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Review Article

Plants used by Thai Hmong to treat related infectious symptoms

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ABSTRACT

Infectious diseases have historically threatened humans, and antibiotics have been developed. Many micro-organisms causing infections have evolved antibiotic-resistant strains. Traditional medicinal plant uses can guide the search for new drugs. Thai Hmong possess vast ethnomedicinal plant knowledge. This study highlights medicinal plants for treating infectious diseases among the Thai Hmong ethnic minority. Information on Hmong ethnobotany was extracted from all available publications. The study supplemented literature-based data with newly collected field data from six Hmong villages in Nan Province, Thailand, totaling 25 studied villages. Hmong disease names were carefully interviewed to understand symptoms and match modern medical terms. The study documented 486 uses of 225 plant species for treating infectious disorders. Most used plants were *Strobilanthes cusia*, *Houttuynia cordata*, *Anethum graveolens*, *Verbena officinalis*, *Biancaea sappan*, *Teucrium viscidum*, and *Paederia pilifera*. Many species have proven antimicrobial activity in lab tests, while others still lack scientific proof of efficacy. Some common Hmong anti-infectious plants were used by other ethnic groups for similar purposes, suggesting potential pharmacological efficiency. Further studies should focus on testing efficacy of remaining plants and developing them into novel drugs for treatments.

Keywords:
Ethnobotany, Medicinal plants, Ethnic people, Traditional knowledge, Infections

1. INTRODUCTION

Humans have suffered from infections throughout history, with many new emerging infectious diseases threatening lives. Some well-known examples include Cocoliztli, SARS, H5N1, MERS, Ebola, and Zika. Since the end of 2019, a new emerging virus, COVID-19, has significantly affected human cultures and economies, leading to millions of deaths worldwide. Foodborne bacterial infections, such as *Escherichia coli* and *Salmonella* spp., have also caused a considerable number of deaths[1]. Over millennia, humans have fought infectious diseases, leading to the development of vaccines and antibiotics to protect our species. However, evolutionary processes have given rise to antibiotic-resistant strains of microorganisms causing infections[1]. Apart from the mentioned deadly diseases, we also face seasonal infections like fever and the common cold, which can pose significant challenges, leading governments to allocate substantial budgets for treatment. Infection rates tend to increase globally during the summer period[2-4]. In Thailand, high infection rates occur during seasonal transitions.

Due to decreasing air transportation costs, over 100,000 flights transport people to new places daily, accelerating the global spread of infectious diseases. This trend was evident during the COVID-19 pandemic, highlighting the need to consider transportation restrictions for disease control. Warm conditions favor the proliferation of organisms causing infectious diseases. Projections indicate that by the mid-21st century, nearly half of the

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world's population, including 60% of its children, will reside in tropical regions[5]. Most of these regions are developing countries with inadequate medical and public health systems, leading to extremely high death rates caused by infections. In such areas, utilizing medicinal plants could serve as a viable alternative[6]. Moreover, traditional plant knowledge holds immense value as a source for modern drug development, safeguarding the global population[7-8].

Ethnomedicinal plants in Thailand have been extensively studied for three decades, resulting in a listing of over 2,000 ethnomedicinal species in Thai publications[9]. The Hmong, comprising over 200,000 individuals across 20 provinces in Thailand, represent the second-largest hill ethnic minority[10]. They have a significant reliance on medicinal plants[11-12].

A previous study on Thai ethnomedicinal plants used to treat infectious diseases covered 16 villages, including four Hmong villages, from seven ethnic minority groups. This study documented 143 plant species used to treat 21 infectious diseases[13]. Despite these findings, a comprehensive understanding of the ethnomedicinal uses of plants by the Hmong to treat infections in Thailand remains lacking.

The present study aims to identify potential medicinal plants to treat infectious diseases, based on Thai Hmong traditional knowledge. Specifically, the study seeks to answer the following questions: 1) How many plant species do the Thai Hmong use to treat infection-related symptoms and diseases? 2) Which infectious diseases and symptoms were most frequently treated using medicinal plants by the Thai Hmong? Additionally, the study aims to identify plant species with potential for treatments and propose them for future drug development.

2. MATERIALS AND METHODS

The data used in this study were derived from published literature and additional field studies conducted in Nan Province, Thailand.

2.1. Literature data sources

Published ethnomedicinal plant studies of Hmong villages in Thailand were carefully screened for relevant information. The inclusion criteria for the published data sources were as follows: 1) The study must be based on accepted ethnobotanical methods for data collection[14]; 2) all utilized species must be identified by their scientific names using standard botanical nomenclature; 3) the studies should have been conducted in Hmong villages in Thailand; 4) the publications must have been released between 1990 and 2019; 5) repeated data, such as information published in a student thesis and subsequently published in journal articles, were consolidated into a single record.

