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# Knowledge, Attitudes, and Practices on Climate Change and Dengue in Lao People's Democratic Republic and Thailand

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## Knowledge, attitudes, and practices on climate change and dengue in Lao People's Democratic Republic and Thailand

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## ABSTRACT

**Background:** Dengue is linked with climate change in tropical and sub-tropical countries including the Lao People's Democratic Republic (Laos) and Thailand. Knowledge about these issues and preventive measures can affect the incidence and outbreak risk of dengue. Therefore, the present study was conducted to determine the knowledge, attitudes, and practices (KAP) among urban and rural communities and government officials about climate change and dengue in Laos and Thailand.

**Methods:** A cross-sectional KAP survey about climate change and dengue were conducted in 360 households in Laos (180 urban and 180 rural), 359 households in Thailand (179 urban and 180 rural), and 20 government officials (10 in each country) using structured questionnaires. Data analysis was undertaken using descriptive methods, principal component analysis (PCA), Chi-square test or Fisher's exact test (as appropriate), and logistic regression.

**Results:** Significant differences among the selected communities in both countries were found in terms of household participant's age, level of education, socioeconomic status, attitude level of climate change and KAP level of dengue ( $P < 0.05$ ; 95% CI). Overall, participants' KAP about climate change and dengue were low except the attitude level for dengue in both countries. The level of awareness among government officials regarding the climatic relationship with dengue was also low.

In Lao households, participants' knowledge about climate change and dengue was significantly associated with the level of education and socioeconomic status (SES) ( $P < 0.01$ ). Their attitudes towards climate change and dengue were associated with educational level and internet use ( $P < 0.05$ ). Householders' climate change related practices were associated with SES ( $P < 0.01$ ) and dengue related practices were associated with educational level, SES, previous dengue experience and internet use ( $P < 0.01$ ).

In Thailand, participants' knowledge about climate change was associated with the level of education and SES ( $P < 0.01$ ). Their attitudes towards climate change were associated with residence status (urban/rural) and internet use ( $P < 0.05$ ); climate change related practices were associated with educational level and SES ( $P < 0.05$ ).

**Abbreviations:** DENV, Dengue virus; KAP, Knowledge, attitude, and practice; Laos, Lao People's Democratic Republic; PCA, Principal component analysis; SES, Socioeconomic status.

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Dengue related knowledge of participants was associated with SES and previous dengue experience ( $P < 0.05$ ); participants' dengue related attitudes and practices were associated with educational level ( $P < 0.01$ ).

**Conclusion:** The findings call for urgently needed integrated awareness programs to increase KAP levels regarding climate change adaptation, mitigation and dengue prevention to improve the health and welfare of people in these two countries, and similar dengue-endemic countries.

## 1. Introduction

There is a growing concern about the effect of climate change on human health and wellbeing (Haines and Ebi, 2019). As climate change continues, the global surface temperature will increase and rainfall patterns change (Pachauri et al., 2014), which affects the environmental suitability for the growth and survival of mosquitoes and potentially their transmission of dengue viruses (Xu et al., 2020). This may subsequently change the burden of dengue globally, nationally and locally.

Dengue is a climate-sensitive vector-borne viral infectious disease and is a major public health threat to more than 120 countries, with approximately half of the global population living under risk (Bhatt et al., 2013; WHO, 2020a). An estimated 390 million infections occur each year and 70% of the actual burden is shouldered by Asia (Bhatt et al., 2013). Dengue virus (DENV) is transmitted by *Aedes aegypti* (primary vector) and *Aedes albopictus* (secondary vector) mosquitoes. Dengue vectors are intrinsically dependent on climate, specifically temperature, for their growth, survival, and feeding behavior, and rainfall, for their proliferation, all of which ultimately regulate the transmission of the virus (Liu-Helmersson et al., 2014; Naish et al., 2014; Padmanabha et al., 2010; Rocklöv and Tozan, 2019; Rueda et al., 1990).

A spike in the number of reported dengue cases in 2019 was observed in most countries in Asia and South-East Asia, including Afghanistan, Bangladesh, Cambodia, Lao People's Democratic Republic (Laos), Malaysia, Maldives, Philippines, Singapore, Sri Lanka, Taiwan, and Thailand (WHO, 2019). Record numbers were reported in the Philippines (420,453 cases, 1,565 deaths), Malaysia (127,407 cases, 176 deaths) and Bangladesh (101,354 cases, 164 deaths) (DGHS, 2019; WHO, 2020b) as of December 2019. Outbreaks of dengue occurred in Laos and Thailand with 38,753 cases and 70 deaths in Laos (WHO, 2020b) and 98,741 dengue cases and 106 deaths in Thailand (MOPH Thailand, 2019).

Laos and Thailand also experienced severe dengue outbreaks in 2013 and 2015 (MOPH Thailand, 2013; MOPH Thailand, 2015; Vannavong et al., 2019). Dengue is endemic in both urban and rural areas (Vannavong et al., 2017) and peak transmission occurs in June–October (Khampanongpane et al., 2014; Limkittikul et al., 2014). South-East Asian countries are particularly vulnerable regions to climate risks (Bowen and Ebi, 2017) including Laos and Thailand. Climate change is expected to have numerous negative environmental impacts in these two countries through increased temperatures, more warm days, higher rainfall variability, flooding and droughts, which may result in detrimental effects on public health, including dengue (Marks, 2011). Expected vulnerability to climate change and its diverse local direct and indirect effects will likely increase the risk of dengue outbreaks in Southeast Asia, including Laos and Thailand (Servadio et al., 2018; WHO, 2017). Vaccine for any disease is considered the most effective control measure; however, to date, there is no licensed vaccine available for dengue. In the absence of vaccines or an effective cure, the only possible or available measures limiting transmission is through mosquito control and awareness campaigns (Hairi et al., 2003). To develop a successful dengue control strategy, it is important to understand the current knowledge, attitudes, and practices (KAP) regarding climate change adaptation/mitigation, dengue and vector control in affected communities.

Despite the accelerating global climate change (Ramasamy and Surendran, 2012; Watts et al., 2018) and increasing incidence of dengue, no study, as far as we know, has assessed the KAP of people regarding

climate change adaptation/mitigation and dengue transmission prevention practices. The KAP research design among at-risk populations is useful to inform prevention, control and mitigation measures, as well as understanding current awareness of any infectious diseases (AbbiRami and Zuharah, 2020). Hence, the present study was designed and carried out to investigate KAP on climate change and dengue among urban and rural communities and government officials in Laos and Thailand.

