ENVIRONMENTAL FACTORS FOR MALARIA INFECTION IN THANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Public Health Program in Public Health
College of Public Health Sciences
Chulalongkorn University
Academic Year 2015

ปัจจัยสิ่งแวดล้อมต่อการติดเชื้อมาลาเรียในภูมิภาคทะเนียนทายี ประเทศเมียนมาร์: การศึกษาแบบย้อนหลังจากผลไปหาเหตุ

นายยี เมี๊ยท ไทก์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
สาขาวิชาสาธารณสุขศาสตร์
วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2558

Thesis Title	ENVIRONMENTAL FACTORS FOR MALARIA INFECTION IN THANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY
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Field of Study	Public Health
Thesis Advisor	Nutta Taneepanichskul, Ph.D.

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ยี เมี๊ยท ไทก์ : *ปัจจัยสิ่งแวดล้อมต่อการติดเชื้อมาลาเรียในภูมิภาคทะเนียนทายี ประเทศเมียนมาร์: การศึกษาแบบย้อนหลังจากผลไปหาเหตุ* (ENVIRONMENTAL FACTORS FOR MALARIA INFECTION IN THANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: อ. ดร. ณัฏฐา ฐานีพานิชสกุล, 118 หน้า.

บทนำ: ปัจจัยด้านสิ่งแวดล้อมของบ้านเรือนเป็นปัจจัยสำคัญปัจจัยหนึ่งที่ส่งผลต่อการติดเชื้อมาลาเรีย ซึ่งการติดเชื้อมาลาเรียนั้นสามารถพบได้อย่างแพร่หลายในพื้นที่ชนบทที่มีความแตกต่างของลักษณะบ้านและสิ่งแวดล้อมของบ้าน

วัตถุประสงค์: เพื่อศึกษาปัจจัยเสี่ยงทางด้านสิ่งแวดล้อมที่มีความสัมพันธ์กับการติดเชื้อมาลาเรียในภูมิภาคในทะเนียนทายี ประเทศเมียนมาร์

ระเบียบวิธีวิจัย: การศึกษาครั้งนี้ใช้วิธีการศึกษาแบบย้อนหลังจากผลไปหาเหตุในกลุ่มผู้ติดเชื้อมาลาเรียจำนวน 153 คนและกลุ่มผู้ไม่เคยติดเชื้อมาลาเรียนจำนวน 406 คน ช่วงฤดูร้อน ปี 2559 ในภูมิภาคในทะเนียนทายี ประเทศเมียนมาร์ การบ่งชี้ผู้ติดเชื้อมาลาเรียใช้วิธี Rapid Diagnosis Test ขององค์การอนามัยโลก (World Health Organization) ในคลินิคเคลื่อนที่ ผู้เข้าร่วมงานวิจัยทั้งหมดได้รับการสัมภาษณ์ข้อมูลส่วนบุคคล ลักษณะของบ้าน และลักษณะของสิ่งแวดล้อมรอบตัวบ้าน การวิเคราะห์การถดถอยโลจิสติกได้นำมาใช้วิเคราะห์ทางสถิติเพื่อหาปัจจัยเสี่ยงด้านสิ่งแวดล้อมต่อการติดเชื้อมาลาเรีย

ผลการศึกษา: จากการศึกษาพบว่าประชากรส่วนใหญ่เป็นเพศชาย (54.5%) มีอายุโดยเฉลี่ย (±ส่วนเบี่ยงเบนมาตรฐาน) 35 (±12.3) ปี กลุ่มประชากรที่มีรายได้ต่ำพบว่ามีโอกาสเสี่ยงต่อการติดเชื้อมาลาเรียมากกว่ากลุ่มประชากรที่มีรายได้สูง ปัจจัยเสี่ยงของสิ่งแวดล้อมบ้านเรือนต่อการติดเชื้อมาลาเรีย เช่น การสร้างกำแพงบ้านด้วยไม้ไผ่ [OR=3.63, 95%CI : 2.13,6.20] บ้านที่ไม่มีเพดาน [OR=1.95, 95%CI : 1.25,3.03] บ้านที่อยู่ใกล้ลำธาร [OR=1.66, 95%CI :1.12, 2.45] และบ้านที่มีพื้นที่เล็กกว่า 1 เอเคอร์ [AOR= 13.96, 95%CI :3.16, 61.6] เป็นต้น นอกจากนี้การศึกษาครั้งนี้ยังพบว่ากลุ่มประชากรที่มีความรู้เกี่ยวกับมาลาเรียต่ำ มีโอกาสเสี่ยงต่อการติดเชื้อมาลาเรียมากกว่ากลุ่มประชากรที่มีความรู้มากกว่า [AOR=5.58, 95%CI :2.61,11.9]

บทสรุป: การปรับปรุงลักษณะของบ้านและสิ่งแวดล้อมของบ้าน รวมทั้งการให้ความรู้เกี่ยวกับการติดเชื้อมาลาเรียสามารถเป็นแนวทางหนึ่งการลดความเสี่ยงต่อการติดเชื้อมาลาเรียได้

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต .....

ปีการศึกษา 2558 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

5878825553 : MAJOR PUBLIC HEALTH
KEYWORDS: ENVIRONMENTAL FACTORS, MALARIA, CASE-CONTROL STUDY, THANINTHARYI REGION, MYANMAR

YE MYAT HTIKE: ENVIRONMENTAL FACTORS FOR MALARIA INFECTION IN THANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY. ADVISOR: NUTTA TANEEPANICHSKUL, Ph.D., 118 pp.

Introduction: The risk of malaria can be influenced by the household environment. The range of these risks can be more diverse in rural areas, which can include a mix of different housing styles and environments.

Objective: This study aimed to identify environmental risk factors related to malaria infection in Tanintharyi Region, Myanmar.

Methodology: A case-control study was conducted among 153 malaria cases and 406 controls in Thanintharyi Region, Myanamar during summer 2016. WHO Rapid Diagnosis Test was used to diagnose malaria infection at mobile clinique. All participants completed questionnaires to obtain socioeconomic, house characteristics, and house environments by face-to-face interview. Multiple logistic regression was performed to quantify environmental risk factors to malaria infection.

Results: Most of participants (54.5%) were male. Average age (±Standard deviation) was 35 (±12.3) years old. A lower annual income of participants was increased risk of malaria infection. Building house wall with bamboo [OR=3.63, 95%CI : 2.13,6.20], house without ceiling [OR=1.95, 95%CI : 1.25,3.03], located house close to stream [OR=1.66, 95%CI :1.12, 2.45], and area of house less than one acres [AOR= 13.96, 95%CI :3.16, 61.6] were significant risk factors of malaria infection. Moreover, participants having a poor knowledge regarding malaria [AOR=5.58, 95%CI :2.61,11.9] was increased odd of malaria infection.

Conclusion: The findings of this study suggest that improving of the house and household environment and promoting the knowledge about malaria infection could be a feasible way to reduce the risk of malaria.

Field of Study: Public Health Student's Signature .....

Academic Year: 2015 Advisor's Signature .....

ACKNOWLEDGEMENTS

This research have been completed successfully with excellent advice from Dr. Nutta Taneepanichskul, Ph.D whom must be thanked for suggestion all time about research and mental support to study during the entire process of the research.

I would like to thanks again to Dr. Nutta Taneepanichskul, Ph.D for statistics supporting and suggestion to analyze my research.

Grateful thanks to my advisory chairperson Assoc. Prof. Dr. Wattasit Siriwong, Ph.D, advisory examiner Tapanata Pumpaibool , Ph.D, and external examiner Dr.Saowanee Norkaew, Ph.D from Faculty of Public Health, Thammasat University for their advice which has enabled me to develop my thesis.

I would like to express my sincere gratitude to Assoc. Prof. Ratana Somrongthong, Ph.D, Tapanata Pumpaibool , Ph.D and Dr. Myo Min, Malaria Project Manager, MMA for their kind review and revision of my research questionnaires.

Grateful thanks to every sample in my data collection, moreover, thanks to Dr. Pyae Linn Aung, Dr. Sann Minn and project staffs from MMA (Myanmar Medical Association) Malaria Project for help during data collection.

Moreover, I would like to extend my thanks to Mr. Soe Myint and Mrs. Khin Soe Soe. They are my parents who have been supporting me mentally. Grateful thanks also to others who supported me during entire process of this research.

Any values and advantages originated from this thesis, the researcher would like to announce them as gratitude to father, mother, advisor, every teacher, colleagues and supporters.

Finally, if there are any mistakes in this study, the researcher would like to apologize for them.

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LIST OF ABBREVIATION

ACT	**-**	**Artemisinin-based Combination Therapy**
CI	**-**	**Confident Interval**
INGO	**-**	**International Non-Governmental organization**
IRS	**-**	**Indoor Residual Spraying**
ITN	**-**	**Insecticide-Treated Net**
LLIN	**-**	**Long Lasting Insecticidal Net**
MMA	**-**	**Myanmar Medical Association**
NGO	**-**	**Non-Governmental Organization**
OR	**-**	**Odd Ratio**
RDT	**-**	**Rapid Diagnosis Test**
SD	**-**	**Standard Deviation**
SPSS	**-**	**Statistic Package for Social Sciences**
WHO	**-**	**World Health Organization**

CHAPTER I

INTRODUCTION

1.1 Background and Rationale

Nowadays ,Malaria become one of the most severe public health problems worldwide (CDC, 2015c). In many developing countries, it is a major cause of death and disease. Malaria occurs mostly in poor tropical and subtropical areas of the world (CDC, 2015c). Malaria is a life-threatening disease caused by malaria parasites which are spread to people by the bites of the infected female *Anopheles* mosquitoes, called "malaria vectors." There are malaria parasite 5 species that cause malaria in humans, and among them, *P. falciparum* and *P. vivax* – cause the greatest threat (WHO, 2015b).

Approximately half of the world's population is at the risk of malaria. The deadliest form of the diseases is the because of *Plasmodium falciparum* malaria and it causes nearly one million deaths per year (Murray et al., 2012). Approximately, malaria caused 262 million cases (range 205 to 316 million) and 839 000 deaths (range 653 000 to 1.1 million) in 2000. (UNICEF & WHO). Malaria caused an estimated 198 million cases and 584 000 malaria deaths occurred worldwide in 2013 (WHO, 2014b). According to the latest WHO estimates which was released in September 2015, malaria caused 214 million cases and 438 000 deaths in 2015. Between 2001 and 2015, by estimation, there were 1.2 billion fewer malaria cases and 6.2 million fewer malaria deaths occurred globally and the case incidence and mortality rates remained unchanged since 2000 (WHO, 2015b).

In all six WHO regions, there is malaria transmission (WHO, 2015a). There are approximately 3.2 billion of people which is nearly half of the world's population were at risk of malaria in 2015. Sub-Saharan Africa is the region where there were most malaria cases and deaths. But Asia, Latin America, and, to a lesser extent the Middle East and parts of Europe are at risk too. Ninety seven countries and areas had ongoing malaria transmission in 2015 (WHO, 2015b). The WHO African Region continues to bear the brunt of the global burden of malaria (WHO, 2015b). Malaria caused an estimated 198 million cases worldwide (95% uncertainty interval, 124–283 million) and among these cases, 82% were in the WHO African Region, 12% were in the WHO South-East Asia Region and 5% were in the WHO Eastern Mediterranean Region. According to World Malaria Report 2014, in the 10 malaria-endemic countries, there were about 1.4 billion people at risk for malaria and among them, there were 352 million at high risk in South-East Asia Region. In 2013, three countries accounted for 97% of cases were (55%) in India, (21%) in Myanmar and (21%) in Indonesia (WHO, 2014b). According to the World Malaria Report 2014, in Myanmar, there were 37% of high transmission (> 1 case per 1000 population) and 23% of low transmission (0–1 cases per 1000 population) in 2013. There were 375,503 cases (annual parasite index 7.7 per 1,000 population) of total number of confirmed malaria cases and 403 deaths (0.8 per 100,000 population) of total number of malaria deaths during 2012 in Myanmar (Lwin, TT, T, W, & A, 2015).

Myanmar is the highest in the malaria burden among the six Mekong countries. In Myanmar, malaria became a major public health problem because of changes in climatic and ecology, migration in population, emerged of multidrug resistant *P.*

falciparum malaria and vectors that resistant to insecticides, and changes of behavior in malaria vectors (WHO, 2009). There was an increase in the incidence of confirmed malaria (3.6 cases per 1,000 population) in 2006 recorded in Myanmar if compared with 1.8 cases per 1,000 in 1998 (WHO, 2010). In Tanintharyi Region, malaria morbidity rate is 15.86% in 2008 (MOH, 2010). According to population living under various risk areas in 2011, high risk areas is 44.5%, moderate risk areas is 28.6% and low risk areas is 20.9% in Tanintharyi Region (IOM, 2012).

According to data from 2011 related to malaria epidemic from all 21 townships, overall reported malaria morbidity rates in Shwegyin Township in Bago (East) and in all the 10 townships of Tanintharyi Region were much higher than in Mon State. In Myeik, the morbidity rates was (66.4 per 1,000 population), followed by Kawthaung (58.6) and Launglon (55.4) Townships and that all townships are with high proportions of migrant clusters living or working hillside agricultural farms or in plantations (55% - 77%) (MOH, 2012).

The abundance, distribution and malaria transmission of different malaria vectors are driven by different environmental factors. A better understanding of the specific ecological parameters of each malaria mosquito species will also help define their current distributions, and how they may currently and prospectively be affected by climate change, interventions and other factors (Kelly-Hope, Hemingway, & McKenzie, 2009). Changes in the local environment are important to understand because they can create, or reduce the number of, suitable breeding sites for local vectors, thereby affecting their abundance and transmission patterns (Kelly-Hope et al., 2009). Similarly, the impact of interventions such as insecticide-treated bed nets

(ITNs), long-lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS) should be considered as they may affect species differently, especially if distributed widely over large geographical areas (Kelly-Hope et al., 2009).

As with other vector-borne diseases, malaria typically was driven by climatic, ecological and human factors (Zhou, 2010). Malaria transmission is complex, and more knowledge on the relationship between the environment, mosquito vectors, human disease and demography will help implement appropriate control measures in a rapidly changing landscape (Kelly-Hope et al., 2009). Factors related with population vulnerability are also critically important in malaria transmission. The presence of parasite resistance to the usual antimalarial and to insecticides, population movements and the presence of other underlying infections (e.g., HIV) are responsible for a large part of the variability in the incidence of malaria (Gomez-Elipe, Otero, Van Herp, & Aguirre-Jaime, 2007). A better understanding of the malaria epidemiology patterns among the populations would lead to better solutions of malaria infection control (MOH, 2012). Reduction in man-vector contact may be achieved by the use of protective clothing, insect repellents, bed nets, insecticides or environmental management (Nkuo-Akenji et al., 2008). In Europe and North America, malaria was eliminated through use of insecticides and manipulation of the environment (Nkuo-Akenji et al., 2008). Malaria occurs mainly in or near forests, but also in some coastal areas and plantations. Because of these some environmental factors, the malaria burden is particularly high among national races in remote areas and migrants, who seek economic opportunities in rural economic frontier areas, and the economic development activities such as forestry, mining, plantations and road-building (MOH, 2012).

Malaria cases were distributed unevenly both between villages and within villages. This heterogeneity attributed to a variety of environmental factors and has been observed elsewhere. These are the characteristics of the house where people live, the usage of protective measures for the mosquito vector, the presence of a vector-breeding site close to house, working patterns which may also result in human contact with the vector, population movements or- socio-economic, culture & and demographic characteristics of the population (Guthmann et al., 2001). Factors favoring mosquitoes may include the bushes, swamps and clean water that surround many houses in the village. The poor housing conditions may also encourage man-vector contact (Nkuo-Akenji et al., 2008). Inhabitants of houses surrounded by bushes or garbage heaps and swamps or stagnant water showed higher malaria parasite prevalence and densities compared with those from cleaner surroundings (Nkuo-Akenji et al., 2008). Socio-economic and housing factors also played an important role in malaria transmission, including the presence of open eaves or the lack of ceilings, population density and the presence of animal close to the house, education and available income in household (Zhou, 2010). As mention above, quality housing is thought to provide protection from malaria by blocking entry and reducing the density of the mosquito vector. Poor-quality material used for walls, such as mud, may provide more entry points through cracks in their surface (Snyman et al., 2015). The household environment can also influence the risk of malaria. The range of risks can be diverse more in semi-urban areas, which can include a mix of different housing styles and environments in West Africa (Yamamoto, Louis, Sié, & Sauerborn, 2010).

Tanintharyi Region is located in Southest part of Myanmar and is flanked by Mon State on the North, the Thai border to the East and Southeast and the Andaman Sea on the West. Tanintharyi Region provides a perfect favorable ground for breeding of malaria because the climate in this region alternates between a cool-dry from December to March and hot and humid-wet season from April to November, with a heavy torrential rain falls in May to September. This largely rural region covers an area of over 43,328 square kilometres (km^2) and is home to the Myeik (Mergui) Archipelago, comprising some 800 islands. Agriculture, fisheries, forestry, mining and to some extent tourism are the main economy of this region (UNDP, 2014). A prominent and controversial driver of the Tanintharyi economy are the vast rubber and palm oil plantations, most of which are in the lowland south, and are often connected to their own processing plants (UNHCR, 2014). Total migrant population is 54804 and it is the 37.1% of total Tanintharyi Region population (IOM, 2012). The mobile population are at an increased risk of exposure to malaria (Kaewwaen & Bhumiratana, 2015). In Tanintharyi Region, rural population is about 76%. There are 283,066 households in Tanintharyi Region comprising just 2.6 percent of the country's total. These are among the largest in the country at 4.8 persons per household (the national average is 4.4) (UNDP, 2014). The housing styles of this Region include a mix of different housing styles and housing environments are also mixture environments. Houses of urban areas are built with brick and wood. A large proportion of housing units in rural areas are made of wood or bamboo. A large majority of housing units are privately owned and others are rental houses and houses from government. The lowest proportion of electricity used in Myanmar is in Tanintharyi Region, with 8.0 percent of households using electricity for lighting. Percentage of households that use Charcoal or

Firewood as fuel for cooking at Tanintharyi Region is 95% (UNFPA, 2015). According to the annual report from Vector Borne Disease Control 2013, the confirmed malaria cases is 20853. The morbidity rate is 15.62 and the mortality rate is 1.05. The population who live under malaria high risk area is 775483, under malaria moderate risk area is 402971, under malaria low risk area is 122980, under malaria no risk area is 34427. Another fact is that no other study was conducted in this area relating to household risk factors with malaria. Another fact is that there is also emerging of Artemisinin resistant malaria (Tun et al., 2015). Therefore, it is reasonable to assess house and housing environmental risk factors for malaria in Tanintharyi Region.

1.2 Research Question

Are there any association between environmental factors and malaria infection in adults who stay in Tanintharyi Region, Myanmar?