2.2. Translation of Hmong epic names of symptoms and sicknesses to modern medical terms

The 19 Hmong villages studied were located across eight provinces in northern Thailand. All ethnomedicinal information for each species was filtered to identify the uses of plants for treating infectious diseases and symptoms, following the medicinal cate-gories outlined in the ICPC-2 standard[15]. Epic sicknesses and symptoms found in the literature were carefully translated to etic symptoms and diseases in the ICPC-2 categories. The translation was conducted by the authors based on in-depth interviews regarding the diseases and symptoms with Hmong informants during field studies in Nan Province.

Fever and common cold symptoms arise from complex body responses, but many cases of fevers and common colds are caused by infections. This study encompassed fevers and colds as symptoms of infectious diseases.

2.3. Field study interviews

In addition to the villages reported in the already published literature, six Hmong villages in Nan Province, Thailand were selected to supplement the literature-based data and possibly provide additional field-based information on ethnomedicinal uses for treating infectious diseases (Figure 1). The field interviews were conducted from March 2020 to February 2021, covering all three seasons in Thailand. During this period, the authors successfully located all plants known to the informants.

Community leaders were contacted to request permission and to obtain the names and addresses of the communities' traditional healers. Subsequently, the traditional healers were visited at their homes, and general information was collected, including any knowledge of other traditional healers. The traditional healers were then asked about their use of any plants for treating infectious diseases. Semi-structured interviews were employed to gather data on the vernacular names of the plants, the diseases treated, symptoms related to infectious diseases, and the methods of using the plants as medicines. Whenever the interviewed informants mentioned symptoms or sickness, the field investigators asked for further details to match the local names of symptoms and sickness with the corresponding names in modern medical classification.

Photographs of all species used by the informants were taken, and herbarium specimens were collected for identification. The scientific plant names were later determined in the laboratory, utilizing taxonomic keys, specimen comparisons, and consultation with Thai plant family experts. Voucher specimens were deposited at the Queen Sirikit Botanic Garden Herbarium (QBG) in Chiang Mai, Thailand, and the herbarium of Mahidol University (PBM).