## 2. Materials and methods

### 2.1. Study design and population

This cross-sectional study was carried out between February and April 2019 in eight study villages (four urban and four rural) in Laos and Thailand. This study was conducted within a larger project (DENCLIM project; 2018–2021) which aims to evaluate the effects of climate change and variability on community vulnerability and exposure to dengue in geographically and culturally similar, but socioeconomically different locations. The study sites were selected based on high dengue incidence during 2014–2018, feasibility and logistics. The selected villages in Laos were urban Phonesikhai (15°09'02.4"N, 105°46'03.8"E) and rural Houay Yangkham Tai (15°07'18.5"N, 105°50'27.3"E) in Champasak province and urban Phonsavang-tai (16°34'30.2"N, 104°45'37.0"E) and rural Tonhen (17°02'44.7"N, 104°53'38.1"E) in Savannakhet province. In Thailand, the villages selected were urban Tat Khaen (16°33'18.4"N, 104°42'01.2"E) and rural Na Sameng (16°17'46.5"N, 104°52'10.4"E) in Mukdahan province and urban Don Yung (15°17'32.9"N, 104°49'11.8"E) and rural Phon Duan (14°38'38.1"N, 105°05'34.5"E) in Ubon Ratchathani province (Fig. 1). A random sample of 90 households from each village was selected by simple random sampling to represent each village, amounting to 360 households in Laos (180 rural and 180 urban) and 359 households in Thailand (180 rural and 179 urban; one household withdrew from the study). Thus, a total of 719 households were surveyed. The study area has a tropical climate with a dry season from October to April and a rainy season, dominated by the southwest monsoon, with high rainfall, high humidity and high temperatures from May to September. Dengue is mainly transmitted during the rainy season.

A total of 20 government officials (10 in each country) were also purposively selected and interviewed between June and August 2019 with officials from the Ministry of Public Health in Thailand, the Ministry of Health in Laos, the Provincial Disaster Prevention and Mitigation offices in Thailand, the National Disaster Management offices in Laos, the Meteorology Department in Thailand, and the Department of Meteorology and Hydrology in Laos.

### 2.2. Data collection

Face-to-face interviews were conducted and information on KAP regarding climate change and dengue, including demographic characteristics, were collected from each household head or responsible adult (18 years or above) using a structured questionnaire (File S1 in Supplement). Socioeconomic data, household characteristics, and durable asset ownership (Table S1 in Supplement) were collected from each household prior to the KAP survey during September 2018–February 2019. Another mixed-method study (e-mail survey and face-to-face interview) employing a self-administered questionnaire (File S2 in Supplement) was used to collect information on KAP of government

officials on strengths, actions, and capacity to mitigate climate-induced vulnerability to dengue fever, all data were collected by trained local health officials or public health researchers who were given 5 days' training before implementation. Training of data collectors was given by experienced supervisors who also monitored data collection in the field for data integrity and quality. The KAP questionnaires were developed based on the review of relevant literature from different studies (Harapan et al., 2018; Isa et al., 2013; Udayanga et al., 2018; World Health, 2009) for dengue and (Caminade et al., 2019; Morin et al., 2013; Naish et al., 2014; Ogden, 2017; Parkinson and Evengård, 2009; Rawlins et al., 2007; Woodward et al., 2014; Wu et al., 2016) for climate change. The questionnaires were completed based on experts' opinion in terms of relativity, simplicity and importance following a group discussion held in an international meeting as a part of the project. The household KAP questionnaire (File S1 in Supplement) included 29 questions on knowledge (climate change: 8, dengue: 21), 23 questions on attitudes (climate change: 10, dengue: 13) and 18 questions on practices (climate change: 6, dengue: 12) adding up to a total of 70 questions. The government official questionnaire (File S2 in Supplement) included 5 questions on knowledge, 9 questions on attitudes and 8 questions on practices, adding up to a total of 22 questions intersecting the domains of climate change and dengue.

### 2.3. Data management and statistical analysis

The socioeconomic status (SES) of the households was ranked into low, intermediate and high using principal component analysis (PCA) based on house characteristics and durable asset ownership (Tables S1–S2 in Supplement) (Vyas and Kumaranayake, 2006). Each participants' KAP was assessed using a scoring system based on the total correct responses against the total questions (knowledge: 8, attitude: 10, practice: 6) regarding climate change (questions and summary answers shown in Tables S3–S5 in Supplement) and (knowledge: 21, attitude: 13, practice: 12) for dengue (questions and summary answers are shown in Tables S6–S8 in Supplement). Each question was scored as correct (1

point) or incorrect (0 point). Multiple response questions on knowledge and practices were scored 1 for correct or good answers, 0.5 for moderately good answers, and 0 for incorrect, poor, or “do not know” answers. For attitudes, the answers “positive”, “moderate” and “negative”/“not sure”, were given the scores of 1, 0.5, 0, respectively. Total scores for each KAP component were calculated and converted into percentages (0–100 scale). Participants' knowledge was assessed as ‘good’ percentage knowledge scores were higher than 80%, otherwise ‘poor’ (Dhimal et al., 2014). The same principle was applied to the sections on attitude and practice. Government officials KAP (questions and summary answers are shown in Tables S3–S5 in Supplement) were assessed based on the responses of their understanding, attitudes, or awareness about the relationships between climate change and dengue, climate change adaptation, risk mitigation strategies of dengue and preparation for any type of post-disaster dengue outbreak, key components for determining the activities and the local government's ability to prepare the community for climate change and dengue risk.

Comparison between two countries and their urban and rural populations in terms of basic demographic, socioeconomic, and KAP characteristics of public and government officials were conducted using the Chi-square test or Fisher's exact test (as appropriate). Significant variables in univariate logistic regression analysis ( $p \leq 0.25$ ) were used for multiple logistic regression analysis to determine the predictors of each KAP level “good” vs. “poor” (Harapan et al., 2018). The overall performance of the fitted regression models was evaluated by Pearson chi-square and Hosmer–Lemeshow goodness-of-fit tests using non-significant/larger  $P$ -value (Chandranantha, 2019).

## 3. Results

### 3.1. Knowledge, attitudes and practices on climate change

Almost all of the study respondents reported having heard about climate change (92.4% and 89.7% for Thailand and Laos, respectively) and believed that the climate is changing (91.3% and 83.6% for

