การประเมินความเสี่ยงจากการได้รับสัมผัสสารกำจัดศัตรูพืชตกค้างกลุ่มออร์แกนโนฟอสเฟตผ่านทางผิวหนังของชาวนา ณ พื้นที่เกษตรกรรมรังสิต ปทุมธานี ภาคกลาง ประเทศไทย

นาง อัน เหม่ย ปัน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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ปีการศึกษา 2552

RISK ASSESSMENT FOR DERMAL EXPOSURE OF ORGANOPHOSPHATE PESTICIDES IN RICE-GROWING FARMERS AT RANGSIT AGRICULTURAL AREA, PATHUMTHANI PROVINCE, CENTRAL THAILAND

Mrs. Un Mei Pan

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
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Thesis Title	RISK ASSESSMENT FOR DERMAL EXPOSURE OF ORGANOPHOSPHATE PESTICIDES IN RICE-GROWING FARMERS AT RANGSIT AGRICULTURAL AREA, PATHUMTHANI PROVINCE, CENTRAL THAILAND
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อัน เหม่ย ปัน : การประเมินความเสี่ยงจากการได้รับสัมผัสสารกำจัดศัตรูพืชตกค้างกลุ่มออร์แกนโนฟอสเฟตผ่านทางผิวหนังของชาวนา ณ พื้นที่เกษตรกรรมรังสิต ปทุมธานี ภาคกลางประเทศไทย (RISK ASSESSMENT FOR DERMAL EXPOSURE OF ORGANOPHOSPHATE PESTICIDES IN RICE-GROWING FARMERS AT RANGSIT AGRICULTURAL AREA, PATHUMTHANI PROVINCE, CENTRAL THAILAND) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : อ ,วัฒนสิทธิ์ ศิริวงศ์ .ดร.97 หน้า

การศึกษานี้เป็นการศึกษาเชิงพรรณาชนิดภาคตัดขวางโดยทำการศึกษาเส้นทางการรับสัมผัสและประเมินความเสี่ยงต่อสุขภาพจากการสัมผัสสารกำจัดศัตรูพืชคลอร์ไพรีฟอสและโพรพีโนฟอสผ่านทางผิวหนังของชาวนาในพื้นที่เกษตรกรรมรังสิต จ .ปทุมธานี ภาคกลาง ประเทศไทย โดยการสัมภาษณ์ชาวนาจำนวน 29 คน เพื่อเข้าใจถึงการใช้สารกำจัดศัตรูพืชของชาวนาในพื้นที่เกษตรกรรมนาข้าวนี้ พบว่าเกษตรกรมีอาการและสัญญาณบ่งชี้ผลต่อระบบประสาทที่เกี่ยวข้องกับสารกำจัดศัตรูพืชกลุ่มออร์แกนโนฟอสเฟต อย่างไรก็ตามชาวนาไม่สามารถระบุชื่อของสารกำจัดศัตรูพืชที่ก่อให้เกิดอาการดังกล่าวได้ จากการสำรวจ พบว่าสารกำจัดศัตรูพืชที่นิยมใช้ในพื้นที่นี้ ได้แก่ คลอร์ไพรีฟอส ไดโครโทพอส และ อะบาเม็กติน ในการเลือกซื้อสารกำจัดศัตรูพืชนั้น ชาวนามักจะได้ข้อมูลจากการพูดคุยสนทนากับเพื่อนบ้านและมีการใช้สารกำจัดศัตรูพืชมากกว่า 1 ชนิด โดยผสมสารกำจัดศัตรูพืชมักจะผสมเกินกว่าอัตราแนะนำข้างฉลากในการฉีดพ่นสารแต่ละครั้ง และจะเพิ่มมากขึ้นหากการฉีดพ่นที่ผ่านมาไม่สามารถควบคุมและกำจัดแมลงศัตรูพืชได้ แสดงให้เห็นว่า กลุ่มเกษตรกรควรตระหนักถึงผลต่อสุขภาพและอันตรายจากการได้รับสัมผัสสารกำจัดศัตรูพืช ในการประเมินความเสี่ยงต่อสุขภาพจากการได้รับสัมผัสสารผ่านทางผิวหนังนั้นตัวอย่างที่ได้จากการเช็ดมือชาวนาจำนวน 14 คนนั้น ได้ถูกวิเคราะห์ปริมาณสารกำจัดศัตรูพืชตกค้างกลุ่มออร์แกนโนฟอสเฟต)คลอร์ไพรีฟอสและโพรพีโนฟอส (ที่ตกค้างบนมือของชาวนาภายหลังจากการฉีดพ่น พบว่าความเข้มข้นเฉลี่ยของคลอร์ไพรีฟอส เท่ากับ 10.48 มิลลิกรัมต่อกิโลกรัม)อยู่ในช่วง 0.29-105.62 มิลลิกรัมต่อกิโลกรัม) และ โพรพีโนฟอส เท่ากับ 4.38 มิลลิกรัมต่อกิโลกรัม)อยู่ในช่วง 0.51-22.86 มิลลิกรัมต่อกิโลกรัม) ผลการบ่งชี้ความเสี่ยงต่อสุขภาพชี้ให้เห็นว่า ชาวนาที่ได้รับสัมผัสสารคลอร์ไพรีฟอสและโพรพีโนฟอสผ่านทางผิวหนังหลังจากการฉีดพ่นนั้น อาจจะเกิดผลต่อสุขภาพในระยะยาวได้ โดยมีค่าดัชนีชี้ระดับความเสี่ยงของสารคลอร์ไพรีฟอสและโพรพีโนฟอสมากกว่า 1

สาขาวิชาสาธารณสุขศาสตร์..... ลายมือชื่อนิสิต.....

ปีการศึกษา 2552..... ลายมือชื่อ อ. ที่ปรึกษาวิทยานิพนธ์หลัก.....

#5279125553: MAJOR PUBLIC HEALTH
KEYWORDS : ORGANOPHOSPHATE PESTICIDES/ PESTICIDE DERMAL EXPOSURE/ HUMAN HEALTH RISK ASSESSMENT/ PESTICIDE

UN MEI PAN: RISK ASSESSMENT FOR DERMAL EXPOSURE OF ORGANOPHOSPHATE PESTICIDES IN RICE-GROWING FARMERS AT RANGSIT AGRICULTURAL AREA, PATHUMTHANI PROVINCE, CENTRAL THAILAND. THESIS ADVISOR: WATTASIT SIRIWONG, Ph.D., 97 pp.

This cross-sectional descriptive study investigated the dermal route exposure of organophosphate pesticides and assessed the health risk due to Chlorpyrifos and Profenofos among rice farmers in the Rangsit Agricultural Area, Pathumthani Province, central Thailand. Interviews were conducted with 29 subjects to understand the characteristics of the rice farmers and pesticides use in the community. Neurological signs and symptoms that could be related to organophosphate pesticides existed among the community. The respondents generally could not identify the names of the pesticides which could cause their symptoms. The most common pesticides used were Chlorpyrifos, Dicroptophos and Abamectin. Neighbor influence was an important factor in pesticide purchasing. The surveyed farmers used at least one type of hazardous pesticide; often mixed more pesticides than recommended in each spray and even more if the previous application was ineffective, which shows that the sampled farmers are of particular concern since they were experiencing extensive potential exposure to harmful pesticides. For health risk assessment for dermal exposure portion, hand-wipe samples were collected from 14 subjects who sprayed organophosphate pesticides, specifically Chlorpyrifos and Profenofos. The residues of Chlorpyrifos and Profenofos contaminated on the hands of the rice farmers after they applied pesticides were quantified. The mean concentration of Chlorpyrifos was 10.48 mg/Kg, and concentrations ranged from 0.29 to 105.62 mg/Kg. The mean concentration of Profenofos was 4.38 mg/Kg, and concentrations ranged from 0.51 to 22.86 mg/Kg. The result of risk characterization indicated that the farmers may be at risk from Chlorpyrifos and Profenofos exposure (Hazard Index (HQ), Chlorpyrifos and Profenofos >1). Long term dermal exposure of these two non-carcinogenic pesticides in these rice farmers may result in chronic adverse health effects.

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

Academic Year : 2009 ..... Advisor's Signature.....

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I thank my late mom, and dad and siblings, for their encouragement, and for the –eare” packages they sent which were heartily welcomed.

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LIST OF ABBREVIATIONS

ACFS	National Bureau of Agricultural Commodities and Food Standards
ADD	Average daily dose
AOAC	Association of Analytical Community, United States
CDC	Center of Disease Control, United States
ChE	Cholinesterase
DA	Absorbed dose
DOA	Department of Agriculture, Thailand
DOF	Department of Fisheries, Thailand
ECD	Electron capture detection
ED	Exposure duration
EDL	Estimation detection limit
EF	Exposure frequency
EPA	Environmental Protection Agency, United States
EV	Event frequency
GC	Gas chromatography
HI	Hazard Index
HQ	Hazard Quotient
LD	Lethal dose
LOAEL	Lowest Observed Adverse Effects Level
MS	Mass spectrometry
MDL	Method detection limit
NOAEL	No Observed Adverse Effect Level
NPD	Nitrogen-phosphorus detection
OP	Organophosphate pesticide
OECD	Organization for Economic Cooperation and Development
PAHO	Pan American Journal of Public Health
RfD	Reference dose
SA	Skin surface area available for contact
UF	Uncertainty factor
WHO	World Health Organization

CHAPTER I
INTRODUCTION

1.1 Background & Rationale

Thailand leads the world in producing and exporting rice, rubber, and canned pineapple. Even with agriculture in decline in relative importance in terms of income with rising industrialization, it continues to provide employment, self sufficiency, rural support, and cultural heritage (Zamroni, 2006). Organophosphates are the most widely used of imported pesticide, followed by carbamates and pyrethroids. Most of the compounds used are herbicides, insecticides, and fungicides. From 1994 to 2005, the quantity of imported pesticides increased three times to more than 80 thousand tons. The most insecticide-intensive crops in Thailand are rice, tropical fruit, cassava, cotton, soybean, sugarcane, vegetable, and chili (Tirado, 2008).

Organophosphates (OPs) are a diverse group of chemical compounds which include pesticides and nerve gases. OPs were first synthesized in the early 1800s, and in 1934, Lange in Berlin and Schrader, a chemist at Bayer AG in Germany investigated the use of OPs as pesticides. However, Germany developed OPs as chemical warfare agents (*ie*., tabun, sarin, and soman). In 1941, OPs were reintroduced for agricultural use, as originally intended (Satoh, 2006). Relative to organochlorines, organophosphates have gained popularity as pesticides in the past several decades because organophosphates break down in the environment more rapidly than do organochlorines (Kushik, 2003).

The basic chemical structure of OPs is shown in figure 1. Essentially, OPs are esters of phosphoric acid with varying combinations of oxygen, carbon, sulfur, or nitrogen attached. R1 or R2 (alkyl) are usually either ethyl or methyl. The pesticide with a double bonded sulfur are organothiophosphates, but are converted to organophosphates in the liver. Phosphonate contains an alkyl(R-) in place of one alkoxy (RO-). "X" is called the "leaving group" and is the principal metabolite for specific identification (Gallo, 1991; Gupta, 2006).

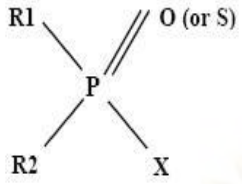


Figure1: General structure of organophosphate (Gallo, 1991; Gupta, 2006).

OPs are potent nerve agents. These compounds can exert adverse effects primarily cholinergic toxicity in non-target species including humans. OPs inhibit the action of acetylcholinesterase at the neuromuscular junctions by the process of phosphorylation of the enzyme to exert primarily an acute cholinergic toxicity. However, they can also cause a delayed polyneuropathy (Costa, 2006). Signs and symptoms of acute OPs toxicity include bronchospasm, bradycardia, muscle weakness, hypertension, central nervous depression, or even coma (Asaroff, 1999). In chronic toxicity, nausea, headache, dizziness, blurred vision, vomiting, chest tightness are the common signs reported (Kushik, 2003). Issues currently being debated and investigated in the toxicology of OPs include possible long- term effects of chronic low level exposures; genetic susceptibility to OP toxicity; developmental toxicity and neurotoxicity; common mechanisms of action, and mechanisms of delayed neurotoxicity (Costa, 2006; De Silva, 2006).

1.1.1 Organophosphate Pesticide Exposure

The route of exposure is the pathway by which the chemical gets into the body. The three major routes are 1) penetration through the skin (dermal), 2) absorption through the lungs (inhalation), 3) passage across the walls of the gastrointestinal tract (oral). According to the study in the Pan American Journal of Public Health, OP exposure can be classified as occupational exposure and environmental exposure. Most occupational exposures are through inhalation, dermal, and ocular routes. In occupational exposure, organophosphate exposure is highest for agricultural workers mainly from mixing, loading, spraying, or transporting the chemicals. Exposure can also occur from accidental spills of chemicals, leakage, or faulty equipment. Table 1 shows the conditions of organophosphate exposure in occupational and non-occupational settings (Kushik, 2003).

