nonetheless, the studies found a relationship between knowledge, attitude, and practice of patients in hospitals [15] and knowledge- and attitude-related practices regarding dengue among the resident population and suggested that future dengue awareness campaigns should target communities in both endemic and potentially endemic areas [16]. There was no correlation between knowledge of dengue and preventive practices among residents [17]. A qualitative study on the perception of dengue focused on perception as a behavioral response and reported misperceptions, including confusion with other febrile diseases, lack of knowledge of transmission mechanisms, and misconceptions about mosquito behavior [18]. Another study compared knowledge, attitude, and practice among communities living in hotspot and non-hotspot dengue areas in Selangor, Malaysia. The results showed that 20 communities in hotspot areas had better knowledge and attitudes than 20 communities in non-hotspot areas [19]. However, key stakeholders in all communities required adequate and appropriate public health education. These studies have exclusively examined knowledge, attitudes, practices, and perceptions. There are no studies that focus on understanding dengue solution (UDS) and larval indices surveillance systems (ULISS). Furthermore, no studies have compared these matters in high-and low-risk dengue areas.

"Understanding" is the second step in the six-step process within the cognitive domain of Bloom's revised taxonomy for learning, which includes knowledge, understanding, application, analysis, synthesis, and evaluation [20,21]. It is consistent with the meaning of conceptual understanding, which consists of four dimensions: factual and procedural knowledge, making connections, knowledge transfer to practice, and metacognition for how to organize knowledge [22]. Therefore, UDS refers to the capacity of VHVs to interpret, identify, classify, conclude, refer to resources, compare, and describe dengue prevention, control, and self-care. In contrast, ULISS refers to the capacity of VHVs to interpret, identify, classify, conclude, refer to resources, compare, and describe larval indices that consist of larval index surveillance system processes and larval index levels. The standard levels for the three indices in the community as proposed by the Thai Ministry of Public Health are the Breteau Index (BI) <50, House Index (HI) <10, and Container Index (CI) <1 [8,23]. To resolve dengue-related issues in Thailand, VHVs assess larval indices in certain infestation areas once weekly (or monthly) and communicate the dengue risk to community members.

Therefore, VHVs in a district must ensure a correct understanding of dengue prevention to effectively communicate with others through activities. In this study, we aimed to assess and compare the UDS and ULISS of VHVs in villages predicted to be high- and low-risk, based on community participation. The results could inform the sustainable implementation of dengue prevention and control based on the larval indices surveillance system by the VHVs in the district and other areas.

2. Material and methods

The study was an analytic and descriptive cross-sectional survey of a district after dengue risk villages were predicted, setting the larval indices surveillance system and the dengue education training program within 12 months. The study collected data from October and December 2019 and was approved by the Institutional Review Board's Ethical Review Committee for Research Subjects at Walailak University, Thailand (Protocol approval number: WUEC-19-144 – 01, September 20, 2019).

2.1. The context of high- and low-risk dengue villages and larval indices surveillance system in the study area

The *Kanchanadit* district, which is in *Surat Thani* Province, southern Thailand, is at a high risk for dengue. This district comprised 104,951 people, 40,746 households, 117 villages, 13 sub-districts, 18 PCUs, a community hospital, and a public health office. The dengue epidemic, which had stretched over five years, had morbidity rates of 107.97, 143.25, 65.20, 175.32, and 317.29 cases/100,000 inhabitants during 2014, 2015, 2016, 2017, and 2018, respectively [7]. Villages in the district are predicted to be at high and low risk for dengue based on a community participatory action approach. This prediction was divided into three steps [24,25]. Step 1 was to determine the risk of dengue using prediction criteria. Dengue risk refers to the opportunity for dengue to emerge in a particular region. The following factors related to dengue emergence in the past five years were considered:

1) The *severity factors* for dengue were determined by whether the villages were endemic for dengue, that is, whether they had an ongoing incidence of dengue cases, whether herd immunity was demonstrable within the community, as reflected by the dengue morbidity rate of each village, and the comparison of dengue morbidity rates in the current year with the median rates of the past five years.
2) The *opportunity factors* for a dengue outbreak were determined by a) population movement, which refers to whether the area would facilitate migration that allows the virus to circulate in particular regions; b) the population density because as dengue spreads through mosquitoes, a dense population could increase the risk of exposure to dengue epidemics; and c) community participation and strength in contributing to a dengue solution, which refers to activity assessment and stakeholders' participation in resolving dengue-related issues in each village. Both activity assessment and stakeholder participation must be emphasized, especially in areas where management is an issue.

The second step was to conduct a village-level evaluation of risk areas under the responsibility of a PCU. If a district had multiple PCUs, the evaluation was conducted according to the specified criteria established during a conference wherein official representatives were tasked with solving dengue-related problems on behalf of each PCU. Furthermore, information about the illness rate, fatality rate, and total population of each district was comprehensively researched.

Step 3 was to predict high- and low-risk dengue villages using half of the total scores (33 points) from the severity and opportunity factors in Step 1. Therefore, the risk cut-off value was determined to be 17 of 33 points [25]. Villages were considered high-risk if they scored 17 or more points, and low-risk if they scored <17 points. As of January 2019, the district included 117 villages with <18 PCUs that were predicted to be 71 high risk dengue villages (H-RDVs; 60.68%) and 46 low-risk dengue villages (L-RDVs; 39.32%).