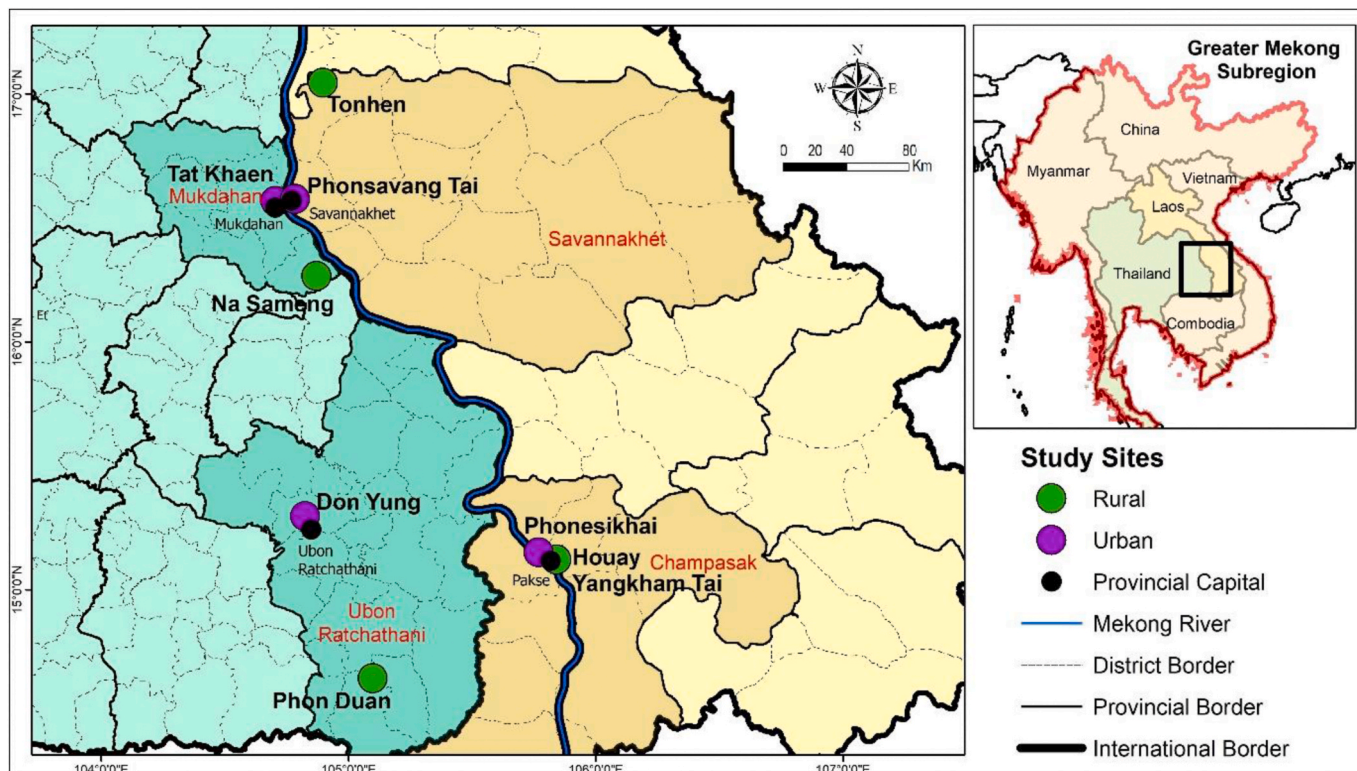


Fig. 1. Location of study sites.

Thailand and Laos, respectively) (Table S3 in Supplement). More than 85% of the study respondents in both countries believed that the changes in climate can affect dengue fever. However, study communities in both countries had limited understanding and awareness about local, global, and possible future effects of climate change (Table S3 in Supplement). More than 80% of the study respondents had a positive attitude to receiving updated information about the impacts of climate change and mitigation of dengue risk (Table S4 in Supplement). Only a few respondents (35.3% and 33.8% for Thailand and Laos, respectively) took extra actions to prepare to adapt to the impact of climate change (floods, droughts, storms, etc.) and reduce dengue risk (Table S5 in Supplement). However, most of the study respondents reported practices (e.g. cleaning drains, cleaning or helping to maintain public drainage systems from waste, etc.) following an extreme event and prevent dengue risk (Table S5 in Supplement).

### 3.2. Knowledge, attitudes and practices on dengue

The study respondents had limited knowledge of transmission, symptoms, and warning signs of dengue (Table S6 in Supplement). The majority of the respondents correctly perceived only two transmission modes of dengue, including a vulnerable person can get dengue more than once and mosquito bites. Less than 50% of the study respondents knew about the dengue virus serotypes and vectors (*Ae. aegypti* and *Ae. albopictus*). As for correct knowledge of dengue symptoms, fever was the most common symptom among study respondents, followed by headache and muscle pain. Few respondents knew that pain behind the eyes (44.0% and 43.6% for Thailand and Laos, respectively) and nausea/vomiting (46.7% and 35.2% for Thailand and Laos, respectively) were also signs or symptoms of dengue. Regarding vector morphology, few study respondents knew that *Aedes* mosquitos have white spots on their legs. However, more than 80% of the study respondents knew that these mosquitos are daytime biters (Table S6 in Supplement). For dengue risk mitigation, the majority of the study respondents showed a positive attitude of requiring improved awareness and knowledge, and more educational programs on symptoms and treatments of dengue including additional training on vector control strategies (Table S7 in Supplement). In both countries, dengue prevention practices related to *Aedes* breeding sites and steps to prevent mosquito breeding during an outbreak were not satisfactory. The most common good practices among respondents included preventing mosquito-man contact followed by covering the body with clothes, disposing of water-holding containers, covering water containers in the home, the use of mosquito repellent and mosquito netting, cleaning of the garbage/trash, and insecticide sprays to reduce mosquitoes (Table S8 in Supplement).

### 3.3. Knowledge, attitudes and practices scores of study participants

The overall mean scores for KAP on climate change in Laos were K = 64%, A = 71%, and P = 63% (Fig. 2) and the corresponding figures for dengue were K = 59%, A = 79%, and P = 71%. Overall mean scores for KAP on climate change in Thailand were K = 59%, A = 70%, and P = 61% and the corresponding figures for dengue were K = 65%, A = 84%, and P = 66% (Fig. 2). Urban residents in both countries had higher KAP scores regarding climate change and dengue compared to rural residents, except in Laos where climate change knowledge was higher in rural than in urban sites (Table 1A). Mean scores for knowledge on climate change was highest among urban residents of Thailand, but mean scores for attitude and practice on climate change were highest among urban residents of Laos (Table 1A). Mean scores for knowledge and practice on dengue were highest among urban residents of Thailand, but mean scores for practice on dengue was highest among urban residents of Laos (Table 1B).

Young participants (age < 30 years) had higher KAP scores regarding climate change and dengue than other age groups (> 30 years) in both countries. Mean scores for KAP on climate change and dengue were also among higher educated participants (completed higher than secondary education) and participants having higher SES.

People having previous experience of dengue had comparatively higher KAP scores regarding climate change and dengue in both countries. Internet users in both countries also had higher KAP scores on climate change and dengue than non-users. Mean scores for KAP on climate change were highest among internet users in Laos. Mean scores for knowledge and attitude on dengue were highest among internet users in Thailand, but mean scores for practice on dengue were highest among internet users in Laos (Table 1B).