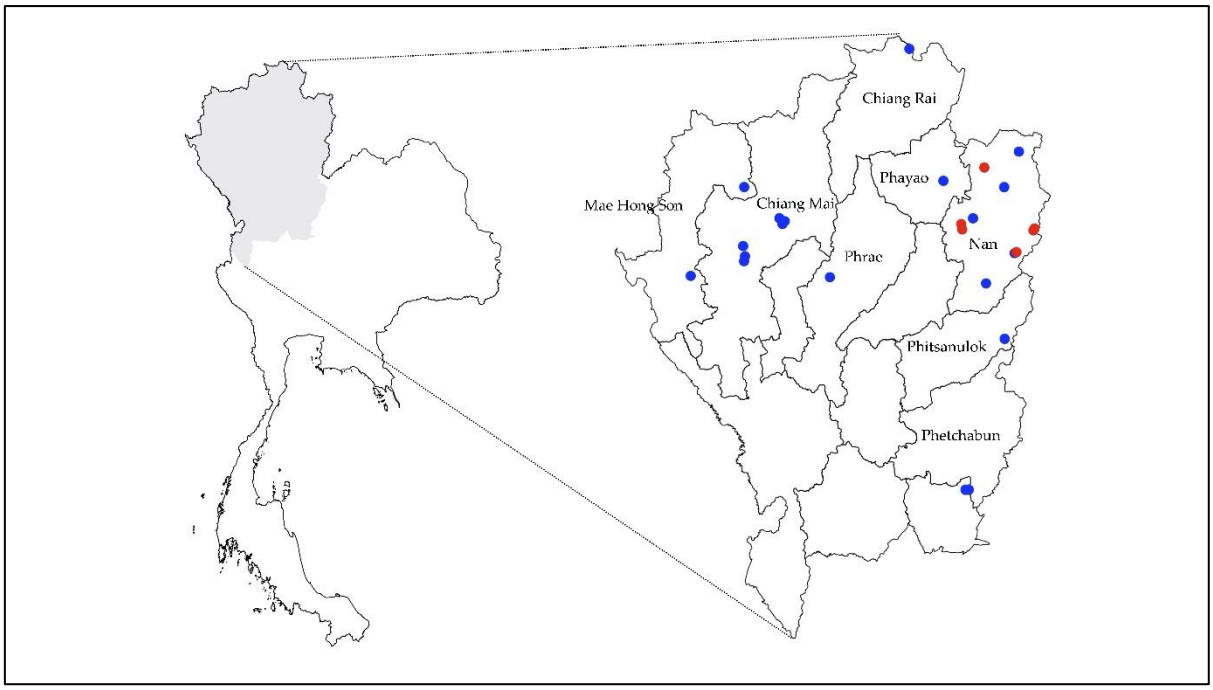

Figure 1. Location of 25 Hmong villages for which data for this study were derived. Blue circles represent 19 villages mentioned in the published literature and red circles represent the location of six villages in Nan province studied by field interviews.

2.4. Data Analysis

Data from published records and field interviews were integrated. The scientific plant names were standardized using the accepted plant names from the World Checklist of Vascular Plants website[16]. Important medicinal plants for treatments were ranked based on the Species Use Value (UV)[17], calculated using the following equation.

$$UV = \frac{\Sigma Ui}{n}$$

Where Ui represents the number of use reports mentioned by each informant i for a given species, and n is the total number of interviewed informants. In this study, we incorporated data from both previous studies and our recent field observations. Identifying which respondent cited which use proved challenging. To standardize n, we replaced the term "informant" with "studied site," which refers to an "area" reporting uses of a given species, rather than representing a "person" providing information[9]. A higher UV indicates a higher number of areas or villages where the species is used.

3. RESULTS AND DISCUSSIONS

The combined data from both the literature and recent fieldworks encompassed ethnomedicinal knowledge from 25 Thai Hmong villages in eight provinces in northern Thailand. The data offered examples of treatments for 30 symptoms and disorders related to infections. The infectious diseases and symptoms listed in both the literature and field interviews were meticulously analyzed to elucidate the Hmong names of diseases as explained by informants in the visited villages in Nan (Table S1, Supplementary data). The informants mentioned 486 uses of 225 plant species from 87 families (Table S2, Supplementary data).

Fever was the most commonly treated symptom, mentioned in 186 reports. This disorder was also frequently treated using medicinal plants among infectious diseases and disorders by the rural Thai people and the Karen ethnic group in Thailand[18-19]. Fever, in general, is a complex symptom of the body's responses. Sometimes, it may or may not be caused by a viral infection[20-21], but most fevers are caused by viruses, such as dengue, yellow fever, swine fever, or the common fever[22-24]. The abundance of plants used to treat fevers reflects the prevalence of such infections. The Division of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand, reported a high incidence of fevers, especially in northern Thailand[25].

Abscesses were treated by plants in 44 cases and were the most common bacterial infection reported in our data. chickenpox ranked as the third most commonly reported disorder (Figure 2), and traditional Hmong healers used many plants to treat chickenpox and the common cold, both of which are prevalent among all ethnic minority groups in northern Thailand[13]. Among the recorded treatments, there were 27 reports for each of malaria, dermatophytosis, and foot dermatosis. Notably, many treated bacterial and fungal conditions manifested as skin infections. As the Hmong are farmers and labor workers[26], open wounds are common work-related hazards. Due to low hygienic standards, symptoms of infected wounds, dermatophytosis, athlete's foot, etc., were abundant in the population.