Table1: Situations of Organophosphate Exposure

Occupational exposure	Environmental or nonoccupational exposure
Agricultural workers	Residential exposure:
Manufacturing industry workers	• resident use, exterminator use
Pesticide exterminators	• dietary exposure
Greenhouse workers and florists	• accidental exposure[a]
Office workers	Agricultural worker take-home exposure
Health care workers	Close proximity to farms
Veterinary employees	Aerial spraying
Prosectors performing autopsies	Public places
Store employees	Contaminated organ donor
Gulf War veterans	Suicidal (intentional) poisoning[a]
	Chemical warfare

Table adapted from (Kushik, 2003).

1.1.2 Knowledge gap/ Significance of dermal exposure assessment

Driven by the high historic prevalence of respiratory illness, the study of occupational and environmental exposure to chemicals has traditionally focused on the quantity of dust, aerosol, or vapor inhaled. Pesticides generally have a mid to low level of volatility and the amount of material inhaled is likely to be low unless a particularly vigorous application results in significant aerosol formation. The most volatile OP is dichlorvos (2,2-dichlorovinyl-dimethyl phosphate) has a vapor pressure of 7x 10^{-3} KPa at 25^{0}C. The unit KPa stands for kilopascal. One pascal is one Newton per square meter ($N \cdot m^{-2}$ or $kg \cdot m^{-1} \cdot s^{-2}$). The popular OP chlorpyrifos has a vapor pressure of 2.5 x 10^{-6} kPA at 25^{0}C (Franklin, 2005).

Many chemicals can cross the unbroken skin, for example, the ability of organic materials such as tetra-ethyl lead entering the blood after contact with the skin was recognized as early as the 1920s. The importance of dermal exposure has been recently highlighted by a special edition of the journal *Annals of Occupational Hygiene* (Frenske, 2000; Semple, 2004) and an international conference on occupational and environmental exposure of skin to chemicals was held by the US National Institute of Occupational Safety and Health (Semple, 2004). According to their findings, work practices show the highest association with dermal exposure, mainly by hand contamination. Workers exposed to pesticides or solvents can receive most of their body burden via the dermal route (Kushik, 2003; Semple, 2004).

Nowadays, quantitative estimates of pesticide absorption have become an integral component of the regulatory decision-making process. There is a lack of

knowledge about dermal uptake because dermal absorption was thought unlikely to be the dominant route of exposure in the workplace and in the general environment. Moreover, until the mid-1960s, skin was incorrectly considered as an almost impermeable barrier for chemicals. The general interest in skin absorption of chemicals has increased in recent years due to the following factors (Sartorelli, 2002):

1) As inhalational exposures to chemicals have decreased as the consequence of both improved control technologies and the lowering of occupational exposure limits, the contribution of exposure through the skin to total exposure has increased.
2) There are more data relating to dermal absorption of chemicals
3) There are more data relating to the protective capabilities of gloves and clothing that are used to limit skin absorption
4) There are regulatory requirements to assess dermal exposure for certain types of compounds, such as pesticides
5) Advances in biological monitoring have made total exposure or total internal dose more easily measured.

Therefore, data not just from inhalation or ingestion, but from the dermal pathway of exposure are required to highlight the need for accurate estimates of exposure over a wide range of circumstances or scenarios, so improved methods for analyzing pesticides and more precise ways of extrapolating the data are necessary (Franklin, 2005).

1.2 Research Questions

1) What are the different major organophosphate pesticide compounds and their different concentrations found from the Rangsit rice field farmers‘ hands?
2) Are farmers in Rangsit paddy field at risk of organophosphate pesticide exposure from dermal pathway determined by the information of the concentrations of organophosphates from hand-wipe procedure; hand dermal exposure assessment; and risk assessment?
3) To explore the demographic background, health information, pesticide use and exposure data, as well as work practices for use of pesticides of the rice farmers in the Rangsit Agricultural Area community.

1.3 Objectives

1) To describe indicators of OPs dermal exposure on the rice farmers‘ hands using a hand wipe procedure.
2) To investigate the exposure risk of Ops pesticides from the estimated concentrations of OPs from hand assessment using a computation method from the US Environmental Protection Agency (USEPA).
3) To understand the demographic background, health information, pesticide use, exposure data, and work practices on pesticides in the community.
4) To provide recommendations on health and exposure reduction, and to reflect any limitation of the risk assessment method for future improvement.

1.4 Hypothesis

1) There are organophosphate pesticide residues of different concentrations found on the rice farmers‘ hands.
2) Farmers in Rangsit paddy fields are at risk of organophosphate pesticide exposure from dermal pathway.

1.5 Study Area

The study area is located in the Rangsit Agricultural Area, Klong 7 village, Khlong Luang district, Pathumthani Province, Central Thailand. The most common crop is rice. Less common crops include bitter cucumber, long bean, cucurbit, gourd, cucurbita pepo, chili, lemon grass, and marigold. The average income of the villagers in the area is 30,000-40,000 BATH/person/year. Figure 2 shows the sampling area of Klong 7 village. Annotations: U-upper stream, M-middle stream, L-lower stream.

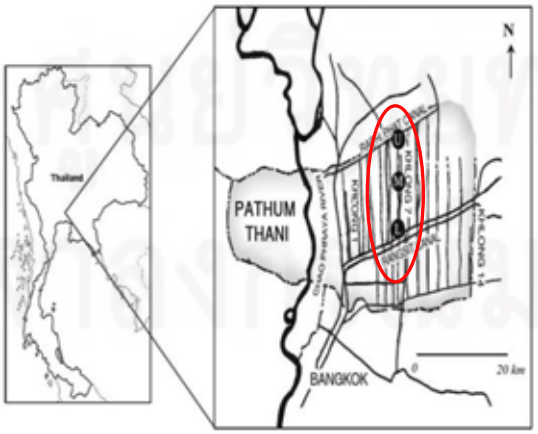
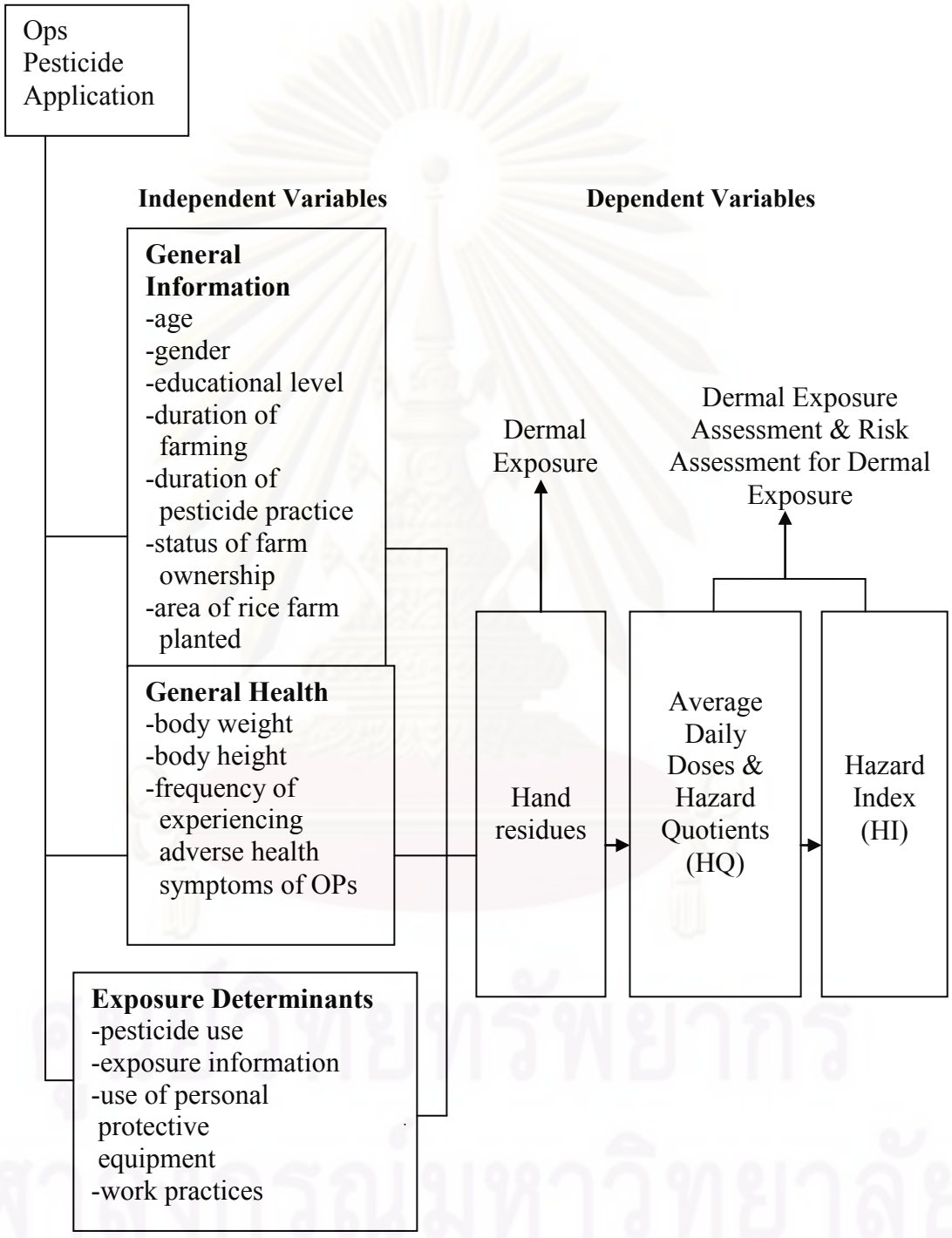


Figure 2: The map of Rangsit Agricultural Area, Pathum Thani Province, Thailand.

Map adapted from (Siriwong, 2008).

1.6 Conceptual framework



Annotation: Ops are organophosphates
HQ is an indicator of risk of individual pesticide
HI is the measure of the organophosphate chemical mixture risk assessment

Figure 3: Conceptual framework

1.7 Variables to be studied

1.7.1 Independent Variables

- Socio-demographic

  General characteristics concentrated on age, gender, education level, duration of farming, duration of pesticide practice, status of farm ownership, and area of rice farm planted.

- General Health

  Rice farmers‘ body heights and body weights, and frequencies of adverse health symptoms experienced by these rice farmers who apply pesticides, in particular, organophosphate pesticides.

- Exposure Determinants

  Information on pesticide use, exposure information, use of personal protective equipment, and work practices.

1.7.2 Dependent Variable(s)

- Hand Residues

  The amount of OP pesticide(s) found on both hands of the rice farmers, based on the wipes and their laboratory analysis.

- Hazard Quotients (HQ) of individual pesticides

  HQ is an indicator of risk to a specific chemical. HQ>1 indicates the rice Farmers are at risk to a particular OP as calculated, where HQ<1 is considered to provide a sufficient margin of safety and is therefore not associated with unacceptable health risks.

- Hazard Index (HI) of OPs mixture

  HI is the measure of the OPs chemical mixture risk assessment,

  HI is obtained by summing up the hazard quotients (HQs) for similar chemical groups.

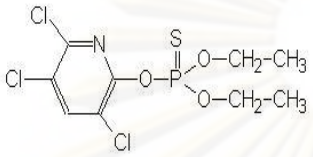
1.7.3 Operational Definitions

- Application

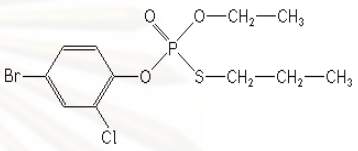
  Application refers to any combination of mixing, filling, and /or spraying of the OP pesticide(s).

- OP Pesticide Application

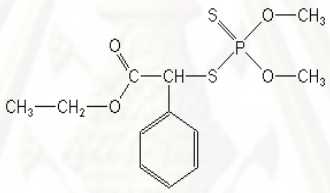
  Routine application of OPs by the Rangsit rice farmers. Examples might include common OPs such as Chlorypyrifos, Phenthoate, and Profenofos, *etc*. Their structures are shown in the following figure.



Chlorpyrifos



Profenofos



Phenthoate

Figure 4: Structures of Chlorpyrifos, Phenthoate, and Profenofos (O'Neil, 2001).

- Dermal Exposure

  Exposure is attributed to any condition which provides an opportunity for an external environmental agent to enter the body. Dermal exposure means exposure of the agent via the skin route. In the Context of this research, dermal exposure refers to exposure of OP Pesticides via the skin of the rice farmers‘ hands after the OPs pesticide application activities

- Dermal Exposure Assessment

  Applies to the characterization of the exposure settings, and the quantification of the dermal exposure in terms of intensity (how much), frequency (how often), and duration (how long) of the exposure.

- Risk Assessment for Dermal Exposure

  To assess risk by comparing dermal exposure assessment finding with risk information databases (EPA, 2009)

CHAPTER II
LITERATURE REVIEW

2.1 Dermal Exposure Measurement Methods

Current methods of measurement of dermal exposure can be divided into five main types. The five types are surrogate skin techniques, chemical removal techniques, visualization, biomarkers monitoring, and dermal exposure modeling.