### 3.4. Factors associated with knowledge, attitudes and practices

Participants having higher than secondary education were more likely to have good knowledge regarding climate change in both countries (Laos: OR: 8.32 and 95% CI: 3.95–17.54; Thailand: OR: 6.55, CI: 2.46–17.39) compared to participants who had only completed secondary school or lower (Table 2A). The highest level of education was also significantly associated with good dengue knowledge in Laos. Higher educated participants had five times higher knowledge regarding dengue compared to participants who did not complete higher education (Table 2B). Participants living in households with higher SES had higher odds of having good knowledge on climate change in Laos (OR: 2.15, CI: 0.84–5.50) and Thailand (OR: 10.57, CI: 3.88–28.73) compared to participants in households with lower SES (Table 2A). SES and previous dengue experience were found to be significant predictors of good

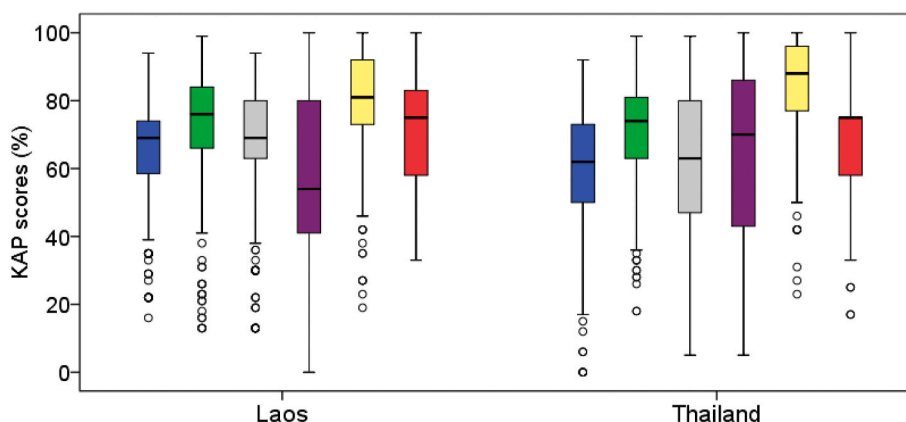


Fig. 2. Boxplots showing the percentage of householders' knowledge, attitude, and practice (KAP) scores in Laos and Thailand, respectively during February–April 2019. The blue = K, green = A, and grey = P boxplots show the KAP scores for climate change while the purple = K, yellow = A and red = P boxplots show the KAP scores for dengue. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

**Table 1**

Knowledge, attitudes and practices scores of study participants by socio-demographic variables regarding A: Climate change and B: Dengue in Laos and Thailand (n = 719). Maximum scores are 100 for each KAP component.

A. Climate change								
Variable	n (%)		Mean score					
			Knowledge (SD)		Attitudes (SD)		Practices (SD)	
	Laos	Thailand	Laos	Thailand	Laos	Thailand	Laos	Thailand
<b>Age group (in years)</b>								
<30	45 (12.5)	20 (5.6)	69.3 (14.6)	66.6 (18.8)	72.2 (16.0)	76.7 (10.4)	64.4 (22.3)	66.6 (19.9)
31–45	121 (33.6)	84 (23.4)	66.0 (12.1)	64.5 (15.0)	71.0 (18.2)	72.1 (14.5)	65.1 (19.1)	63.9 (17.1)
>45	194 (53.9)	255 (71.0)	62.8 (16.3)	57.8 (17.5)	71.7 (17.7)	69.8 (16.9)	62.2 (21.6)	60.5 (19.4)
<b>Sex of person</b>								
Male	102 (28.3)	113 (31.5)	69.3 (13.2)	60.7 (17.8)	73.2 (17.6)	71.4 (15.8)	68.3 (19.6)	63.4 (17.3)
Female	258 (71.7)	246 (68.5)	62.8 (15.2)	59.4 (16.9)	70.9 (17.6)	70.4 (16.3)	61.5 (21.1)	60.8 (19.7)
<b>Marital status</b>								
Married	321 (89.2)	326 (90.8)	64.2 (14.8)	59.5 (16.9)	71.3 (18.0)	70.3 (15.5)	63.1 (21.2)	61.8 (19.1)
Unmarried	36 (10.0)	29 (8.1)	68.5 (15.8)	61.5 (20.7)	73.1 (15.0)	75.7 (10.4)	66.0 (19.1)	60.2 (17.2)
Divorced	3 (0.8)	4 (1.1)	74.6 (1.1)	72.2 (5.5)	77.6 (13.3)	70.5 (15.0)	71.6 (8.5)	53.0 (24.6)
<b>Level of education</b>								
Secondary school or lower	291 (80.8)	331 (92.2)	62.4 (14.7)	58.7 (16.6)	69.7 (17.8)	70.1 (16.4)	61.0 (21.8)	60.9 (18.8)
Higher than secondary school	69 (19.2)	28 (7.8)	74.1 (12.3)	72.9 (18.7)	79.8 (14.7)	78.2 (9.7)	73.6 (12.1)	70.4 (19.6)
<b>Type of residence</b>								
Rural	180 (50)	180 (50.1)	67.2 (12.7)	56.7 (18.4)	67.8 (19.4)	67.5 (15.7)	60.1 (22.8)	58.5 (18.9)
Urban	180 (50)	179 (49.9)	62.1 (16.5)	62.9 (15.2)	75.3 (14.8)	73.9 (16.0)	66.8 (18.3)	64.7 (18.6)
<b>Socioeconomic status</b>								
Low	114 (31.7)	125 (34.8)	16.5 (15.6)	54.4 (18.0)	67.6 (18.3)	69.1 (17.0)	50.9 (22.4)	50.6 (17.9)
Intermediate	118 (32.8)	123 (34.3)	65.5 (11.5)	60.3 (13.9)	71.7 (17.3)	69.8 (16.5)	67.8 (17.6)	61.9 (17.7)
High	128 (35.5)	111 (30.9)	66.7 (16.7)	65.3 (17.7)	74.9 (16.8)	73.6 (14.4)	70.6 (17.0)	73.7 (13.3)
<b>Previous dengue experience</b>								
No	325 (90.3)	339 (94.4)	64.9 (14.3)	59.8 (17.3)	71.2 (18.1)	70.5 (16.2)	62.5 (21.3)	61.9 (19.0)
Yes	35 (9.7)	20 (5.6)	62.6 (18.5)	60.3 (14.2)	74.9 (12.6)	74.7 (14.4)	72.74 (12.7)	57.2 (18.4)
<b>Internet use</b>								
No	194 (53.9)	92 (25.6)	63.0 (15.5)	57.2 (18.5)	65.6 (19.2)	67.5 (17.2)	56.3 (19.9)	48.9 (18.7)
Yes	166 (46.1)	267 (74.4)	66.6 (14.1)	60.7 (16.6)	78.4 (12.5)	71.8 (15.6)	71.8 (18.8)	66.0 (17.0)
B. Dengue								
Variable	n (%)		Mean score					
			Knowledge (SD)		Attitudes (SD)		Practice (SD)	
	Laos	Thailand	Laos	Thailand	Laos	Thailand	Laos	Thailand
<b>Age group (in years)</b>								
<30	45 (12.5)	20 (5.6)	66.5 (28.2)	77.5 (24.8)	81.5 (11.7)	88.2 (9.6)	73.0 (19.0)	70.8 (15.9)
31–45	121 (33.6)	84 (23.4)	61.4 (24.0)	69.6 (24.0)	78.7 (13.9)	84.1 (13.2)	71.9 (17.4)	66.5 (16.6)
>45	194 (53.9)	255 (71.0)	56.3 (23.3)	63.5 (24.2)	78.9 (15.0)	83.7 (15.9)	70.7 (16.0)	66.1 (17.2)
<b>Sex of person</b>								
Male	102 (28.3)	113 (31.5)	66.2 (24.9)	66.5 (25.4)	81.6 (12.4)	87.2 (12.7)	76.1 (16.8)	66.8 (17.3)
Female	258 (71.7)	246 (68.5)	56.4 (23.6)	65.3 (24.0)	78.2 (14.8)	82.7 (15.8)	69.5 (16.5)	66.3 (16.9)
<b>Marital status</b>								
Married	321 (89.2)	326 (90.8)	58.4 (23.9)	64.9 (24.3)	78.9 (14.3)	84.0 (15.3)	71.2 (16.4)	66.5 (17.0)
Unmarried	36 (10.0)	29 (8.1)	66.0 (27.7)	72.3 (25.6)	81.9 (13.7)	85.3 (13.3)	74.1 (21.0)	64.6 (17.8)
Divorced	3 (0.8)	4 (1.1)	61.6 (16.0)	77.7 (19.3)	80.6 (10.2)	83.5 (7.6)	61.0 (5.1)	77.0 (14.4)
<b>Level of education</b>								
Secondary school or lower	291 (80.8)	331 (92.2)	53.5 (20.8)	64.0 (24.2)	78.1 (15.1)	83.2 (15.2)	68.1 (14.6)	66.6 (16.7)
Higher than secondary school	69 (19.2)	28 (7.8)	83.3 (23.3)	85.5 (17.4)	83.8 (8.1)	94.5 (7.0)	85.4 (18.6)	76.7 (17.7)
<b>Type of residence</b>								
Rural	180 (50)	180 (50.1)	54.0 (24.1)	60.2 (23.3)	77.9 (14.8)	82.6 (16.5)	69.8 (15.1)	64.8 (17.3)
Urban	180 (50)	179 (49.9)	64.4 (23.5)	71.2 (24.3)	80.4 (13.5)	85.6 (13.3)	72.9 (18.3)	68.2 (16.6)
<b>Socioeconomic status</b>								
Poor	114 (31.7)	125 (34.8)	43.9 (16.2)	57.9 (22.3)	76.9 (14.9)	80.9 (17.8)	65.4 (13.5)	60.5 (19.4)
Intermediate	118 (32.8)	123 (34.3)	58.5 (21.8)	63.2 (23.0)	79.4 (14.1)	85.1 (13.9)	69.2 (15.6)	68.2 (14.9)
Rich	128 (35.5)	111 (30.9)	73.5 (24.2)	77.2 (24.1)	81.0 (13.5)	86.5 (11.9)	78.7 (18.0)	71.2 (14.2)
<b>Previous dengue experience</b>								
No	325 (90.3)	339 (94.4)	58.2 (23.5)	64.90 (24.1)	78.2 (14.4)	83.9 (15.1)	70.5 (17.0)	65.9 (17.1)
Yes	35 (9.7)	20 (5.6)	68.9 (27.0)	79.65 (25.8)	88.7 (8.2)	87.3 (13.5)	79.7 (13.0)	75.7 (11.4)
<b>Internet use</b>								
No	194 (53.9)	92 (25.6)	55.0 (25.0)	66.1 (25.7)	71.0 (15.3)	80.9 (18.8)	67.8 (17.0)	64.5 (18.1)
Yes	166 (46.1)	267 (74.4)	64.1 (22.6)	65.5 (24.0)	81.8 (12.3)	85.2 (13.4)	75.5 (15.7)	67.1 (16.6)