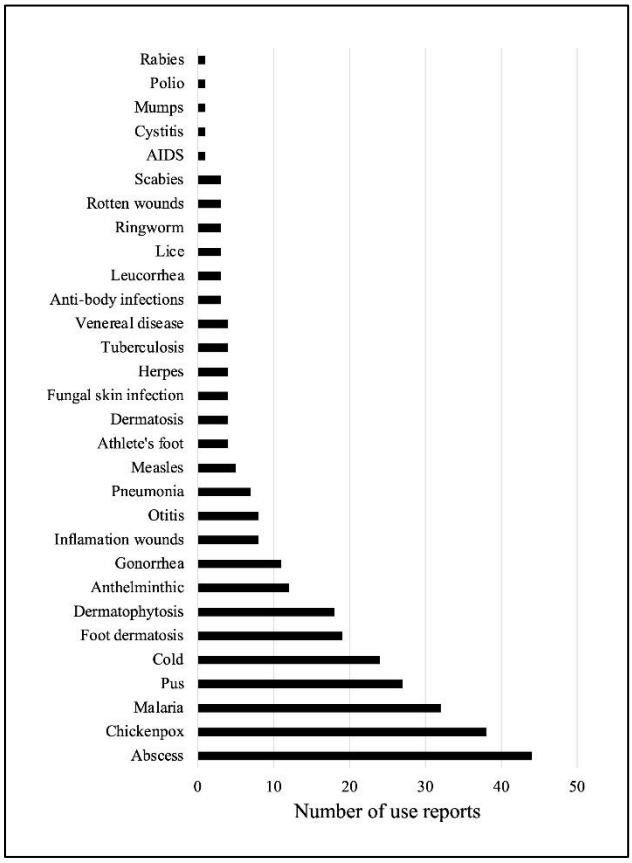

Figure 2. The number of uses of medicinal plants for treatments of various infectious sicknesses in five categories as observed in Thai Hmong traditional knowledge. This figure does not show the 186 uses for treatment of fever because the number would be an outlier at the scale of the figure.

Among the 225 used plants, 22 species from 15 families had high UVs (Table 1 and Table S2, Supplementary data), and most of them belonged to important Thai medicinal plant families[27]. The most used species were *Strobilanthes cusia* (UV=0.68), followed by *Houttuynia cordata* (0.56), *Anethum graveolens* (0.52), and *Verbena officinalis* (0.52). Other noteworthy plants included *Biancaea sappan*, *Paederia pilifera*, *Ageratum conyzoides*, *Artemisia vulgaris*, and *Bidens biternata* (Table 1 and Table S2, Supplementary data). These plant species are also commonly used for medicinal purposes by other Thai ethnic groups[9,13,28].

All Hmong traditional healers interviewed for this study unanimously agreed that the most frequently used species, *Strobilanthes cusia*, was effective in treating fever, and one healer mentioned its use for treating the common cold as well. This species was also utilized for fever treatments by seven other ethnic minority groups in northern Thailand[13], although the Karen used it less frequently for this purpose[19]. Beyond Thailand, *S. cusia* is known in China for its traditional uses in treating various ailments, particularly common flu, encephalitis B, viral pneumonia, and mumps. Extracts of S. cusia exhibited antipyretic effects in mice and rat models[29], and other research demonstrated that tryptanthrin and indigodole B extracts from *S. cusia* exhibited anti-human coronavirus activities[30].

Other plant species mentioned for their efficacy in treating fever were *Ageratum conyzoides*, *Artemisia vulgaris*, *Biancaea sappan*, *Houttuynia cordata*, *Paederia pilifera*, and *Teucrium viscidum* (Table 1). Species with fewer Hmong use reports for the treatment of the common cold were *Ageratum conyzoides*, *Bidens pilosa*, *Houttuynia cordata*, and *Plantago major*, even though they were widely used for such treatments of infections among other Thai ethnic groups[13,19].

Chickenpox was mentioned in many use reports as being treated with medicinal plants by the Hmong (Figure 2). This disorder was also one of the most treated infections among seven other ethnic groups in northern Thailand[13]. In our study, we recorded four species, *Anethum graveolens*, *Biancaea sappan*, *Imperata cylindrica*, and *Teucrium viscidum*, which were used for such treatments (Table 1 and Table S2, Supplementary data). The traditional knowledge related to bacterial and fungal infections primarily revolved around treatments for symptoms on the skin. Abscesses, pus, and infected wounds were the most commonly treated symptoms. Skin dermatophytosis, dermatosis, and athlete's foot were also extremely common conditions mentioned by the Hmong healers. The most useful plants listed for these treatments were *Buddleja asiatica*, *Kalanchoe pinnata*, *Persicaria chinensis*, *Procris repens*, and *Verbena officinalis* (Table 1 Table S2, Supplementary data).

Many of these 22 most commonly used medicinal plants (Table 1) have been studied for their biological activities. *Ageratum conyzoides* extracts have shown antimicrobial activities against *Porphyromonas gingivalis*, *Staphylococcus aureus*, *Lasiodiplodia theobromae*, and *Giardia duodenalis*[31-34]. *Artemisia* spp. have been ethnobotanically widely used to treat various health problems in the northern hemisphere[35] and are known for their antimicrobial activity[36-37], especially *Artemisia annua*, which produces high amounts of artemisinin with significant anti-plasmodium activity. The plant has also been used for fever treatments in China[38]. More recently, many researchers have proposed the use of extracts from various species of *Artemisia* for the treatment of COVID-19[39-40]. *Biancaea sappan* has exhibited anti-*Haemophilus influenzae* activity[41]. *Buddleja asiatica* produces phytochemical compounds against *Staphylococcus aureus*, which can cause skin diseases[42]. These examples confirm that many of the ethnomedicinal plants used by the Hmong for treating infectious diseases possess antimicrobial activity. Nevertheless, many medicinal plants proposed from Hmong traditional knowledge have not been chemically or pharmacologically studied for their anti-infectious activities. However, many of the species were used for the treatment of related infectious symptoms by other ethnic groups[13,18-19], who have different ethnic backgrounds and ethnomedicinal knowledge[12].