2.2. Larval indices surveillance system in the study area

After *Kanchanadit* district villages were stratified as high- and low-risk dengue villages, the PCUs underwent a larval indices surveillance system following the *Lansaka* model [10]. All 2561 VHVs in the district participated in workshop training programs on UDS and ULISS. The 18 PCUs that used the complete larval indices surveillance system followed a seven-step procedure. First, the household inspected water containers, such as drinking water containers, water containers, cupboard sauces, vases, plant-related containers, and discarded containers in and out of the household every seven days. Second, VHVs were divided into three to four groups per village to conduct larval index surveys every 25th day of the month. A VHV surveyed the larval indices of 10–15 households and recorded the number of water containers inspected and the number of larval positive containers in their "violet book" and sent their larval indices data to the head of their group. Third, the heads of the groups collected data from their VHVs in their "blue book". Fourth, the head of the VHV in each village collected the total data from each head of the VHV groups in their "yellow book". Fifth, the PCUs collected and recorded data from all villages in the online program found at http://surat.denguelim.com, where they analyzed and reported on the 30th of each month. Sixth, three traditional larval indices, the BI, HI, and CI, were reported in a VHVs meeting every 9th day of the month. The PCU proposed information on all VHVs for prevention in H-RDVs. Seventh, information was communicated to all stakeholders in the community, including local administrative organizations, primary schools, and households. The VHVs in the district followed these seven steps, which the study needed to evaluate their understanding of the system.

2.3. Population and sample size

The total population included 2561 VHVs. The sample size of the study included 1302 VHVs. Calculations were performed using the G*Power 3.1 calculus program [26], power = 0.8, α = 0.05, effect size = 0.20, degrees of freedom (Df) = 1 (Df = [r − 1][c-1]), and the selected difference between two independent means (two groups) (http://www.gpower.hhu.de/en.html. 3.11.61), which was increased by 10% to account for lost samples. Simple random sampling was used to select high-risk and low-risk villages from each PCU. A total of 895 VHVs were present in H-RDVs and 839 in L-RDVs (Table 4).

2.4. Questionnaires

Questionnaires assessing understanding were implemented, as previously described [27]. UDS and ULISS were validated by three experts to show the content validity indices of 0.90 and 0.91, respectively. The reliability test on 120 VHVs made up of 60 VHVs from H-RDVs and 60 from L-RDVs showed that Conbrach's alpha coefficient of UDP and ULISS were 0.59 and 0.75, respectively.

The format of the self-reported questionnaire consisted of three parts. Part I included eight items of general characteristics, such as sex, age, education level, experience, and time in a VHV role. Part II consisted of 15 UDS items which included understanding the cause, major signs and symptoms, dangers of dengue, mosquito bite prevention, mosquito life cycle, and methods of mosquito elimination. Part III constituted the ULISS, which included 15 items with five possible answers for each, and tested the understanding of meaning, importance, calculation, and activities of larval index surveillance. Parts II and III each took 15 min to complete. The correct answer was awarded 1 point per item, with a total possible score for understanding larval indices of 15 points per part. We devised mean scores for both UDS and ULISS at good and poor levels based on Bloom's cut-off score criteria of 80% [21,28]. Good understanding corresponded to a percentage of correct answers of ≥80% (≥12 points), and poor understanding corresponded to <12 points.

2.5. Data collection and analysis

Data were collected from 1302 VHVs in 117 villages and 18 PCUs in the district. General characteristics are described as frequencies and percentages. Chi-squared tests were used to compare significant differences between the percentages of items that were correctly and incorrectly understood by VHVs from H- and L-RDVs. Mean scores were calculated using independent *t*-tests. Finally, the total score (good and poor) of UDS and ULISS among VHVs from H- and L-RDVs were compared using odds ratios (OR).

3. Results

3.1. Characteristics of village health volunteers

A total of 1302 VHVs were included as H-RDVs ($n = 895$) and L-RDVs ($n = 407$). The VHVs were predominantly female ($n = 1145$; 87.9%, $p < 0.01$). The following questions yielded a statistically significant difference ($p < 0.05$) between VHVs in H-RDVs and L-RDVs: "Time in work position," "Experienced dengue illness personally," and "Experienced dengue illness with a neighbor." "Experience with dengue illness in the past 12 months" was significantly different (p < 0.01). The other characteristics were not significantly different ($p > 0.05$), such as age group, dengue education course in the previous 12 months, education level, experience of dengue illness with a family member, VHV role as head of the zone, and VHV role as head of the village (Table 1).

3.2. Understanding of dengue solution and understanding larval indices surveillance system

Responses regarding UDS were divided into 15 items. Of these items, most VHVs in the H- and L-RDVs incorrectly understood items 3, 5, 9, 14, and 15. Only two items, number 6 ("If a patient has a high fever lasting 2 to 7 days, nausea, and vomiting with possible abdominal pain, the patient presents in the fever stage") and number 15 ("Household members must complete larval surveys and eliminate contaminated water container infestation in their house every 7 days") were statistically significant at $p < 0.01$ and $p < 0.05$, respectively (Table 2).

Of the 15 ULISS items, more VHVs had incorrect rather than correct understandings of item numbers 6, 8, 9, 12, 13, and 15. Unlike VHVs from H-RDVs, those from L-RDVs correctly responded to four items (1, 2, 11, and 14); this difference in response was statistically significant (p < 0.05). The results for three items (8, 9, and 12) showed statistically significant (p < 0.01) responses, and item 7 yielded a response with a statistically significant inter-group difference ($p < 0.001$). These results show that the ULISS of VHVs needs improvement in both H- and L-RDVs (Table 3).