dengue knowledge in both countries. Participants in higher SES quantile had twenty times and four times higher dengue knowledge in Laos and Thailand, respectively, compared to participants in lower SES quantiles. Participants who had a history of dengue were two times and three times more likely to have a good knowledge regarding dengue knowledge in Laos and Thailand, respectively (Table 2A).

The attitudes level concerning climate change and dengue significantly differed between urban and rural residences ( $p < 0.05$ ) in Laos and Thailand (Table 2B). Factors associated with a good attitude regarding climate change were higher education level and internet use in Laos. However, internet use was the only significant factor for a good attitude about climate change in Thailand. Higher education level,

**Table 2**

Multiple logistic regression analysis showing only significant predictors ( $p < 0.05$ ) for good vs poor knowledge (A), attitudes (B), and practices (C) on climate change and dengue. A percentage higher than 80% was classified as 'Good'. OR = odds ratio, CI = confidence intervals.

Independent variable	Laos				Thailand			
	Climate change		Dengue		Climate change		Dengue	
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
<b>A. Knowledge</b>								
<b>Age group (in years)</b>				<0.05				<0.05
<30			1					
31–45			0.72 (0.25–2.08)				1.09 (0.35–3.43)	
>45			0.33 (0.11–0.93)				0.48 (0.16–1.46)	
<b>Level of education</b>		<0.01		<0.01		<0.01		<0.01
Secondary school or lower	1		1		1		1	
Higher than secondary school	8.32 (3.95–17.54)		5.68 (2.82–11.42)		6.55 (2.46–17.39)		4.41 (2.39–8.10)	
<b>Socioeconomic status</b>		<0.01		<0.01		<0.01		<0.01
Low	1		1		1		1	
Intermediate	0.57 (0.19–1.68)		7.95 (3.10–20.33)		1.44 (0.49–4.26)		1.17 (0.67–2.04)	
High			20.54 (8.02–52.62)		10.57 (3.88–28.73)		4.41 (2.39–8.10)	
<b>Previous dengue experience</b>				<0.05				<0.05
No			1				1	
Yes	2.15 (0.84–5.50)		2.49 (1.06–5.86)				3.32 (1.22–9.06)	
<b>B. Attitude</b>								
<b>Level of education</b>		<0.01		<0.05				<0.05
Secondary school or lower	1		1				1	
Higher than secondary school	2.85 (1.53–5.29)		1.84 (0.98–3.45)				12.47 (1.60–97.03)	
<b>Residence status</b>						<0.01		
Rural					1			
Urban					2.51 (1.53–4.12)			
<b>Socioeconomic status</b>								<0.01
Low							1	
Intermediate							2.07 (1.19–3.60)	
High							2.91 (1.53–5.54)	
<b>Previous dengue experience</b>				<0.01				
No			1					
Yes			6.87 (2.32–20.30)					
<b>Use of internet</b>		<0.01		<0.01		<0.05		
No	1		1		1			
Yes	3.92 (2.43–6.33)		1.89 (1.19–2.99)		1.88 (1.06–3.32)			
<b>C. Practice</b>								
<b>Level of education</b>				<0.01		<0.05		<0.01
Secondary school or lower			1		1		1	
Higher than secondary school			6.65 (3.45–12.82)		2.92 (1.18–7.23)		19.12 (6.22–58.71)	
<b>Socioeconomic status</b>		<0.01		<0.01		<0.01		
Low	1		1		1		1	
Intermediate	3.22 (1.55–6.69)		1.61 (0.78–3.34)		4.95 (2.27–10.80)			
High	3.96 (1.91–8.19)		3.24 (1.60–6.55)		12.61 (5.63–28.26)			
<b>Previous dengue experience</b>				<0.01				
No			1					
Yes			3.52 (1.53–8.10)					
<b>Internet use</b>				<0.01				
No			1					
Yes			2.09 (1.21–3.60)					