1.3 Research Objectives

General Objective

- To identify environmental factors related to malaria infection in Tanintharyi Region, Myanmar

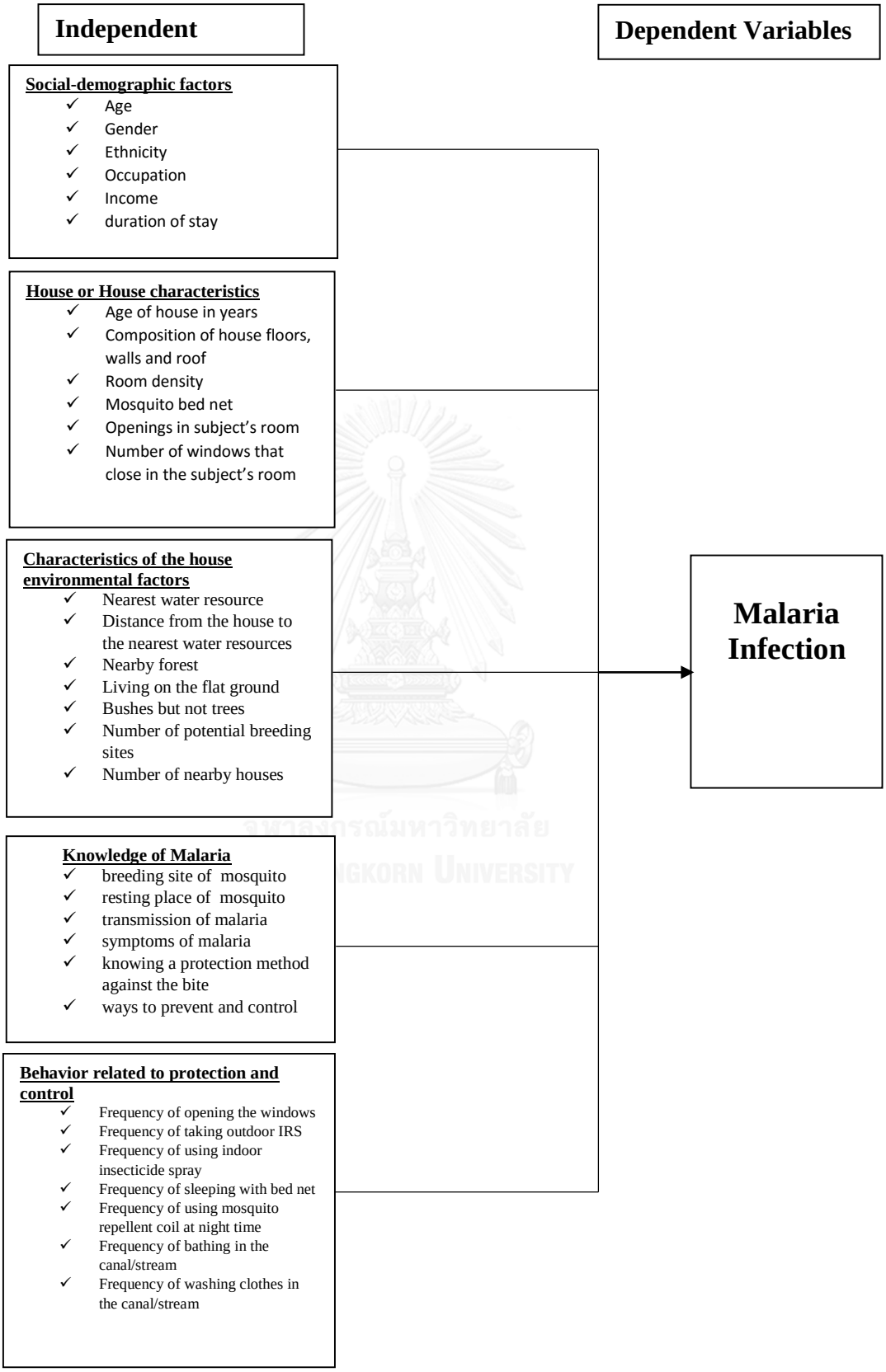
Specific Objectives

- To investigate the association between socio-economic factors and malaria infection in Tanintharyi Region, Myanmar
- To investigate the association between house characteristics and characteristics of the house environmental factors and malaria infection in Tanintharyi Region, Myanamar
- To investigate the association between knowledge and protective behaviors and malaria infection in Tanintharyi Region, Myanmar

1.4 Research Hypotheses

There is an association between environmental risk factors and malaria cases in Tanintharyi Region, Myanmar

1.5 Conceptual Framework



1.6 Operational Definitions

1.6.1 Malaria refers to a person with malaria-related symptoms (fever, chills, severe malaise, headache or vomiting) at the time of examination with the Rapid Diagnosis Test was positive.

1.6.2 Social-demographic factors refers to age, gender, marital status, occupation, ethnicity, number of children currently living together, education level, monthly income and duration of stay in study area (Woldu, 2013).

1.6.3 House or House characteristics refers to age of house in years, house tenure, housing conditions, room density, animals sleep in house, mosquito bed net, kind of mosquito bed net, number of hole in the mosquito bed net, opening in the subject's room and number of windows that close in the subject's room (Guthmann et al., 2001). It mostly refers to the characteristics that relate with house and inside the house.

1.6.4 Characteristics of the house environment refers to nearest water resource, number of canals, distance from the house to the nearest canal, nearest forest, living on the flat ground, having bushes but not trees, number of nearby houses, number of potential breeding sites, number of owned hectares/acres of land and numbers of livestock in the compound (Yamamoto et al., 2010). It mostly refers to the characteristics that relate with housing environment.

1.6.5 Knowledge about malaria refers to knowing vector which can transmit malaria to human, breeding site of malaria mosquito, resting place of malaria mosquito, transmission of malaria, symptoms of malaria, knowing a protection method against the bite and ways to prevent and control malaria (Guthmann et al., 2001).

1.6.6 Behavior related to protective and control refers to frequency of opening the window in the subject's room, house of sprayed IRS (Indoor Residual Spray), frequency of use of household insecticide spray, frequency of sleeping with bed net, frequency of using insecticide treated net, frequency of using mosquito repellent coil at night time, frequency of bathing in the canal or stream and frequency of washing clothes in the canal/stream (Guthmann et al., 2001).

1.6.7 Age of house in years refers to the age of year of house that was built.

1.6.8 Composition of house walls refers to kind of materials which are used for house walls, floor and roof.

1.6.9 Openings in subject's room refers to hole of at least 10 x 10 cm^2 in roof or wall (less than 10 x 10 cm^2 was neglected) (Guthmann et al., 2001).

1.6.10 Room density refers to number of persons sleep in the room and in the bed.

1.6.11 Living on the flat ground refers to house that was built on ground having a surface that is without marked projections or depressions.

1.6.12 Distance from the house to the nearest canal refers to the distance between house and nearest canal which is measured in meter and grouped in quintile.

1.6.13 Bushes but not trees refers to the bushes which are less than 200m from the house not including trees

1.6.14 Number of nearby houses refers to the houses which are within 50m around the subject's house (Guthmann et al., 2001).

1.6.15 Number of potential breeding sites refers to total number of potential breeding sites such as collect water, swamps which are within 200m around the subject's house.

1.6.16 Number of canals refers to the canals within 200m around the house (Guthmann et al., 2001).

1.6.17 Nearest water resource refers to the water resources such as well, canal, stream or river which is near to the subject's house and measured in meter.

1.6.18 Nearby forest refers to the nearest forest, rubber plantation or oil palm plantation within 150m from the subject's house.

1.6.19 Breeding site of mosquito refers to where malaria mosquitos breed.

1.6.20 Resting place of mosquito refers to where malaria mosquitos rest from flying.

1**.6.21 Transmission of malaria** refers to how malaria infection can be transmitted from one person to another person.

1.6.22 Symptoms of malaria refers to fever, headache, chill, sweating, vomiting, joint weakness, backache and shivering which can be suffered because of malaria (WHO, 2015b).

1.6.23 Knowing a protection method against the bite refers to the knowledge about how to protect from the mosquito bite.

1.6.24 Ways to prevent and control malaria refers to knowing the prevention and control methods of malaria such as utilizing bed net and mosquito repellent coil at night time.

1.6.25 Frequency of opening the window in the subject's room refers to how often the subject open the window of his/her room (Opening at least 1hour per time was counted).

1.6.26 Frequency of taking outdoor IRS refers to how often the subject take outdoor IRS (Insecticide Residual Spray) for his/her house.

1.6.27 Frequency of using indoor insecticide spray refers to how often the subject uses indoor insecticide spray in his/her house.

1.6.28 Frequency of sleeping with bed net refers to how often the subject sleeps with bed net.

1.6.29 Frequency of using mosquito repellent coil at night time refers to how often the subject uses mosquito repellent coil at night time.

1.6.30 Frequency of bathing in the canal/stream refers to how often the subject baths in the canal or stream.

1.6.31 Frequency of washing clothes in the canal/stream refers to how often the subject washes clothes in the canal or stream.

CHAPTER II

LITERATURE REVIEW

2.1. Malaria

Malaria is one of the infectious diseases which can lead to death. It is caused by Plasmodium parasites that can be transmitted by the bite of the mosquito or blood transfusion or by using a contaminated needle. Malaria which is caused by *Plasmodium falciparum* parasite is the most deadly type. Persons who are the most vulnerable to the disease are young children, pregnant women and non-immune travelers from malaria-free areas than those from malaria endemic area when they become infected. Five species of Plasmodium parasite cause malaria in humans. These five species are *Plamodium falciparum, Plamodium vivax, Plamodium ovale, Plasmodium malariae and Plamodium knowlesi*. Among them, the greatest threat caused by malaria come from *P. falciparum* and *P. vivax* species (WHO, 2015b). *Plasmodium falciparum* specie is not only typically as life threatening but also the major cause of malaria deaths worldwide. In sub-Saharan Africa, this species is the major cause of malaria. *Plamodium vivax* is the second most major species and it is the major cause of disease is Latin America and Southeast Asia. *Plasmodium vivax* and *Plasmodium ovale* have the further additional complication of a dormant liver stage, which can be activated again without the bite of a female mosquito, causing clinical malaria symptoms. Only a small percentage of infections are represented by *Plasmodium malariae* and *Plasmodium ovale*. A fifth and latest species is the *Plasmodium knowlesi* that causes malaria only in primates and then now human can also be infected by this species although the precise mode of transmission of this remains ambiguous (MMV, 2016).

Major plasmodium species in Myanmar are *P. falciparum* (74%) and *P. vivax* (26%) whereas major *Anopheles* species are *An. minimus* and *An. dirus* (WHO, 2014b).

2.2 Anopheles mosquitoes

Distinguished features of *Anopheles* mosquitoes from other mosquitoes are by the palp, which has the same length with the proboscis, and by the wings, having presence of black and white scales discrete blocks. Adult *Anopheles* can also be recognized by their typical positions of resting: both males and females mosquitoes rest with their abdomens sticking up in the air rather than parallel to the surface on which they are resting. A better understanding of the behavior and biology of *Anopheles* mosquitoes can help not only transmission malaria and aiding in designing of proper control strategies (CDC, 2015a).

2.3 Life span

Like all mosquitoes, there are four stages of life cycle in the *Anopheles* mosquito. Depending on the species and the environment temperature, the first three stages (egg stage, larva stage and pupa stage) are aquatic and last 5-14 days. The stage when the female *Anopheles* mosquito becomes as vector of malaria is the last stage which is also called the adult stage. Although the adult one can live up to a month, mostly it live not more than 1-2 weeks in nature (CDC, 2015a).

2.4 Patterns of Feeding and Resting

The nature of the most of *Anopheles* mosquitoes is either active at dusk and dawn which is called crepuscular nature or active only at night which is called nocturnal nature. Some *Anopheles* mosquitoes feed indoor which are endophagic while others are feed outside which are exophagic. Some *Anopheles* mosquitoes are endophilic which rest indoors while others are exophilic which rest outdoors after their blood feeding.

Nocturnal, endophagic *Anopheles* mosquitoes' bite can be significantly reduced by using of insecticide-treated bed nets (ITNs) or improving housing construction to prevent mosquito entry (e.g., window screens). Endophilic mosquitoes can be readily controlled by indoor spraying of residual insecticides. In contrast, both exophagic and exophilic vectors can be successfully controlled by the destruction of the breeding sites (source reduction) (CDC, 2015a).

2.5 Breeding sites

Adult females can lay 50-200 eggs per oviposition and laid directly on water and are unique in having floats on either side. In cold climates, hatching may take up to 2-3 weeks, whereas hatching may only take within 2-3 days in dry climates. Most species prefer to lay in clean, unpolluted water even through the larvae occur in a wide range of breeding sites. However, larvae of *Anopheles* mosquitoes have been found in fresh- or salt-water, rice fields, grassy ditches, marshes, mangrove swamps, small, temporary rain pools, the edges of streams and rivers. Although many species prefer habitats with vegetation, others prefer habitats that have none. Some breed in open, sun-lit pools while others are found only in shaded breeding sites in forests. Only a few species like to breed in tree holes or the leaf axils of some plants (CDC, 2015a).

2.6 Mode of Transmission

Malaria transmission is mainly by the bites of female *Anopheles* mosquitoes. The intensity of transmission depends on some factors which are related to the parasite, the vector, the human host, and the environment. A blood meal is sought by the female mosquito to foster it eggs. Each species of *Anopheles* mosquito has its own preferred aquatic habitat; for instance, some prefer small, shallow collections of fresh water, such as puddles and hoof prints, which are plentiful during the rainy season in tropical

countries. Transmission is more intense in places where the mosquito lifespan is longer and where it prefers to bite humans rather than other animals. The transmission and survival of mosquitoes are also influenced by climate (CDC, 2015a).

2.7 Signs and Symptoms

According to WHO, an acute febrile illness is one of the malarial symptoms. Symptoms occur 1week or more (commonly 10–15 days) in a non-immune individual after the bite of infective mosquitoes. The symptoms that appear first are fever with chills and rigor, headache, vomiting and sometimes abdominal pain may occur which may be minor and difficult to diagnose as malaria. If it not treated within 24 hours, *P. falciparum* malaria can advancement to severe illness often can cause to death. Children with severe malaria frequently show one or more of the following symptoms: respiratory distress which is related to metabolic acidosis, severe malaria or cerebral malaria. Adults can suffer from multi-organ involvement frequently. People may acquire partial immunity, allowing occurrence of asymptomatic infections to occur in malaria endemic areas (WHO, 2015b).

2.8 Diagnosis and treatment

Both disease and reducing malaria death can be prevented by early diagnosis and treatment of malaria. It also reduce malaria transmission. Artemisinin-based combination therapy (ACT) is the best available treatment, especially for P. falciparum malaria. According to WHO recommending, all cases of suspected malaria can be confirmed by using parasite-based diagnostic testing (either microscopy or rapid diagnostic test) before administering treatment. Parasitological confirmation results can be available in 30 minutes or less. When a parasitological diagnosis is not possible, treatment that based only on symptoms should be considered (WHO, 2015b).

2.9 Life Cycle

There are two types of hosts: female *Anopheles* mosquitos and humans in the natural ecology of malaria parasites infection. First of all, the parasites grow and multiply in the human liver cells and then in the red blood cells. The parasites still grow inside the red blood cells and then destroy the red blood cells. By destroying the red cells, they release merozoites (daughter parasites) which can carry on the cycle by invading other red blood cells.

The malaria symptoms are caused by the parasites of the blood stage which are also called gametocytes. During a blood meal, a female *Anopheles* mosquito pick up some gametocytes to start a further, diverse cycle of growth and multiplication in it.

After 10-18 days, the parasites in the salivary glands of mosquitos are called “sporozoites”.They are injected into the another human together with saliva of mosquito during a blood meal of the female *Anopheles* mosquito. Then it continue another infection in human when the liver cells are parasitized. (Figure 1)

Therefore, the mosquito acts as the vector to carry the disease between humans. However, the mosquito vector never suffer the disease from the presence of parasites. This is the difference between two hosts of malaria infection (CDC, 2015b).

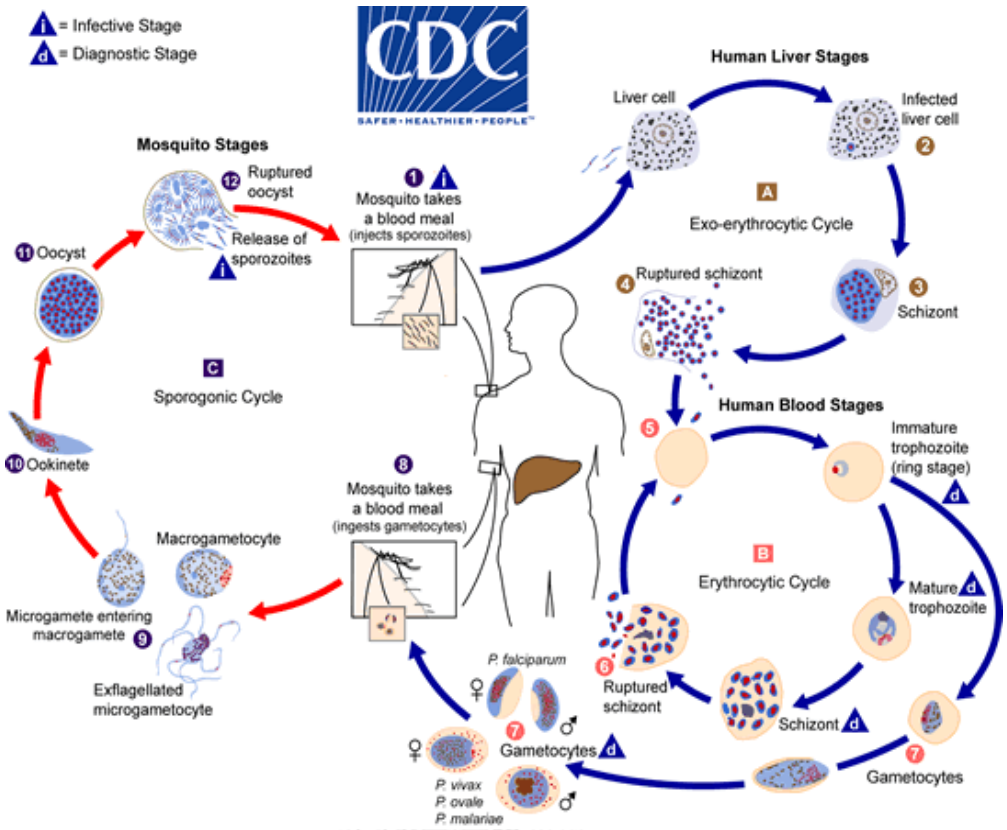


Figure 1 Life cycle of malaria infection

2.10 *Anopheles minimus*

2.10.1 Habitats

Larvae are generally found in small to moderate-sized streams or canals with slow running, clear and cool water, partially shaded and with grassy margins where females prefer to lay their eggs. They develop in various pools (rock, ground, stream). Unusual larval habitats for *An. minimus* (e.g. rain water tanks) have also been reported in the suburbs of Hanoi, Vietnam. *Anopheles minimus s.l.* is commonly found at elevations ranging from 200m to 900m but is rare at altitudes above 1500m. In northern Vietnam and western Thailand, *An. minimus* occupies a greater variety of habitats, ranging from dense canopy forest to open agricultural fields, particularly traditional rice agro-ecosystems. *Anopheles harrisoni* has a narrower habitat preference, being more

closely linked to recently altered agro-ecosystems (e.g. maize cultivation) in deforested areas (MAP 2015b).

2.10.2 Resting and feeding preferences

The adult behaviour of *Anopheles minimus s.l.* is reported as highly diverse for two main reasons: (1) most studies do not differentiate *An. minim*us and *An. harrisoni* and (2) these two species are highly opportunistic in their habits, exhibiting considerable behavioral and ecological plasticity. Females of *An. minimus* mainly bite humans (up to 93% in Assam, India), but the degree of anthropophily/zoophily depends on the availability of alternative hosts (e.g. cattle). This species is mainly endophagic in India, Thailand and central Vietnam, and more exophagic in Cambodia and northern Vietnam. Studies showed that housing in central Vietnam, made with incomplete walls of split bamboo and very large eaves, allows easy entry of the mosquito which would otherwise show exophagic behaviour. Its resting behavior is reported as exophilic in southern China, Thailand and Vietnam, and mainly endophilic in India. However, the degree of endophagy and endophily of *An. minimus* is also largely influenced by the use of indoor residual spraying, provoking either a modified behavioral response or a drastic reduction in population density. In contrast, the few studies conducted on *An. harrisoni* have shown a greater tendency for exophagy, exophily and zoophily. *Anopheles harrisoni* exhibits two peaks of biting activity in western Thailand, the first in the early evening, between 18:00 and 21:00, with a second, smaller peak from midnight to 02:00 or from 03:00 to 06:00. The early evening peak (before 22:00) has also been observed in northern Vietnam. *Anopheles minimus* tends to bite later, with peak activity occurring around 22:00 in Cambodia and Thailand, after 22:00 in Vietnam and between 01:00- 04:00 in Assam, India (MAP 2015b).