Table 1
Characteristics of village health volunteer in high- and low-risk dengue villages.

VHV characteristics	VHV responses, n (%)			χ^2
	H-RDV	L-RDV	Total	
	n = 895	n = 407	*n* = 1302	
Sex				
Male	91 (10.2)	66 (16.2)	157 (12.1)	
Female	804 (89.8)	341 (83.8)	1145 (87.9)	9.652**
Age group (years) Min = 19, Max = 80, Mean = 50.47, SD = 9.85				
20–35	478 (53.4)	194 (47.7)	672 (51.6)	
36–59	293 (32.7)	161 (39.6)	454 (34.9)	
69–80	124 (13.9)	52 (12.8)	176 (13.5)	5.760^{ns}
Time in work position (years) Min = 1, Max = 48, Mean = 11.71, SD = 8.08				
1–10	218 (24.4)	74 (18.2)	292 (22.5)	
11–20	433 (48.4)	203 (49.9)	636 (48.8)	
21–48	244 (27.3)	130 (31.9)	374 (28.7)	7.018*
Dengue education course conducted in the preceding 12 months (Standard 12 times) Min = 1, Max = 50, Mean = 5.3, SD = 6.2				
1–11	651 (70.2)	277 (29.8)	928	
≥12	244 (65.2)	130 (34.8)	374	2.991^{ns}
Education level				
Basic elementary	186 (20.8)	66 (16.2)	252 (19.4)	
High elementary	239 (26.7)	114 (28.0)	353 (27.1)	
Junior high school	161 (18.0)	78 (19.2)	239 (18.3)	
Senior high school	204 (22.8)	91 (22.4)	295 (22.7)	
Diploma (High/Low)	59 (6.6)	33 (8.1)	92 (7.1)	
Bachelor degree	46 (5.1)	25 (6.1)	71 (5.5)	4.849^{ns}
Experience with dengue illness in past 12 months				
Yes	503 (56.2)	266 (65.4)	769 (59.1)	
No	392 (43.8)	141 (34.6)	533 (40.9)	9.699**
Experienced dengue illness personally				
Yes	50 (5.6)	37 (9.1)	87 (6.7)	
No	845 (94.4)	370 (90.9)	1215 (93.3)	5.510*
Experienced with dengue illness with a neighbor				
Yes	412 (46.0)	213 (52.3)	625 (48.0)	
No	483 (54.0)	194 (47.7)	677 (52.0)	4.450*
Experienced dengue illness with a family member				
Yes	60 (6.7)	33 (8.1)	93 (7.1)	
No	835 (93.3)	374 (91.9)	1209 (92.9)	0.832^{ns}
VHV role as head of zone				
Yes	174 (19.4)	79 (19.4)	253 (19.4)	
No	721 (80.6)	328 (80.6)	1049 (80.6)	0.000^{ns}
VHV role as head of village				
Yes	46 (5.1)	29 (7.1)	75 (5.8)	
No	849 (94.9)	378 (92.9)	1227 (94.2)	2.032^{ns}

VHV, village health volunteer; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; $\mathscr{X}^2$, Chi-square test; **p < 0.01; *p < 0.05; ^{ns}: Not significant.

3.3. *Comparison of correct understanding of dengue solution and understanding larval indices surveillance system among 18 PCUs*

PCU_1 (H-RDV and L-RDV) and PCU_4 (L-RDV) had good levels of correct UDS with mean scores ≥12 points (≥80%). Almost all PCUs had a poor UDS, with a mean score of <12. Furthermore, VHVs from H-RDVs had a greater mean of correct responses than those from L-RDVs, except in $PCU_{6,\ 7,\ 13,\ 15,\ \text{and}\ 18}$. The six PCUs with statistically significant differences in mean UDS were PCU_6 and PCU_{13} (H-RDV > L-RDV, $t_{3.724}$, and $t_{4.071}$, $p < 0.001$, respectively); PCU_3 and PCU_{10} (H-RDV < L-RDV, $t_{-3.437}$ and $t_{-3.406}$, $p < 0.01$), and PCU_4 and PCU_5 (H-RDV < L-RDV, $t_{-2.474}$ and $t_{-0.187}$, $p < 0.05$). However, the total mean UDS scores among the remaining 12 PCUs were not significantly different ($p > 0.05$) (Table 4).

In contrast, only the PCUs showed a good level of ULISS, with mean scores of ≥12 points (≥80%). There were 12 PCUs without statistically significant differences in the means (p > 0.05), and six PCUs had statistically significant differences in the means of PCU_4 and PCU_{12} (H-RDV < LRDV, $t_{-4.376}$ and $t_{-3.819}$, $p < 0.001$), PCU_{11} and PCU_{15} (H-RDV > L-RDV, $t_{3.091}$ and $t_{3.338}$, $p < 0.01$), and PCU_{14} and PCU_{16} (H-RDV < L-RDV, $t_{-2.302}$ and H-RDV > L-RDV, $t_{2.293}$, $p < 0.05$). The total mean (standard deviation) scores of correct ULISS in H-RDVs and L-RDVs were

Table 2
Comparing the understanding of dengue solution among village health volunteers from high- and low-risk dengue villages.