previous dengue experience and internet use were associated with a good attitude regarding dengue prevention in Laos. Higher education and high SES were significantly associated with a good attitude regarding dengue prevention in Thailand. Participants having higher education had a higher attitude level regarding climate change in Laos (OR: 2.85, 95% CI:1.53–5.29), and dengue in Laos (OR: 1.84, 95% CI:0.98–3.45) and in Thailand (OR:12.47, 95% CI:1.60–97.03). Participants having high SES were more likely to have a good attitude regarding dengue prevention in Thailand (OR: 2.91, 95% CI:1.53–5.54). Participants in Laos having previous dengue exposure had almost seven times higher good attitude levels compared to participants who had no previous dengue exposure. Internet users were more likely to have a good attitude regarding climate change (OR:3.92, 95% CI:2.43–6.33)

and dengue (OR:1.89, 95% CI:1.19–2.99) in Laos. Internet users were also more likely to have a good attitude regarding climate change in Thailand (OR: 1.88, 95% CI 1.06–3.32) (Table 2B).

The highest level of education, socioeconomic status, previous dengue experience and internet use were significant factors for good dengue prevention practices in Laos (Table 2C). The highest level of education was the only significant factor regarding good dengue prevention practices in Thailand (Table 2C). Increased odds of having good practice regarding climate change (OR 2.92, 95% CI:1.18–7.23) and dengue (OR 19.12, 95% CI:6.22–58.71) were identified among higher educated participants in Thailand. Higher educated participants were more likely to have good prevention practices (OR 6.65, 95% CI:3.45–12.82) in Laos. Also, participants having high SES had higher



odds of having good practices regarding climate change (OR 3.96, 95% CI:1.91–8.19) and dengue (OR 3.24, 95% CI:1.60–6.55) compared to participants having low SES in Laos. Participants having high SES in Thailand were also more likely to have good dengue prevention practices (OR 12.61, CI: 5.63–28.26). Participants who suffered from dengue were three times more likely to have good dengue prevention practices compared with those having no previous history of dengue exposure in Laos. Internet users were two times more likely to have good dengue prevention practices in Laos.

Urban residents in both countries had access to the internet and more than 60% of respondents in each site were using it as a source of information. In rural areas of Thailand, 68.3% had sufficient access to the internet, whereas only 32.2% in rural areas of Laos had sufficient access (Table S5 in Supplement). In rural and urban communities of both countries, more than 90% of residents reported that television was the primary source of information about climate literacy (adaptation and mitigation capacities) (Table S5 in Supplement).

Among government officials, only 20% in Thailand and 30% in Laos reported good understanding and awareness about climate change and dengue (Table 3). However, most of them had positive attitudes (Table 4) regarding important components (availability of funding and acceptability of different projects within the community, regular monitoring, and designing and implementing household targeting systems) to consider or address during the implementation of the climate change adaptation and risk preparation for dengue. They reported a lack of local policy models, regularity authority, trained public health staff, funding, scientific information, and support from local politicians, which were affecting the local government’s ability to prepare the community for the impacts of climate change and mitigation against dengue (Table 4). Climate change and its health impacts were considered in health planning in Laos (40%) and Thailand (50%). However, more than 80% of government officials in both countries reported that health facilities (hospitals, medical equipment, diagnostic tests) were neither well equipped nor well prepared for any type of natural disaster (drought and flood events) or post-disaster dengue outbreak (Table 5).

**Table 3**

Summarized knowledge of government officials regarding climate change adaptation and risk mitigation of dengue fever in Laos and Thailand (percentages in parentheses) *n*=20.

Factors	Laos	Thailand	P-value
<b>Do you believe the climate is changing?</b>			0.531
No	2 (20)	1 (10)	
Yes	8 (80)	9 (90)	
<b>Your understanding and awareness about the climatic connection to dengue</b>			0.476
Good	2 (20)	3 (30)	
Medium	8 (80)	6 (60)	
Poor	0 (0)	1 (10)	
<b>How serious a problem do you think climate change and more spread of dengue fever at this moment?</b>			0.178
Moderately serious	6 (60)	3 (30)	
Extremely serious	4 (40)	7 (70)	
<b>Do you think climate change adaptation strategies can reduce vulnerability to health risks, and more particularly dengue fever?</b>			0.653
No	5 (50)	4 (40)	
Yes	5 (50)	6 (60)	
<b>Are climate change and its health impacts ever considered in health planning in your setting?</b>			0.653
No	6 (60)	5 (50)	
Yes	4 (40)	5 (50)	

All *P*-values are based on a Chi-square test or Fisher’s exact test (as appropriate) for independence analysis based on knowledge characteristics regarding dengue (in respective study sites, separately).

**Table 4**

Summarized attitudes of government officials regarding climate change adaptation and risk mitigation of dengue fever in Laos and Thailand (percentages in parentheses) *n*=20.