2.10.3 Vectorial capacity

Anopheles minimus and *An. harrisoni*, are vectors of malaria parasites throughout their respective distributions, although further investigation needs to be conducted on *An. harrisoni* as its role in malaria transmission appears weaker than that of *An. minimus*, despite it being reported as a main vector in China. *Anopheles minimus s.l.* is considered a primary malaria vector in the hilly forested regions of mainland Southeast Asia. *Anopheles yaeyamaensis* is restricted to the Ryukyu Archipelago in southern Japan where it played a major role as a disease vector until 1962 when malaria was eradicated (MAP 2015b).

2.11 *Anopheles dirus*

2.11.1 Range

The *Anopheles dirus* complex includes non-vector and vector species of human malaria. *Anopheles dirus* (formerly *A. dirus* species A) is distributed in eastern Asia (Myanmar, Thailand, Cambodia, Laos, Vietnam, and Hainan Island in China).

2.11.2 Habitats

Members of the *Dirus* Complex inhabit forested mountains and foothills, cultivated forests, plantations (e.g. rubber) and forest fringes. Larvae typically inhabit small, shallow, usually temporary, mostly shaded bodies of fresh, stagnant(or very slowly flowing) water, such as pools, puddles, small pits (e.g. gem pits), animal footprints (e.g. elephant footprints), wheel ruts, hollow logs, streams and even wells located in primary, secondary evergreen or deciduous forests, bamboo forests and fruit or rubber plantations. Water can be clear or turbid, and habitats with nitrogenous wastes, due to elephant and buffalo excreta or rotten leaves, appear more productive.

These species are most abundant during the rainy (monsoon) season due to the larval requirement and oviposition preference for small temporary pools (MAP 2015a).

2.11.3 Resting and feeding preferences

Anopheles dirus and *An. baimaii* are highly anthropophilic, exophagic as well as endophagic, and exophilic. Studies have shown that biting activity is species-specific, for example in Thailand, *An. dirus* has a tendency to bite between 20:00 and 23:00 and *An. baimaii* from 22:00 to 02:00, although in India earlier biting at 20:00 to 21:00 was also recorded for *An. baimaii*. *An. scanloni* is also anthropophilic and is an early evening biter with peak activity starting at dusk, between 18:00 to 19:00 (MAP 2015a).

2.11.4 Vectorial capacity

Anopheles dirus is a very efficient vector. Its long life and highly anthropophilic nature means that only a small population is necessary to maintain high malaria endemicity. The situation is, however, more complicated because the *Dirus* Complex includes seven species that vary from highly competent vectors of malaria to non-vectors. The primary disease vectors are *An. dirus* and *An. baimaii* which both transmit *Plasmodium falciparum* and *P. vivax*. *An. scanloni* plays a more focal role in malaria transmission of both *P. falciparum* and *P. vivax* in Thailand. There is no clear evidence that *An. cracens* (restricted to the Thai-Malaysian peninsular) and *An. elegans* (only present in hill forests of southwestern India) are involved in malaria transmission. The two remaining species of the complex, *An. nemophilous* and *An. takasagoensis*, (the latter species being restricted to Taiwan) appear to be non-vectors of human malaria due to their strict zoophilic behavior (MAP 2015a).

2.12 Reviews of relevant finding

Behavior of the parasites that can cause malaria in Human has adapted to the changes in global environment, so that the transmission of the parasites also affected profoundly. Deforestation caused by various mechanisms around the world has been the most driving force for these adaptations of mosquitos. In addition to that, the rate of deforestation is expected to increase in the coming years. Epidemiologists strongly believe that deforestation definitely increase malaria risk in Africa and America and diminishes it in South-East Asia. Closed forests within areas of malaria risk cover approximately 1.5 million km^2 in the Amazon region, 1.4 million km^2 in Central Africa, 1.2 million km^2 in the Western Pacific, and 0.7 million km^2 in South–east Asia. Human that are at risk of malaria due to deforestation and increasing human population that force to live near the forests are total 11.7 million, 18.7 million, 35.1 million and 70.1 million, respectively. The more increased in the country-specific rates of deforestation in countries, it can be said that we can rank the countries with high risk of malaria by concluding that the more increased change in the population at risk of malaria as a result of deforestation.(Guerra, Snow, & Hay, 2006).

The ambient temperature clearly affects the transmission of malaria in both transmission and distribution since both mosquitos and parasites are susceptible to temperature. These changes result in the synergistic effect on potential distribution of malaria and causing burden on the poor and vulnerable regions of the world. But, climate conditions in most of the poor countries with high malaria burden are already in the favor of malaria transmission. Therefore, deforestation is a bigger problem than

climate changes in poorest countries. (Van Lieshout, Kovats, Livermore, & Martens, 2004).

Socio-economic status, entomological inoculation to human during activities at night, and highly mobile activities of the community were identified as high risk factors for malaria transmission in a village in Botswana. Limited use of malaria protective measures such as insecticide treated nets, house structure (traditional or modern), and close location of homesteads in relation to breeding sites exposed individuals to mosquito bites (Chirebvu, Chimbari, & Ngwenya, 2014).

During the combined efforts of South East Asia's Greater Mekong Sub-region, mobile and migrant workers are recognized barriers for the efforts to eliminate malaria. Since mobile and migrant workers are mostly engaged in construction and agricultural production in remote areas where malaria is common, these workers often lack 1) knowledge about malaria and vectors, 2) accessibility to malaria services, and 3) access of information on preventive measures and proper health-seeking behavior. Upon returning home to their families with low malaria risk, they endanger both their homes and the entire community with low malaria resistant by bringing infection with them (CAP-Malaria, 2014).

One study was conducted to investigate factors influencing self-reported malaria among migrants living along the Thai-Myanmar border. Songkaria Village, with 1600 people living in the village and 290 households in Sangkhla Buri District, Kanchanaburi Province, was selected for the study because of its high malaria infection rate. The result of the study stated that working conditions among migrants played a major role in acquiring malaria. The affordability for preventive measures against malaria, eg, a mosquito net or mosquito repellent during work is an important factors

for increased transmission of malaria infection. The concept of improving the working conditions for migrants for protection of malaria needs to be examined. Recommendations from a literature said that we need to find ways and means of improving the social economic status of migrants to reduce exposure to the vector(Tipmontree, Fungladda, Kaewkungwal, Tempongko, & Schelp, 2009).

One of the studies from Bangladesh which was conducted in in the Chittagong Hill which is bordering District with the western Myanmar between October 2009 and May 2012 showed that risk factors for malaria infection were living in the high endemic areas, age, and certain types of occupation such as jhum cultivation and/or daily labor. P. falciparum malaria continues to be hypo-endemic in the Chittagong Hill Districts of Bangladesh, has seasonal variations, and is much more confined to limited areas and among certain occupations(Ahmed et al., 2013).

Higher malaria risk is also associated with low literacy rates of female households, nocturnal activities, living near channeled swamp water and near forests, lack of ceiling in the house, a separate kitchen and having pet animals and livestock in the compound. The additional risk factors contributing to the malaria risk includes living in flat land, living close to fields such as maize, paddy, and without having trees in close vicinity. Water accumulation could easily happen for people living in the flat lands found by Cohen et al. (2008) that demonstrated topography, moisture in the environment is highly correlated with malaria risk (Ernst et al., 2009).

One study which was conducted in Bhutan showed that if there was high coverage of LLINs region and if the residents used LLINs (Long Lasting Insecticide Nets) correctly and consistently throughout the year, the malaria new infections can be effectively reduced. LLIN is used for the purpose of prevention of malaria infection.

With high coverage and regular use of LLINs, and a zero prevalence of malaria infection found in historically high-risk communities during the peak malaria season (Wangdi, Gatton, Kelly, & Clements, 2014).

One study which was conducted in Bangladesh showed that the environmental temperature was not a significant effects on the horde of mosquito vectors for malaria in Bangladesh. This study demonstrates that the nature of relationship between mosquitos and climatic were influenced by multiple factors. Detailed studies of entomological details, continuous monitoring and malaria transmission dynamics is essential for predicting disease outbreaks and vector control in the region (Bashar & Tuno, 2014).

One study showed that prevalence of malaria infection was significantly associated with multiple spaying factors such as frequency of spray in the child's house, spray coverage with effective insecticide in the neighborhood, bed net use, and time taken between spray times. Careful scheduling of spray coverage and timing is crucial to get better effectiveness of Insecticide Residual Sprays and to contribute in the reduction of Malaria infection (Kleinschmidt et al., 2007).

Field observations in northern coastal Peru, new infections of malaria is more prone to happen during the agricultural season, suggested that the risk of disease was different according to the characteristics of the house and the house environment. In a case control study for the Environmental determinants of the risk of clinical malaria with 3:1 ratio of controls verses cases 323 clinical cases of malaria, recruited through community-based active case-finding, and 969 age-, sex- and village-matched controls were recruited into the study over a period of 12 months.. An important result of this study was that close distance from the house to the nearest canal is a risk factor for

malaria infection. This is probably due to presence of breeding areas in canal where the far canal around the home has negatively associated with malaria infection in logistic regression (Guthmann et al., 2001).

One study showed that there were higher entomological and parasite prevalence ($P = 0.001$) and parasite density ($P = 0.03$) in the individuals of wooden plank houses than those of cement brick houses. Inhabitants of houses which are surrounded by potential breeding sites such as bushes or garbage heaps and swamps or stagnant water showed higher malaria parasite prevalence and densities compared with those from cleaner surroundings (Nkuo-Akenji et al., 2008).

There was a significant difference between education level and knowledge on transmission ($p < 0.001$) and about 56% of respondents was associated with occurring disease by mosquito bites in the study of Geita district, northwest Tanzania in 2009. Education status was associated with knowledge of mosquito breeding areas ($P < .001$) and it was also associated with usage of bed nets by the respondents ($p < 0.1$). About 86.3% of respondents agreed with indoor residual spraying of insecticides (Mazigo et al., 2010).

A study in two areas in Bangladesh regarding their behavior shows that near 50% of residence experienced malaria episodes in the previous year during face to face interview with the locals. More than three quarter of the locals did not know the mode of transmission of malaria is vector-borne transmission. Awareness of the respondents on the transmission of malaria and symptoms of the malaria in the different areas are not the same from the study. Most of the people residing in the areas responded that sleeping under the bed net is extremely important for prevention of malaria, but association between sleeping with a bed net and prevalence cannot be established in the

study. The things that have association with malaria prevalence are education, family members, working outside the house at night, having pets near the resident and Housing Status of the residents. Among the associated factors, Housing conditions are shown to be most prominent factor and almost half of the people living in both areas suffered from malaria infection (Bashar, Al-Amin, Reza, Islam, & Ahmed, 2012).

CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Design

This was an unmatched case-control study targeting in age 18 to 60 years who stay in Tanintharyi Region, Myanmar during April, 2016 to May, 2016.

This study was conducted to know the odd ratio and to find out the environmental risk factors of malaria of cases and controls. This study was conducted also to find risk factors regarding to environment for prevention and control intervention of guideline recommendation. They are not only less costly and less time-consuming but also advantageous when exposure data is expensive or hard to obtain. They are advantageous when studying dynamic populations in which follow-up is difficult. They can be conducted for small sample sizes and have less ethic problem.

3.2 Study Area

The study was conducted in four townships in Tanintharyi Region, Myanmar. The people in this four townships have similar characteristics of socio-economic status. Their occupation are mainly rubber farm workers, oil palms workers, farmers and fishermen. The four townships are Boke-pyin, Kyun-su, Palaw and Tha-yet-chaung which are the malaria high endemic area. (MOH, 2012) (Figure 2)

Tanintharyi Region lies at the southern end of Myanmar. The Region has common borders with Thailand on the east and south-east, Mon State on the north, and Andaman Sea on the west. The area of the Region is 16,735 square miles. Out of about 1,000 islands along Myanmar's coastline over 800 are in Tanintharyi coast.

The population in Tanintharyi Region was about 1334861 and total confirmed malaria cases was 20853 according from the data of Myanmar Annual Malaria Report 2013. In this study area, there were 618 cases in Boke-pyin Township, 2856 cases in Kyun-su Township, 1573 cases in Palaw Township and 1051 cases in Tha-yet-chaung Township. (Unpublished Data)

Throughout the border region, the contribution of *P. vivax* to overall malaria morbidity is increasing. Drug resistance in local parasite populations is also a major concern. *P. falciparum* parasite populations in the region have an apparent proclivity for developing resistance to anti-malarials, having historically been among the first to develop resistance to successive lines of drugs (Parker, Carrara, Pukrittayakamee, McGready, & Nosten, 2015).

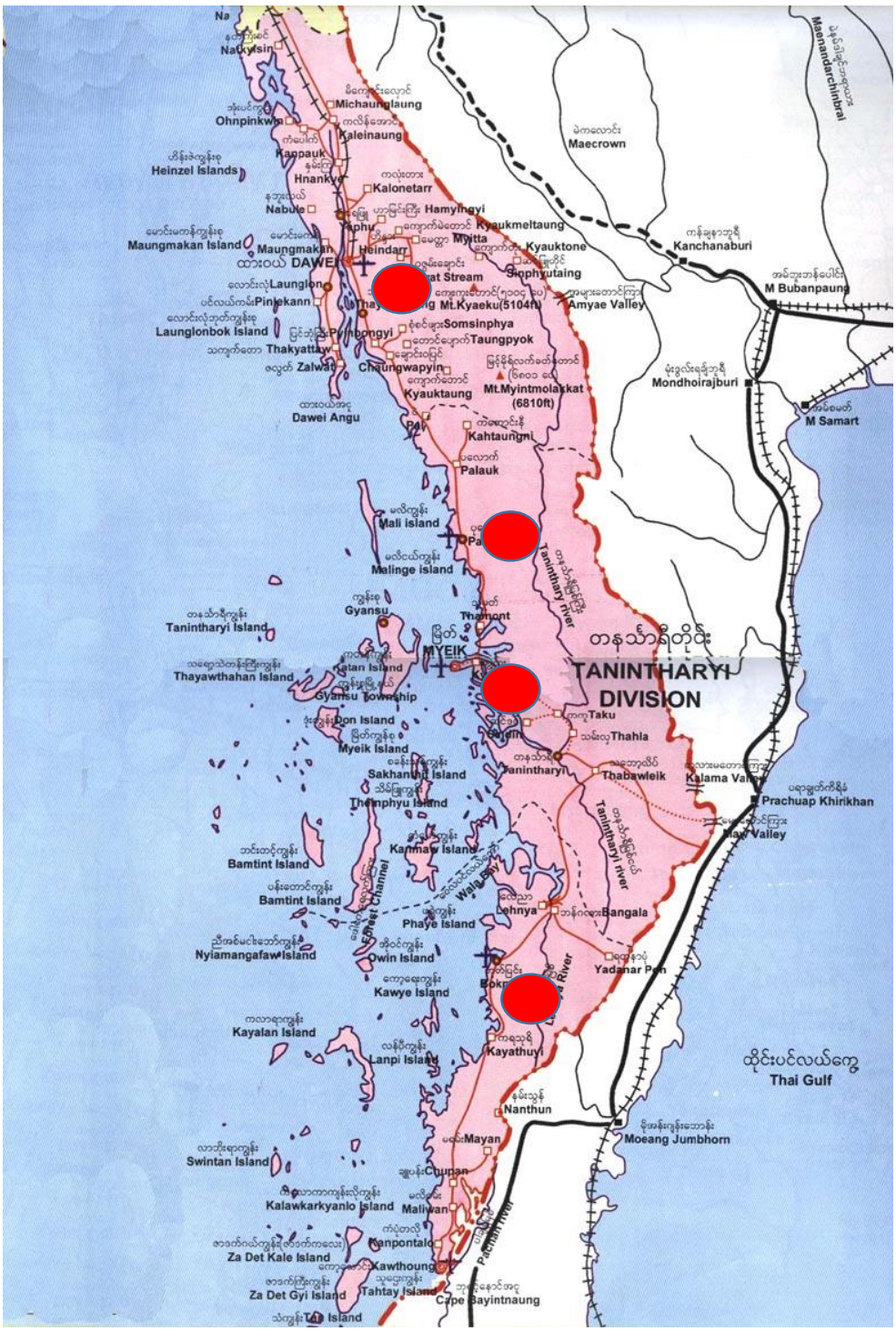


Figure 2 Map of Four Townships in Tanintharyi Region, Myanmar

3.3 Study Population

The study was conducted among population of age 18 to 60 years who living in four townships, Tanintharyi Region, Myanmar.

3.4 Sample and Sample Size Calculation

The sample size was calculated by the following formula which was described in Kelsey et. al (1996) is

$$n = (\frac{r+1}{r}) \frac{(\bar{p})(1-\bar{p})(Z_{\beta} + Z_{\alpha/2})^2}{(p_1 - p_2)^2}$$

Where, For 80% power, Z_{β}, desired power =.84 (typically .84 for 80% power)

For 0.05 significance level, Z_{α}, desired level of statistical significance =1.96 (typically 1.96)

$p_1 - p_2$ = Effect Size (the difference in proportions)

r=2 (ratio of controls to cases)

The estimated proportion exposed in the control group is 30%

Odd Ratio (Number of Canal) = 2.13 (Guthmann et al., 2001)

To get proportion of cases exposed:

$$p_{case\exp} = \frac{ORp_{control\exp}}{p_{control\exp}(OR-1)+1}$$

$$Pcase\exp = \frac{(2.13)(0.30)}{(0.30)(2.13-1)+1} = 0.48$$

Average proportion exposed = (0.48+0.30)/2=0.39

$$n = 1.5\frac{(0.39)(1-0.39)(0.84+1.96)^2}{(0.48-0.30)^2} = 153$$

Therefore, total participants is 459 (153 cases, 306 controls)

3.4. a Case and Control Selection

A malaria case was a person living currently in the study area who had malaria symptoms and Rapid Diagnosis Test was positive at the time of examination by mobile clinics.

A malaria control was a person living currently in the study area who had not positive Rapid Diagnosis Test at the time of examination by mobile clinics.

3.4.b How to get Cases and Controls in this study

Case: A person attending mobile clinic during April, 2016 to May, 2016 and Rapid Diagnosis Test was positive at the time of examination by mobile clinics.

Control: A person attending mobile clinic during April, 2016 to May, 2016 and Rapid Diagnosis Test was not positive at the time of examination by mobile clinics.

The use of antigen detecting rapid diagnostic tests (RDTs) is the basis for extending access to malaria diagnosis by providing parasite-based diagnosis in areas where good-quality microscopy cannot be maintained. The test can detect *P.faciparum* infection, *P.Vivax* infection, Mix infection and no infection. The RDTs is the test kit that use to test the client's blood. The client's blood need to be add to the test kit and after 15 minutes, we can observe the result (WHO, 2014a)(Figure 3).