UDS Items	Response	VHV responses n (%)			χ^2
		H-RDV	L-RDV	Total	
		n = 895	n = 407	n = 1302	
1. If a patient has a high fever lasting 2 to 7 days, petechiae, and an enlargement of the liver with pain, the patient shows signs of dengue infection.	*Incorrect*	32 (3.6)	16 (3.9)	48 (3.7)	0.100^{ns}
	Correct	863 (96.4)	391 (96.1)	1254 (96.3)	
2. If the patient presents dengue signs and symptoms, the patient shows dengue viral infection.	*Incorrect*	51 (5.7)	29 (7.1)	80 (6.1)	0.988^{ns}
	Correct	844 (94.3)	378 (92.9)	1222 (93.9)	
3. If a person living in a high dengue risk area is infected with one dengue serotype, they may have lifelong immunity to that strain. However, they would still be vulnerable to other serotypes and could be infected with the other dengue virus serotypes later in their life.	*Incorrect*	562 (62.8)	254 (62.4)	816 (62.7)	0.018^{ns}
	Correct	333 (37.2)	153 (37.6)	486 (37.3)	
4. If the patient is protected from *Aedes aegypti* bites, the patient will be safe from dengue disease.	*Incorrect*	107 (12.0)	40 (9.8)	147 (11.3)	1.264^{ns}
	Correct	788 (88.0)	367 (90.2)	1155 (88.7)	
5. If a patient has a high fever lasting 2 to 7 days, nausea, vomiting, and with possible abdominal pain, the patient presents in the fever stage.	*Incorrect*	461 (51.5)	199 (48.9)	660 (50.7)	0.765^{ns}
	Correct	434 (48.5)	208 (51.1)	642 (49.3)	
6. If a patient of dengue hemorrhagic fever presents with pain at right lower costal, case shows hepatomegaly.	*Incorrect*	232 (26.0)	136 (33.4)	368 (28.3)	7.682**
	Correct	662 (74.0)	271 (66.6)	933 (71.7)	
7. If a patient of dengue hemorrhagic fever presents signs of shock from pathology of leakages of plasma, the patient will have poor tissue perfusion, weak pulse, and narrowed pulse pressure.	*Incorrect*	179 (20.0)	86 (21.1)	265 (20.4)	0.220^{ns}
	Correct	716 (80.0)	321 (78.9)	1037 (79.6)	
8. If your neighbor presents with poor tissue perfusion, weak pulse, and clammy skin, you will need to send them to hospital.	*Incorrect*	235 (26.3)	116 (28.5)	351 (27.0)	0.716^{ns}
	Correct	660 (73.7)	291 (71.5)	951 (73.0)	
9. Dengue patients should avoid consuming aspirin or NSAID because they may cause gastritis with massive gastrointestinal or hepatic injury.	*Incorrect*	553 (61.8)	262 (64.4)	815 (62.6)	0.799^{ns}
	Correct	342 (38.2)	145 (35.6)	487 (37.4)	
10. If your neighbor presents with a high fever on day 1, you give paracetamol every 6 h and tepid sponge bath.	*Incorrect*	181 (20.2)	71 (17.4)	252 (19.4)	1.405^{ns}
	Correct	713 (68.0)	336 (82.6)	1049 (80.6)	
11. You suggest that your neighbor prevent	*Incorrect*	298 (33.3)	137 (33.7)	435 (33.4)	0.017^{ns}
	Correct				

(*continued on next page*)

Table 2 (*continued*)

UDS Items	Response	VHV responses n (%)			χ^2
		H-RDV	L-RDV	Total	
		n = 895	n = 407	n = 1302	
mosquito bites with skin lotion.		597 (66.7)	270 (66.3)	867 (66.6)	
12. If a village has an index of dengue disease, you suggest a dengue prevention strategy that will destroy mosquito breeding sites and larva around their house.	*Incorrect*	123 (13.7)	49 (12.0)	172 (13.2)	0.708^{ns}
	Correct	772 (86.3)	358 (88.0)	1130 (86.8)	
13. Yanang (*Tiliacora triandra*) leaves are not a natural herbal remedy for a mosquito repellent.	*Incorrect*	221 (24.7)	112 (27.5)	333 (25.6)	1.174^{ns}
	Correct	674 (75.3)	295 (72.5)	969 (74.4)	
14. *Temephos* Sand is used to eliminate larval mosquitos, but is not used to eliminate mosquitos egg.	*Incorrect*	816 (91.2)	363 (89.2)	1179 (90.6)	1.287^{ns}
	Correct	79 (8.8)	44 (10.8)	123 (9.4)	
15. Household members must complete larval surveys and eliminate contaminated water container infestation in their house every 7 days.	*Incorrect*	540 (60.3)	276 (67.3)	816 (62.7)	6.688*
	Correct	355 (39.7)	131 (32.2)	486 (37.3)	

VHV, village health volunteer; UDS, understanding dengue solution; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; χ^2, Chi-square test; **p < 0.01; *p < 0.05; ^{ns} Not significant.

8.3 (2.9) and 7.8 (2.9), respectively; the difference in mean total score was statistically significant (H-RDV > L-RDV, $t_{3.178}$, p < 0.01) (Table 4).