Factors	Laos	Thailand	P-value
<b>Availability of funding</b>			0.301
Not Important	0 (0)	1 (10)	
Important	6 (60)	3 (30)	
Very Important	4 (40)	6 (60)	
<b>Acceptability of the project within the community</b>			0.041
Not Important	0 (0)	2 (20)	
Important	6 (60)	1 (10)	
Very Important	4 (40)	7 (70)	
<b>Designing and implementing household targeting systems</b>			0.403
Not Important	1 (10)	2 (20)	
Important	7 (70)	4 (40)	
Very Important	2 (20)	4 (40)	
<b>Regular monitoring and making adjustments along the way</b>			0.653
Not Important	0 (0)	0 (0)	
Important	5 (50)	4 (40)	
Very Important	5 (50)	6 (60)	
<b>Lack of scientific information</b>			0.819
Not at all	1 (10)	2 (20)	
Somewhat	8 (80)	7 (70)	
A great deal	1 (10)	1 (10)	
<b>Lack of funding</b>			0.534
Not at all	1 (10)	3 (30)	
Somewhat	4 (40)	3 (30)	
A great deal	5 (50)	4 (40)	
<b>Lack of trained public health staff</b>			0.061
Not at all	0 (0)	4 (40)	
Somewhat	7 (70)	3 (30)	
A great deal	3 (30)	3 (30)	
<b>Lack of regulatory authority</b>			0.565
Not at all	1 (10)	3 (30)	
Somewhat	7 (70)	4 (40)	
A great deal	2 (20)	3 (30)	
<b>Lack of local policy models</b>			0.093
Not at all	0 (0)	3 (30)	
Somewhat	7 (70)	3 (30)	
A great deal	3 (30)	4 (40)	

All *p*-values are based on a Chi-square test or Fisher’s exact test (as appropriate) for independence analysis based on knowledge characteristics regarding dengue (in respective study sites, separately).

Most of the participants (more than 60%) in both countries reported that activities of updating flood plain maps, water supply models, and stormwater control, and considering climate change when developing local land use plans were not undertaken. However, more than 50% reported that activities of improving public health infrastructure, outbreak preparedness teams, and educating community members were undertaken in both countries.

**4. Discussion**

This study presents findings of a KAP study on climate change and dengue of inhabitants in rural and urban areas of Laos and Thailand, as well as of government officials in both countries. Despite climate change and dengue being major threats in the region, low levels of knowledge and practices on both topics were found in both countries based on the overall KAP scores. A low level of attitudes was found towards climate change, but the attitude level for dengue was good. A similar result for dengue knowledge and preventive practices was obtained in a previous study in Indonesia where more than 50% and 65% of the participants had poor knowledge and preventive practices regarding dengue, respectively (Harapan et al., 2018). In contrast, another study in Malaysia reported good knowledge and preventive practices but a poor attitude regarding dengue infection (Firdous et al., 2017). The difference may be due to intensified education and an increase in access to health

facilities and other information sources which was reflected in the communities' level of knowledge, attitudes and practices.

#### 4.1. Socio-demographic factors of knowledge, attitudes and practice

KAP regarding climate change adaptation and dengue control was significantly higher in urban than in rural communities in both countries, as has been reported in previous studies related to dengue KAP in Thailand and India (Gupta et al., 1998; Van Benthem et al., 2002). Urban communities are known to have a higher education level, better SES and access to internet facilities compared to rural communities and thus possess relatively good knowledge, positive attitudes, and better practices towards climate change adaptation and dengue prevention practices. The reason for the poor KAP among rural communities might be due to the lack of proper education, lower SES and communication strategies. For example, we found that only 14.4% of the rural participants in Laos and 6.1% of the rural participants in Thailand had higher than secondary school level of education. It is worth to mention that only 23% of the rural people in both countries had high SES. Low literacy rate and poor socioeconomic condition were likely key factors resulting in insufficient KAP regarding climate change and dengue. This could be accredited to the actuality that individuals belonging to low SES might not possess resources to afford a better education which could

**Table 5**

Summarized practices of government officials to prepare the community for the potential effects of climate change and dengue fever (percentages in parentheses)  $n=20$ .

Factors	Laos	Thailand	P-value
<b>How prepared do you feel health facilities (hospital, medical equipment, diagnostic test) in this area are for any type of disaster (flood event)?</b>			0.305
Completely unprepared	1 (10)	0 (0)	
Somewhat prepared	9 (90)	10 (100)	
Completely prepared	0 (0)	0 (0)	
<b>How prepared do you feel health facilities (hospital, medical equipment, diagnostic test) in this area are for any type of post-disaster dengue outbreak?</b>			0.589
Completely unprepared	1 (10)	1 (10)	
Somewhat prepared	8 (80)	9 (90)	
Completely prepared	1 (10)	0 (0)	
<b>Updating flood plain maps</b>			0.639
Yes, and this activity has not been undertaken	7 (70)	6 (60)	
Yes, and this activity has already been undertaken	3 (30)	4 (40)	
<b>Improving public health infrastructure, outbreak preparedness team</b>			0.361
Yes, and this activity has not been undertaken	5 (50)	3 (30)	
Yes, and this activity has already been undertaken	5 (50)	7 (70)	
<b>Updating water supply models</b>			0.639
Yes, and this activity has not been undertaken	6 (60)	7 (70)	
Yes, and this activity has already been undertaken	4 (40)	3 (30)	
<b>Updating stormwater controls</b>			0.639
Yes, and this activity has not been undertaken	7 (70)	6 (60)	
Yes, and this activity has already been undertaken	3 (30)	4 (40)	
<b>Educating community members</b>			0.639
Yes, and this activity has not been undertaken	3 (30)	4 (40)	
Yes, and this activity has already been undertaken	7 (70)	6 (60)	
<b>Considering climate change when developing local land use plans</b>			0.639
Yes, and this activity has not been undertaken	7 (70)	6 (60)	
Yes, and this activity has already been undertaken	3 (30)	4 (40)	

All  $p$ -values are based on a Chi-square test or Fisher's exact test (as appropriate) for independence analysis based on knowledge characteristics regarding dengue (in respective study sites, separately).

have a major role to play in their KAP on these two topics.

In both countries, SES was significantly associated with climate change adaptation and mitigation related practices; whereas, educational level and SES were significant factors associated with dengue control practices. One of the possible reasons behind the association of SES with better knowledge and practices regarding climate change and dengue is that people with higher SES might have better access to information sources through multiple channels (television, radio, newspapers) (Castro et al., 2013). A combination of better access to information and higher education level might assure a better understanding and knowledge (Castro et al., 2013) regarding climate change and dengue. Participants who had a previous history of dengue infection were two and three times more likely to have a good knowledge regarding dengue knowledge in Laos and Thailand, respectively. This indicates that previously infected people might have tried to get more information regarding dengue for learning more about the disease. Education was only significantly associated with good knowledge about dengue among participants in Laos. For example, higher educated participants in Laos had five times higher odds to have good knowledge about dengue compared to participants who did not complete higher education. One of the reasons for this might be that the education program of different countries varies in their content on dengue which in turn may affect the knowledge level among people (Harapan et al., 2018).