Figure 3 Rapid Diagnosis Test

3.4.c Inclusion criteria of Case

Respondents who attended to the Mobile Clinics during April, 2016 to May, 2016

Both Male and Female of age 18 to 60 years

Respondents who had willingness to answer the questionnaires

Respondents who were the residents in the study area more than 3 months

Respondents who had positive Rapid Diagnosis Test (*Both new cases and old cases*)

If respondents of case and control come from the same family and same house, only cases were included in the study

3.4.d Exclusion criteria of Case

Respondents who were unconscious, extremely ill or severe stage of malaria and in need of immediate medical attention at the time of testing

Respondents who were temporary residents of the study area

3.4.e Inclusion criteria of Control

Respondents who attended to the Mobile Clinics during April, 2016 to May, 2016

Both Male and Female of age 18 to 60 years

Respondents who had negative Rapid Diagnosis Test

Respondents who had never experienced on malaria infection

Respondents who had willingness to answer the questionnaires

Respondents who were the residents in the study area more than 3 months

3.4.f Exclusion criteria of Control

Respondents who were temporary residents of the study area

If respondents of case and control come from the same family and same house, controls were excluded from the study.

According to the data from Vector Borne Disease Control 2013, total confirmed malaria cases from Boke-pyin township was 618 cases, from Thayet-chaung township was 1051 cases, from Palaw township was 1573 cases and from Kyun-su was 2856 cases respectively (Unpublished Data). Cases and Controls were collected as proportional to actual prevalence of malaria of respective townships. Therefore, (15 cases and 30 controls) were collected from Boke-pyin, (26 cases and 52 controls) were collected from Thayet-chaung, (40 cases and 80 controls) were collected from Palaw and (72 cases and 142 controls) were collected from Kyun-su respectively.

3.5 Research Instruments

The questionnaires were constructed to get the information needed in this study. It was composed of five sections:

3.5. a Part A – Question about Social-demographic factors (11 Items)

This part of questionnaire consisted of questions on the socio-demographic factors of the sample population with including age, gender, marital status, occupation, ethnicity, education level, monthly income and duration of stay in study area (Woldu, 2013).

3.5. b Part B – Question about House or House characteristics (11 Items)

This part of questionnaire consisted of questions on house or house characteristics of the sample population with including age of house in years, house tenure, housing conditions, room density, animals sleep in house, mosquito bed net, kind of mosquito bed net, number of hole in the mosquito bed net, size of hole in the mosquito bed net, opening in the subject's room and number of windows that close in the subject's room (Guthmann et al., 2001).

3.5 .c Part C – Question about Characteristics of the house environmental factors (8 Items)

This part of questionnaire consisted of questions on the characteristics of the house environmental factors of the sample population with including nearest water resource, nearest forest, living on the flat ground, bushes but not trees, number of nearby houses, number of potential breeding sites, number of owned hectares/acres of land and numbers of livestock in the compound (Yamamoto et al., 2010).

3.5. d Part D – Question about Knowledge of Malaria (7 Items)

This part of questionnaire consisted of questions on the knowledge on malaria of the sample population with including vector which can transmit malaria to human, breeding site of malaria mosquito, resting place of malaria mosquito, transmission of malaria, symptoms of malaria, knowing a protection method against the bite and ways to prevent and control malaria (Guthmann et al,. 2001) (Woldu, 2013).

-The correct answer get: 1 score

-The wrong answer get: 0 score

There were 7 items and each item had sub-questions. The possible score ranged from 0 to 39 for knowledge on malaria. Respondent's knowledge was classified into

three levels. The cut-off point for ‘Good knowledge’: greater than 80% of 39 scores, ‘Moderate knowledge’: from 60% to 80% of 39 scores, ‘Poor knowledge’: less than 60% of 39 scores (Yimer, Abera, Mulu, & Belay, 2014).

3.5. e Part E – Question about Behavior related to protective and control (8 Items)

This part of questionnaire consisted of questions on the behavior related to protective measurement of the sample population with including frequency of opening the window in the subject’s room, frequency of taking IRS (Insecticide Residual Spray), frequency of use of household insecticide spray, frequency of sleeping with bed net, frequency of using insecticide treated net, frequency of using mosquito repellent coil at night time, frequency of bathing in the canal or stream and frequency of washing clothes in the canal/stream (Guthmann et al,. 2001).

The answers were categorized into three levels: Always, Sometimes, and Never. For those who answered “Always” get 2scores, “Sometimes” get 1score, and “Never” get 0 score. The possible scores ranged from 0 to 16 scores. The obtained data was categorized in tertile because the data are not normally distributed. The respondents’ practice was classified into three levels “Good practice”: greater than 66.6 percentile of available scores, “Moderate practice”: from 33.3 percentile to 66.6 percentile of available scores, “Poor practice” less than 33.3 percentile of available scores (Abedi, Khan, Ansari, & Amir, 2011).

3.6 Validity and Reliability

To achieve the validity of the questionnaires, the reviewing literature and 3 consulting content experts were performed. The 3 consulting consent experts were obtained from 2 academic experts and 1 local expert. Two academic experts’ opinions

were obtained from Assoc. Prof. Ratana Somrothong, PhD and Dr. Tapanata Pumpaibool, Ph.D. One local expert opinion was obtained from Dr. Myo Min, Project Manager of Malaria, Myanmar Medical Association. The average IOC (Item-Objective Congruence) result from three experts was 0.77.

To establish the reliability, I conducted the pilot study. The questionnaires were tested with 30 respondents among population in Dawei Township, Tanintharyi Region, Myanmar. The internal reliability result was 0.70.

3.7 Data Collection Method

The face-to-face interview was conducted to collect the data.

Before starting the data collection, the researcher requested volunteers from each of the fixed and mobile clinics of Myanmar Medical Association to collect the data .The researcher trained those volunteers to understand the questionnaires. The researcher and the volunteers such as Field coordinator, Field Health Assistant and health volunteers from each Fixed and Mobile Clinics interviewed the respondents during their mobile clinics. The Rapid Diagnosis Tests (RDTs) confirmed malaria cases were included as cases and the RDTs negative cases were included as controls. The RDTs were performed by Field coordinator, Field Health Assistant and health volunteers of the mobile clinics and they confirmed malaria cases according to RDTs results. The data were collected by face-to-face interviewing using structured questionnaires at the same day after the RDT results. The interviewing time took 15min for each respondent.

After briefing all and made sure that the respondent understood all, he or she was asked to participate in the interview and to fill the informed consent form before answering the questionnaires.

3.8 Data Analysis

To analyze the collected data, SPSS version 16 was used.

Descriptive statistics was utilized to find out mean, percentage and standard deviation.

Bivariate analysis, [crude odds ratio (OR), 95% confidence interval and corresponding p-value < 0.05] was employed. The univariate analysis included the frequency, the percentage distribution of the respondents' socio-demographic factors, house and housing conditions, characteristics of the housing environmental factors, knowledge of malaria and behavior related to protective and control of malaria cases and malaria controls.

Binary logistic regression was used to test relative importance of independent variables which was adjusted for age, sex, etc.

Multivariate analysis was utilized. Variables were first assessed using bivariate analysis. Those significant at the <0.25 level were then grouped into the four main categories: socio-demographic, housing characteristics, housing environment and knowledge and analyzed by multiple logistic regression. Those individual variables analyzed within categories that were significant at the 0.05 level were included in the final model, which was also adjusted for reported bed net use.

3.9 Ethical Approval

Ethical approval to conduct this study was sought from Ethics Review Committee of Chulalongkorn University. After receiving the permission from Ethical Committee, investigator contributed to collect data. The objective and purpose of this study were clearly explained to the respondents before signing the consent form and voluntary participation. Every completed questionnaires was kept carefully and confidentially. The respondents could refuse to join this study and no need to explain for reasons. This data were used only for this study and their information was kept secretly.

3.10 Expected Benefits and Application

The study provided information for studies that are needed to confirm the importance of particular risk factors. It can be used to be guideline of home improving and home environment for malaria prevention in Myanmar border (Costal area). In addition, further study can be done depending on the data of this study. Health promotion program such as utilization of bed net and indoor residual spraying campaigns can also be implemented depending on the study.

CHAPTER IV

RESULT

The study was an analytical case-control research to study about environmental factors related to malaria in Tanintharyi Region, Myanmar. This chapter presents the finding from data analysis. The data analysis reports on the survey, outcomes, and results in following orders:

1) Socio-demographic characteristics of the respondents
2) Housing conditions and house environment characteristics of malaria cases and controls
3) Knowledge about malaria and behavior related to protective and control of malaria cases and controls
4) Association between socio-demographic factors of malaria cases and controls and malaria
5) Association between Housing conditions and house environment characteristics of cases and controls and malaria
6) Association between knowledge and behavior regarding malaria cases and controls and malaria
7) Multivariate model of association between measure variables and malaria risk

The total number of subjects in this study was 459 (**153 cases and 306 controls)**. Malaria cases and controls ratio was accountable for a ratio of 2:1. The study was conducted among population of age 18 to 60 years who attended to the Mobile

Clinics during April, 2016 to May, 2016 who living in four townships, Tanintharyi Region, Myanmar. Data from cases and controls from four townships of Thanintharyi Region, Myanmar were collected using questionnaires.

4.1. Socio-demographic characteristics of the respondents

Table 1 showed the socio-demographic factors such as age, sex, ethnicity, occupations, marital status, education, total yearly family income and years of staying of 459 respondents in Tha-yet-chaung township, Boke-pyin township, Kyun-su township, and Palaw township in Tanintharyi Region, Myanmar. The age of the sample was ranged from 18 to 60 years and grouped in three groups using mean and standard deviation. The first group was from age 18 to 25years, the second group was from age 26 to 45 years and the last group was from age 46 to 60 years. Most of them 222 (48.4%) were in the age group from 26 to 45 years. Among that age group, cases were 80 and controls were 142. Some of them were in the age group 18 to 25 years, 27.0% (Case/control: 45/79) and 46 to 60 years, 24.6% (Case/control: 28/85) respectively. (54.5%) of the respondents were female and the rest of them were male (45.5%). Cases were 66 males and 87 females and there were 143 male controls and 163 female controls respectively.

Majority of the respondents (76.7%) (Case/control: 120/232) were Burma. There were 10.7% (Case/control: 14/35) Kayen, 4.2% (Case/control: 4/15) Mon and 8.5% (Case/control: 15/24) others. About 29.5% (Case/control: 31/106) of daily wages were related to working more than two kinds of sector. The occupation of the rest of respondents were 26% (Case/control: 46/74) housewives, 18.8% (Case/control: 44/39) farmers, 10% (Case/control: 4/40) government employees. A few percentage were

fishermen, foresting men and students 6.7% (Case/control: 15/16), 3.4% (Case/control: 2/14) and 5.6% (Case/control: 9/17) respectively.

Table 1 Number and Percentage Distribution of Respondents by Socio-demographic Factors of malaria cases and controls (n = 459)

Socio-demographic Factors	Cases (n=153) (%)	Controls (n=306) (%)	Total
Age:			
18 to 25 years	45 (29.4%)	79 (25.8%)	124 (27.0%)
26 to 45 years	80 (52.3%)	142 (46.4%)	222 (48.4%)
46 to 60 years	28 (18.3%)	85 (27.8%)	113 (24.6%)
Mean = 35 , Median = 34, SD =12.3			
Sex:			
Male	66 (43.1%)	143 (46.7%)	209 (45.5%)
Female	87 (56.9%)	163 (53.3%)	250 (54.5%)
Ethnicity:			
Burma	120 (78.4%)	232 (75.8%)	352 (76.7%)
Mon	4 (2.6%)	15 (4.9%)	19 (4.2%)
Kayen	14 (9.2%)	35 (11.4%)	49 (10.7%)
Others	15 (9.8%)	24 (7.8%)	39 (8.5%)
Occupation:			
Farmer	44 (28.8%)	39 (12.7%)	83 (18.8%)
Fisherman	15 (9.8%)	16 (5.2%)	31 (6.7%)
Student	9 (5.9%)	17 (5.6%)	26 (5.6%)
Housewife	46 (30.1%)	74 (24.2%)	120 (26.0%)
Government employee	6 (3.9%)	40 (13.1%)	46 (10.0%)
Foresting man	2 (1.3%)	14 (4.6%)	16 (3.4%)
Others	31 (20.3%)	106 (34.6%)	137 (29.5%)
Marital status:			
Married:	85 (55.6%)	159 (52.0%)	244 (53.2%)
Single	55 (35.9%)	115 (37.6%)	170 (37.0%)
Window	8 (5.2%)	25 (8.2%)	33 (7.2%)
Divorced	5 (3.3%)	7 (2.3%)	12 (2.6%)
Income:			
110000 to 1200000 kyats	58 (37.9%)	43 (14.1%)	101 (22.0%)
1200001 to 2600000 kyats	88 (57.5%)	206 (67.3%)	294 (64.1%)
2600001 to 4500000 kyats	7 (4.6%)	57 (18.6%)	64 (13.9%)
Mean = 1904302.83, Median = 1900000, SD = 729581.783			
Education:			
No education	20 (13.1%)	30 (9.8%)	50 (10.9%)
Primary education	49 (32.0%)	109 (35.6%)	158 (34.4%)
Secondary education	49 (32.0%)	90 (29.4%)	139 (30.3%)
High school education	21 (13.7%)	30 (9.8%)	51 (11.1%)
Graduated/Post-graduated education	14 (9.2%)	47 (15.4%)	61 (13.3%)
Years of Staying:			
1 to 4 years	42 (27.5%)	57 (18.6%)	99 (21.5%)
5 to 27 years	83 (54.2%)	201 (65.7%)	284 (61.9%)
28 to 57 years	28 (18.3%)	48 (15.7%)	76 (16.6%)
Mean = 15.35, Median = 12, SD = 11.58			

More than half of respondents surveyed, 53.2% were married. There were 37% single and very few respondents were windows, 7.2% and divorced or separated persons, 2.6% respectively. Majority of respondents, 34.4% had completed primary school education while 30.3% of them had attained middle school education. 10.9% of respondents had never attended school and 11.1% of them had attended high school education. Only 13.3% had college or university education. Majority of occupation of cases, 30.1% were housewives whereas majority of occupation of controls, 34.6% were working at others or more than two sectors.

The level of economic status of the respondents had been assessed on the basic of yearly total family income. Total yearly income ranged from 110,000 to 4,500,000 kyats. The first group was from 110,000 to 1,200,000 kyats, the second group was from 1,200,001 to 2,600,000 kyats and the last group was from 2,600,001 to 4,500,000 kyats. Majority of respondents, 64.1% had yearly family income of 1,200,001 to 2,600,000 kyats. Years of staying ranged from 1 to 57 years. The first group was from 1 to 4 staying years, the second group was from 5 to 27 staying years and the last group was from 28 to 57 staying years. Majority of respondents, 61.9% had 5 to 27 staying years. The other two groups, first and last groups, were 21.5% and 16.6% respectively.

Most of the workers (33.21%) worked at other farming sites than rice field, rubber plantation, oil palms and vegetables fields. (Appendix table 15).

4.2. Housing conditions and house environment characteristics of malaria cases and controls

Table 2 revealed house and housing conditions of malaria cases and controls such as age of house in years, house tenure, number of floor, materials used for first floor of house and compositions of house walls of 459 respondents. Age of house in

years ranged from 1 to 80 years. The first group was from 1 to 6 years, the second group was from 7 to 33 years and the last group was from 33 to 80 years. Majority of respondents, 68% had 7 to 33 staying years. The other two groups, first and last groups, were 19% and 13.1% respectively. 85% of respondents had own houses whereas only 15.1% of them had rented houses.

Majority of respondents' houses, 71% were one floor houses and the rest, 29% were two floor houses. Almost half of first floor of houses, 41% were made of wood. 14.4% were used no materials for the first floor of houses. Brick, 13.9%, cement, 14.8% and bamboo, 9.8% were used for the first floor of houses. Only a few percent, 6.1% of them were made of other materials. Nearly half of house walls for first floor of houses, 46.2% were composed of wood or branches not covered with mud or branches covered with mud. The rest of compositions of house walls for first floor of house were brick or adobe, 25.1% and bamboo, 28.8% respectively.

Table 2 Number and percentage distribution of house and housing conditions of malaria cases and controls (n = 459)

House or Housing condition	Cases (n=153) (%)	Controls (n=306) (%)	Total
Age of house in years:			
1 to 6 years	39 (25.5%)	48 (15.7%)	87 (19.0%)
7 years to 33 years	91 (59.5%)	221 (72.2%)	312 (68.0%)
34 years 80 years	23 (15.0%)	37 (12.1%)	60 (13.1%)
Mean = 19.25, Median = 16, SD = 13.22			
House tenure:			
Own	127 (83.0%)	263 (85.9%)	390 (85.0%)
Rent	26 (17%)	43 (14.1%)	69 (15.1%)
Number of floor:			
1 floor	104 (68.0%)	222 (72.5%)	326 (71.0%)
2 floor	49 (32.0%)	84 (27.5%)	133 (29.0%)
Materials used for first floor of house:			
None	13 (8.5%)	53 (17.3%)	66 (14.4%)
Brick	28 (18.3%)	36 (11.8%)	64 (13.9%)
Wood	57 (37.3%)	131 (42.8%)	188 (41.0%)
Bamboo	11 (7.2%)	34 (11.1%)	45 (9.8%)
Cement	37 (24.2%)	31 (10.1%)	68 (14.8%)
Others	7 (4.6%)	21 (6.9%)	28 (6.1%)
Compositions of house walls for first floor of house:			
Brick or Adobe	32 (20.9%)	83 (27.1%)	115 (25.1%)
Wood or branches	44 (28.8%)	168 (54.9%)	212 (46.2%)
Bamboo	77 (50.3%)	55 (18.0%)	132 (28.8%)

Materials used for second floor of all houses were made of wood. Majority of compositions of house walls for second floor of houses, 73.7% were wood or branches not covered with mud. The rest, 26.3% were composed of brick. (Appendix table 16)

Table 3Number and percentage distribution of house and housing conditions of malaria cases and controls (n = 459)

House or Housing condition	Cases (n=153) (%)	Controls (n=306) (%)	Total
Materials used for roof of house:			
Straw or palm	65 (42.5%)	25 (8.2%)	90 (19.6%)
Zinc sheet	87 (56.9%)	277 (90.5%)	364 (79.3%)
Other	1 (0.7%)	4 (1.3%)	5 (1.1%)
Ceiling:			
Yes	35 (22.9%)	112 (36.6%)	147 (32.0%)
No	118 (77.1%)	194 (63.4%)	312 (68.0%)
Sleep in the room: number of people in bedroom			
Alone	30 (19.6%)	85 (27.8%)	115 (25.1%)
With 1 or 2	72 (47.1%)	158 (51.6%)	230 (50.1%)
With 3 or more than 3	51 (33.3%)	63 (20.6%)	114 (24.8%)
Sleep in the bed:			
Alone	30 (19.6%)	85 (27.8%)	115 (25.1%)
With 1	59 (38.6%)	77 (25.2%)	136 (29.6%)
With 1+	64 (41.8%)	144 (47.1%)	208 (45.3%)

Table 3 revealed house and housing conditions of malaria cases and controls such as materials used for roof of house, ceiling, number of people who sleep in the bedroom and number of people who sleep on the bed of 459 respondents. Most of roof of houses, 79.3% were made of zinc sheet. Straw or palm, 19.6% were used for roof of houses and the other materials used for roof of houses were only 1.1%. Almost half of respondents, 50.1% slept together with one or two persons in their bed room. 25.1% slept alone in their bed room and 24.8% slept with three or more than 3 persons in their bed room. Nearly half of respondents, 45.3% slept together with more than 1 person on the bed while 25.1% slept alone on the bed and 29.6% slept together with one person on the bed of their rooms.