The 18 PCUs can be described in four groups regarding UDS and ULISS: a) the group of PCUs with a statistically significant difference in the means for both UDS and ULISS ($n = 1$; PCU_4); b) the group of PCUs with a statistically significant difference in the means for UDS only ($n = 5$; $PCU_{3, 5, 6, 10, 13}$); c) the group of PCUs with a statistically significant difference in the means for ULISS only (n = 5; $PCU_{11, 12, 14, 15, 16}$); and d) the group of PCUs with no statistically significant differences in the means for either UDS or ULISS ($n = 7$; $PCU_{1, 2, 7, 8, 9, 17, 18}$) (Table 4).

According to the level of correct UDS, the total score of VHVs' responses showed that those who had a good UDS were 1.064 times more likely to stay in the high- than low-risk group (OR = 1.064, 95% CI = 0.798–1.419); however, this result was not statistically significant ($p > 0.05$) (Table 5).

Village health volunteers who had a good ULISS were 1.504 times more likely to live in high- than low-risk villages (OR = 1.504, 95% CI = 1.044–2.167). This result was statistically significant ($p < 0.05$) (Table 6).

4. Discussion

In this study, we described the UDS and ULISS among VHVs from low- and high-risk areas. VHVs were educated regarding dengue and received training in larval indices surveillance skills to enhance their understanding. During a 12-month training period (January to December 2019), we found a reduction in dengue morbidity rate from December 2018 to December 2019 with 175.56 and 64.71 cases/ 100,000 populations, respectively. The larval indices surveillance system decreased based on the findings (https://SURAT.denguelim.com) [29].

For almost all 15 items concerning UDS, VHVs from H-RDVs gave more correct responses than those from L-RDVs. However, this difference was not statistically significant for 13 UDS items ($p > 0.05$). In contrast, VHVs from L-RDVs responded with fewer correct responses than incorrect responses to items 3, 9, 14, and 15. A possible explanation could be that, although all VHVs were trained under the district's program for the larval indices surveillance system, additional training from a public health officer may be required for better UDS. Our findings are consistent with those of another study that showed that public health workers' knowledge, attitudes, and practices towards dengue prevention were associated with training time [28].

The responses to only two UDS items, namely number 6 ("If a case of dengue hemorrhagic fever present pain at right lower costal, case shows hepatomegaly") and number 15 ("Householder is important person for larval mosquito in their house every 7 days") were significantly different ($p < 0.01$ and $p < 0.05$, respectively). This shows that VHVs in L-RDVs lacked an understanding of the correct signs and symptoms of dengue and the importance of eliminating contaminated water every seven days in each household. Our results are similar to those of a review article that found a lack of understanding of dengue virus and disease-mitigating processes. Thus, there is a need to understand the complex epidemiology and pathogenesis of dengue [30].

In a total of 15 items regarding the larval indices surveillance system, fewer correct than incorrect responses were observed for five items (8, 9, 12, 13, and 15); of these, the inter-group differences in the percentages of responses were statistically significant for three items (8, 9, and 12; $p < 0.01$). In contrast, significantly more correct responses were seen for item 7 ($p < 0.001$). These results show that VHVs from both H- and L-RDVs need to improve their understanding. The full course of the dengue training program was completed in a short period because we assessed the VHVs' understanding after conducting the larval indices surveillance system over the preceding 12 months. This could explain why VHVs did not correctly understand the signs and symptoms of dengue. A previous report found that participants had a low score of dengue knowledge (4.6/19) and recommended improving the literacy level and dengue-related understanding among the target population [15]. Notably, the effectiveness of dengue solution programs is seen to increase with duration, that is, programs were more effective districts where they were conducted for more than three years [10].

We found that VHVs from both H- and L-RDVs had poor understanding of nearly all dengue solution items. The questions used in this study required the participant to understand a concept more than remember it. A possible reason could be that, although all VHVs were equally trained regarding the process of the surveillance system, only the head of VHVs and the health care officer received training concerning dengue solutions. Alternatively, dengue risk assessment may be known to all VHVs, but they may not be able to effectively communicate its results [25]. It is also possible that VHVs from H-RDVs had greater UDS than those from L-RDVs because of differences in factors such as the public health officer's training in PCUs, sex, time of work, and dengue experience in the past 12 months. Similar findings were observed in a cross-sectional study of 330 dengue patients at a hospital in Vietnam who had experienced dengue but only possessed basic knowledge about the illness [15]. For both parameters, namely the UDS and ULISS, the differences in the mean of correct responses were significant in the six PCUs, such that the overall mean of correct responses was higher among VHVs from H-RDVs than among those from L-RDVs. However, this overall difference was only significant for the UDS and not for the ULISS. This showed that the level of UDS and ULISS is challenging to predict because the activities of healthcare officers in PCUs differed. Our findings corroborate those of another study that showed that the knowledge, attitude, and practice of dengue disease among healthcare professionals who undertook dengue training were 10.23 times higher than those who did not receive such training [28]. Thus, specific training programs can help to improve dengue-related understanding.

More PCUs in H-RDVs responded with the correct ULISS than those in L-RDVs (11 PCUs). It is possible that VHVs in H-RDVs received more training than those in L-RDVs. For example, PCU_1 had five villages, of which four were predicted as high-risk and one as low-risk. However,

Table 3
Comparing the understanding larval indices surveillance system among village health volunteers from high- and low-risk dengue villages.

