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Estimation of dengue infection for travelers in Thailand

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Summary   *Background:* Dengue infection among travelers has become one of the most public health concerns in present days. The importation of dengue virus can initiate an outbreak in non-endemic regions. Thailand is one of the countries topping the list of highest dengue infections in travelers.
Method: This study estimates the risk of dengue infection among travelers during their visit in Thailand by using a mathematical model with seasonal variations.
Results: The risk of dengue infection in high dengue season is 2.50—4.07 times that on low dengue season depending on the locations. The average daily risk of dengue infections of Thailand per 100,000 travelers is 2.14 and 7.03 for low and high dengue season, respectively. The highest rate of infection is Rayong and the lowest rate is Sing Buri. Several popular tourist provinces are high dengue endemic areas.
Conclusions: This study provides useful information on dengue infection among travelers. The main factors are the time of arrival in the year, the duration of stay of the travelers and the locations where the travelers spend most of their time.
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1. Introduction

Dengue is a mosquito-borne infectious disease in humans, caused by a virus of the *Flavivirus* genus, *Flaviviridae* family. The dengue virus (DENV) consists of four distinct serotypes, DENV1-4 [1]. The symptoms of DENV individuals range from asymptomatic to high fevers, headache, muscle and joint pain. Severe cases of dengue are plasma leakage, hemorrhagic fever and the worst scenario is death. Around 3.5 billion people are living in countries with dengue virus, the major disease burden being in South East Asia, South Asia and Latin America. The DENV is transmitted to humans if bitten by infected female mosquitoes. The primary vector of DENV is *Aedes aegypti* and the secondary is *Aedes albopictus*. Aedes mosquitoes are found throughout tropical and subtropical areas and have adapted to cohabit with humans in both urban and rural environments. Additionally,

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A. albopictus is locally inhabited in many countries in the Southern Europe, North America and East Asia [2].

In 2014, the first dengue outbreak since the World War II in Japan occurred with the number of confirmed cases was 160 [3]. It is assumed that the DENV might have been imported from outside the country [4]. Moreover, there have already been reported several incidents of autochthonous dengue outbreak in Europe (Italy, France, Croatia, Madeira) [5]. The number of patients with cases of dengue fever imported into Europe and dengue cases in travelers are rising due to globalization [6]. Many of dengue endemic countries are popular tourist destinations and dengue has emerged as a frequent problem in international travelers. Travelers returning home with DENV can transmit the virus to local mosquitoes and increase the risk of further outbreaks. The actual number of dengue cases among travelers may be underestimated because of variations in report requirements in different countries [7,8]. These are significant reasons to quantify the burden of dengue infection in international travelers who had visited endemic areas. The factors for acquiring DENV include the duration of stay, the time of arrival and the locations of stay in the dengue endemic-regions.

Thailand is located in the dengue endemic region with averaging 91,650 cases (141 per 100,000 population) and 93 fatalities annually during 2009−2015 [9]. The high dengue endemic period is June to September during the rainy season. Thailand is one of the most popular tourist destinations in the world, over 30 million overseas visitors in 2015 and this number is expected to rise. Nearly half of the tourists come from non-dengue endemic regions [10]. Traveling in dengue endemic areas carries a risk of acquiring the virus. Several reports show that Thailand is on the top of the listed country that travelers are most likely to be infected by dengue [11,12]. The objective of this study is to calculate the risk of dengue infection for travelers during a stay in Thailand. The risk of dengue infection can be obtained by using a mathematical model. The local data of dengue transmission and other essential information about Thailand are included in this model study.

2. Methods

We employed a mathematical model for dengue transmission with seasonal variables described by Polwiang [13], with adjusting parameters to fit the data of dengue cases in the provinces of Thailand. The model is based on the demography of Thailand. In this study, we estimated the probability of acquiring dengue of travelers after entering Thailand by considering three major factors, the duration of stay, the season of arrival and locations. The season of arrival is defined into two time periods, high dengue season, June to September, which is the rainy season, and low dengue season, October to May, which is the dry season. Travelers are defined as persons entering Thailand for a short period of time, regardless of the purpose of travel.