Table 4 showed house and housing conditions of malaria cases and controls such as animals sleep in house, mosquito bed net, kind of mosquito bed net, number of hole at the mosquito bed net, opening in the subject's room and number of windows that close in the subject's room of respondents. Animals sleep in houses were 48.8%

while as no animals sleep in houses were 51.2%. Almost all of houses, 96.3% had mosquito bed net. Only a few, 3.7% had no mosquito bed net. Almost half of mosquito bed nets, 46.4% were neither LLIN (Long Lasting Insecticides Net) nor ITN (Insecticide Treated Net). 33.3% of them had ITNs while 20.4% had LLINs. Although majority of mosquito bed net, 76.9% had no hole, 9.5% of them had one to six holes. 13.6% of respondents who had the mosquito bed net didn't know or didn't remember whether their bed net had holes or not. Majority of respondents, 67.6% didn't know or didn't remember about size of hole in their mosquito bed nets (Appendix table 16). More than half of respondents' houses, 55.6% had no openings (10cm x 10cm) in the subject's room. 36.6% of them had openings in their rooms while 7.8% of them didn't know or didn't remember whether there were openings in their rooms. Although 44.9% of respondents had no windows that close in their rooms, 34.4% of them had one window in their rooms. Only 20.7% of them had more than one window in their rooms.

Table 4 Number and percentage distribution of housing conditions of malaria cases and controls (n=459)

House or Housing condition	Cases (n=153) (%)	Controls (n=306) (%)	Total
Animals sleep in house: (n=459)			
Yes	72 (47.1%)	152 (49.7%)	224 (48.8%)
No	81 (52.9%)	154 (50.3%)	235 (51.2%)
Mosquito bed net: (n=459)			
Present	150 (98.0%)	292 (95.4%)	442 (96.3%)
Absent	3 (2.0%)	14 (4.6%)	17 (3.7%)
Kind of mosquito bed net: (n=442)			
LLIN	14 (9.3%)	76 (26.0%)	90 (20.4%)
ITN	43 (28.7%)	104 (35.6%)	147 (33.3%)
Others	93 (62.0%)	112 (38.4%)	205 (46.4%)
Number of hole in the mosquito bed net: (n=442)			
None	113 (75.3%)	227 (77.7%)	340 (76.9%)
1 to 6	22 (14.7%)	20 (6.8%)	42 (9.5%)
Don't know/Don't remember	15 (10.0%)	45 (15.4%)	60 (13.6%)
Openings in the subject's room: (n=459)			
Yes	56 (36.6%)	112 (36.6%)	168 (36.6%)
No	83 (54.2%)	172 (56.2%)	255 (55.6%)
Don't know/Don't remember	14 (9.2%)	22 (7.2%)	36 (7.8%)
Number of windows that close in the subject's room: (n=459)			
None	72 (47.1%)	134 (43.8%)	206 (44.9%)
1	41 (26.8%)	117 (38.2%)	158 (34.4%)
>1	40 (26.1%)	55 (18.0%)	95 (20.7%)

Table 5 revealed characteristics of the housing environmental factors of malaria cases and controls such as canal, number of canal, stream, number of stream, river, well and number of well of respondents. Majority of respondents, 92.6% had no canal around their houses while as minority of them, 7.4% had canals around their houses. Majority of the number of canal within less than 200m from the houses, 91.2% were only one canal. Only a few, 8.8% were two canals. Although 42.7% of respondents' houses had streams around their houses, 57.3% of them had no stream around their houses. Only one stream within less than 200m around respondents' houses had 92.9% while as two or three streams had 7.1%. 14.4% of streams around respondents' houses were within 50m to 100m (Appendix table 17). Although 89.3% of houses had no river

around their houses, 10.7% of houses had around their houses. But houses which had river around were situated more than 150 m, 4.8% (Appendix table 17). Most of the houses, 81.5% had well around their houses and only 18.5% had no well around their houses. Nearly half of the wells, 44.4% were situated within less than 50m from the houses (Appendix table 18). Majority of them, 75.9% had only one well within less than 200 from the houses while two wells and three or more than three wells had 16.8% and 7.2% respectively.

Table 5 Number and percentage distribution of characteristics of the housing environmental factors of malaria cases and controls (n=459)

Characteristics of the housing environmental factors	Cases (%)	Controls (%)	Total
Canal: (n=459)			
Yes	17 (11.1%)	17 (5.6%)	34 (7.4%)
No	136 (88.9%)	289 (94.4%)	425 (92.6%)
Number of canal: (within <200m from the house) (n=34)			
One	17 (94.4%)	14 (87.5%)	31 (91.2%)
Two	1 (5.5%)	2 (12.5%)	3 (8.8%)
Stream: (n=459)			
Yes	78 (51.0%)	118 (38.6%)	196 (42.7%)
No	75 (49.0%)	188 (61.4%)	263 (57.3)
Number of stream: (within <200m from the house) (n=196)			
One	76 (97.4%)	106 (89.8%)	182 (92.9%)
Two or Three	2 (2.5%)	12 (10.1%)	14 (7.1%)
River: (n=459)			
Yes	29 (19.0%)	20 (6.5%)	49 (10.7%)
No	124 (81.0%)	286 (93.5%)	410 (89.3%)
Well: (n=459)			
Yes	121 (79.1%)	253 (82.7%)	374 (81.5%)
No	32 (20.9%)	53 (17.3%)	85 (18.5%)
Number of well: (within <200m from the house) (n=374)			
One	88 (72.7%)	196 (77.5%)	284 (75.9%)
Two	22 (18.2%)	41 (16.2%)	63 (16.8%)
Three or More than three	11 (9.0%)	16 (6.3%)	27 (7.2%)

Table 6 showed characteristics of the housing environmental factors of malaria cases and controls such as nearest forest, living on the flat ground, bushes but not tree

(within less than 200m from the house), number of any kinds of breeding sites (within less than 200m from around the house), acres of owned house land, livestock in the compound and number of nearby houses (within less than 50m around the house) of respondents. 47.5% of respondents' houses were near the forest. Most of respondents' houses, 74.7% were on the flat ground. 44.2% of houses had bushes but not trees within less than 200m around their houses. Almost half of houses, 49.5% had no breeding sites within less than 200m around the houses. Only one breeding site within less than 200m around the houses was 26.4%. Two breeding sites and three or more than three breeding sites were 20% and 4.1% respectively. Majority of respondents had less than one acres of owned house land and only 17.4% of them owned one to two acres. 43.1% had livestock in their compounds. Number of nearby houses within less than 50m were none to fifteen houses. The first group was from none to 1 house. The second group was from two to six houses and the third group was from seven to fifteen houses. More than half of respondents, 66% had two to six nearby houses within less than 50m around their houses. None to 1 nearby house and seven to fifteen houses within less than 50m were 19.8% and 14.2% respectively.

Table 6 Number and percentage distribution of characteristics of the housing environmental factors of malaria cases and controls (n=459)

Characteristics of the housing environmental factors	Cases (n=153) (%)	Controls (n=306) (%)	Total
Nearest forest:			
Yes	102 (66.7%)	116 (37.9%)	218 (47.5%)
No	51 (33.3%)	190 (62.1%)	241 (52.5%)
Living on the flat ground:			
Yes	125 (81.7%)	218 (71.5%)	343 (74.7%)
No	28 (18.3%)	87 (28.5%)	115 (25.2%)
Bushes but not trees: (<200m from the house)			
Yes	91 (59.5%)	112 (36.6%)	203 (44.2%)
No	62 (40.5%)	194 (63.4%)	256 (55.8%)
Number of any kinds of breeding sites: (<200m around the house)			
None	57 (37.3%)	170 (55.6%)	227 (49.5%)
1	38 (24.8%)	83 (27.1%)	121 (26.4%)
2	42 (27.5%)	50 (16.3%)	92 (20.0%)
3 or More than 3	16 (10.5%)	3 (1.0%)	19 (4.1%)
Acres of owned house land:			
Less than one	150 (98.0%)	229 (74.8%)	379 (82.6%)
One to Two acres	3 (2.0%)	77 (25.2%)	80 (17.4%)
Livestock in the compound:			
Yes	45 (29.4%)	153 (50%)	198 (43.1%)
No	108 (70.6%)	153 (50%)	261 (56.9%)
Number of nearby houses: (<50m around the house)			
0 to 1 house	46 (30.1%)	45 (14.7%)	91 (19.8%)
2 to 6 houses	90 (58.8%)	213 (69.6%)	303 (66.0%)
7 to 15 houses	17 (11.1%)	48 (15.7%)	65 (14.2%)
Mean = 3.59, Median = 3, SD = 2.66			

4.3. Knowledge about malaria and behavior related to protective and control of malaria cases and controls

Table 7 showed knowledge about malaria cases and controls such as good knowledge, moderate knowledge and poor knowledge of respondents. The possible score ranged from 0 to 39 for knowledge on malaria, and respondent's knowledge was classified into three levels. The cut-off point for 'Good knowledge': greater than 80% of 39 scores, 'Moderate knowledge': from 60% to 80% of 39 scores, 'Poor knowledge': less than 60% of 39 scores. More than half of total respondents, 56.9% had poor

knowledge. 25.7% of them had moderate knowledge and only 17.4% had good knowledge. Most of the wrong answers came from questions about resting places of malaria mosquitoes and transmission of malaria.

Table 7 Number and percentage distribution of knowledge about malaria cases and controls (n=459)

Knowledge of Malaria	Case (n=153) (%)	Control (n=306) (%)	Total (%)
Good knowledge	35 (22.9%)	45 (14.7%)	80 (17.4%)
Moderate knowledge	83 (54.2%)	35 (11.4%)	118 (25.7%)
Poor knowledge	35 (22.9%)	226 (73.9%)	261 (56.9%)

Table 8 revealed behavior related to protective and control of malaria cases and controls such as good practice, moderate practice and poor practice of respondents. The obtained data was categorized in tertile because the data are not normally distributed. The respondents' practice was classified into three levels "Good practice": greater than 66.6 percentile of available scores, "Moderate practice": from 33.3 percentile to 66.6 percentile of available scores, "Poor practice" less than 33.3 percentile of available scores. Almost nearly half of total respondents, 43.6% had moderate practice. 33.1% of them had poor practice and only 23.3% had good practice. Most of the poor behavior related to protective and control of malaria came from question about taking outdoor anti-mosquito spraying.

Table 8 Number and percentage distribution of behavior related to protective and control of malaria cases and controls (n=459)

Behavior related to protective and control	Case (n=153) (%)	Control (n=306) (%)	Total (%)
Good practice	27 (17.6%)	80 (26.1%)	107 (23.3%)
Moderate practice	60 (39.2%)	140 (45.8%)	200 (43.6%)
Poor practice	66 (43.1%)	86 (28.1%)	152 (33.1%)

4.4. Association between socio-demographic factors of malaria cases and controls and malaria

Table 9 described the association between socio-demographic factors such as age, sex, ethnicity, occupations, farming sites with malaria cases and controls. Age between 26 to 45 years was significantly associated with malaria cases and controls (Crude OR = 1.71, p value = 0.04). Age between 26 to 45 years was the risk factor for malaria and it increased the risk of malaria 1.71 times higher than reference group (age 46 to 60 years). For occupation, government employee was significantly associated with malaria cases and controls and it was protective factor (Crude OR = 0.28, p value =0.04). It decreased the risk of malaria 0.28 times than the reference group (student). There was a significantly associated of oil palms workers with malaria cases and controls (Crude OR = 32.67, p value = 0.001) and it was risk factor for malaria. It increased the risk of malaria infection 32.67 times higher than reference group (vegetables field workers). Sex, ethnicity and farmers working in rice field were not associated with malaria cases and controls.

Table 9 Association between socio-demographic factors to malaria cases and controls (n=459)

Socio-demographic factors	Malaria		Crude			p-value
	Cases	Controls	OR	95% C.I		
Variables				Lower	Upper	
Age: (n=459)						
46 to 60 years	28	85	1			
26 to 45 years	80	142	1.71	1.03	2.841	0.038*
18 to 25 years	45	79	1.729	0.985	3.035	0.056
Sex: (n=459)						
Female	87	163	1			
Male	66	143	0.865	0.585	1.278	0.47
Ethnicity: (n=459)						
Mon	4	15	1			
Burma	120	232	1.94	0.63	5.973	0.248
Kayen	14	35	1.5	0.423	5.315	0.53
Others	15	24	2.344	0.653	8.411	0.191
Occupation: (n=459)						
Student	9	17	1			
Fisherman	15	16	1.771	0.606	5.173	0.296
Farmer	44	39	2.131	0.853	5.325	0.105
Housewife	46	74	1.174	0.483	2.853	0.723
Government employee	6	4	0.283	0.087	0.921	0.036*
Foresting man	2	14	0.27	0.05	1.459	0.128
Others	31	106	0.552	0.224	1.361	0.197
Farming sites:						
Vegetable fields	14	23	1			
Oil palms	14	1	23	2.72	194.47	0.004*
Rubber plantations	15	46	0.536	0.221	1.296	0.166
Rice field	27	49	0.905	0.401	2.042	0.81
Others	31	69	0.808	0.366	1.784	0.598

Table 9 (Continued) Association between Socio-demographic Factors to malaria cases and controls (n=459)

Socio-demographic factors	Malaria		Crude	95% C.I		p-value
Variables	Cases	Controls	OR	Lower	Upper	
Marital status: (n=459)						
Divorced	5	7	1			
Married:	85	159	0.748	0.231	2.429	0.63
Single	55	115	0.67	0.203	2.205	0.509
Window	8	25	0.448	0.111	1.811	0.26
Income: (n=459)						
2600001 to 4500000 kyats	7	57	1			
1200001 to 2600000 kyats	88	206	3.479	1.526	7.927	0.003*
110000 to 1200000 kyats	58	43	10.983	4.563	26.44	<0.001*
Education: (n=459)						
Graduated/Post-graduated education	14	47	1			
No education	20	30	2.238	0.983	5.094	0.06
Primary education	49	109	1.509	0.76	2.995	0.239
Secondary education	49	90	1.828	0.916	3.647	0.087
High school education	21	30	2.35	1.038	5.318	0.04*
Years of staying in this house: (n=459)						
28 to 57 years	28	48	1			
5 to 27 years	83	201	0.708	0.416	1.205	0.203
1 to 4 years	42	57	1.263	0.684	2.332	0.455

Table 9 (continued) described the association between socio-demographic factors such as marital status, total family yearly income, education and years of staying in this house with malaria cases and controls. Lowest income (110,000 to 1,200,000 kyats) and middle income (1,200,001 to 2,600,000 kyats) were significantly associated with malaria cases and controls (Crude OR = 10.98, p value = <0.001 and Crude OR = 3.47, p value = 0.003 respectively) and they were the risk factors for malaria infection. They increased the risk of malaria 10.98 times and 3.47 times higher than the reference group (2,600,001 to 4,500,000 kyats). For education, people who had attended high

school education were associated with malaria cases and controls as risk factors (Crude OR = 2.35, p value = 0.04). It increased the risk of malaria infection 2.35 times higher than the reference group (Graduated/Post-graduated education). Marital status and years of staying in this house were not associated with malaria cases and controls.

4.5. Association between Housing conditions and house environment characteristics of cases and controls and malaria

Table 10.1 described the association between house and housing conditions such as age of house in years, house tenure, number of floor, materials used for first floor of house and compositions of house walls of malaria cases and controls and malaria. There was association between wood (Crude OR = 0.37, p value = 0.001) with malaria cases and controls for materials used for first floor of house and it was the protective factor for malaria. It decreased the risk of malaria 0.37 times than the reference group (cement). Bamboo (Crude OR = 0.27, p value = 0.002) was associated with malaria cases and controls for materials used for first floor of house and it was the protective factor for malaria. It decreased the risk of malaria 0.27 times than the reference group (cement).There were associations between no materials (Crude OR = 0.2, p value = <0.001) and other materials (Crude OR = 0.28, p value = 0.01) with malaria cases and controls for materials used for first floor of house and they were protective factors for malaria infection. They decreased the risk of malaria 0.2 times and 0.28 times respectively than the reference group (cement). For compositions of house walls, bamboo was significantly associated with malaria cases and controls (Crude OR = 3.63, p value = <0.001) and it was the risk factor. It increased the risk of malaria 3.63 times higher than the reference group (brick and adobe). Age of house in

years, house tenure and number of floor had no association with malaria cases and controls.

Table 10.1 Association between house and housing conditions of malaria cases and controls and malaria (n=459)

House or Housing condition Variables	Malaria		Crude			p-value
	Cases (n=153)	Controls (n=306)	OR	95% C.I		
				Lower	Upper	
Age of house in years:						
1 to 6 years	39	48	1			
7 years to 33 years	91	221	1.536	0.6	3.936	0.371
34 years 80 years	23	37	2.44	0.9	6.616	0.08
House tenure:						
Own	127	263	1			
Rent	26	43	1.252	0.736	2.129	0.407
Number of floor:						
2 floor	49	84	1			
1 floor	104	222	0.803	0.526	1.225	0.309
Materials used for first floor of house:						
Cement	37	31	1			
Brick	28	36	0.652	0.328	1.295	0.222
Wood	57	131	0.365	0.206	0.644	0.001*
Bamboo	11	34	0.271	0.118	0.622	0.002*
None	13	53	0.206	0.095	0.445	<0.001*
Others	7	21	0.279	0.105	0.744	0.011*
Compositions of house walls for first floor of house:						
Brick or Adobe	32	83	1			
Wood or branches not covered with mud or branches covered with mud	44	168	0.679	0.402	1.149	0.15
Bamboo	77	55	3.631	2.127	6.199	<0.001*

Table 10.2 (Continued) Association between house and housing conditions of malaria cases and controls and malaria (n=459)

House or Housing condition	Malaria		Crude			p-value
	Cases	Controls	OR	95% C.I		
Variables	(n=153)	(n=306)		Lower	Upper	
Materials used for roof of house:						
Zinc sheet	87	277	1			
Straw or palm	65	25	8.278	4.92	13.929	<0.001*
Other	1	4	0.796	0.088	7.216	0.839
Ceiling:						
Yes	35	112	1			
No	118	194	1.946	1.25	3.032	0.003*
Sleep in the room: (number of people in bedroom)						
With 3 or more than 3	51	63	1			
With 1 or 2	72	158	0.563	0.354	0.894	0.015*
Alone	30	85	0.436	0.25	0.76	0.003*
Sleep in the bed:						
With 1+	64	144	1			
With 1	59	77	1.724	1.1	2.701	0.017*
Alone	30	85	0.794	0.477	1.322	0.376

Table 10.3 (Continued) Association between house and housing conditions of malaria cases and controls and malaria (n=459)

House or Housing condition	Malaria		Crude			p-value
	Cases	Controls	OR	95% C.I		
Variables				Lower	Upper	
Animals sleep in house: (n=459)						
Yes	72	152	1			
No	81	154	1.11	0.753	1.638	0.597
Mosquito bed net: (n=459)						
Present	150	292	1			
Absent	3	14	0.417	0.118	1.474	0.175
Kind of mosquito bed net (n=442):						
LLIN	14	76	1			
ITN	43	104	2.245	1.147	4.394	0.018*
Others	93	112	4.508	2.394	8.488	<0.001*
Number of hole in the mosquito bed net: (n=442)						
None	113	227	1			
1 to 6	22	20	2.21	1.158	4.217	0.016*
Don't know/Don't remember	15	45	0.67	0.358	1.253	0.21
Openings in the subject's room: (N=459)						
No	83	172	1			
Yes	56	112	1.036	0.685	1.568	0.867
Don't know/Don't remember	14	22	1.319	0.642	2.708	0.451
Number of windows that close in the subject's room: (n=459)						
None	72	134	1			
1	41	117	0.652	0.413	1.03	0.067
>1	40	55	1.354	0.823	2.227	0.233

Table 10.4 (Continued) Association between house and housing conditions of malaria cases and controls and malaria (n=459)

House or Housing condition	Malaria		Crude	95% C.I		p-value
Variables	Cases	Controls	OR	Lower	Upper	
Compositions of house walls for second floor of house: (n=133)						
Brick	12	23	1			
Wood or branches not covered with mud	38	60	1.214	0.541	2.722	0.638
Size of hole in the mosquito bed net: (n=102)						
1 to 2 cm	7	6	1			
3 to 4 cm	6	9	0.571	0.127	2.566	0.465
5 to 6 cm	3	2	1.286	0.158	10.45	0.814
Don't know/Don't remember	21	48	0.375	0.112	1.251	0.111

Table 10.2 (continued) showed the association between house and housing conditions such as materials used for roof of house, ceiling, sleep in the room and sleep in the bed of malaria cases and controls and malaria. Straw or palm had significant association with malaria cases and controls for materials used for roof of house (Crude OR = 8.28, p value = <0.001) as risk factor. It increased the risk of malaria 8.28 times higher than the reference group (zinc sheet). No ceiling in the house was also risk factor with significant association to malaria cases and controls (Crude OR = 1.95, p value = 0.003). It increased the risk of malaria 1.95 times higher than the reference group (with ceiling). For number of people sleep in the bed room, sleeping alone and sleeping together with one or two persons were significantly associated with malaria cases and controls at (Crude OR = 0.44, p value = 0.003) and (Crude OR = 0.56, p value = 0.02) respectively and they were protective factors. They decreased the risk of malaria 0.44 times and 0.56 times respectively than the reference group (sleep in the room with 3 or more than 3 persons). Sleeping with one person on the bed was risk factor for malaria and it was statically significant (Crude OR = 1.72, p value = 0.02). It increased the risk

of malaria 1.72 times than the reference group (sleep in the bed with more than one person).