#### 4.2. Sources of information on climate change and dengue fever

The study found a higher ratio of internet users as a source of information among study participants, specifically for social media, which provides useful information on climate change and dengue. The use of the internet was significantly associated with householders' attitudes towards climate change while their attitudes towards dengue were associated with educational level. In this study, television was the main source of information regarding climate change and dengue among the participants from both countries. People also used social media (Facebook, Line, Instagram, etc.) and radio as a source of information collection and communication tools on both topics. For example, more than 90% of the participants preferred to receive information using television about climate change updates (climate literacy for adaptation and mitigation capacities) and control strategies of dengue risk. Similar results were reported by several other studies where television was found as the main source of information regarding dengue (AbbiRami and Zuharah, 2020; Al-Dubai et al., 2013; Itrat et al., 2008). This finding highlights the importance of educating the target population who are not knowledgeable (on dengue and climate change) and most vulnerable (to dengue and climate change) using the above information sources. The use of social media, radio and television can also play a vital role through the dissemination of information about adaptation and mitigation measures for climate change and also monitoring and preventing dengue (Boonchutima et al., 2017; Nalongsack et al., 2009).

#### 4.3. Stakeholders knowledge, knowledge, attitudes and practices

Government authorities have a significant role in implementing the strategies for disaster control and environmental protection and they must have strong knowledge about the KAP of climate change and dengue. The study revealed that most of the government officials working under local government organizations for health and disaster management have a medium level of understanding and awareness for climate change and dengue. They also mentioned that almost all government institutes were poorly equipped and do not have any preparation regarding climate change attributed to additional dengue prevention. Hence, it is important to point out that the general community is expecting greater contributions from relevant entities (government, NGOs, and volunteers) in providing the required KAP for climate change and dengue control. Based on the community and

stakeholder's response, the level of KAP (climate change and dengue) can be improved through effective and immediate possible initiatives, including education programs, training, and improved resources by introducing the collaborative working of academia and government institutes of each country. These programs will help to inform both participants of the available scientific knowledge on both issues so that it could be used to bring changes in attitudes and practices for better health. Similar recommendations were provided by previous studies in Laos and Thailand (Kittigul et al., 2003; Nalongsack et al., 2009; Sayavong et al., 2015).

Education programs regarding climate change (mitigation and adaptation) and dengue (control and prevention) strategies at the household level can be provided through television and social media platforms from health and environment authorities of both countries (such as short documentaries, weekly updates, case studies, and early warning). The information for pre- and post-disaster dengue outbreaks can also be provided through these platforms. Similar information on climate change and dengue can also be provided through subscribed mobile information messages from the environment and health authorities. During the survey, communities expressed an interest that they need more information about climate change updates (global and local) and dengue (effective mosquito control practice and symptoms of dengue). All these interventions can improve health-seeking behavior among communities (Rifkin, 2014). To enhance the awareness about climate change and dengue, posters, booklets and brochures could be distributed in schools, universities, workplaces, markets, hospitals, parks and other public places that can ultimately help to reduce dengue transmission.

#### 4.4. Climate change and dengue prevention and control strategies

To control vector-borne diseases, including dengue, multi-sectoral approaches must be considered according to WHO's Framework for a National Vector Control Needs Assessment (WHO 2017). Therefore, it is crucial to develop, employ and integrate different programs, such as campaigns, social mobilization, communication on climate change adaptation and mitigation strategies and vector control to focus on finding and destroying mosquito breeding sites for whole communities or regions. Joint efforts are needed from government agencies, local government units, schools, offices, health professionals, and community leaders about these topics. More importantly, proper communication and coordination between different entities working on climate change and dengue and the local communities to recognize key constraints/practical difficulties in dengue management are required. Greater interaction between research, industry, community, and policy is crucial for the all-important scale-up of new strategies that can explicitly address local and regional priorities around ecosystems, climate change, health risks, and economics (Devine et al., 2019).

#### 4.5. Limitation of the study

As the first study to determine the KAP of people in Laos and Thailand regarding climate change and dengue, the results must be interpreted with caution. This study adopted an 80% cut-off score to distinguish good and poor KAP and questionnaires included general KAP characteristics, but certainly could not cover various specific community correctness scores, which might introduce a potential limitation when interpreting certain KAP features. The results may not be generalizable and representative of all government officials in both countries. A comparison of the other studies presented serious challenges because the studies varied in sample size and study area including different risk factors such as urbanization problem causing dengue. It is noteworthy that despite some limitations, this study provides crucial baseline information on the overall KAP of people and government officials regarding climate change and dengue and relevant differences between urban and rural communities in Laos and Thailand.

## 5. Conclusion

In comparison with rural communities, urban communities in both countries possess relatively good KAP towards climate change and dengue. However, the communities in both countries generally have poor KAP in both disciplines, but are aware of the seriousness of these issues. More than 80% of the respondents were concerned about climate change and dengue and were interested in receiving more information, for example through government and non-governmental organizations. The KAP information collected from the government officials in both countries revealed that these departments also have inadequate KAPs in both areas under discussion. The insufficient knowledge and poor preparation of these departments towards the dengue control and climate change mitigation affect their capability to cope with the current situation of climate change and dengue in their respective countries. The use of the internet and television is widespread in these communities. Social and mainstream media can be used to build awareness about climate change and dengue among communities. We propose governments in both countries to improve citizens' knowledge on climate change, especially regarding future effects on local and global levels. We also propose that knowledge on dengue should be improved, especially regarding transmission modes, signs and symptoms, and effective vector control strategies. This can be achieved by trained and knowledgeable project managers, health planners, policy makers and local government officials who can help to educate the least knowledgeable and most vulnerable populations in dengue endemic areas. This will ultimately help to promote better knowledge, attitudes, personal protective practices and build resilient communities so that citizens can prevent themselves from climate change induced dengue fever.

## Research data for this article

The data underlying the results presented in the study are available from the Norwegian Center for Research Data (NSD). Access to the data sets must be requested from NSD using a Data Access form at this link: <https://nsd.no/nsd/english/order.html> and referring to the RCN DENCLIM project ID no. 281077 or contact the corresponding author.

## Author contribution

Conceptualization; UH, MSR, MM, HJO, RP, CP, SP; Data curation; MSR, UH, SZ, HJO, NV, MM; Formal analysis; MSR; Funding acquisition; HJO, UH; Investigation; MSR, SZ, HJO, CP; Methodology; MSR, HJO, UH; Project administration; MSR, HJO, CP, TE, MM, OS; Resources; MSR, HJO, CP, TE, MM, OS; Supervision; MSR, HJO, UH, CP, TE; Validation; MSR, HJO, UH, MM, RP, MM; Writing - original draft: MSR; Writing - review & editing: All authors.

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## Ethics approval and consent to participate

The study was approved by the Khon Kaen University Ethics Committee for Human Research (ref. no. HE611228 given on August 02, 2018); the National Ethics Committee for Health Research, Ministry of Health, Vientiane, Lao PDR (ref. no. 057/NECHR given on May 15, 2018); and the Regional Committees for Medical and Health Research Ethics in Norway (2018/1085/REK sør-øst C given on June 27, 2018). Written consents were obtained from the household head and study participants before interviews of all participating households and all data collected were kept confidential.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.envres.2020.110509>.

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