2.1.1 Chemical removal techniques

Chemical removal methods use washing or wiping techniques to determine the amount of chemical on the skin at a given time point. The standard method described by Durham and Wolfe and Davis involves the hand place in a plastic bag with solvent, typically ethanol, and shaken for 30 seconds (Durham, 1962; Davis, 1980). The procedure is then repeated with a new bag and solvent, and for each hand. The four bags are then pooled to provide a single hand wash sample. It is remarkable that that virtually no validation studies have been conducted for this technique during its 40 years of use in the field. Skin wipe methods have also been developed to assess pesticide applicator exposure.

2.1.2 Surrogate skin Techniques

Surrogate skin methods use patches or body garment to capture the potential exposure. Patch technique is more common. In most cases, ten patches are attached to clothing or directly to the skin on different body regions: chest (1); back (1); upper arms (2); forearms (2); thighs (2); lower legs (2). Chemical loading on the patch (mass per unit area) is then extrapolated to the skin surface area of the appropriate anatomical region. In body garment methods, whole body garments generally consists of long underwear garments or coveralls worn next to the skin with no protective layer. Thus there is potential for penetration of pesticides through the garments to the skin resulting in an underestimation of exposure. In addition, the garment typically represents the torso and the limbs, but not the head, face, neck, hands and feet. Whole body garments have been proposed as a standard method for measuring pesticide exposure for registration purposes (Teschke, 1994). The principle advantage of the body garment method when compare to the patch technique

is that no extrapolation to total surface area is required for the torso. The two most commonly used sampling protocols are published by the World Health Organization (WHO) and the Organization for Economic Cooperation and Development (OECD) (Souta, 2000). A key assumption of this technique is that patch or garment captures and retains chemicals in a manner similar to that of skin.

2.1.3 Visualization technique

Visualization uses a fluorescent tracer added to the material being handled to determine the area of exposure and to quantify the mass deposited on the skin followed by video imaging in a darkened area under ultraviolet light. Compounds known as fluorescent whitening agents were first demonstrated to be useful tools for characterizing skin deposition of pesticide sprays in Franklin and Fenske‘ groups (Franklin, 1981; Fenske, 1985 & 1986). Fluorescent visualization technique requires no assumption regarding the distribution of exposure across skin surfaces. However, this method requires pre- and post-exposure images of skin surfaces. In addition, the method requires the introduction of the tracer fluorescence compound into the agricultural spray mix. Moreover, development of a standard curve relating dermal fluorescence to skin-deposited tracer, and chemical residue sampling to quantify the relationship between the tracer and the chemical substance of interest as they are deposited on the skin is required. These limitations make fluorescent tracer methods technically challenging (Franklin, 2005). Qualitative studies with tracer can provide information about skin deposition patterns, protective clothing performance and work practices, and can produce exposure estimates for virtually the entire body (Fenske, 1988; Bierman, 1998).

2.1.4 Biomarkers monitoring

Biomarkers monitoring methods of organophosphate pesticides include measuring cholinesterase (ChE) activity in red blood cells (RBCs) and serum. Measuring OP metabolites in blood and urine have also been studied. For ChE monitoring, since ChE depression is diagnostic of organophosphate toxicity, both the two enzymes, namely RBC ChE (EC 3.1.1.7 under the enzyme nomenclature system of the International Union of Biochemistry and Molecular Biology) and serum or pseudo ChE (EC 3.1.1.8) should be measured. The findings of both tests are significant and useful in assessing organophosphate toxicity. The serum ChE enzyme

is produced in the liver, it is depressed by organophosphates very rapidly and it is also restored to normal levels quickly. As a result serum ChE level is a more reliable measure for detecting acute organophosphate poisoning than is the RBC ChE. In the acute phase of organophosphate poisoning, serum ChE activity is usually depressed within a few hours to a few days (Kushik, 2003). On the other hand, the RBC ChE, which is present in nervous tissue and the RBCs, is depressed less rapidly by organophosphate insecticides than the serum ChE. During the acute phase of organophosphate poisoning, the RBC ChE activity is usually not depressed. It takes a few hours to a few days for RBC ChE activity to decrease, and about 60 to 90 days for the depressed RBC ChE levels to be restored to normal. A person with symptoms of organophosphate poisoning may not necessarily have low RBC ChE activity; it does not always correlate with acute cholinergic symptoms**.** Moreover, inter-worker variability in metabolism can make it difficult to compare exposures from this monitoring data, workers exposed to organophosphate insecticides should ideally have a pre-employment or pre-exposure (baseline) ChE measurement to compare with a post-exposure ChE level to determine the extent of organophosphate toxicity (Kushik, 2003; Vermeulen, 2002). Without question, blood taking is invasive.

Measurement of OPs metabolites in urine could also estimate exposure. Sample collection is relatively simple and non-invasive. Studies in animals and humans for several pesticides have shown a good correlation between the amount of pesticide applied to the skin and the urinary output (Franklin, 1986; Franklin et al, 1981). One study evaluated dialkylphosphates in first-morning void urine samples to compare OP pesticide exposure of preschool children living near the farm with those children living outside the farm (Patchuay, 2006)**.** In another study, alkyl phosphate metabolites of Ops monitoring in urine to assess cumulative exposure to OP pesticides has been conducted, their result showed variability when compared with Center of Disease Control (CDC) data (Duggan, 2003). Most OPs are rapidly absorbed, metabolized, and excreted in urine within hours. However, in some cases, five to six days of 24-hour urine sample collection may be necessary for complete collection from a single exposure depending upon the dose and half-lives of the Ops (Bravo, 2002). Hence, the pharmacokinetics of OPs in humans must be known, and this information has yet to be obtained. Moreover, urinary metabolite measurement

from spot samples requires adjustment by urinary creatinine concentration to account for hydration effects. However, creatinine itself may exhibit substantial intra-and inter-individual variability resulting in inaccurate exposure assessments (Franklin, 2005).

2.1.5 Modeling

Finally, dermal exposure modeling utilizes statistical or deterministic methods to help estimate the amount of OPs likely to be deposited in the skin (Semple, 2004; Vermeulen, 2002).

2.2 Hand-Wipes

Hand- wipes are easy to use and relatively inexpensive for pesticide exposure assessment. One study used cotton wool balls wetted with 70% ethanol to determine chlordane levels on workers‘ hands (Hirai, 1993). In Geno‘s article, a simple, rapid, and reproducible hand-wipe sampling and analysis procedure for the measurement of pesticides resulting from direct dermal contact is described (Geno, 1996). Their procedure used two 10cm x10 cm ‗Sof-Wick‘ surgical gauze sponges, which are sold in sealed packages of two sterile pieces. The technique calls for each of the two sponges to be wetted with 10 ml of pesticide- grade 2-propanol and used sequentially to thoroughly wipe the entire surface of the hand, being careful to thoroughly wipe each digit and in between. Immediately following sampling, the sponges are placed in a solvent-rinsed, oven-dried wide mouth glass jar with a polytetrafluoroethylene lined lid and an additional 50 ml of 2-propanol is added to the container before sealing with polytetrafluoroethylene tape and packing on dry ice for transport to the laboratory. This two-step wiping procedure is described to make certain that the entire hand is sampled. Results suggest that the procedure may remove pesticide residues that are deeply embedded in the skin and not removed by soap-and-water washing. Extraction efficiency studies for 29 other pesticides show that the proposed extraction method may be applicable for a wide range of pesticides including phenoxy- acid herbicides. Field testing of the procedure indicates that it is easily implemented.

Hand-wipes have been shown to be more effective than hand washes with

alcohol rinses at recovering pesticide residues. For example, Lu‘s group reported a 43% recovery of Chlorpyrifos residues from human hands with 10% 2-propanol in water immediately after exposure to dried formulations. Undiluted ethanol was reported to remove only 30% of the residue with residence time on the skin having no effect on recovery (Lu, 1999). A single bag wash of hand with 10% aqueous 2-peopanol was found to recover 67-78% of Captan, which is less efficiently absorbed by the skin, immediately after exposure. A double bag washing resulted in 78-91% recoveries (Fenske, 1998).

In the study of Lopez, hand -wipes methods was utilized to assess residues of Chlorpyrifos and Methamidophos on hands during application among 30 subsistence farmers in Nicaragua. The results of the Chlorpyrofos and Methamidophos quantification were then modeled with video observations of determinants of exposure among these farmers (Lopez, 2009). In another study, hand-wipes were taken from 41 children of Hispanic farm workers‘ hands for analysis as part of a project to develop and evaluate a culturally appropriate pesticide education intervention for farm worker families (Quandt, 2004).

2.3 Analytical Instrumental Analysis Tools

2.3.1 Extraction

Before analysis, OPs must be extracted from the hand-wipe samples. For solid samples, the selected extraction technique should be essentially exhaustive. In Lopez‘s study, sonication-assisted extraction (SAE) is used. Chlorpyrifos and Methamidophos are extracted from hand-wipe gauze samples by ultrasonication with acetone as the solvent (Lopez, 2009). In Geno‘s study, the pesticides were extracted from the samples with shake-assisted extraction using 100 ml volumes of 1:1 ether: hexane. The ether hexane extract is then concentrated with a TurboVap® R evaporator (Geno, 1996). Quandt‘s group also used shake-assisted extraction to extract wipe samples taken from floor surfaces, toys, and children‘s hands for agricultural and residential pesticides from farmworker family residences. Wipe samples are shake extracted, first with 2-propanol, and then twice with 1:1 diethyl ether: hexanes. The combined extract is then concentrated with an N-Evap® evaporator (Quandt, 2004). Before analysis, samples are thawed out and the OPs from the gauze pads are extracted by adding 30 ml of ethyl acetate and shaking on a

mechanical shaker for 30 minutes. The extracted supernatant is then re-concentrated (Jaipieam, 2008). Alternatively, accelerated solvent extraction, *i.e.*, extraction using high temperature and pressure, can be used (Pohl, 2002).

2.3.2 Separation and detection

2.3.2.1 Separation of different Ops

The goal of chemical analysis is to separate a sample into its individual components in order to evaluate each component free from interference from the other components. Chromatography is a general technique that separates a mixture into its individual components. Chromatography is then coupled with a detection system that can characterize each type of component appropriately. Gas Chromatography (GC) is generally the method of choice to separate pesticides in separation science. In gas chromatography (GC), the sample is vaporized and injected onto the head of a chromatography column. Elution is brought about by the flow of an inert gaseous mobile phase, typically helium, nitrogen, or argon. The mobile phase does not interact with molecules of the analytes, its only function is to transport the analytes through the column (stationary phase). Separation of chemical analytes is based upon the partition of the analytes between the gaseous mobile phase and a liquid phase immobilized on the surface inert solid column (stationary phase) (Skoog, 1992).

Studies in Geno‘s group, Lopez‘s group, Quandt‘s group, and in Jaipieam‘s study all utilized GC as the separation technique (Geno, 1996; Jaipieam, 2008; Lopez, 2009; Quandt, 2004).

2.3.2.2 Detection of OP pesticides

2.3.2.2.1 Nitrogen-phosphorus detection (NPD)

In this detection method, the GC is interfaced with an NPD detector. NPD detection, also called thermionic detection, is a widely used flame photometric detection (by means of flame ionization) technique in the analysis of air and water pollutants, pesticides, and coal hydrogenation products. In this detector, the eluent from the GC is passed into a low-temperature (about 250^0C) hydrogen/air flame. The NPD sensor contains a rubidium or cesium chloride bead inside a heater coil situated close to the hydrogen jet. The heated bead emits electrons by thermionic emission which are collected at the anode and provide background current through the electrode system. When a solute that contains phosphorus is eluted, the partially

combusted phosphorus materials are adsorbed on the surface of the bead and the current collected at the anode rises. The signal from the current is amplified and recorded. Thus the specificity of this detection is very high**.** The sensitivity of NPD is very high too, with estimated detection levels (EDL) and method detection limits (MDL) in the parts per billion (ppb) range (Jaipieam, 2008; Skoog, 1992).

2.3.2.2.2 Mass Spectrometry (MS)

MS is another option. MS is a detection technique for the determination of a sample or molecule. It is also used for elucidating the chemical structures of molecules. The principle of MS is the ionization of the chemical compounds to generate charged molecules or molecular fragments and measure their mass-to-charge ratio. In selected ion monitoring (SIM) mode, the MS is set to scan over a very small mass range. The narrower the mass range the more specific the SIM assay. The SIM plot (output of detection) is a plot of the ion current resulting from this small mass range. Only compounds with the selected mass are detected and plotted. This mode increases the specificity in identification of unknown compounds. Moreover, the SIM mode is more sensitive than the full scan mode because the MS can dwell for a longer time over a small mass range (Skoog, 1992). Geno‘s group used MS coupled with SIM as their detection method (Geno, 1996)**.**

2.3.2.2.3 Electron capture detection (ECD)

In ECD, the effluent from the column passes over a b-emitter, such as nickel-63 or tritium adsorbed on platinum or titanium foil. An electron from the emitter causes ionization of the carrier gas (often nitrogen) and the production of a burst of electrons. In the absence of organic species, constant standing current between a pair of electrodes results from this ionization process. The current decreases, however, in the presence of organic molecules that tend to capture electrons. The response is non-linear unless the potential across the detector is pulsed. ECD is selective and sensitive in its response toward molecules that contain electronegative functional groups such as halogens, peroxides, quinines, and nitro groups. It is insensitive toward functional groups such as amines, alcohols, and hydrocarbons. An application of the ECD has been for the detection and determination of chlorinated pesticides. The advantage of ECD includes not altering the sample significantly (in contrast to flame detector). However, since the detection response is non-linear, the linear response range is

usually limited to about two-orders of magnitude (Skoog, 1992). Lopez's study used ECD to detect Chlorpyrifos and Methamidophos from farmers' hands (Lopez, 2009).