Table 10.3 (continued) revealed the association between house and housing conditions such as animals sleep in house, mosquito bed net, kind of mosquito bed net, number of hole in the mosquito bed net, openings in the subject's room and number of windows that close in the subject's room to malaria cases and controls and malaria. There were significant association of ITN (Crude OR = 2.25, p value = 0.02) and other kind of bed nets (Crude OR = 4.51, p value = <0.001) with malaria cases and controls and they were risk factors. They increased the risk of malaria 2.25 times and 4.51 times respectively than the reference group (LLIN). Number of one to six holes was also significantly associated with malaria cases and controls (Crude OR = 2.21, p value = 0.02) and it was risk factor for malaria infection. It increased the risk of malaria 2.21 times higher than the reference group (no holes in the bed net). Animals sleep in house, present or absent of mosquito bed nets, openings in the subject's rom and number of windows that close in the subject's room were not associated with malaria cases and controls.

Table 10.4 (continued) revealed the association between house and housing conditions such as compositions of house walls for second floor of house and size of hole in the mosquito bed nets to malaria cases and controls and malaria. Compositions of house walls for second floor of house and size of hole in the mosquito bed nets had no association with malaria cases and controls.

Table 11.1 described the association between characteristics of the housing environmental factors such as canal, number of canal within less than 200m from the house, stream, number of stream within less than 200m from the house, river, well and

number of well within less than 200m from the house to malaria cases and controls and malaria. Canals around houses had significant association with malaria cases and malaria controls (Crude OR = 2.13, p value = 0.04) and it was risk factor for malaria. It increased the risk of malaria 2.13 higher than the reference group (no canal). Streams and rivers around houses also has significant association with malaria cases and malaria controls at (Crude OR = 1.66, p value = 0.01) and (Crude OR = 3.34, p value = <0.001) respectively and they were the risk factors for malaria infection. Streams around houses increased the risk of malaria 1.66 times higher than the reference group (no streams). River around the house increased the risk of malaria infection 3.34 times higher than the reference group (no river). There were no associations between number of canal within less than 200m from the house, number of stream within less than 200m from the house, well around house and number of well within less than 200m from the house.

Table 11.1 Association between characteristics of the housing environmental factors of malaria cases and controls and malaria (n=459)

Characteristics of the housing environmental factors	Malaria		Crude	95% C.I		p-value
Variables	Cases	Controls	OR	Lower	Upper	
Canal: (n=459)						
No	136	289	1			
Yes	17	17	2.125	1.053	4.29	0.035*
Number of canal: (within <200m from the house) (n=34)						
One	17	14	1			
Two	1	2	0.412	0.034	5.029	0.487
Stream: (n=459)						
No	75	188	1			
Yes	78	118	1.657	1.12	2.452	0.012*
Number of stream: (within <200m from the house) (n=196)						
One	76	106	1			
Two or Three	2	12	0.232	0.051	1.069	0.061
River: (n=459)						
No	124	286	1			
Yes	29	20	3.344	1.822	6.139	<0.001*
Well: (n=459)						
No	32	53	1			
Yes	121	253	0.792	0.486	1.292	0.351
Number of well: (within <200m from the house) (n=374)						
One	88	196	1			
Two	22	41	1.195	0.672	2.126	0.544
Three or More than three	11	16	1.531	0.683	3.435	0.301

Table 11.2 (Continued) Association between characteristics of the housing environmental factors of malaria cases and controls and malaria (n=459)

Characteristics of the housing environmental factors	Malaria		Crude	95% C.I		p-value
Variables	Cases	Controls	OR	Lower	Upper	
Nearest forest:						
No	51	190	1			
Yes	102	116	3.276	2.179	4.925	<0.001*
Living on the flat ground:						
Yes	125	218	1			
No	28	87	0.561	0.348	0.906	0.018*
Bushes but not trees: (<200m from the house)						
No	62	194	1			
Yes	91	112	2.542	1.708	3.785	<0.001*
Number of any kinds of breeding sites: (<200m around the house)						
None	57	170	1			
1	38	83	1.365	0.839	2.223	0.21
2	42	50	2.505	1.507	4.165	<0.001*
3 or More than 3	16	3	7.953	2.04	30.999	0.003*
Acres of owned house land:						
One to Two acres	3	77	1			
Less than one	150	229	16.812	5.209	54.258	<0.001*
Livestock in the compound:						
Yes	45	153	1			
No	108	153	2.4	1.587	3.63	<0.001*
Number of nearby houses: (<50m around the house)						
0 to 1 house	46	45	1			
2 to 6 houses	90	213	0.413	0.256	0.667	<0.001*
7 to 15 houses	17	48	0.346	0.174	0.69	0.003*

Table 11.2 (continued) described the association between characteristics of the housing environmental factors such as nearest forest, living on the flat ground, bushes but not trees within less than 200m around the house, number of any kind of breeding sites within less than 200m around the house, acres of owned house land, livestock in the compound and number of nearby houses within less than 50m around the house to malaria cases and controls and malaria. Forest near respondents' houses was risk factor

for malaria and it was statically significant (Crude OR = 3.28, p value = <0.001). It increased the risk of malaria 3.28 times higher than the reference group (no forest). There were also significant association between not living on the flat ground and having bushes but not trees within less than 200m from the house with malaria cases and controls at (Crude OR = 0.56, p value = 0.02) and (Crude OR = 0.39, p value = <0.001) respectively. Not living on the flat ground decreased the risk of malaria infection 0.56 times than the reference group (living on the flat ground). It was the protective factor for malaria infection. Having bushes but not trees within less than 200m from the house increased the risk of malaria 2.54 times than the reference group (Not having bushes but not trees within less than 200m). It was the risk factor for malaria infection. Number of two and three or more than three breeding sites within less than 200m around the houses were also risk factors for malaria and statically significant at (Crude OR = 2.5, p value = <0.001) and (Crude OR = 7.95, p value = 0.003) respectively. Having two breeding sites within less than 200m around the houses increased the risk of malaria 2.5 times higher than the reference group (no breeding sites). Having three or more than three breeding sites around the houses increased the risk of malaria 7.95 times higher than the reference group (no breeding sites). There were significant associations between acres owned house land less than one and having no livestock in the compound with malaria cases and controls (Crude OR = 16.81, p value = <0.001) and (Crude OR = 2.4, p value = <0.001) respectively and they were risk factors for malaria. Acres owned house land less than one increased the risk of malaria 16.81 times higher than the reference group (acres owned house land one to two acres). Having no livestock in the compound increased the risk of malaria infection 2.4 times higher than the reference group (having livestock in the compound). Having nearby houses two to six houses and

seven to fifteen houses were protective factors for malaria and statically significant at (Crude OR = 0.41, p value = <0.001) and (Crude OR = 0.35, p value = 0.003) respectively. They decreased the risk of malaria 0.41 times and 0.35 times than the reference group (having no house or one house).

4.6. Association between knowledge and behavior regarding malaria cases and controls and malaria

Table 12 described the association between knowledge of malaria such as good knowledge, moderate knowledge and poor knowledge to malaria cases and malaria controls. Having moderate knowledge and poor knowledge of malaria were risk factors for malaria and statically significant at (Crude OR = 15.31, p value = <0.001) and (Crude OR = 5.02, p value = <0.001) respectively. They increased the risk of malaria 15.31 times and 5.02 times higher than the reference group (having good knowledge).

Table 12 Association between knowledge of malaria cases and controls and malaria (n=459)

Knowledge of Malaria	Malaria		Crude			p-value
	Cases	Controls	OR	95% C.I		
Variables	(n=153)	(n=306)		Lower	Upper	
Good knowledge	35	45	1			
Moderate knowledge	83	35	15.313	8.997	26.062	<0.001*
Poor knowledge	35	226	5.022	2.848	8.857	<0.001*

Table 13 revealed the association between behaviors related to protective and control of malaria cases and controls and malaria such as good practice, moderate practice and poor practice to malaria. Having moderate practice had significant association with malaria (Crude OR = 0.5, p value = 0.01) and it was protective factor.

It decreased the risk of malaria 0.5 times than the reference group (having good practice).

Table 13 Association between behaviors related to protective and control of malaria cases and controls and malaria (n=459)

Behavior related to protective and control Variables	Malaria Cases (n=153)	Malaria Controls (n=306)	Crude OR	95% C.I Lower	95% C.I Upper	p-value
Good practice	27	80	1			
Moderate practice	60	140	0.498	0.29	0.856	0.012*
Poor practice	66	86	1.569	0.556	4.429	0.395

4.7. Multivariate model of association between measure variables and malaria risk

Table 14 described association between measure variables and malaria risk. The variables included in the final model were shown in this table. Socio demographic factors associated with an increased risk of malaria included total family yearly income at groups between 1,200,001 to 2,600,000 kyats and 110,000 to 1,200,000 kyats (p value = <0.001). They increased the risk of malaria 15.46 times and 5.84 times respectively higher than the reference group (2,600,001 to 450,000 kyats). Housing characteristic that were found to lower the risk of malaria included floor constructed with bamboo and no materials used for 1 floor of house (p value = 0.007). They decreased the risk of malaria 0.22 times and 0.26 times respectively than the reference group (cement). Bamboo that used for compositions of house walls for 1 floor of house was increased the malaria risk 10.02 times than the reference group (brick or adobe) and it was statically significant (p value = <0.001). It was the risk factor for malaria

infection. Housing environmental characteristic associated with an increased risk of malaria included presence of bushes but not trees within 200m around the house (p value = 0.05) and acres of owned house land which was less than one acres (.p value = 0.001). Having bushes but not trees within 200m around the house increased the risk of malaria 1.78 times higher than the reference group (Not having bushes) and it was the risk factor for malaria infection. Acres of owned house land which was less than one acres also increased the risk of malaria 13.96 times higher than the reference group (acres of owned house land one to two acres) and it was the risk factor for malaria infection. Moderate knowledge and poor knowledge were also risk factor for malaria and they were statically significant (p value = <0.001). They increased the risk of malaria 19.05 times and 5.58 times respectively higher than the reference group (good knowledge). Age, livestock in the compound and number of nearby houses within less than 50m from the house were not associated with malaria risk.

Table 14 Association of variables such as socio demographic, housing condition, housing environmental and knowledge about malaria with risk of clinical malaria in multivariate analyses (n=459)

Variables	Adjusted OR	95% C.I		p-value
		Lower	Upper	
Age:				0.595
46 to 60 years	1			
26 to 45 years	0.677	0.289	1.587	
18 to 25 years	0.93	0.438	1.971	
Income:				<0.001*
2600001 to 4500000 kyats	1			
1200001 to 2600000 kyats	15.461	5.138	46.527	
110000 to 1200000 kyats	5.848	2.181	15.677	
Materials used for first floor of house:				0.007*
Cement	1			
Brick	2.016	0.684	5.939	
Wood	1.016	0.395	2.613	
Bamboo	0.227	0.061	0.846	
None	0.357	0.073	0.905	
Others	1.188	0.267	5.287	
Compositions of house walls for first floor of house:				<0.001*
Brick or Adobe	1			
Wood or branches	1.594	0.719	3.531	
Bamboo	10.017	4.079	24.602	
Bushes but not trees: (<=200m from the house)				0.049*
No	1			
Yes	1.782	1.003	3.168	
Acres of owned house land:				0.001*
One to Two acres	1			
Less than one	13.961	3.164	61.609	
Livestock in the compound:				0.057
Yes	1			
No	1.81	0.982	3.337	
Number of nearby houses: (<=30m around the house)				0.065
0 to 1 house	1			
2 to 6 houses	0.474	0.229	0.98	
7 to 15 houses	0.331	0.12	0.914	
Mosquito bed net:				0.112
Present	1			
Absent	0.236	0.04	1.404	
Knowledge:				<0.001*
Good knowledge	1			
Moderate knowledge	19.053	9.107	39.861	
Poor knowledge	5.577	2.612	11.907	

CHAPTER V

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter first presents about discussion, limitations, conclusion and recommendations of research findings of this study.

An unmatched case-control study was carried out among populations from four townships: Tha-yet-chaung, Boke-pyin, Kyun-su and Palaw in Tanintharyi region, Myanmar. Data were collected by using structured questionnaires. The respondents were 459 aged 18-60 years resided in the study area.

The general objective of this study is to identify environmental risk factors related to malaria infection in Tanintharyi Region, Myanmar.

More specifically, this study aimed to:

- To investigate the association between socio-economic factors and malaria infection in Tanintharyi Region, Myanmar
- To investigate the association between house characteristics and characteristics of the house environmental factors and malaria infection in Tanintharyi Region, Myanamar
- To investigate the association between knowledge and protective behaviors and malaria infection in Tanintharyi Region, Myanmar
- To investigate the association between multiple variables and malaria risk in Tanintharyi Region, Myanmar

5.1 Discussion

5.1.1 Socio-demographic Factors

From this study, the majority of the respondents for both cases and controls were 26 to 45 years old, female Burma, married people, attained primary school education, having income of 120,001 Kyats to 2,600,000 Kyats and years of staying at the house were 5 to 27 years. However, occupation of most of the cases was housewife and working at two or more sectors for the controls.

The study revealed that age of the respondents from 26 to 45 years was statistically associated with risk of malaria infection at p value of 0.038. Age from 26 to 45 years was risk factor for malaria infection. This may be because that was working age group and most of them sometimes sleep at their places such as oil palms and rubber plantations. Respondents' occupation, government employee was protective factor for risk of malaria infection (p value = 0.037). This may be because most of them have better knowledge about malaria and then better practice. Working at oil palms farming sites for non-rice field worker was strongly associated with malaria and risk factor for malaria at p value of 0.001. This may be because most of them have to stay at their working farming sites and houses of their farming sites are temporary houses with poor housing conditions. Another fact is that their housing environment have many potential breeding sites such as bushes. This finding agreed with other study which the risk factors of malaria is much more confined to limited areas and among certain occupations (Ahmed et al., 2013). Total family yearly income from 1200001 to 2600000 Kyats and 110000 to 2600000 were risk factors for malaria infection and strongly associated with malaria at p value of 0.003 and <0.001 respectively This finding was similar with other study from Thailand (van der Hoek, Konradsen, Dijkstra,

Amerasinghe, & Amerasinghe, 1998). Mostly, lower income family have poor housing conditions because they have not enough money to repair or maintain their houses. Attaining high school education was risk factor for malaria infection at p value of 0.04. This finding was different with other study (Guthmann et al., 2001). This may be because most of the respondents who attained high school education or their parents owned oil palms or rubber plantations. In fact, most of them lived at their working places which have more breeding sites at surrounding environment.

5.1.2 House and Housing Condition Factors

The majority of the houses of respondents both cases and controls were one floor, owned house and 7 to 33 years of age of houses. The first floor of house were mostly composed of wood and second floor were completely with wood. Compositions of house walls for first floor of house were mostly with bamboo for cases and with wood or branches not covered with mud or branches covered with mud for controls. Compositions of house walls for second floor of house was wood or branches not covered with mud for both cases and controls. Materials used for roof of houses was mostly with zinc sheet for both cases and controls and the majority of both houses had no ceiling. This may be because of their traditional housing styles. For both cases and controls, most of the respondents slept with one or two persons in their rooms, more than one persons in their beds and no animals sleep in the houses. Almost all of them had mosquito bed nets. However, for the cases, the mosquito bed nets they had were neither LLIN nor ITN while for the controls, most of them had ITNs. There were no openings (10cm x 10cm) in the rooms for both cases and controls.

This study did not observe associations between age of houses and house tenure, in line with the findings of other study (Yamamoto et al., 2010). Respondents who didn't have owned house, renters were risk factor for malaria but it wasn't statically significant. In this study, materials used for first floor of house, compositions of house walls for first floor of house and materials used for roof of house were strongly associated with malaria at p value of 0.007, <0.001 and <0.001 respectively. However, first floor of houses which were composed of wood, bamboo and no materials decreased the risk of malaria. This may be because almost all of the respondents' houses were made of wood, bamboo or no materials and there is same chance for entry of mosquitoes with or without floors for first floor of houses. On the other hand, Compositions of house walls for first floor of houses which were built with bamboo and straw or palms for the roof of houses increased the risk of malaria. This finding was similar with other study (Yamamoto et al., 2010). Poorly constructed houses have been linked to an increased risk of malaria in several studies (Gunawardena et al., 1998) (Konradsen et al., 2003). No ceiling in the house was the risk factor for malaria and statically significant at p value of 0.003. This finding was different from other study (Guthmann et al., 2001). Houses without ceiling have more chance for entry of mosquitoes. Sleeping with one or two persons in the bed rooms was protective factors for malaria and statically significant at p value of 0.015. This finding agreed with other study (Guthmann et al., 2001). Since spaces in the sleeping room increase the risk of malaria, a reasonable assumption is that building houses without spaces in the sleeping rooms could be one interesting measure to decrease malaria. However, sleeping with one person on the bed was risk factor for malaria at p value of 0.017. The mechanisms of this association remains therefore unclear. Using neither LLIN nor ITN increased the

risk of malaria infection and strongly associated with malaria risk at p value of <0.001. This is because using insecticide treated nets and long lasting insecticide nets can decrease the risk of malaria significantly. If the residents used LLINs (Long Lasting Insecticide Nets) correctly and consistently throughout the year, the malaria new infections can be effectively reduced. LLIN is used for the purpose of prevention of malaria infection (Wangdi et al., 2014).Therefore, this study results suggest that use of normal bed nets could not be a very effective protective measure in settings such as that of our study, and agree with other study (Mendez, Carrasquilla, & Muñoz, 2000). The condition of the house was further investigated by looking at open surfaces in walls or roof, which were defined as 'openings'. The presence of a wooden wall with gaps between the timbers, or a roof with a zinc sheet missing was often an indicator of a poor or a deteriorated house. However, openings in the subject's room were not found to be associated with malaria and similar with study from Grau (Guthmann et al., 2001).