Table 1. Highly used plants for treatment of infectious disorders by Thai Hmong in 25 studied villages.

Plants of the world	Treated symptoms	Part used	Preparation & application
Acanthaceae			
Strobilanthes cusia (Nees) Kuntze	Cold, Fever	Leaves	Crushed and poulticed on wrist and ankle
Actinidiaceae			
Saurauia roxburghii Wall.	Fever, Malaria, Pus	Whole plant	Decocted or made chicken soup for oral ingestion
Amaranthaceae			
Cyathula prostrata (L.) Blume	Dermatophytosis, Pus	Whole plant	Decocted for skin bathing
Apiaceae			
Anethum graveolens L.	Chickenpox, Fever	Whole plant	Made chicken soup for oral ingestion
Asteraceae			
Ageratum conyzoides L.	Cold, Fever	Leaves	Steamed with egg for oral ingestion
Artemisia vulgaris L.	Fever	Leaves	Steamed with egg for oral ingestion
Bidens biternata (Lour.) Merr. & Sherff	Chickenpox	Whole plant	Decocted for oral ingestion
Cyanthillium cinereum (L.) H.Rob.	Chickenpox, Fever, Herpes	Leaves	Pounded for oral ingestion
Monosis parishii (Hook.f.) H.Rob. & Skvarla	Fever	Whole plant	Decocted for oral ingestion
Euphorbiaceae			
Jatropha curcas L.	Foot dermatitis, Inflamation wounds, Pus	Leaves	Decocted and washed target organs
Fabaceae			
Biancaea sappan (L.) Tod.	Chickenpox, Fever	Stem/root	Decocted for oral ingestion
Lamiaceae			
Clerodendrum glandulosum Lindl.	Foot dermatitis	Whole plant	Decocted and washed target organs
Teucrium viscidum Blume	Chickenpox, Fever	Leaves	Decocted for oral ingestion
Plumbaginaceae			
Plumbago zeylanica L.	Foot dermatitis	Leaves	Crushed and applied to target organs
Rubiaceae			
Paederia pilifera Hook.f.	Foot dermatitis	Leaves	Pounded and poulticed on target organ
	Fever, Malaria	Leaves	Decocted for oral ingestion
Rutaceae			
Citrus maxima (Burm.) Merr.	Fever, Malaria	Leaves	Decocted for oral ingestion
Melicope glomerata (Craib) T.G.Hartley	Cold, Fever, Malaria	Whole plant	Decocted for oral ingestion
Saururaceae			
Houttuynia cordata Thunb.	Venereal diseases, Cold, Fever, Malaria, Pneumonia	Leaves/ whole plant	Decocted for oral ingestion
Verbenaceae			
Verbena officinalis L.	Athlete's foot, Dermatophytosis, Fever, Foot dermatitis, Fungal skin infection	Leaves/ whole plant	Decocted and washed target organs
Vitaceae			
Cissus discolor Blume	Abscess, Dermatophytosis	Leaves	Burned and poulticed on target organs
Leea indica (Burm.f.) Merr.	Fever, Inflamation wounds, Pus	Leaves	Decocted for oral ingestion
Zingiberaceae			
Zingiber purpureum Roscoe	Chickenpox, Cold, Fever	Rhizomes	Decocted for oral ingestion

When different ethnic groups use the same species for similar treatments, it suggests that it may have pharmacological activities, which in turn may be relevant for formal treatments[43-45]. We present our results with the intention that they may guide future pharmacological studies of plant efficacy for the treatment of infectious diseases and contribute to the development of novel drugs for treating antibiotic-resistant strains.

4. CONCLUSION

The Hmong, the second largest ethnic minority in northern Thailand, possess vast knowledge of ethnomedicinal plants. The compiled ethnomedicinal plant use data by the Hmong for treating infectious diseases highlights 19 medicinal plant species that could serve as candidates for drug development. Several of these species have chemically and pharmacologically confirmed antibiotic activities, but some remain to be studied in this respect. Therefore, the Hmong's ethnomedicinal plant knowledge for treating infectious diseases provides new hope for novel drug development and the treatment of antimicrobial resistant strains. The next step in the studies should involve intensive investigation of the potential and safety of these candidates.

Conflicts of Interests
The authors declare no conflict of interest.

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Ethics approval and consent to participate
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