Depending on the availability of instrumentation, due to big decrease of extraction time and solvent usage, as well as the sensitivity of mass spectrometry, accelerated solvent extraction is the desired extraction method and MS is the desired detection technique for solid samples (Barr, 2009).

2.4 Dermal Exposure assessment

Exposure assessment is one part of risk assessment. Exposure assessment focusing on the dermal route is discussed separately in this section. The objective of exposure assessment is to determine the nature and extent of contact with chemical substances experienced or anticipated under different conditions. In 1992, the US EPA published guidelines to clarify the use of terms and units for quantifying exposure (EPA, 1992).

External boundary: the visible exterior of a person, e.g. nose, mouth, skin and eyes.

Exchange boundary: also known as absorption barrier. It is the boundary of the body that allows differential diffusion of various substances, e.g., skin, lung, gastrointestinal tract wall.

Exposure assessment: the quantitative and qualitative evaluation of that contact, which includes consideration of the intensity, frequency and duration of contact, the route of exposure, intake rates, and the resulting dose.

Intake rate: Rate of inhalation, ingestion and dermal contact depending on the route of exposure. For ingestion, the intake rate is simply the amount of food containing the contaminant of interest that an individual ingests during some specific time period. For inhalation, the intake rate is the rate at which contaminated air is inhaled. Factors that affect dermal exposure are the amount that comes into contact with the skin, and the rate at which the contaminant is absorbed.

Exposure Frequency: The number of times exposure occurs in a given period; exposure may be continuous, discontinuous but regular (e.g., once daily) or intermittent (e.g., less than daily, with no standard quantitative definition).

Dose: Dose is the magnitude of exposure. It is the amount of agent available at human exchange boundaries (skin, lungs, gut) where absorption takes place during some specified time.

Dermal exposure: the quantifiable measure of the amount of residues deposited on skin, normally expressed as a density, or mass per unit time, deposited on a defined skin surface area (e.g., mg/h hand exposure); equivalent to potential dose for the dermal route.

Potential dose: the amount of chemical that could be inhaled without wearing a respirator, or which could be deposited on the skin without wearing any clothing. Potential dose is typically expressed as mass per unit body weight per unit time (e.g., mg/kg/d).

Protective clothing: clothing provided to personnel to minimize the potential for skin, personal and company-issued clothing contamination. Also referred as _anticontamination clothing‘.

Exposure factors: the inputs used to translate unit exposure values (µg/Kg active ingredient handled) to estimates of an individual‘s daily exposure (µg/Kg body weight/day), which can then be compared to no effect levels (NOAEL) in mammalian toxicology studies or acceptable operator levels (AOELs). Exposure factors can be categorized as i) physiological (inhalation rates, body weights and lifespan), ii) pesticide usage (duration of activity, acreage treated per day, etc.) and iii) lifestyle activity patterns and co-occurrence information.

OPs are classified as non-carcinogens (O'Neil, 2001; EPA, 2009; ATSDR, 2009). The term Average Daily Dose (ADD) is used for expression of magnitude of exposure (dose) of substances which have non-carcinogenic effects. ADD can be calculated by averaging the potential dose over body weight and average time (EPA, 1992). The general equation of ADD is as follow:

ADD = Total potential Dose/ (Body Weight * Averaging time). Specifically, the equation for dermal dose according to EPA Exposure Handbook (EPA, 1997):

$ADD_{dermal} = (DA_{event} * EV * ED * EF * HSA) / (BW * AT)$ *Equation 1*

ADD = Average daily dose with unit of mg/Kg-day, where:

DA_{event} = absorbed dose per event (mg/cm^2-event)

EV = Event frequency (events/day)

ED = Exposure duration (years)

EF = Exposure frequency (days/year)

HSA = Hand Skin surface area available for contact (cm^2)

BW = Body weight (Kg)

AT = Averaging time in days; for non-carcinogenic effects of OPs, AT = ED in days

The surface area of skin exposed to a contaminant can be determined using measurement or estimation techniques. Then the estimation of the surface area for the specific body part can be used to calculate the contact rate for the pollutant. The data in Table 2 may be used to estimate the total surface area of the particular body part(s). For example, to assess exposure to chemical(s) for which only the hands are exposed, surface area values for hands are shown in table 2.

Table 2: Surface area by body parts for adults (m^2). Table adapted from (EPA, 1997).

Body part	Men						Women					
	N[a]	Mean	(sd)[b]	Min.	-	Max.	N	Mean	(sd)	Min.	-	Max.
Head	32	0.118	(0.0160)	0.090	-	0.161	57	0.110	(0.00625)	0.0953	-	0.127
Trunk (Incl. Neck)	32	0.569	(0.104)	0.306	-	0.893	57	0.542	(0.0712)	0.437	-	0.867
Upper extremities	48	0.319	(0.0461)	0.169	-	0.429	57	0.276	(0.0241)	0.215	-	0.333
Arms	32	0.228	(0.0374)	0.109	-	0.292	13	0.210	(0.0129)	0.193	-	0.235
Upper arms	6	0.143	(0.0143)	0.122	-	0.156	-	-	-	-	-	-
Forearms	6	0.114	(0.0127)	0.0945	-	0.136	-	-	-	-	-	-
Hands	32	0.084	(0.0127)	0.0596	-	0.113	12	0.0746	(0.00510)	0.0639		0.0824
Lower extremities	48	0.636	(0.0994)	0.283	-	0.868	57	0.626	(0.0675)	0.492	-	0.809
Legs	32	0.505	(0.0885)	0.221	-	0.656	13	0.488	(0.0515)	0.423	-	0.585
Thighs	32	0.198	(0.1470)	0.128	-	0.403	13	0.258	(0.0333)	0.258	-	0.360
Lower legs	32	0.207	(0.0379)	0.093	-	0.296	13	0.194	(0.0240)	0.165	-	0.229
Feet	32	0.112	(0.0177)	0.0611	-	0.156	13	0.0975	(0.00903)	0.0834	-	0.115
TOTAL		1.94[c]	(0.00374)[d]	1.66	-	2.28[e]		1.69[c]	(0.00374)[d]	1.45	-	2.09[e]

[a] number of observations.
[b] standard deviation.
[c] median (see Table 6-2).
[d] standard error.
[e] percentiles (5th - 95th).
Source: Adapted from U.S. EPA, 1985.

According to Appendix 6A in EPA Exposure Handbook, total body surface area can be obtained from estimation of body weight and body height. The following equation was obtained by researchers using least square best fit in their studies of 81 subjects of widely varying physique ranging from thin to obese, expressed logarithmically as (EPA, 1997):

$$\ln TSA = \ln 0.024265 + 0.3964 \ln H + 0.5378 \ln W \qquad \textit{Equation 2}$$

Where: TSA = Total surface area in square meters

H = height in centimeters

W = weight in kilogram

Using surface area data of hands from table 2 is straightforward. But the data were obtained studies of average Caucasian adults. For surface area estimation for relatively petite Thais, equation 2 is preferred. However, equation 2 only calculates total body surface area, therefore, in order to obtain surface area of the hands applicable for Thais, the result of the calculated total surface area must be modified.

2.5 Risk Assessment

Risk: The likelihood that an individual will develop a specified adverse health effect. Risk can be characterized in quantitative term such as the probability of the adverse health effect or the margin of exposure which is the ratio of the dose with a specified probability of the adverse health effect and an individual‘s dose from exposure (EPA, 1996).

Risk assessment: frequently described as involving four processes, *i.e.*, hazard identification, exposure assessment, dose-response assessment and risk characterization. Risk assessment may be an input of risk management (Franklin, 2005; EPA, 2009; EPA, 1996; Robson, 2007).

1) Hazard identification: Qualitative determination of whether human exposure to a specific agent has the potential for adverse health effects. This is carried out by review and analysis of toxic data, for example, the LD_{50} for various agents. LD_{50} is the amount of material, given all at once, which causes the death of 50% of a group of animals, expressed in milligrams per 100 grams or kilogram of the body weight of the test animal. Toxicologists can use many kinds of animals but most often testing is carried out with rats and mice. The evidence that the agent causes various toxic effects also needs be weighed, for example, description of the form of neurotoxicity (potential endpoint is the nervous system where potential endpoint is the organ that might have the effect of the chemical) of the OPs is reviewed and described in chapter 1. Toxicity data sources include human studies and animal studies. Due to ethical issues, animal studies are carried out more often. In a variety of animal species over a range of doses administered by the dermal route at

various life stages and for increasing duration of time ranging from a single acute exposure, a short-term exposure and a chronic (lifetime) exposure. Only toxic endpoints that are relevant to humans are used in the risk assessment.

2) Dose-response assessment: Also known as toxicity assessment. It is the qualitative estimate of the hazard potency inherent in receiving a dose from a specific agent.

Very often people compare toxins based on their LD_{50}'s and base decisions about the safety of a chemical based on this number. This is an over simplified approach to comparing chemicals because the LD_{50}'s is simply one point on the dose response curve that reflects the potential of the compound to cause death. What is more important is assessing chemical safety is the threshold dose, and the slope of the dose-response curve, which shows how fast the response increases as the dose increases. While the LD_{50} can provide some useful information, it is of limited value in risk assessment because the LD_{50} only reflects information about the lethal effects of the chemical. It is quite possible that a chemical will produce a very undesirable toxic effect (such as a reproductive or neurotoxicity or birth defect) at doses which causes no deaths at all. Most chemicals do not cause toxic or adverse effect until a certain dose has been given. These are called threshold doses. The lowest dose at which there are no adverse effects observed in the test animals is called the No Observed Adverse Effect Level (NOAEL) at any biologically significant endpoint, and is the starting point for the calculation of the reference dose (RfD). It is important to note that care should be taken to choose the NOAEL for an effect which is relevant to humans and that the duration, frequency and route of exposure in the test animals are relevant to the human exposure. Then the next step is to calculate the RfD by dividing the NOAEL by the safety or uncertainty factors (UF) appropriate for the OPs under review. Another way of expressing the assessment is to divide the NOAEL by the expected exposure value to derive a margin of exposure. Sometimes the dose range in a study will not display a NOAEL, but it may give a dose where there is a Lowest Observed Adverse Effects Level (LOAEL). In this case the estimated NOAEL is calculated by dividing the LOAEL by an uncertainty factor of 10. A typical dose-response curve for non-carcinogen is illustrated in figure 5.

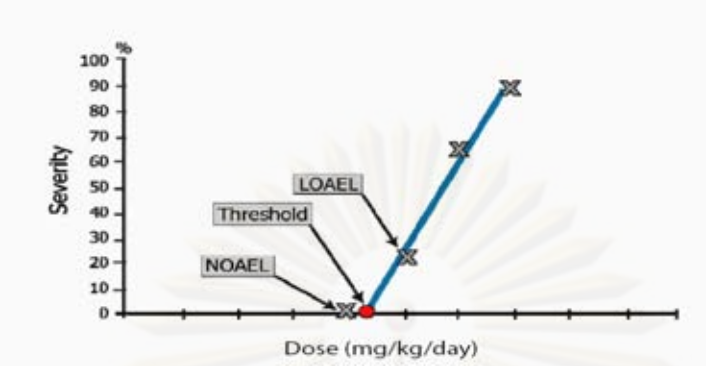


Figure 5: Dose-response curve for Non-Carcinogen. Adapted from (Siriwong, 2009)

Reference dose (RfD): an estimation of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciate risk of deleterious effects during a lifetime. RfD can be derived from NOAEL and LOAEL with uncertainty factors generally applied to reflect limitations of the data used. RfD is expressed in mg of substance /Kg body weight-day.

Uncertainty factor (UF): a number used to divide NOAEL or LOAEL values derived from measurements in animals or small groups of humans, in order to estimate a NOAEL or LOAEL value for the whole human population; also known as margin of exposure. For risk assessment, use 10 for human variability, 10 for extrapolation from animals to humans, 10 for use of less than chronic data, and 10 for using LOAEL instead of NOAEL.

3) Exposure assessment: its definition and emphasis on dermal exposure assessment is discussed in section 2.4.
4) Risk characterization: estimate of the dose and accompanying adverse risk for people who have been exposed to a specific agent.