5.1.3 Housing Environmental factors

The majority of the respondents' houses had no canals, streams and river within less than 200m around the houses. Most of them had wells within less than 200m around their houses and the numbers of well were mostly one. Most of the houses for cases were built near the forest and far from forest for controls. Majority of respondents' houses for both cases and controls were situated on the flat ground, acres of owned house land were less than one and number of nearby houses within less than 50m around the house were two to six houses. There were no livestock in the majority of cases' houses and the proportion was same in the controls' houses. Majority of the cases' houses had bushes but not trees within less than 200m from the house whereas majority

of the controls' houses hadn't. There were no breeding sites within less than 200m around the houses of both cases and controls. This may be because they didn't know well which are the breeding sites.

Presence of canals, streams, river within less than 200m from the houses and presence of nearby forests were statically significant associations with risk of malaria at p value of 0.035, 0.012, <0.001 and <0.001 respectively. They were the risk factors for malaria infection. Closer proximity to forest border was associated with increased malaria risk and is consistent with other findings (Brooker et al., 2004; Ernst et al., 2009; Lindblade, Walker, Onapa, Katungu, & Wilson, 2000). The result of our study that had the association between malaria and the distance from the house to the nearest canal was congruent with the findings of other study (Guthmann et al., 2001). Larva collections had shown that canals were often good breeding sites for *Anopheles* mosquitoes (species identification was not done), and night catches had shown that houses with the higher human biting rates were often the ones located near a drain or a canal (Guthmann et al., 2001). Living close to the stream which was a risk factor for malaria is also similar with one study from Sri Lanka (van der Hoek et al., 1998). Other studies also have observed that houses located close to streams and canals had a higher risk of malaria because of proximity to mosquito breeding sites (Al-Taiar et al., 2009; Ghebreyesus et al., 2000; Staedke et al., 2003). Presence of two and three or more than three breeding sites within less than 200m around the house increased the risk of malaria and statically significant at p value of <0.001 and 0.003 respectively. This finding agreed with other study (Guthmann et al., 2001). In the final multiple regression, having bushes but not trees within less than 200m around the house was

also associated with malaria risk at p value of 0.05 and it increased the risk of malaria. Studies have shown that the closer the proximity of the living place to a potential breeding site of the vector, the higher the risk. As shown by some authors in Dakar (Trape et al., 1992), this is probably due to a high vector density in the area close to the breeding site, which decreases in areas located farthest away. Not living on the flat ground decreased the risk of malaria and statically significant at p value of 0.018. Living on flat ground, where water is most likely to accumulate, was associated with increased risk corroborating results found by (Cohen et al., 2008). Acres of owned house land which was less than one acres increased the risk of malaria and statically significant at p value of <0.001. This may be because the less the area of house land, the more bushes close to the house. Absence of livestock in the compound was risk factor for malaria and statically significant at p value of <0.001. This finding is different from other study which was done in Pakiston (Hewitt, Kamal, Muhammad, & Rowland, 1994). This may because the animals can be deployed to form a barrier between that vector and man. Presence of nearby houses within less than 50m was associated with risk of malaria. However, in the final model of multiple regression, the association was not statically significant at p value of 0.06.

5.1.4 Knowledge about malaria

Majority of respondents of cases had moderate knowledge (54.2%) whereas controls had poor knowledge (73.9%).

There was a significant association with knowledge and malaria infection at p value of <0.001. In the final model of multiple regression, the respondent who hadn't good knowledge were at high risk of malaria infection at p value of <0.001.

Respondents who had good knowledge about malaria knew well about transmission of malaria, breeding sites of mosquitoes, how to prevent from the bites of mosquitoes and also protective behaviors than the others. Therefore, they had less chance from the bites of mosquitoes and to get malaria. As a result, the program of health education needs to enhance the knowledge on malaria vector, transmission as well as symptoms which are very important and essential information in terms of malaria infection.

5.1.5 Behavior related to protective and control

Majority of respondents of cases had poor practice (43.1%) whereas controls had moderate practice (43.6%).

There was an association with moderate practice and malaria infection and it was statically significant at p value of 0.012. The moderate practice decreased the risk of malaria. Limited use of protective measures and practice exposed an individual to malaria. This finding is similar with other study at Botswana (Chirebvu et al., 2014).

5.2 Conclusion

5.2.1 Socio-demographic Factors

Most of the respondents of cases and controls were Burma, female, age between 26 to 45 years, married, attained primary school education, total yearly family income between 1200001 to 2600000 Kyats and years of staying at the house of 5 to 27 years. Majority of occupation for cases was housewife and for controls was working at more than one sector.

5.2.2 House and Housing Condition Factors

Most of the respondents' houses were 7 to 33 years of age of house and owned houses. Materials used for first floor of houses was mostly with wood and for the second floor was completely with wood. Most of the walls of respondents' houses of cases were composed of bamboo whereas of controls were composed of wood or branches not covered with mud or branches covered with mud. For the wall of second floor of all respondents' houses, most of them were composed of wood or branches not covered with mud. Most of houses had no ceiling and roofs were made of zinc sheet. There were no openings in the subject's rooms of most of houses and mostly no windows that close in the subject's rooms too. Most of the respondents of both cases and controls slept with one or two persons in the bed room and slept with more than one person on the bed. Almost all of them had bed nets and however, most of the bed nets were neither LLIN nor ITN. Most of the bed nets had no holes. Most of the houses had no animals sleep in the houses.

5.2.3 Housing Environmental Factors

Most of the houses of total respondents of both cases and controls had no canals, no streams, no river within less than 200m around the houses. Most of them had wells, no potential breeding sites within less than 200m around the house, less than one acres of owned house land, no livestock in the compound, two to six nearby houses and are built on the flat ground. Most of the houses of cases had nearby forests and bushes but not trees within less than 200m around the houses whereas of controls had no nearby forest and no bushes around the houses.

5.2.4 Knowledge about Malaria

Majority of cases respondents had moderate knowledge and of controls respondents had poor knowledge.

5.2.5 Behavior related to protective and control

Most of the cases respondents had poor practice and of controls respondents had moderate practice.

5.2.6 The association between socio-demographic characteristics, housing condition, housing environment, knowledge about malaria and malaria infection in multiple regression

In terms of association between socio-demographic characteristics and malaria infection, we found that only one variable was significantly associated such as total family yearly income (p value = < 0.001). Lower total family income can increase the risk of malaria.

For housing condition, materials used for the first floor of house and compositions of house walls for 1 floor of house were statically associated with malaria infection at p value of 0.007 and <0.001 respectively. The walls of the first floor of the house which were composed of bamboo and wood or branches not covered with mud or branches covered with mud increased the risk of malaria. Poor housing conditions can increase the risk of malaria.

For housing environment, bushes but not trees within less than 200m around the houses and less than one acres of owned house land increased the risk of malaria and statically significant at 0.05 and 0.001 respectively. Having livestock in the compound and presence of nearby houses within less than 50m around the houses are not

associated with risk of malaria. Houses having favorable resting places and breeding sites for mosquitoes can increase the risk of malaria infection.

Knowledge is statically associated with malaria infection and lack of good knowledge increased the risk of malaria. Having good knowledge about malaria infection can decrease the risk of malaria infection.

5.3 Recommendation

Based on the findings of this study, the following issues should be considered for reducing the risk of malaria.

1. Enhancing the knowledge on housing condition and housing environment with malaria. Poor housing can increase the risk of malaria and so promoting housing improvement campaign should be done by local government.

2. Encouraging people to build their housing environment keeping clean and reducing potential breeding sites for mosquitoes could be one of the messages of an educational and information campaign, and could have some impact on the prevalence of the disease. Larval habitats may be destroyed by filling depressions that collect water, by draining swamps or by ditching marshy areas to remove standing water. Mosquitoes that breed in irrigation water can be controlled through careful water management.

3. Encouraging the use of raised beds concurrently with bed nets or other types of mosquito repellents, repairing and maintaining existing homes and reducing the number of potential breeding sites for mosquitoes in and around the house or courtyard are

interventions that could be reasonably implemented, particularly in semi-urban areas by NGOs and INGOs. The availability of different materials and expertise in these areas could also facilitate the implementation of such interventions. Thus, modifying the housing environment of those living in semi-urban, endemic areas may be a practical way to reduce the risk of malaria.

4. Enhancement of people's knowledge on malaria prevention is still needed under health education program even though there are some intervention programs about bed net use, spraying insecticide by NGOs and INGOs. Health education program should emphasize especially on:

- Malaria vector
- Malaria transmission
- Malaria symptoms

In addition, information about drug also should be provided and explained in detail what could happen if the medication is not taken completely; for example, drug resistant. However, based on this study, the current or existed health education program needs to be adjusted or modified in terms of teaching procedure, teaching method, intervention's activities and planning.

5. A number of respondents did not always use mosquito nets or use mosquito repellent and spray because of financial problem and insufficient of materials. Therefore, making bed nets sufficient to all family members and mosquitoes repellent and spray available should be carried out by local government, NGOs and INGOs.

6. A simple practice should be introduced and encouraged such as:

- Cleaning bushes and stagnant water around the house
- Clearing dark corner in the house
- Using mosquito net when going to and working at the forest
- Using mosquito coil and repellent
- Wearing long-sleeve cloth when staying outside at night

5.4 Limitations

There were some problems in interpreting some terms in the questionnaires such as meter, so the researcher used approximation to describe the terms. The study recalled bias which is a design limitation. Since this study was done at only four townships from Thanintharyi Region, it cannot represent the whole population of this region. This is very limited to generalize the results to a wider population. The findings of this study was not generalizable but may be considered as additional research for malaria.

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APPENDIX

APPENDIX A

Questionnaires (English Version)

SURVEY TOOL USED FOR DATA COLLECTION
Environmental risk factors for Malaria in Tanintharyi Region, Myanmar
Structured Survey Questionnaire
ID#_____

A) Socioeconomic information

1. Age :_____ years

2. Sex:
□ Male ……...1
□ Female…….….0

3. Ethnicity
□ Burma ……....1
□ Mon.…….…….…….……2
□ Kayen ……..……3
□ Others……..……....4

4. Occupation:
□ Farmer ……..……..……..1
□ Fisherman……..…….……..…....……2
□ Student ……..……3
□ Housewife ……..……...4
□ Government employee ……....…...…….5
□ Foresting man ……...…6
□ Others ……..…...…..…7

5. If you are farmer do you work in the rice field?
□ Yes [***skip to question 7***]…….……1
□ No ……..……0

6. If no, where do you normally farm?
□ Rubber plantations …….……..…….1
□ Oil palms ……..…….2
□ Vegetable fields …….…….……3
□ Other _____…….…77

7. If you work in the irrigation field which one of the following do you usually do?
□ Weeding ……..……..1
□ Planting ……2
□ Harvesting ……...…….3
□ Threshing and loading……..4
□ Plough……...……5
□ Transportation of the cereal…….……6

8. Marital status:
□ Married…….1
□ Single …….……..2
□ Widowed…….……..3
□ Divorced……4
□ Separated …….…….5

9. Income _____ kyats

10. Education
□ No education ……...……1
□ Primary education ……...…2
□ Secondary education ……...…3
□ High School education…….4
□ Graduated/Post-graduated education……5

11. How long have you been stayed in this house? _____months_____years

B) House or House Characteristics

12. Age of House in years _____

13. House tenure
□ Own.……...……..1
□ Rent..…….……..2

14. Housing condition:
a. Number of floor
□ 1 floor **[*Skip the question 14c and 14e*]**…...……...…..……..1
□ 2 floors……...……..2

b. Materials used for first floor of house
□ None. ……..0
□ Brick……...……..1

□ Wood……..……..2
□ Bamboo……..……3
□ Cement……..……..….4
□ Other ……..77

c. Materials used for second floor of house
□ Brick……..……..1
□ Wood…….……..2
□ Bamboo……..……3
□ Cement……..……..….4
□ Other ……..77

d. Composition of House Walls for first floor of house
□ Brick……..……1
□ Adobe (local bricks of straw mixed with mud)……...……...2
□ Wood or branches covered with mud……..……..….3
□ Wood or branches not covered with mud……..4
□ Bamboo……..5
□ Other (banana leaves, straw, maize leaves)……...6

e. Composition of House Walls for second floor of house
□ Brick……..……1
□ Adobe (local bricks of straw mixed with mud)……...……...2
□ Wood or branches covered with mud……..……..….3
□ Wood or branches not covered with mud……..4
□ Bamboo……..5
□ Other (banana leaves, straw, maize leaves)……...6

f. Materials used for roof of house
□ Cement……..……1
□ Straw or palm…….……...2
□ Wood ……..…….……..….3
□ Zinc sheet…….……...4
□ Tile…….….5
□ Other……..…….....6

g. Ceiling
□ Yes……1
□ No……..0

15. Bed room Density:
a. Sleep in the room
□ Alone…….……..1
□ With 1……..2
□ With 2…..……...……3

□ With 3……..……4
□ With 3+……..……..5

b. Sleep in the bed
□ Alone…….……..1
□ With 1……..2
□ With 1+…..…….…….3

16. Animals sleep in house
□ Yes……1
□ No……..0

17. Mosquito bed net
□ Present ……..……1

18. Kind of mosquito bed net
□ LLIN (Long Lasting Insecticide Net)……1
□ ITN (Insecticide Treated Net)…..…….……2
□ Other……..…….3

19. Number of hole in the mosquito bed net
□ None **[*skip to question 20*]**……..…… …0
□ 1-3……..……1
□ 4-6…….……2
□ More than 6……..…….3
□ *Don't know/Don't remember ……..4*

20. Size of hole in the mosquito bed net
□ 1-2cm……..……0
□ 3-4cm……..……1
□ 5-6cm…….……2
□ More than 6cm……..…….3
□ *Don't know/Don't remember ……,,,,,,……..4*

21. Openings in the subject's room (hole of at least 10*10 cm2 in roof or wall)
□ Yes……..…..…….1
□ No……..…..……...…..0
□ *Don't know/Don't remember ……,,,,,……..2*

22. Number of windows that close in the subject's room
□ None……..…….….0
□ 1……..…..……...…….....1
□ >1……..…..…….…..……...2

C) Characteristics of the house environmental factors

23. Nearest water source:
a. Canal
□ None **[*skip to question 23b*]**……..……..0
□ Within less than 50m……..1
□ Within 50m-100m…..…….2
□ Within 100m-150m……..……..…….3
□ Within more than 150m……..……...…….4

b. Number of canal (within <200m from the house)
□ One……...…….……..1
□ Two……...……..2
□ Three…..…….3
□ More than three……..……..……..…….4

c. Stream
□ None **[*skip to question 23d*]**……..……..0
□ Within less than 50m……..1
□ Within 50m-100m…..…….2
□ Within 100m-150m……..……..…….3
□ Within more than 150m……..……4

d. Number of stream (within <200m from the house)
□ One……...…….……..1
□ Two……...……..2
□ Three…..…….3
□ More than three……..……..……..……4

e. River
□ None……..……..0
□ Within less than 50m……..1
□ Within 50m-100m…..…….2
□ Within 100m-150m……..……3
□ Within more than 150m……..……4

f. Well
□ None **[*skip to question 23g*]..**……..……..0
□ Within less than 50m……..1
□ Within 50m-100m…..…….2
□ Within more than 100m……..……3
□ Within more than 150m……..……4

g. Number of well (<200m from the house)
□ One……..…….……..1
□ Two……...……..2
□ Three…..…….3
□ More than three……..……..……..……4

24. Nearest forest
□ None……...…….……..0
□ Within less than 50m……..1
□ Within 50m-100m…..…….2
□ Within 100m-150m……..……3
□ Within more than 150m……..……4

25. Living on the flat ground
□ Yes…….…….1
□ No……..…..……...0

26. Bushes but not trees (<200m from the house)
□ Yes…….1
□ No……..…..……...0

27. Number of nearby houses (<50m around the house) _____houses

28. Number of any kinds of potential breeding sites (temporary rain pools, marshes, swamps, etc..) (200m around the house)
□ None……..…….0
□ 1 ……..……...1
□ 2…….…….2
□ 3……..…….……...3
□ 4…….…….4
□ >4……..…..……...5

29. How many hectares/acres of house land do you own?
□ None…….0
□ Less than one ……..….1
□ One hectares …….……...2
□ Two hectares……...……...……..3
□ Three hectares……..……4
□ More than 3 hectares….. ……5

30. Are there livestock in your compound?
□ Yes……..…….1
□ No ……..…….0

D) Knowledge of Malaria

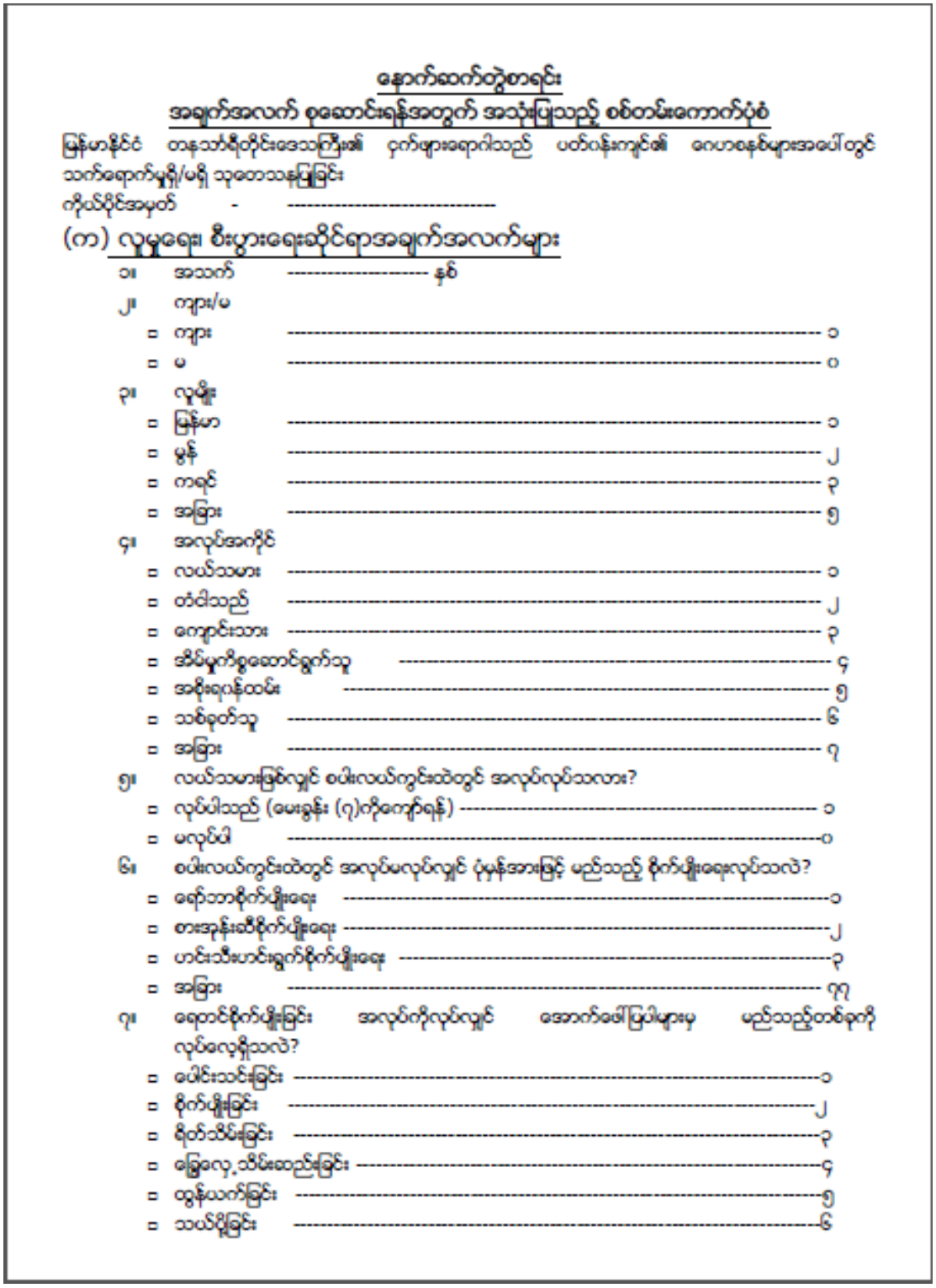
No	Statement	Yes	No	Don't know
31	**Vector which can transmit malaria to human** - Rat			
	- Mosquito			
	- Fly			
	- Cockroach			
32	**Breeding site of malaria mosquito** - Pond or lake			
	- Stagnant water			
	- Canal			
	- Old tires			
	- Dry			
	- Clean place			
33	**Resting place of malaria mosquito** - Bushes			
	- Domestic animal shelters			
	- Tropic forest			
	- Dark corner in the house			
	- Open space where sunlight reach			
No	**Statement**	**Yes**	**No**	**Don't know**
34	**Malaria can be transmitted through** - Drinking contaminated water			
	- Drinking mosquito eggs			
	- Eating contaminated food			
	- Eating mangoes			
	- Eating banana			
	- Close contact with malaria infected patient			
	- The bite of malaria infected mosquito			
35	**Symptoms of malaria** - Fever			
	- Headache			
	- Chill			
	- Sweating			
	- Vomiting			
	- Joint weakness			
	- Backache			
	- Shivering			
36	**Knowing a method of protection against the bite** - Sleep in bed net			

	- Using insecticide treated bed net			
	- Insecticide spray			
	- Mosquito repellant			
	- Mosquito coil			
37	**Ways to prevent and control malaria** - Emptying and removing stagnant water			
	- Trimming bushes around the house			
	- Clearing dark corner in the house			
	- Using larvicides			

E) Behavior related to protective and control

No	**Statement**			
		Always (5-7 times/week)	**Sometimes (1-4 times/week)**	**Never (0 time/week)**
38	How often do you open the windows in your room?			
39	How often do you use indoor anti-mosquito spray in your house?			
40	How often do you sleep in bed net?			
41	How often do you use insecticide treated bed net?			
42	How often do you use mosquito repellent coil at night time?			
43	How often do you bath in the canal/stream?			
44	How often do you wash clothes in the canal/stream?			
No	**Statement**			
		Always (yearly)	**Sometimes (2-3yearly)**	**Never (zero time)**
45	How often do you take outdoor anti-mosquito spraying in your house?			