ULISS Items	Response	VHV responses, n (%)			$\mathcal{X}^2$
		H-RDV	L-RDV	Total	
		n = 895	n = 407	n = 1302	
1. VHVs survey larva every 25th of the month, send data to the head of the zone every 28th of the month, send data to head of the village every 30th, send data to PCU for analysis, and report to all stakeholders to prepare a dengue solution program. This process is called the "larval indices surveillance system."	*Incorrect*	410 (45.8)	162 (39.8)	572 (43.9)	4.098*
	Correct	485 (54.2)	245 (60.2)	730 (56.1)	
2. The objective of VHVs' larval survey is to "reduce dengue outbreaks."	*Incorrect*	51 (5.7)	10 (2.5)	61 (4.7)	6.582*
	Correct	844 (94.3)	397 (97.5)	1241 (95.3)	
3. Larval indices formula $\frac{\textbf{No of positive containers}}{\textbf{No of houses inspected}} \times \textbf{100}$ Name is Breteau index (BI)	*Incorrect*	305 (34.1)	159 (39.1)	464 (35.6)	3.035^{ns}
	Correct	590 (65.9)	248 (60.9)	838 (64.4)	
4. Larval indices formula $\frac{\textbf{No of positive containers}}{\textbf{No of houses inspected}} \times \textbf{100}$ Name is House index (HI)	*Incorrect*	287 (32.1)	134 (3.9)	421 (32.3)	0.094^{ns}
	Correct	608 (67.9)	273 (67.1)	881 (67.7)	
5. Larval indices formula $\frac{\textbf{No of positive containers}}{\textbf{No of houses inspected}} \times \textbf{100}$ Name is Container index (CI)	*Incorrect*	326 (36.4)	158 (38.8)	484 (37.2)	0.688^{ns}
	Correct	569 (63.6)	249 (61.2)	818 (62.8)	
6. The standard number of positive containers per 100 houses inspected is <50	*Incorrect*	620 (69.3)	299 (73.5)	919 (70.6)	2.366^{ns}
	Correct	275 (30.7)	108 (26.5)	383 (29.4)	
7. The standard level for percentage of houses infested with larva and/or pupae is <10	*Incorrect*	335 (37.4)	199 (48.9)	534 (41.0)	15.199***
	Correct	560 (62.6)	208 (51.1)	768 (59.0)	
8. Standard level of percentage of water-holding infested containers with larvais <1	*Incorrect*	551 (61.6)	287 (70.5)	838 (64.4)	9.774**
	Correct	344 (38.4)	120 (29.5)	464 (35.6)	
9. If the survey found 20 houses with 4 houses infested, or 1000 water containers with 200 water containers infested. It shows BI = 1000.	*Incorrect*	674 (75.3)	336 (82.6)	1010 (77.6)	8.448**
	Correct	221 (24.7)	71 (17.4)	292 (22.4)	
10. If the survey found 20 houses with 4 houses infested, or 1000 water containers with 200 water containers infested. It shows HI = 20.	*Incorrect*	288 (32.2)	126 (31.0)	414 (31.8)	0.192^{ns}
	Correct	607 (67.8)	281 (69.0)	888 (68.2)	
11. If the survey found 20 houses with 4 houses infested, or 1000 water containers with 200 water containers infested. It shows CI = 20.	*Incorrect*	236 (26.4)	132 (32.4)	368 (28.3)	5.074*
	Correct	659 (73.6)	275 (67.6)	934 (71.7)	
12. If the water container capacity is 100 l, we can use red lime in the container.	*Incorrect*	602 (67.3)	308 (75.7)	910 (69.9)	9.411**
	Correct	293 (32.7)	99 (24.3)	392 (30.1)	
13. The larval indices survey need to be done every 7 days because the life cycle of *Aedes aegypti* is 7 to 11 days.	*Incorrect*	728 (81.3)	340 (83.5)	1068 (82.0)	0.916^{ns}
	Correct	167 (18.7)	67 (16.5)	234 (18.0)	
14. The larval indices surveillance system must be documented every 25th of the month in the "Violet book."	*Incorrect*	103 (11.5)	67 (16.5)	170 (13.1)	6.047*
	Correct	792 (88.5)	340 (83.5)	1132 (86.9)	
15. VHV's who are head of village collect data from head of zone and send to PCUs every 30th of the month.	*Incorrect*	469 (52.4)	232 (57.0)	701 (53.8)	2.382^{ns}
	Correct	426 (47.6)	175 (43.0)	601 (46.2)	

VHV, village health volunteer; ULISS, understanding larval indices surveillance system; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; PCU, primary care unit; $\mathcal{X}^2$, Chi-square test; ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; ^{ns} Not significant.

VHVs were alerted to dengue solutions in both H- and L-RDVs because their roles included training, developing dengue solution projects, coordinating and surveying larval indices, and being monitored by public health officers in the PCU. In contrast, a previous study showed that people living in hotspot areas, wherein a dengue outbreak persisted for >30 days, had lower knowledge and attitude than people in non-hotspot areas [19]. Our findings show that through the activities of public health officials and VHVs' knowledge regarding dengue can be enhanced in high-risk areas.

However, PCU_6 had several activities for supporting the larval indices surveillance system, collection, and following the steps reported at https://SURAT.denguelim.com [29]. Meanwhile, four PCUs (PCU_3, PCU_4, PCU_5, and PCU_{10}) showed significantly higher mean correct UDS scores among VHVs from L-RDVs than from H-RDVs. These findings

Table 4
Comparison of correct understanding dengue solution and understanding larval indices surveillance system in high- and low-risk dengue villages.