Once the estimated human exposure level has been quantified (ADD as discussed in exposure assessment in section 2.4), its acceptability is determined by comparing it to the RfD, simply represented by the ratio which is often called a Hazard Quotient (HQ). HQ is for individual chemicals (organophosphates in this study):

HQ = ADD /RfD *equation 3*

Where,

HQ = Hazard quotient

ADD = Average daily dose (mg/Kg-day) determined from equation 1

RfD = Reference dose (mg/Kg-day), determine from database (EPA, 2009)

Defined this way, adverse non-carcinogenic health effects are expected to be present if this quotient exceeds unity. In other words, if the HQ is greater than 1, it indicates that the rice farmers are at risk to that particular organophosphate as calculated. On the other hand, if HQ is less than 1, it is considered to provide a sufficient margin of safety and is therefore not associated with unacceptable health risks. Correspondingly, for the margin of exposure method, if margin of exposure is greater than the target margin of exposure, which is a value based on the required safety and /or uncertainty factors, the organophosphate is considered to pose an unacceptable risk. A different hazard quotient is estimated for each chemical (organophosphate) and sometimes for each pathway (dermal for this study) if pathway specific reference doses are known. Notably, consideration must be given to the strengths, limitations and uncertainties in the exposure and hazard assessments to accurately characterize risk and the potential for adverse effects. For chemical (organophosphate) mixtures:

For chemical mixture risk assessment, the hazard quotients are combined to form a Hazard Index (HI) which assumes that the effects of the different compounds and effects are additive. HI method is recommended for groups of toxicologically similar chemicals that have dose response data. The guideline formulae for the HI are general (EPA, 1986; EPA, 2000):

$HI = \sum ADDi / RfD_i$ *equation 4a* OR $HI = \sum HQ_i$ *equation 4b*

Where,

ADD_i = Average daily dose (mg/Kg-day) for i^{th} chemical

RfD_i = EPA Reference dose for the i^{th} chemical

HI = Hazard index

HQ = Hazard Quotient

Chapter III
Research Methodology

3.1 Research Design

This study is a descriptive observational cross-sectional survey with a laboratory component, supplemented by questionnaire.

Since we do not assign organophosphate exposure as it is unethical to deliberately spray the farmers with the pesticides, there is no control group and the study has to be an observational study. We could not spray the farmers with pesticides repeatedly so it also has to be a one-time (snapshot) measurement. Therefore, a cross sectional study will be the method of choice. A laboratory is necessary to quantify the amount of organophosphates residues on the farmers‘ hands. A cross-sectional study is the simplest method of descriptive or observational epidemiology that can be conducted on representative samples of a population. Such a study would throw some light on the risk assessment of occupational dermal (hand) exposures of organophosphate pesticides of the farmers in the Rangsit rice fields.

The methodology in the design should satisfy the following aims:

i) Economical

ii) Easily implemented

iii) Environmental friendly (no extra volume of waste from hand washing or extra chemicals such as fluorescent agent added)

iv) No harsh chemicals used, such as hexane, toluene, acetone, acetonitrile, *etc*.

v) Non-invasive

The Measuring techniques should provide the following characteristics:

i) The amount of chemicals removed from the hands should represent the amount of chemicals present in the skin (minimal hydrolysis, efficient chemical analysis, *etc*.)

ii) High removal efficiency (relatively exhaustive removal and extraction)

iii) High recovery (both in extraction and retention steps)

3.2 Study Population

The target population of this research is the rice field farmers who apply

organophosphate pesticides on paddy fields in the Klong 7 area of the Rangsit Agricultural Area, Pathum Thani Province, central Thailand.

3.3 Sampling technique and sample selection

3.3.1 Target sample characteristics

There are 9 Moos in the Klong 7 village. As of April 20, 2009, the population in the village is 5565. Total household is 1266. There are 581 households (1771 persons)in Moo1, 116 households (640 persons) in Moo2, 91 households (486 persons) in Moo3, 57 households (308 persons) in Moo4, 102 households (562 persons) in Moo5, 45 households (252 persons) in Moo6, 111 households (597 persons) in Moo7, 116 households (669 persons) in Moo8, and 47 households in (280 persons) Moo9, respectively. The ratio of male to female villagers is approximately 1:1. Among the 5565 villagers, 70% (3896) are farmers. The exact number of rice farmers is unknown. However, according to a leader from the area, the major crop in the area is rice, though the farmers supplement that with other crops.

3.3.2 Sample size and selection criteria

In Lopez's study, hand–wipes methods were utilized to assess residues of Chlorpyrifos and Methamidophos on hands during application among 30 subsistence farmers in Nicaragua (Lopez, 2009). In another study, hand-wipes are taken from 41 children of Hispanic farm workers' hands for analysis to develop an education intervention program (Quandt, 2004). In this study, due to budget and time constraints, availability of farmers, farmers' spraying schedules and schedules of interviewers, a small sample size of only 29 subjects was recruited. The subjects were selected by stratified randomization from different Moos as best as the village headman could find.

3.3.2.1 Inclusive criteria

- Adult (age over 18) farmers who plant rice as the major crop and mix and/or load, and /or spray pesticides in the Klong 7 village, Rangsit Agricultural Area.
- Willing and be able to participate in the study
- Capable of giving informed consent

3.3.2.2 Exclusive criteria

- Rice farmers with palms/dorsum of both hands and/or fingers not intact. This criteria is set to avoid potential unsafe situation and accidents

3.4 Research instrument for data collection

The Rangsit Agricultural Area has its own irrigation system. It has the capacity of farming 5 crops of rice/ 2 years. Each crop takes around 3-4 months. Data collections were carried out in mid-late March, 2010. Normal active pesticide use is assured as best as we could in this period.

3.4.1 Questionnaire

Qualitative information on exposure was obtained from rice farmers using questionnaires. In addition, the principal researcher evaluated the exposure by site visits and observations.

The interview questionnaire study consisted of three parts as follows:

Part 1: Obtain **general information and personal background** of the rice farmers, namely: ages, gender, education level, pesticide application practices, terms and periods of rice farming.

Part 2: Obtain **information on health** problems to assess any health problems potentially associate with exposure to organophosphate pesticides, including signs and symptoms through history of health, and general health status.

Part 3: Obtain **information on pesticide use, exposure information, and work practice for use in organophosphate exposure assessment**. Farmers‘ behaviors and their activities related to organophosphate exposure such as organization of work and types of the pesticides used, *etc*, were investigated.

The structure of the questionnaire was based on questions from established agricultural health studies (Alavanja, 1996; Arcury *et al*, 2006; Dosemeci, 2002; Jaipieam, 2008; Stallones, 2002). The questionnaire is shown in Appendix A.

Potential participants were approached through the village headman. The village headman was chosen because he was the chief informant of the village. The village headman was the point of contact for this project. With the desire to have well coordinated data collections, the principal researcher‘s advisor, Dr. Siriwong, and the coordinator (a Ph.D. student of Dr. Siriwong contacted the village headman. We had the village headman arranged recruitment and the locations on site at the paddy fields for hand-wipe samplings and interviews. The locations situated at a minimal distance

from the spray areas to reduce the time of transportation, and minimize cross-contamination of participants‘ hands. In such a way we could be able to obtain hand-wipe samples as soon as possible after the participants finished their pesticide applications.

The principal researcher invited Dr. Wattasit Siriwong to translate the informed consent form, the participants‘ information sheet, and the questionnaire. By doing so, the translation was more unified as the interpretation of Dr. Siriwong‘s translation should mean the same to all assistants in order to standardize their performance. Then informal meetings were held with the principal researcher, Dr. Siriwong, and the coordinator and assistants (the other assistants are also fellow graduate students under Dr. Siriwong‘s wings. The details of what were to be carried out on the data collection days were discussed. While the principal researcher conducts the meeting, the interpretation, clarification, and the training were further reinforced by Dr. Siriwong to ascertain that the assistants could fulfill their duties professionally.

The following were carried out on the data collection days:

- After the participants finished application the pesticide(s), they reported to the area arranged by the village head. The principal researcher and the coordinator or other assistant will approach the participant. Since hand-wipe samples should be obtained as soon as possible after pesticide application, the coordinator or the other assistant explained to subjects of the procedures, and what was expected when hand-wiping was done. Oral consent of wiping the participant‘s hands is obtained first. After hand-wiping, information sheets including informed consents were provided. Upon subjects‘ full understanding and willingness, the participants were asked to sign the informed consent forms. The researcher and the coordinator and/or the other assistants served as witnesses for both oral and written consents.
- Each participant was given a name tag with a code number written on it. By doing so, the confidentiality of the participants would be protected when the hand-wipe samples were sent to the laboratory for analysis**.**
- It took about 20-30 minutes for each participant to take part in the interview.
- Compensations for time lost for the participants were offered.

3.4.2 Hand-Wipe Operational Procedure

Exposure to organophosphate pesticides was quantified by measuring the external exposure on the skin of the farmers‘ hands. Residues of pesticides were removed from both hands of farmers by hand- wipes. The hand-wipe sampling of organophosphates on the rice farmers‘ hands followed the studies from Geno and Jaipieam (Geno, 1996; Jaipieam, 2008). A two-step wiping procedure was performed to ascertain that the entirety of each hand of the farmer was sampled. For each step, two moistened sterile cellulose gauze pads with 10 ml of 2-propanol, also known as isopropyl alcohol are used to wipe each hand of the farmer sequentially by the investigator using forceps, being careful to thoroughly wipe each dorsum, palm, digits, and inter-digital surfaces. 2-propanol, also commonly known as rubbing alcohol, may be found in most drug store, and is a common ingredient of antiseptic gel. 2-propanol is relatively non-toxic compare to hexane, acetone, and acetonitrile, and is generally safe for medicinal and household use. However, there should not be an open flame near the hand-wipe sampling area as alcohol is flammable. The wiping procedure took around 5 minutes. Immediately following sampling, the gauze pads were carefully enveloped with aluminum foil, labeled, and transferred to zip-lock plastic bags and put in sealed box packed with dry ice for transport to the laboratory as soon as possible. If the samples are not being analyzed immediately, they were kept frozen at -20^0C.

3.4.3 Organophosphate extraction and instrumental analysis

Due to the availability of instrumentation, the method of extraction according to Jaipiema‘s work was proposed. Before analysis, samples were thawed out and the organophosphates from the gauze pads were extracted by adding 30 ml of ethyl acetate and shaking on a sonicator for 30 minutes. The extracted supernatant was then re-concentrated before analysis (Geno, 1996; Jaipieam, 2008).

Sample analysis was carried out at the Central Laboratory (Thailand) Co.,Ltd, recognized and certified by the Department of Fisheries (DOF) and the Department of Agriculture (DOA) of the Ministry of Agriculture and Cooperatives and the National Bureau of Agricultural Commodities and Food Standards (ACFS) of Thailand. Association of Analytical Community (AOAC) quality control method was chosen by

this laboratory. According to AOAC, a recovery of at least 70% is acceptable (AOAC, 2003).

However, sample extraction was not carried out according to what the researcher proposed, and acetonitrile instead of ethylacetate was used for extraction. The sample was cleaned up and extracted by solid phase extraction via a mult-step procedure instead of a simple application of sonication with ethylacetate for extraction.

The extraction of the gauze samples was carried out according to the following flowchart adapted from the QuEChERs method:

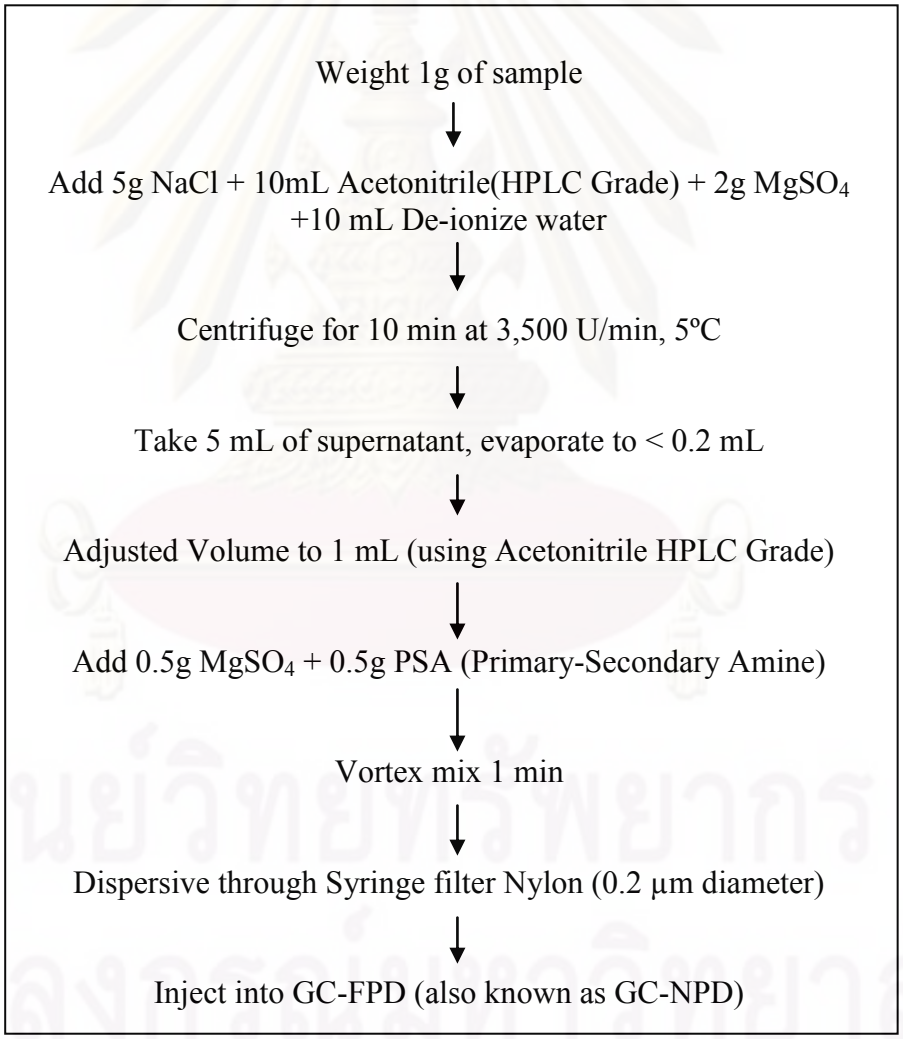


Figure 6: Flow Chart of the modified QuEChERs method (An in-house extraction method of Central Laboratory (Thailand) Co.,Ltd., Khon Kaen, Thailand, courtesy of Miss. Nutta Taneepanichskul, one of Dr. Siriwong's student, for sharing the extraction information provided by this Labortaory).