Questionnaires (Myanmar Version)



နှောက်ဆော်တွဲစာရင်း

အချက်အလက် စုဆောင်းရန်အတွက် အသုံးပြုသည့် စစ်တမ်းကောက်ပုံစံ

မြန်မာနိုင်ငံ တနင်္သာရီတိုင်းဒေသကြီး၏ ၄က်ဖွားရောဂါသည် ပတ်ဝန်းကျင်၏ ဂေဟစနစ်များအပေါ်တွင် သက်ရောက်မှုရှိ/မရှိ သုတေသနပြုခြင်း

ကိုယ်ပိုင်အမှတ် - ----------

(က) လူမှုရေး၊ စီးပွားရေးဆိုင်ရာအချက်အလက်များ

၁။ အသက် ---------- နှစ်

၂။ ကျား/မ

- ကျား ---------- ၁
- မ ---------- ၀

၃။ လူမျိုး

- မြန်မာ ---------- ၁
- မွန် ---------- ၂
- ကရင် ---------- ၃
- အခြား ---------- ၅

၄။ အလုပ်အကိုင်

- လယ်သမား ---------- ၁
- တံငါသည် ---------- ၂
- ကျောင်းသား ---------- ၃
- အိမ်မှုကိစ္စဆောင်ရွက်သူ ---------- ၄
- အစိုးရဝန်ထမ်း ---------- ၅
- သစ်ခုတ်သူ ---------- ၆
- အခြား ---------- ၇

၅။ လယ်သမားဖြစ်လျှင် စပါးလယ်ကွင်းထဲတွင် အလုပ်လုပ်သလား?

- လုပ်ပါသည် (ဖေးခွန်း (၇)ကိုကျော်ရန်) ---------- ၁
- မလုပ်ပါ ---------- ၀

၆။ စပါးလယ်ကွင်းထဲတွင် အလုပ်မလုပ်လျှင် ပုံမှန်အားဖြင့် မည်သည့် စိုက်ပျိုးရေးလုပ်သလဲ?

- ရော်ဘာစိုက်ပျိုးရေး ----------၁
- စားအုန်းဆီစိုက်ပျိုးရေး ----------၂
- ဟင်းသီးဟင်းရွက်စိုက်ပျိုးရေး ----------၃
- အခြား ---------- ၇၇

၇။ ရောင်စိုက်ပျိုးခြင်း အလုပ်ကိုလုပ်လျှင် အောက်ဖေါ်ပြပါများမှ မည်သည့်တစ်ခုကို လုပ်လေ့ရှိသလဲ?

- ပေါင်းသင်းခြင်း ----------၁
- စိုက်ပျိုးခြင်း ----------၂
- ဓိတ်သိမ်းခြင်း ----------၃
- မြေလှန်သိမ်းဆည်းခြင်း ----------၄
- တွန်းယက်ခြင်း ----------၅
- သယ်ပို့ခြင်း ----------၆

၂၈။ ရေလှိုင်းခြင်း/ရေလွှမ်းမိုးခြင်း ဖြစ်ပေါ်လာသော အခြေအနေအကြောင်းအရာ အရေအတွက် (ယာယီပိုးရောဂါ/ရေချိုင့်/မြေနိမ့်ပိုင်း) (အိမ်၏ (၂၈)မီတာ ပတ်လည်အတွင်း)

- ဂ မရှိ ---------- ၀
- ဂ ၁ ခု ---------- ၁
- ဂ ၂ ခု ---------- ၂
- ဂ ၃ ခု ---------- ၃
- ဂ ၄ ခု ---------- ၄
- ဂ ၄ ခုအထက် ---------- ၅

၂၉။ သင်၏ အိမ်မြေအကျယ်အဝန်း ဟက်တာ/ စက မည်မျှပိုင်ဆိုင်သနည်း။

- ဂ မရှိ ---------- ၀
- ဂ (၁) စကထက်နည်း ---------- ၁
- ဂ (၁) စက ---------- ၂
- ဂ (၂) စက ---------- ၃
- ဂ (၃) စက ---------- ၄
- ဂ (၃) စကထက်ပို ---------- ၅

၃၀။ သင်၏မြို့အတွင်း မွေးမြူရေး ရှိ/မရှိ

- ဂ ရှိ ---------- ၁
- ဂ မရှိ ---------- ၀

(ဃ) ဂုဏ်ဖျားရောဂါဆိုင်ရာ ဗဟုသုတ

စဉ်	အကြောင်းအရာ	ရှိ	မရှိ	မသိ
၃၁။	လူကို ဂုဏ်ဖျားရောဂါကူးစက်နိုင်သောအကြောင်းအရင်း - ကြွက် - မြင်း - ယင် - ပိုးဟပ်			
၃၂။	ဂုဏ်ဖျားရောဂါဖြစ်စေသောခြင်ပေါက်ဖွားနိုင်သည့်ရောပေနေရာ - ရေတွင်း/ရေကန် - မစီးဆင်းသောရေဆေး - တူးမြောင်း - တာယာဟောင်းများ - ခြောက်သွေ့သောနေရာ - သန့်ရှင်းသောနေရာ			
၃၃။	ဂုဏ်ဖျားရောဂါဖြစ်စေသောခြင်များ ခိုအောင်းသောနေရာ - မြို့များ - အောလုံး တိရစ္ဆာန်တင်းကုတ်များ - သစ်တောနှင့် ဆက်နွယ်ခြင်း - အိမ်အတွင်း မှောင်သော အခင်းနေရာ - နေရောင်ကျရောက်သော ပွင့်လင်းတည့်နေရာ			

၃၄။	၄င်္ဂ်ာများရောဂါ ကူးစက်နိုင်မှု - မသန့်ရှင်းသောရေသောက်သုံးခြင်း - ပိုးလောက်လန်းများ/ခြင်ဥများပါသောရေကိုသောက်သုံးခြင်း - မသန့်ရှင်းသော အစားအစာစားသုံးခြင်း - ၄င်္ဂ်ပျောသီးစားသုံးခြင်း - ၄င်္ဂ်များရောဂါရှိသူနှင့် အနီးကပ်နေထိုင်ခြင်း - ၄င်္ဂ်များရောဂါ ဖြစ်စေသောခြင်အကိုက်ခံရခြင်း			
၃၅။	၄င်္ဂ်များရောဂါလက္ခဏာများ - ဖျားခြင်း - ဆေးခြင်း - အော်မသာဖြစ်ခြင်း - ချွေးပြန်ခြင်း - အန်ခြင်း - အဆစ်အမြစ်ကိုက်ခဲခြင်း - နောက်ကျောတက်ခြင်း - တုန်ဖျားခြင်း			
၃၆။	ခြင်ကိုက်မခံရအောင် ကာကွယ်သည့်နည်းလမ်း အသိပညာ - ခြင်ထောင်ဖြင့်အိပ်ခြင်း - ခြင်ကာကွယ်ဆေးဖိပ်ထားသော ခြင်ထောင်သုံးခြင်း - ခြင်ဆေးဖြန်းခြင်း - ခြင်မလာအောင် ခြောက်လှန့်ဓောင်းထုတ်ခြင်း - ခြင်ဆေးခွေတွန်းခြင်း			
၃၇။	၄င်္ဂ်များရောဂါကို ထိန်းချုပ်/ ကာကွယ်သည့်နည်းလမ်းများ - ရေဆိုး/ရေပုပ်များ မရှိအောင် ဖယ်ရှားခြင်း - အိမ်ပတ်ဝန်းကျင်မှ မြို့များရှင်းလင်းခြင်း - အိမ်ထဲတွင် အဓောင်ရှိသော ဒေါင့်များကိုရှင်းလင်းခြင်း - ပိုးလောက်လန်းသတ်ဆေးသုံးခြင်း			

(c) ၄င်္ဂ်များရောဂါကို ထိန်းချုပ်/ကာကွယ်ခြင်းနှင့် ဆက်စပ်သော အပြုအမူ သွင်ပြင်လက္ခဏာ

စဉ်	အကြောင်းအရာ	အမြဲ (၅-၇)ကြိမ်/၁၀တီ အတွင်း	တစ်ခါတစ်ရံ (၁-၄)ကြိမ်/၁၀တီ အတွင်း	ဘယ်တော့မှ ဂုံးဝ/၁၀တီ အတွင်း
၃၈။	သင်အခန်းတွင်းမှ ပြူတင်းပေါက်များကို ဘယ် နှစ်ကြိမ်လောက်ဖွင့်သလဲ?			
၃၉။	သင်၏ အိမ်အတွင်းမှာ ခြင်ဆေးကို ဘယ် နှစ်ကြိမ်လောက်ဖြန်းသလဲ?			

၄၀။	ခြင်ထောင်နှင့် ဘယ်နှစ်ကြိမ်လောက် အိပ်သလဲ ?			
၄၁။	ဆေးစိမ်ခြင်ထောင်ကို ဘယ်နှစ်ကြိမ်လောက် အသုံးပြုသလဲ ?			
၄၂။	ညအချိန် ခြင်ဆေးခွေကို ဘယ်နှစ်ကြိမ်လောက် အသုံးပြုသလဲ ?			
၄၃။	စပ်းဆောင်း/တူးခြောင်းများထဲတွင် ဘယ်နှစ်ကြိမ်လောက် ရေချိုးသလဲ?			
၄၄။	စပ်းဆောင်း/တူးခြောင်းများထဲတွင် ဘယ်နှစ်ကြိမ်လောက် အဝတ်များရေလျှော်သလဲ?			

စဉ်	အကြောင်းအရာ	အရှိ (နှစ်ဆဉ်)	တစ်ဖါတစ်ရံ (၂) နှစ်မှ (၃)နှစ်	ဘယ်တော့မှ (၀)ဆ
၄၅။	အိပ်အပြင်ဂန်းရှိုးအတွင်း ခြင်ဆေး မကြာခဏ ဘယ်လောက် ပြန်းသလဲ?			

APPENDIX B

Table 15 Number and Percentage Distribution of Respondents by Socio-demographic Factors

Socio-demographic Factors	Cases (n=153) (%)	Controls (n=306) f(%)	Total
Farming sites			
Vegetable fields	14 (13.86%)	23 (12.23%)	37 (13.07%)
Oil palms	14 (13.86%)	1 (0.53%)	15 (5.30%)
Rubber plantations	15 (14.85%)	46 (24.47%)	61 (21.55%)
Rice field	27 (26.73%)	49 (26.06%)	76 (26.86%)
Others	31 (30.69%)	69 (36.70%)	94 (33.21%)

Table 16 Number and percentage distribution of house and housing conditions of malaria cases and controls

House or Housing condition	Cases (%)	Controls (%)	Total
Materials used for second floor of house: (n=133)			
Wood	49 (100%)	84 (100%)	133 (100%)
Compositions of house walls for second floor of house: (n=133)			
Brick	12 (24.0%)	23 (27.7%)	35 (26.3%)
Wood or branches not covered with mud	38 (76.0%)	60 (72.2%)	98 (73.7%)
Size of hole in the mosquito bed net: (n=102)			
1 to 2 cm	7 (18.9%)	6 (9.3%)	13 (12.7%)
3 to 4 cm	6 (16.2%)	9 (13.8%)	15 (14.7%)
5 to 6 cm	3 (8.1%)	2 (3.0%)	5 (4.9%)
Don't know/Don't remember	21 (56.8%)	48 (73.8%)	69 (67.6%)

Table 17 Number and percentage distribution of characteristics of the housing environmental factors of malaria cases and controls (n=459)

Characteristics of the housing environmental factors	**Cases (n=153)** (%)	**Controls (n=306)** (%)	**Total**
Canal:			
None	136 (88.9%)	289 (94.4%)	425 (92.6%)
Within less than 50m	8 (5.2%)	10 (3.3%)	18 (3.9%)
Within 50m-100m	5 (3.3%)	2 (0.7%)	7 (1.5%)
Within 100m-150m	2 (1.3%)	4 (1.3%)	6 (1.3%)
Within more than 150m	2 (1.3%)	1 (0.3%)	3 (0.7%)
Stream:			
None	75 (49.0%)	188 (61.4%)	263 (57.3%)
Within less than 50m	10 (6.5%)	34 (11.1%)	44 (9.6%)
Within 50m-100m	12 (7.8%)	54 (17.6%)	66 (14.4%)
Within 100m-150m	13 (8.5%)	18 (5.9%)	31 (6.8%)
Within more than 150m	43 (28.1%)	12 (3.9%)	55 (12.0%)
River:			
None	124 (81.0%)	286 (93.5%)	410 (89.3%)
Within less than 50m	10 (6.5%)	3 (1.0%	13 (2.8%)
Within 50m-100m	5 (3.3%)	3 (1.0%)	8 (1.7%)
Within 100m-150m	2 (1.3%)	4 (1.3%)	6 (1.3%)
Within more than 150m	12 (7.8%)	10 (3.3%)	22 (4.8%)

Table 18 Number and percentage distribution of characteristics of the housing environmental factors of malaria cases and controls (n=459)

Characteristics of the housing environmental factors	Cases (n=153) (%)	Controls (n=306) (%)	Total
Well:			
None	32 (20.9%)	53 (17.3%)	85 (18.5%)
Within less than 50m	71 (46.4%)	133 (43.5%)	204 (44.4%)
Within 50m-100m	23 (15.0%)	68 (22.2%)	91 (19.8%)
Within 100m-150m	13 (8.5%)	29 (9.5%)	42 (9.2%)
Within more than 150m	14 (9.2%)	23 (7.5%)	37 (8.1%)
Nearest forest:			
None	51 (33.3%)	190 (62.1%)	241 (52.5%)
Within less than 50m	37 (24.2%)	28 (9.2%)	65 (14.2%)
Within 50m-100m	8 (5.2%)	40 (13.1%)	48 (10.5%)
Within 100m-150m	16 (10.5%)	16 (5.2%)	32 (7.0%)
Within more than 150m	41 (26.8%)	32 (10.5%)	73 (15.9%)

APPENDIX C

Work Plan

Project Procedure	OCT 15	NOV 15	DEC 15	JAN 16	FEB 16	MAR 16	APR 16	MAY 16	JUN 16	JUL 16
1.Literature Review										
2.Writing thesis proposal										
3.Submission for thesis proposal										
4.Proposal exam										
5.Ethical consideration from Chulalongkorn University										
6.Pretest questionnaires										
7.Field preparation and data collection										
8.Data Analysis										
9.Thesis article writing										
10.Final thesis exam										
11.Submission of article for publication										
12.Submission of thesis and article										

Budget

No.	Topic	Estimated Expenses (Baht)
1	Research fees	7500
2	Photocopy	6000
3	Stationary items	2000
4	Travel and lodging related to project	15000
5	Hiring Volunteers cost	9000
6	Printing and binding of the research	4000
7	Miscellaneous	5500
8	Compensation for participants	13100
9	Total	62100

APPENDIX D

AF 02-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University
Jamjuree 1 Building, 2nd Floor, Phyathai Rd., Patumwan district, Bangkok 10330, Thailand.
Tel/Fax: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 098/2016

Certificate of Approval

Study Title No. 054.1/59 : ENIVRONMENTAL FACTORS FOR MALARIA INFECTION IN TANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY

Principal Investigator : MR.YE MYAT HTIKE

Place of Proposed Study/Institution : College of Public Health Sciences, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University, Thailand, has approved constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP).

Signature: ..... Signature: .....

(Associate Professor Prida Tasanapradit, M.D.)
Chairman

(Assistant Professor Nuntaree Chaichanawongsaroj, Ph.D.)
Secretary

Date of Approval : 3 May 2016 Approval Expire date : 2 May 2017

The approval documents including

1) Research proposal
2) Patient/Participant Information Sheet and Informed Consent Form
3) Researcher
4) Questionnaire

Protocol No. 054.1/59
Date of Approval - 3 MAY 2016
Approval Expire Date - 2 MAY 2017

The approved investigator must comply with the following conditions:

1. *The research/project activities must end on the approval expired date of the Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University (RECCU). In case the research/project is unable to complete within that date, the project extension can be applied one month prior to the RECCU approval expired date.*
2. *Strictly conduct the research/project activities as written in the proposal.*
3. *Using only the documents that bearing the RECCU's seal of approval with the subjects/volunteers (including subject information sheet, consent form, invitation letter for project/research participation (if available).*
4. *Report to the RECCU for any serious adverse events within 5 working days*
5. *Report to the RECCU for any change of the research/project activities prior to conduct the activities.*
6. *Final report (AF 03-12) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project. For thesis, abstract is required and report within 30 days after the completion of the research/project.*
7. *Annual progress report is needed for a two- year (or more) research/project and submit the progress report before the expire date of certificate. After the completion of the research/project processes as No. 6.*

VITA

Dr. Ye Myat Htike

MB,BS (Mdy)

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Brief Profile

I am a medical doctor holding a MBBS degree from the University of Medicine, Mandalay, Myanmar. I am a registered doctor from Myanmar Medical Council. I have two years of extensive clinical experience and 8 months field experience in public health sector of Myanmar.

Educational Qualification

[Jan 2011 to Aug 2011]

Certificate for Diagnosis Medicine and Minor Surgical Procedures

Academic Committee of Myanmar Medical Association, Mandalay, Myanmar

[Jan 2004 to Mar 2011]

Bachelor of Medicine and Bachelor of Surgery (MBBS)

University of Medicine, Mandalay, Myanmar