PCU	Total number village	Village: Population: Sample (n)		Correct UDS ($\bar{X}$, SD)		*t* - test	Correct ULISS ($\bar{X}$, SD)		t - test
		H-RDV	L-RDV	H-RDV	L-RDV		H-RDV	L-RDV	
PCU_1^d	5	4: 90: 48	1: 6: 6	13.2 (2.3)	13.3 (1.9)	-0.106^{ns}	12.8 (2.5)	12.0 (2.2)^b	0.79 ^{ns}
PCU_2^d	4	3: 86: 46	1: 27: 16	9.8 (1.8)	10.5 (1.9)	-1.333^{ns}	4.8 (2.2)	8.2 (2.9)	0.349 ^{ns}
PCU_3^b	5	3: 138: 83	2: 28: 28	8.1 (2.0)	9.50 (1.6)	-3.437**	7.4 (3.5)	7.3 (3.1)	0.038 ^{ns}
PCU_4^a	9	5: 92: 49	4: 62: 29	10.9 (2.4)	12.1 (1.4)	-2.474*	9.8 (2.2)	11.7 (1.2)	-4.376***
PCU_5^b	5	3: 105: 52	2: 31: 15	10.0 (2.1)	10.1 (1.9)	−0.187*	10.3 (2.8)	9.0 (3.9)	1.464 ^{ns}
PCU_6^b	10	7: 189: 100	3: 81: 47	9.7 (1.7)	8.5 (2.2)	3.724***	7.6 (2.7)	6.8 (2.8)	1.559 ^{ns}
PCU_7^d	5	3: 85: 58	2: 44: 20	9.8 (1.7)	9.2 (1.6)	1533^{ns}	7.3 (2.2)	6.5 (2.0)	1.530 ^{ns}
PCU_8^d	7	2: 50: 26	5: 106: 45	9.8 (1.9)	10.0 (1.8)	−0.478^{ns}	6.2 (2.9)	6.8 (2.5)	−0.987 ^{ns}
PCU_9^d	9	5: 102: 49	4: 63: 27	9.7 (1.6)	10.1 (2.1)	−0.879^{ns}	7.9 (2.2)	8.6 (1.7)	−1.218 ^{ns}
PCU_{10}^b	5	4: 78: 42	1: 21: 7	9.5 (1.4)	11.4 (1.1)	−3.406**	8.8 (2.3)	9.1 (2.1)	−0.330 ^{ns}
PCU_{11}^c	4	3: 74: 37	1: 10: 6	9.2 (1.4)	9.8 (3.1)	−0.837^{ns}	6.9 (2.3)	4.0 (0.9)	3.091**
PCU_{12}^c	7	5: 100: 55	2: 33: 21	9.8 (1.4)	10.0 (1.6)	−0.446^{ns}	7.2 (2.1)	9.3 (2.0)	−3.819***
PCU_{13}^b	6	3: 70: 34	3: 59: 26	10.2 (1.7)	8.4 (1.8)	4.071***	6.9 (2.5)	6.0 (1.8)	1.646 ^{ns}
PCU_1^c	8	3: 58: 29	5: 91: 47	9.5 (2.3)	9.6 (2.0)	−0.213^{ns}	5.9 (1.9)	7.3 (2.8)	−2.302*
PCU_{15}^c	8	5: 136: 64	3: 34: 16	9.7 (1.9)	8.8 (1.8)	1.567^{ns}	8.2 (2.0)	6.4 (1.8)	3.338**
PCU_{16}^c	5	3: 57: 30	2: 41: 20	8.7 (1.6)	8.8 (2.2)	−0.178^{ns}	7.9 (1.8)	6.6 (2.0)	2.293*
PCU_{17}^d	5	4: 107: 51	1: 8: 3	10.4 (1.7)	10.7 (1.5)	−0.237^{ns}	9.9 (3.1)	10.7 (1.5)	−0.421 ^{ns}
PCU_{18}^d	10	6: 105: 42	4: 56: 28	10.2 (1.6)	9.6 (1.2)	1.763^{ns}	8.6 (2.7)	8.3 (2.1)	0.574 ^{ns}
Total	117	71:1722: 895	46: 839: 407	9.9 (2.1)	9.7 (2.1)	1.115^{ns}	8.3 (2.9)	7.8 (2.9)	3.178**

VHV, village health volunteer; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; PCU, primary care unit; UDS, understanding dengue solution; ULISS, understanding the larval indices surveillance system; $\bar{X}$, mean; SD, standard deviation; df, degrees of freedom.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; ^{ns} Not significant; ^{a} Mean difference statistic significant both UDS and ULISS; ^{b} Mean difference statistic significant only UDS; ^{c} Mean difference statistic significant only ULISS; ^{d}No mean difference statistic significant both UDS and ULISS.

Table 5
Comparing the levels of understanding dengue solution among village health volunteers from high- and low-risk dengue villages.

Level of UDS	VHV n (%)		Total	OR	95% CI	*p*-value
	H-RDV	L-RDV				
Good	194 (14.9)	84 (6.5)	278 (21.4)	1.064	0.798–1.419	0.672^{ns}
Poor	701 (53.8)	323 (24.8)	1024 (78.6)	1		

VHV, village health volunteer; UDS, understanding dengue solution; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; OR, odds ratio; CI, confidence interval; Good: cut-off point ≥80% (≥12 points); Poor: cut-off point <80% (<12 points); ^{ns} not significant.