A 2 µL of the extract is then injected into an Agilent 6890N GC with Flame Photometric Detector (Nitrogen-phosphorus detector) to separate and detect and determine the concentration of the organophosphate pesticides. The capillary column, which uses to separate compound, was DB-1701 (30.0 m length, 0.25 mm i.d., 0.25 µm film thickness) coated with 14% Cyanopropylphenyl and 86% methyl polysiloxane (J&W Scientific). External standards were used to perform sample quantification. The initial temperature of injection was 200ºC. A temperature gradient separation mode was utilized. The oven initial temperature was 80 ºC for 0 min, the programmed to increase at 12ºC/min to 195ºC. Then, it increased at2ºC/min to 210ºC, held for 7 min. It increased to 225ºC at 15ºC/min, held 10min. The last temperature was 275ºC which increased at 35ºC/min and held for 7 min. Total run time was 24 min. Helium gas was used as a carrier gas (mobile phase) with a flow rate at 1.5 mL/min.

3.5 Data Collection

The principal researcher approached potential participants through the help of the coordinator and the assistants who can understand English and Thai to help the participants understood each other. After the participants finished applying the pesticide(s), they reported to the areas arranged by the village head on site. Since hand-wipe samples should be obtained as soon as possible after pesticide application, the coordinator or the other assistants explained the procedures, possible risk and harm, and what was expected when hand-wiping was done. Oral consents of wiping the participants‘ hands were obtained first because we needed to obtain samples as soon as possible before the participants touch anything. Then after hand-wipe sampling, an information sheet including informed consent were provided. Upon full understanding and willingness, the participants were asked to sign the informed consent forms. The researcher and the coordinator or the other assistants served as witnesses for both oral and written consents.

1. Qualitative data

- Collected questionnaires and checked for data input.

2. Quantitative data

- Recovery of organophosphates residues from wipe samples to document validity of the laboratory method

3. Identification of different organophosphates and their concentrations from hand wipe samples from gas chromatography-nitrogen phosphorus detection results. Required the laboratory to provide the following analytical figures of merit in analytical chemical techniques to document method validation (Skoog, 1992):
    - Precision (reproducibility): degree of mutual agreement among data that required repeated measurements. Examples of figures of merit of precision include standard deviations and relative standard deviation.
    - Linearity and Range – calibration plots using peak heights and peak areas.
    - Detection limits: a) limit of detection (LOD)-the minimum concentration of analytes that can be detected at a known confidence level. b) limit of quantification (LOQ)- the minimum concentration of analytes that can be quantified at a known confidence level. c) Method detection limit (MDL) - a statistical concept based on the ability of the measurement method to determine an analyte in a matrix regardless of its source. There is no actual scientific meaning of MDL until it is defined in terms or a measurement process and a statistical method for Analyzing the data produced.

3.6.1 Data Analysis

Quantitative exposure data can be used in different ways (Franklin, 2005; Siriwong *et al*, 2009):

a) To confirm that exposure has occurred

b) Estimate the exposure of rice farmers

c) Validate qualitative or quantitative exposure estimates

d) Develop risk assessment for rice farmers exposed to organophosphates

3.6.1 Calculation

1. Calculate Average dose (ADD) using *equation 1*.

   For surface area estimation for relatively petite Thais, *equation 2* is preferred for obtaining surface area from table 2. However, equation 2 only calculates total body surface area, therefore, in order to obtain surface area of the hand,

the result of the calculated total surface area must be modified. The researcher proposed using the proportion of the mean total surface area to the mean of the hand surface area, and the information body heights and body weights of the rice farmers were obtained via the interviews.

2. Calculate Hazard Quotients (HQs) with *equation 3*
3. Calculate Hazard Index (HI) using *equation 4b*
4. Qualitative analysis of the obtained risk assessment with respect to independent variable information from interviews.

   SPSS software was utilized for statistical analysis.

3.6 Ethical Consideration

Approval was obtained by the Ethical Review Committee for Research Involving Human Subjects and /Use of Animals in research, Health Science Group of faculties, Colleges and Institutes, Chulalongkorn University, Thailand under protocol number 014.1/53. Prior to interview and hand wipe procedure, the respondents were told about the purpose of the study. Informed consents will were obtained. The data was used for research‘s purpose only. The respondents‘ information is kept confidential.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the results obtained from analysis of the interviews, laboratory findings, and the subsequent risk characterization. Data collections were carried out on two separate days. Qualitative information on pesticide exposure was obtained from 29 respondents through interviews. However, due to the farmer‘s spraying schedule and their choice of pesticides, the first 15 farmers sprayed Abamectin on the first day of data collection. Nevertheless, on the second day of data collection, 14 farmers sprayed Chlorpyrifos and Profenofos. Since Abamectin is not an organophosphate pesticide, and it‘s dermal absorption is less than 1%, it does not fit into the organophosphate risk assessment theme (EXTOXNET, 1996). On this account, while the qualitative results from the total 29 respondents‘ interviews are reported in order to understand the general characteristics of the respondents in the community, only the risk characterization of Chlorpyrifos and Profenofos dermal exposure on the 14 farmers who sprayed these two organophosphate pesticides is examined.

4.1 General Information

4.1.1 Socio-demographic characteristics

Twenty- nine participants (n = 29) at the Rangsit Agricultural Area, Pathumthani Province gave consent to complete the face to face interviews. The majority of the participants were male, n_{male} = 23 (79.3%). There were only six female participants, n_{female} = 6 (20.7%). The age ranged from 25-62 years old with one missing data. Among the respondents, there were 4 (13.8%) subjects youngerthan 30 years of age ; 5 subjects (17.2%) between 31-40 years old, ; 7 subjects (24.1%) were between 41-50 years old ; 9 subjects (31%) were between 51 to 60 years old ; and 3 subjects (10.3%) were older than 60. The average age of the participants was 46.1 years old, with a standard deviation of 11.3 years, and the median was 46 years. The majority of the respondents were in the age ranges of 51-60 (31.0%) and 41-50 (24.1%). All had received some formal education, but none of them had gone to school beyond the Matayom 6 level. On the other hand, more than half of them had education level of Patron grade 5 or 6 (58.6%). None of them were

employees in the paddy fields of the studied community. Among these 29 subjects, there were 22 (75.9%) respondents grew rice by themselves, 4 (13.8%) subjects hired others to grow rice, and 3 (13.8%) subjects were doing both. The data discussed above are illustrated in table 3.

Table 3 : Distribution of the respondents' socio-demographic characteristics.

Characteristics	**Number (n= 29)**	**Percentage (%)**
Gender		
Male	23	79.3
Female	6	20.7
Age (years)		
≤ 30	4	13.8
31 – 40	5	17.2
41-50	7	24.1
51-60	9	31.0
>60	3	10.3
Mean ± SD = 46.1 ± 11.3	**Range = 25 to 62**	
Median: 46	**(1 age data missing)**	
Education Level		
Patron grade 4	9	31.1
Patron grade 5 or 6	17	58.6
Matayorn 1-3	2	6.9
Matayorn 4-6	1	3.4
Working characteristics		
Grow rice by themselves	22	75.9
Hire other person(s)	4	13.8
Both	3	10.3

4.1.2 Factors related to rice farming practices

The rice farming practices and pesticide exposure of the 29 subjects are summarized in table 4. The average working years with pesticide application was 19.2 years, with a standard deviation of 14.9. The median year was 15, and working time with pesticide application ranged from 1 to 50 years. With one missing data point, the frequency they used pesticides in a day was found to be 1.52 times/day as the average value, with a standard deviation of 0.71times/day. The median value was 1.6 times/day, and the frequency of pesticide use in a day ranged from 0.03 to 3.5 times/day.

On average, the working hours in the farms were 3.29 hours/day, with a standard deviation of 1.88 hours/day. The median value was 3 hours/day, and their working hours ranged from 1 to 7 hours /day.

With 1 missing data point, the subjects‘ average working frequency in the farms was 4.45 days/week, with a standard deviation of 1.95 days/week. A median of 5 days/week was noted, and their working frequency in the farms ranged from 1 to 7 days in a week.

Including the respondents themselves, the mean number of farmers in the respondents‘ families was 2.48 (2-3), with a standard deviation of 1.55 (~2) persons. The median number was 2 farmers in a family, and the values ranged from 1-7 farmers in a household.

Whether the subjects owned their farms or not, the mean number of rais planted in the previous year were 37.11, with a standard deviation of 21.44. The median figure was 30 rais, and the area they planted rice ranged from 10 to 90 rais.

Table 4: Rice farming practices and pesticides exposure time of the respondents

Variables	Mean (SD)	Median	Range
Working year with pesticide application	19.2 (14.9)	15	1-50
Pesticide use frequency (time(s)/day)	1.52 (0.71)	1.6	0.03-3.5
Working hours in farm (hours/day)	3.29 (1.88)	3.00	1.0-8.0
Working frequency in farm (day(s)/week)	4.45 (1.95)	5.00	1-7
Number of farmers in family (including respondent)	2.48 (1.55)	2.00	1-7
Number of rais planted in previous year	37.11 (21.44)	30.00	10-90

4.2 General Health Information

4.2.1 Symptoms exploration

Since organophosphate pesticides are known neurotoxic agents, the presence of signs and symptoms of both acute and chronic toxic effects after exposure to organophosphate pesticides was explored. From the interviews while and /or after applying pesticides during the last 12 months, it was found that some have only one single symptom and some had more than one symptom. The most frequent signs and symptoms from these subjects were dizziness (11 persons), blurred vision (10 persons), and weakness in arms or legs (10 persons), either during application, or within 24 hours of application of pesticides. There was one subject who reported experiencing dizziness both during and shortly after (within 24 hours of) pesticide application. Other common signs and symptoms were nausea/vomiting (8 persons), tearing (8 persons); difficulty of breathing (7 persons); abdominal cramp (6 persons); numbness or pins and needles in hands or feet (6 persons); and chest pain (5 persons), respectively. The least sign and symptom reported was involuntary twitches or jerks in arms or legs (2 persons). The numbers are indicated in table 5.

Table 5: Symptoms experienced by the respondents after applying pesticides during the last twelve months.

Symptoms	Never (person)	Almost never (person)	During using (person)	Shortly after use (within 24 hours after application) (person)	During using & shortly after using (person)	When not using (person)
Dizziness	15	0	4	6	1	3
Nausea/vomiting	18	0	1	7	0	3
Abdominal cramp	21	0	5	1	0	1
Blurred vision	15	1	7	3	0	3
Tearing	18	1	7	1	0	2
Numbness or pins-and needles in your hands or feet	22	0	3	3	0	1
Weakness in your arms or legs	15	4	6	4	0	0
Involuntary twitches or jerks, in your arms or legs	22	3	2	0	0	1
Chest pain	19	4	1	4	0	1
Difficulty of breathing	18	2	3	4	0	2

To continue, more than half of the surveyed subjects reported that they never experienced any of the signs and symptoms being investigated. There was one missing data point each in the abdominal cramp and involuntary twitches or jerks in arms or legs columns. In another category, 3 subjects reported that they experienced

dizziness, other 3 subjects reported experiencing nausea/vomiting, and another 3 subjects claimed that they experience blurred vision, even when they were not using pesticides. There was one subject who reported that he/she experienced tearing even when he/she was not using pesticide, and one subject reported he/she experienced tearing all the time.

Those who reported having chest pain also reported a history of hypertension. Even though the reporting of signs and symptoms is subjective and subject to recall bias, and, even though we do not have knowledge of any underlying diseases (such as cardiovascular, respiratory diseases, and eye diseases) and the symptoms could also be smoking related, it is still important to show that neurological symptoms that could be related to organophosphate or other neurological agents exist among the community, even though they are not conclusive.

4.2.2 General physique and health status of the respondents

With one data point missing, the average body weight of the respondents was 63.23 kilograms, with a standard deviation of 9.97 kilograms. The median weight was 62 kilograms, and the body weights ranged from 49 to 90 kilograms. The body heights ranged from 152-180 centimeters, with a median height of 166 centimeters. The mean height was 166.4 centimeters, with a standard deviation of 7.97 centimeters.