Fig. 1 illustrates the map of the average number of dengue cases per 100,000 population in Thailand from 2009 to 2015 [9]. The 5 highest dengue cases per 100,000 population are Rayong (300), Krabi (294), Mae Hong Son (278), Chanthaburi (262) and Chiang Rai (243). The 5 lowest provinces are Nong Bua Lam Phu (61), Uttaradit (61), Sakon
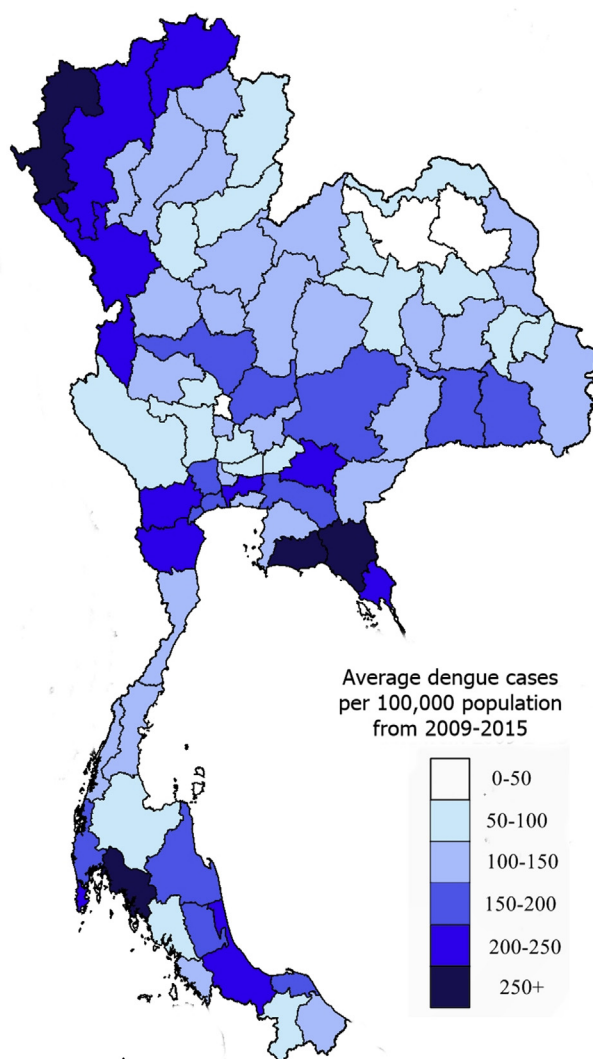

Fig. 1 The map illustrates the average number of dengue cases per 100,000 population for every province in Thailand. The data are collected in 2009−2015 [9]. The map of Thailand is modified from https://commons.wikimedia.org/wiki/File:BlankMap_Thailand.png.

Nakhon (41), Udon Thani (37) and Sing Buri (26). For the top tourist destinations, the number of the dengue cases per 100,000 population are Bangkok (209), Chonburi (144), Phuket (214) and Chiang Mai (242). The degrees of dengue case are different in each province. The data have shown that some of the most popular destinations are high dengue endemic areas.

There are several reports of patients diagnosed with dengue fever shortly after return from Thailand. During 2006−2014, there were 169 cases or 1.49 cases per 100,000 travelers in Japanese travelers [14,15]. Japanese travelers spent, on average, 7.74 days [10]. Reports from South Korea were 30 cases during 2006−2010 or 0.62 cases per 100,000 travelers and an average staying of 7.44 days [16]. The case rate of Swedish travelers during 1995−2010 was 13.6 per 100,000 travelers with 19.48 days of staying [17]. German travelers also display a high case rate of 28.7 during 2008−2013 for 17.53 days of staying [18]. The numbers of dengue cases of returning travelers are shown in Table 1.