Table 6
Comparing the level of understanding larval indices surveillance systems among village health volunteers from high- and low-risk dengue villages.

Level of ULISS	VHV n (%)		Total	OR	95% CI	p-value
	H-RDV	L-RDV				
Good	135 (10.4)	43 (3.3)	178 (13.7)	1.504	1.044–2.167	0.028*
Poor	760 (58.4)	364 (28.0)	1124 (31.3)	1		

VHV, village health volunteer; ULISS, larval indices surveillance system; H-RDV, high-risk dengue village; L-RDV, low-risk dengue village; OR, odds ratio; CI, confidence interval; Good: cut-off point ≥80% (≥12 points); Poor: cut-off point <80% (<12 points); *$p < 0.05$.

corroborate the results of a study of knowledge, attitudes, and practices among communities living in dengue hotspot and non-hotspot areas, which showed that 201 people living in non-hotspot areas had better knowledge and attitudes than 205 people living in hotspot areas [19].

The results were divided into four categories based on the community context and the characteristics of VHVs in each PCU. We found that VHVs of seven PCUs did not differ in understanding dengue solutions because all VHVs from every PCU in the district were trained for the larval indices surveillance system. This contrasts with the findings of another study wherein PCUs in low-risk areas had greater knowledge regarding surveillance systems and dengue prevention than those in high-risk areas [24]. This inconsistency could be due to the difference in questionnaires, as the questions in our study examined whether the individual not only knew the relevant concepts but also understood them. According to Blooms' taxonomy, "understanding" something is a more complex skill than merely remembering or "knowing" it [21]. In our study, the questions for UDS and ULISS of VHVs also contributed information regarding personal characteristics, social factors, environment, and economic factors, which was consistent with the results of a qualitative study of the perceived challenges for dengue prevention and control [31]. Therefore, there is a need to improve dengue-related knowledge and solutions among VHVs and empower them through interventions involving PCUs, health authorities, and/or public health officers [31].

We found that VHVs living in H-RDVs had better UDS and ULISS scores than those living in L-RDVs. However, nearly all VHVs showed a poor ULISS and UDS. They require refresher courses to exceed the cutoff point (≥80%) for a good understanding of the general standard of excellence based on Bloom's taxonomy [11,21,28].

5. Limitations

There are two limitations. First, we could not control how public health officers enhanced VHVs understanding because their approaches to dengue solutions differed across different PCUs. For example, interview data of VHVs revealed that in some PCUs, the priority was to conduct a workshop to understand dengue prevention and larval indices surveillance systems every month. Second, the risk criteria and prediction process were determined by relevant community leaders at the district and sub-district levels. It is possible that not all community leaders were able to communicate these factors to VHVs. Moreover, the prediction criteria focused on the factors may not be comparable and could complicate the assessment. For example, dengue morbidity rates could be assessed based on reports from each PCU or overall.

6. Conclusions

In conclusion, this study highlighted that UDS was not statistically significant, but the ULISS of VHVs and PCUs among H- and L-RDVs were different. Although most VHVs did not understand the signs, symptoms, and complex pathogenesis of dengue, overall, those in H-RDVs had a greater understanding than those in L-RDVs. Understanding something requires more comprehensive skills than simply knowing it. As our knowledge and understanding of dengue in villages improves, these results recognize that VHVs must be better educated and trained in both dengue solutions and surveillance systems.

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Author's contributions

Conceptual, study design, supervision, funding acquisition, project administration, original draft & review was performed by Suwanbamrung, C.; Formal analysis, investigation, methodology was completed by Maneerattanasak, S. and Nontapet, O; Validation, writing draft and review & editing were completed by Phumee, A., Rhaman, M.S., and Jaroenpool, J.; Data curation, data analysis, and review was performed by Krachai, W, Maneerattanasak, S., and Napet, P. All authors conducted the study, read, and approved the final study.

Ethics approval and consent to participant

The study was approved by the Institutional Review Board's Ethical Review Committee for Research Subjects at Walailak University, Thailand (protocol approval number: WUEC-19-144-01; September 20, 2019). Respondents were recruited after they were provided with research information.

Statement

Dengue disease is endemic in many countries and adequate prevention and knowledge are keys to reducing its morbidity and mortality. In Southern Thailand, we utilize the services of village health volunteers to provide on-site information about the risk of dengue in various villages. Our study's objectives were to assess and compare village health volunteers' understanding of dengue solutions and larval indices surveillance systems. An analytical, cross-sectional survey was conducted after 12 months of training regarding dengue solution and larval indices surveillance systems in 117 villages in 18 primary care units within one district in southern Thailand were included and stratified into 71 high-risk and 46 low-risk dengue villages. The 1302 VHVs were included in the study showed their understanding of UDS and ULISS differed between high-and low-risk dengue villages. VHVs who had a good level of UDS and ULISS were more likely to stay in high-risk dengue villages than in low-risk dengue villages. These results need continuous training programs to understand dengue solutions and larval indices surveillance systems regardless of village dengue risk. All stakeholders in primary care unite level should encourage understanding and monitoring in both high- and low-risk dengue villages. The study makes a significant contribution that although education is important, continuous education for village health volunteers is necessary to improve and maintain their understanding of both dengue solutions and larval indices surveillance systems.

Declaration of Competing Interest

The authors declare that they have no competing interests.

Data availability

Data will be made available on request.

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