Among the 29 subjects being interviewed, 8 respondents were smokers, and 3 respondents were ex-smokers. When they were asked if they knew the cause(s) of the signs and symptoms they experience in table 5, the majority (20 subjects) responded with no as the answer, but for the answers for yes, no known cause(s) was/were specified. To add to that, 19 out of 29 subjects reported that their symptoms got worse after smelling odors from pesticides, paints, perfumes, or exhaust. Furthermore, contrary to the response to the question that if subjects experienced symptoms in table 5, their symptoms got worse after smelling pesticides, almost half of them reported that they knew the pesticides‘ names, yet only 1 subject was able to identify and name a pesticide –Cyper 35” (trade name of Cypermetrin, not an organophosphate pesticide. The figures discussed above are summarized in table 6.

Table 6: General physique, smoking status, and health awareness with pesticides of the participants.

Factors	Measurements/ Smoking Status and Health awareness
Weight in Kg.	
Mean (SD)	63.2 (10.0)
Median	62.0
Min.	49.0
Max.	90.0
Height in cm.	
Mean (SD)	166.4 (7.97)
Median	166.0
Min.	152.0
Max	180.0
Smoking Status	
Yes	8
No	18
Ex-smoker	3
Know causes of symptoms in table 5	
Yes	9
No	20
Symptoms get worse after smelling Chemical odors from pesticides, paint, perfume, or exhaust	
Yes	19
No	10
If experience symptom in table 5/ Symptoms get worse after smelling Pesticide(s), able to know pesticide's name	
Yes	14
No	15

4.3 Pesticide Use, Work Practices, and Personal Protection Information

4.3.1 Pesticide Use

4.3.1.1 Common pesticides used by the respondents in the community

The most common pesticides used by the 29 sampled rice farmers at the Rangsit Agricultural Area were Chlorypyrifos, followed by Dicroptophos and Abamectin, where Abamectin is not an organophosphate pesticide. Immediately following that were Quinalphos and Triazophos. Next were Profenofos, Phenthoate, and Cypermetrin. Last of all was Chrotofos. Two subjects reported that they first personally used Chlorypyrifos more than 20 years ago. In the response of how many years did the subjects personally mixed or sprayed the pesticides, varieties of responses ranging from 1 year to more than 20 years were obtained. Common pesticides used by the respondents are shown in figure 7. Note that the objective of this pie chart is to show the estimated proportion of the popular pesticides used among the respondents. In reality, their usage of pesticides is not mutually exclusive, and Chlorpyrifos takes the biggest bite of the pie.

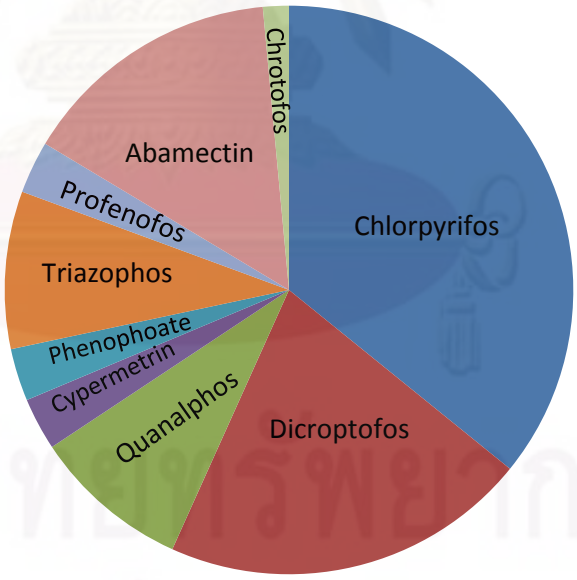


Figure 7: Common pesticides used by the respondents at the Rangsit Agricultural Area, Pathumthani Province, central Thailand.

4.3.1.2 Purchasing and mixing of pesticides

The habits and common practices of purchasing and mixing of pesticides by the respondents are investigated and tabulated:

Table 7: Common practices of purchasing and mixing of pesticides of the respondents.

Purchasing/ Mixing Information	**Most Common**	**Less Common**	**Least Common**	**Remarks**
Purchase pesticides	Listen to neighbors	1.Agricultural officers 2. Shopkeepers 3. Advertisement	Sales Representatives	
How mix pesticides	Mix more than the instruction	Follow the instruction	1. Same technique for all brands, 2. Mix more than one type of pesticides	None reported Follow suggestion from neighbors
Pesticide Additives	Water	Fertilizers, Growth hormones	Other pesticides and fungicides	

Peer influence or peer norm happened to be an important factor for farmers in making decisions concerning the purchase of pesticides. Interestingly, none reported follow suggestions from neighbors in the mixing of pesticides. Water was the most common solvent in pesticide mixing, and additives of fertilizer, fungicide, growth hormone, and other pesticides were applied often.

4.3.2 Work Practices

Furthermore, the respondents‘ behavior and activities related to pesticide exposure were examined. Backpack and mist guns were the common spraying instruments. When they sprayed, they usually sprayed banded instead of furrow, which implied more pesticides were consumed. After they finished pesticide spraying, washing themselves at the end of the day was the most common practice. When the previous pesticide application was ineffective, they opted to change to new

pesticides, and/or mixed higher doses of pesticides. The results are shown in the following table:

Table 8: Work practices of the respondents at the Rangsit Agricultural Area

	Most Common	Less Common	Least Common
Pesticide spraying instrument	Backpack Sprayer	Mist blower	Hand spray gun , boom on tractor, truck or trailer
They spray	Banded	Furrow	
When to wash after pesticide application	End of day	Hands/arms only after mixing, Complete wash right away after spraying	Complete wash at lunch
What they did if previous pesticide application was ineffective	Change to new one	Previous column + mix higher dosage of pesticides	Mix more than one type of pesticides
Time of day of spraying pesticides	Both early morning and late afternoon	Early morning	Depended on sprayer
Smoke while work in farms	Never	Usually, Rarely	
Eat or drink in fields	Never	Sometimes	Rarely

One subject reported he/she did nothing if previous pesticide application was ineffective, and one subject reported he/she usually drank water and ate in the field.

4.3.3 Personal Protection Equipment

Table 9 summarizes the findings of personal protection equipment used respondents.

Table 9: Common personal protection practices of the respondents.

Personal protection	Most Common	Less Common	Least Common
–Protective equipment"	Cloth protecting face and hat	Previous column and cloth overall	Previous column and plastic gloves
Frequency of changing gloves	Don't use gloves	Change each time	Change at least once a month

Additionally, one subject reported wearing socks and one wearing boots for protection; one subject reported not using any protective equipment. However, according to observation, on the days of data collection, no one wore gloves, and one female farmer wore a pair of rubber boots. Apart from their –protective equipment", all farmers except one wore long-sleeved shirts and long pants. However, most had bare feet. Pictures of activities of farmers, interviewers, and the researcher are found in Appendix B.

4.4 Risk Assessment of Rice-Farmers Who Sprayed Chlorpyrifos and Profenofos

4.4.1 Characteristics of the risk assessment target group

Among the 14 respondents who sprayed Chlorpyrofos and Profenofos, 11 were males (78.6%), and 3 were females (21.4%). Tables 10 and 11 provide summaries of their socio-demographic, work practice, and smoking status according to numerical and categorical variables.

Table 10: Age, weights, heights, and work practice distribution of the 14 respondents.

Factors	Median	Range	Mean
Age (years)	47	29-62	47.2
Body Weight (Kg)	62.5	49-90	64.5
Body Height (cm)	166	155-180	165.9
Exposure Duration (years)	10	1-50	16.9
Working days/week	5	2-7	4.9
Working hours/day	2.5	1-6	2.8
***Working days/year**	200	80-280	197.1

*The Rangsit Agricultural Area has its own irrigation system and is a pesticide intensive area. There are 5 crops/2 year, with 3-4 months/ crop. 40 working weeks /year is assumed to obtain working days/year.

Categorical characteristics are shown in table 11.

Table 11: Sex, education levels, pesticide practice, and smoking status distribution of the 14 respondents.

Factors	Number (%)
Sex	
Male	11 (78.6)
Female	3(21.4)
Education Level	
Up to Pratom grade 4	3 (21.4)
Pratom grade 5 or 6	10 (71.4)
Matayom or matayom Seuksa 1-3	1 (7.1)
Pesticide Use Events /Day	1 (57.1)
	2 (42.9)
Farmers do not mix pesticides	5 (35.7)
Smoking Status	
Yes	4 (28.6)
No	8 (57.1)
Ex-smoker	2 (14.3)

4.4.2 Calculations

4.4.2.1 Determination of total body and hand surface areas

4.4.2.1.1 Total body surface area (TSA)

In order to calculate the total surface areas of each of the 14 respondents, equation 2 found on page18 is used:

$$\ln TSA = \ln 0.024265 + 0.3964 \ln H + 0.5378 \ln W$$

Where TSA: Total surface area in m^2

H: Body height in cm

W: body weight in Kg

H and W are obtained from interviews. TSA(s) are then obtained by anti[ln

(TSA)].

4.4.2.1.2 Hand surface areas (HSA) calculations

The computed TSA using equation 2 results only calculated the total surface area of average Caucasian adults. Even though the overall sizes of individuals are different, the proportion of the hands and total body surface areas should be roughly the same. Therefore, in order to obtain the surface areas of the hands of the respondents who are Thais, the researcher proposes to multiply the TSAs values by the proportion of the mean total surface area to the mean of the hand surface area found in table 2 on page 18, that is:

For men: Hand surface area (HSA) = TSA* 0.084/1.94

For women: Hand surface area (HSA) = TSA * 0.0746/1.69

The means of the total surface areas of both males and females are then compared with the default mean of total surface areas found on table 2 (EPA, 1997). The comparison figures are shown in table 12.

Table 12 : Comparison of surface area by body parts between default values and calculated values.

Body Part Surface Area	**Men**			**Women**		
	Mean	Min	Max	**Mean**	Min	Max
Default Whole Body (cm^2)	19,400	16,600	22,800	16,900	14,500	20,900
Calculated Total (cm^2)	**17,575**	14,540	20,400	**160,83**	15,270	16,540
Default Hands (cm^2)	840	596	1130	746	639	824
Calculated Hands (cm^2)	**760**	630	883	**710**	674	730

4.4.2.2 Risk Characterization

Risk characterization requires the calculation of the average daily dermal dose (ADD_{dermal}) and accompanying adverse risk for the respondents who have been exposed to Chlorpyrifos and Profenofos. To calculate ADD_{dermal}, equation 1 found on page 17 is needed (EPA, 1997):

$$ADD_{dermal} = (DA_{event} * EV * ED * EF * HSA) / (BW * AT)$$

The equation calls for the concentrations (C_s) of both Chlorpyrifos and Profenofos in order to determine the absorbed dose per event (DA_{event}), in mg/cm^2-event. Figure 8 and 9 show the concentrations of Chlorpyrifos and Profenofos reported from the Central Laboratory, in mg/Kg of gauze pads:

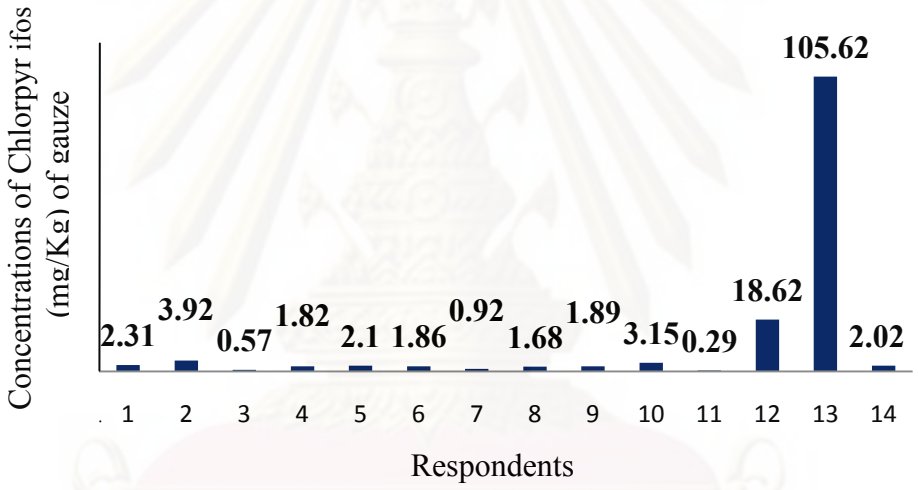


Figure 8: Reported concentrations of Chlorpyrifos from hand-wipe samples (mg/Kg) of gauze of the 14 respondents.

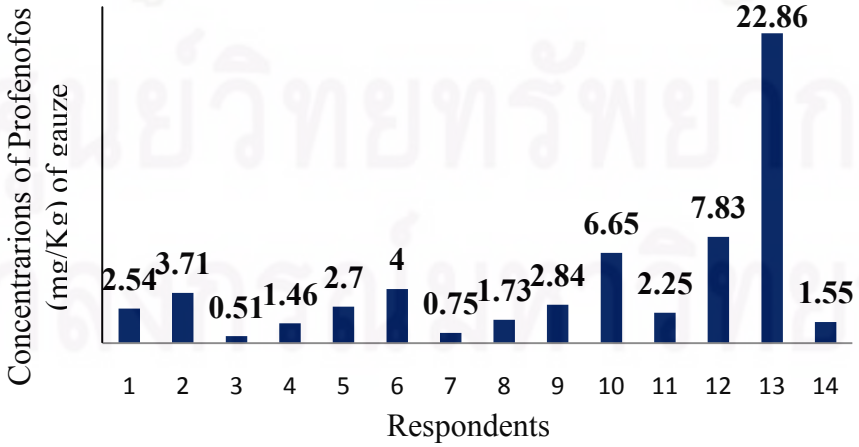


Figure 9: Reported concentrations of Profenofos from hand-wipe samples (mg/Kg) of the 14 respondents.

The mean concentration of Chlorpyrifos was 10.48 mg/Kg, the median was 1.955 mg/Kg, and concentrations ranged from 0.29 to 105.62 mg/Kg. Also, the mean concentration of Profenofos was 4.38 mg/Kg, the median was 2.62 mg/Kg, and concentrations ranged from 0.51 to 22.86 mg/Kg. The reported limit of detection (LOD) of Chlorpyrifos 0.05 mg/Kg, and its limit of quantitation (LOQ) was 0.10 mg/Kg. The LOD of Profenofos was determined to be 0.05 mg/Kg, and its LOQ was found to be 0.10 mg/Kg. Determine average dermal daily dose by equation 1:

$ADD_{dermal} = (DA_{event} * EV * ED * EF * HSA) / (BW * AT)$

Where,

ADD_{dermal} = average daily dermal contact dose (mg/Kg/day, estimated from Concentration analysis

DA_{event} = absorbed dermal dose per event (mg/cm^2-event)

EV = event frequency (events/day from interview: see table 11)

ED = Exposure duration (years: see table 10)

EF = Exposure frequency (days/year, derived from interview of working days /week: see table 10). [Note: Since there are 5 crops /2 years, and 3 to 4 months/ crop, 40 working weeks/year is estimated to calculate EF]

HSA = Hand surface area (cm^2, calculation see section 4.4.2.1.2)

BW = body weight (Kg, from interview: see table 10)

AT = Averaging time (days-ED * 365 days/year for non-carcinogen)

C_s = Concentration of pesticide (mg/on the two pieces of gauze)

$DA_{event,}$ which stands for dermal dose per event, in unit of mg/cm^2-event, can be determined by two methods:

a) By using dermal absorption fraction (EPA, 1997; Jaipieam, 2008), where Cs mg/on 2 gauze ~ mg/2 hands:

ABS = Dermal absorption fraction (unitless):- chemical specific; 0.03 for Chlorpyrifos (EPA, 1999), and 0.5 for Profenofos (EPA, 1998)

Unit analysis: DA_{event} (mg/cm^2-event) = the following:

$$\frac{(C_s)\text{ mg of pesticide}}{\text{Kg weight}} * \frac{10^{-3}\text{Kg}}{\text{1g sample}} * \frac{\text{weight (Kg)}}{\text{(2 gauze)}} * \frac{10^{3}\text{g}}{\text{1Kg}} * \frac{\text{(2 gauze)}}{\text{(HAS, cm}^2\text{)-event}} * \text{ABS}$$

Simplified to:

$\frac{(C_s)\text{ mg of pesticide}}{\text{Kg weight}} * \frac{\text{weight (Kg)}}{\text{(2 gauze)}} * \frac{\text{(2 gauze)}}{\text{(HAS, cm}^2\text{)-event}} * \text{ABS (unitless)}$

However, the weights of the gauzes before extraction were not reported. An estimation of an average weight of the 2 gauzes used per event has to be carried out. The average weight of the 2 gauzes per event was estimated according to:

Average weight of each dry gauze: 2.128 g, therefore

Average weight of 2 dry gauze: $4.256 * 10^{-3}$ Kg

Total volume of 40% 2-propanol added to each of the 2 pieces of gauze was 20 ml. An educated guess of the volume of 40% 2-propanol lost in wiping for both hands is 3 ml, and an assumption of evaporation loss and weights of wiped pesticides on the gauze before analysis are negligible, the estimated average weight of the 2 gauze per event before extraction was determined to be 0.01918 Kg. Note that this figure is the average weight of the 2 gauzes with the best educated guess. The individual weights of the 2 gauzes of each wipe sample could not be determined.

Specific gravity of water: 1g/ml

Specific gravity of 2-propanol: 0.778g/ml

The calculated DA_{event} is substituted in equation 1 to obtain ADD_{dermal}. Once $ADD_{s\ dermal}$ are established, their acceptability is determined by comparing to the reference dose (RfD_s), represented by the ratio which are called Hazard Quotients (HQ_s):

$$HQ = ADD_{dermal} / RfD_{dermal}$$

where HQ = Hazard Quotient

RfD_{dermal} = dermal reference dose (mg/Kg-day). *HQ >1 indicates at risk*

The RfDs according to the EPA Integrated Risk Information System for Chlorpyrifos is 0.0015, and for Profenofos is 0.00005 mg/Kg-day (EPA, 2009). The computed HQs of Chlorpyrifos and Profenofos are shown in figures 10 and 11.

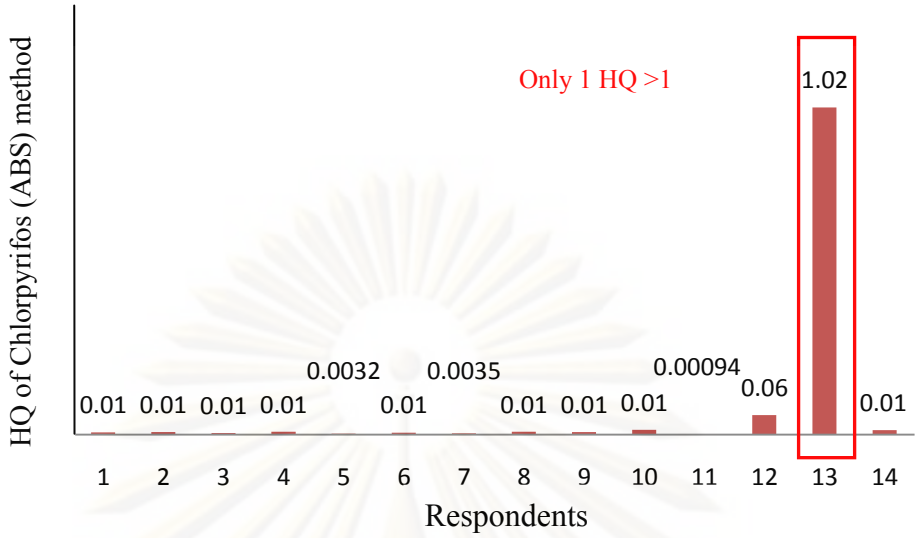


Figure 10: The computed HQs of Chlorpyrifos by dermal absorption fraction (ABS) Method.

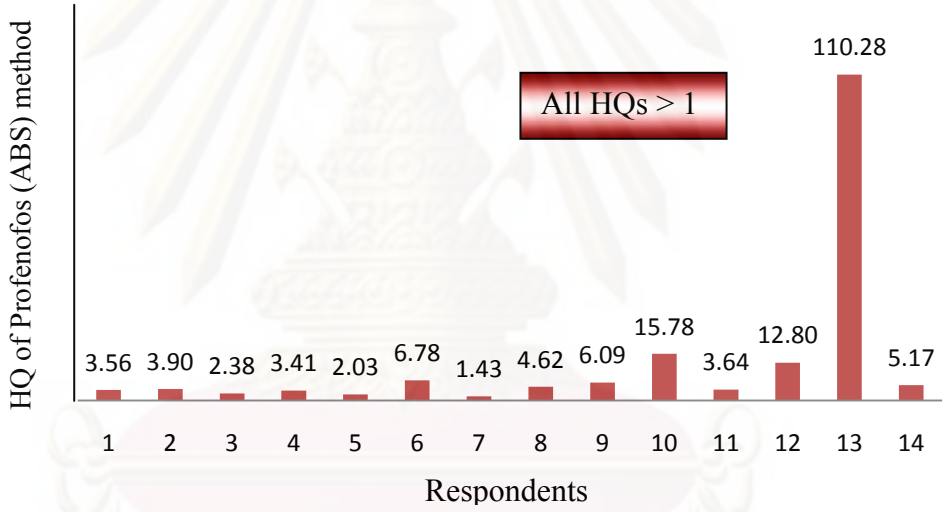


Figure 11: The computed HQs of Profenofos by dermal absorption fraction (ABS) Method.

By using the ABS method, the HQ Chlorpyrifos >1 occurred in only one case, while HQs Profenofos >1 for all cases among these 14 respondents. As a result, farmer 13 is at risk from hand contact to Chlorpyrifos application, whereas all 14 respondents are at risk from hand contact to Profenofos application. Subject 13 had the highest HQs for both Chlorpyrifos and Profenofos. Since all hand-wipe samplings were done by the principal researcher, the wiping performance variation was considered minimal. In addition, on the day of hand-wipe sampling, none of the farmers wore gloves. However, none of them were observed of having ~~–p~~esticide soaked" or particularly ~~–d~~irty" hands. The practice of pesticide handling of farmer 13

Should be investigated further. More discussion are found in section 4.4.3 risk assessment analysis.

b) By using dermal absorption rate:

Unit analysis: DA_{event} (mg/cm^2-event) = the following:

$$\frac{mg}{Kg} * \frac{mg}{cm^2\text{-hour}} * \frac{hours}{day} * \frac{1Kg}{10^6 mg} * \frac{10^{-3}Kg\ gauze}{sample} * \frac{1\ whole\ sample}{0.01918\ Kg} * \frac{1\ day}{\#\ event}$$

Cs: mg/1 Kg gauze sample 1 g of sample extracted

Dermal absorption rate of Chlorpyrifos = 456 ng/cm^2-hour, which is equivalent to 456 * 10^{-6} mg/cm^2-hour (Griffin, 1999). The calculated DA_{event} is substituted in equation 1 to obtain $ADD_{dermal.}$ HQs are obtained the same way as by the dermal absorption factor method. The computed ADD_{dermal} of Chlorpyrifos values are all in really small numbers and all computed HQs << 1 by this method.

In Griffin's study, Chlorpyrifos was administered to each of 5 human volunteers' area of 78 cm^2 of the inner forearm for 8 hours. Dermal absorption rate was determined by measuring urinary metabolites elimination kinetics. From the fractions of the doses recovered from urine and skin washes, the dermal absorption rate was found to be 456 ng/cm^2/hour, and the dermal absorption fraction was determined to be 1% (0.01) (Griffin, 1999). However, Nolan's group determined the dermal absorption factor was 3% (0.03), and this finding was supported and accepted by the USEPA (Nolen, 1984; EPA, 1999), whereas Krieger's study determined the dermal absorption factor of Chlorpyrifos was 10% (0.1). In a comparative analysis of passive dosimetry and biomonitoring for assessing Chlorpyrifos exposure, dermal absorption factor median values were 0.45, 0.71, and 1.28, suggesting the dermal absorption factor is within the range of 3-10% (0.3-1) (Geer, 2004). To look at the two determination methods closely, comparisons of absorbed doses per event, absorbed doses per event, and the hazard quotients are illustrated in table 13:

Table 13: Comparisons of DA_{event}, ADD_{dermal}, and HQs of Chlorpyrifos absorbed by ABS (using factor) and absorption rate (using rate) methods.

	Rate Method			ABS Method		
Subject	**DA event mg/cm²-event**	**ADD dermal (mg/Kg-day)**	**HQ**	**DA event mg/cm²-event**	**ADD dermal (mg/Kg-day)**	**HQ**
1	$1.10*10^{-10}$	$6.62*10^{-10}$		$1.62*10^{-6}$	$9.71*10^{-6}$	
2	$2.80*10^{-10}$	$1.34*10^{-9}$		$2.59*10^{-6}$	$1.24*10^{-5}$	
3	$3.39*10^{-11}$	$6.13*10^{-10}$		$4.44*10^{-7}$	$7.99*10^{-6}$	
4	$6.49*10^{-11}$	$6.33*10^{-10}$		$1.31*10^{-6}$	$1.28*10^{-5}$	
5	$9.99*10^{-11}$	$2.79*10^{-10}$		$1.70*10^{-6}$	$4.73*10^{-6}$	
6	$4.42*10^{-11}$	$2.91*10^{-10}$		$1.44*10^{-6}$	$9.459*10^{-6}$	
7	$2.19*10^{-11}$	$1.49*10^{-10}$	<< 1	$7.80*10^{-7}$	$5.27*10^{-6}$	<1
8	$7.99*10^{-11}$	$8.35*10^{-10}$		$1.29*10^{-6}$	$1.35*10^{-5}$	
9	$4.49*10^{-11}$	$3.18*10^{-10}$		$1.73*10^{-6}$	$1.22*10^{-5}$	
10	$2.25*10^{-10}$	$2.04*10^{-9}$		$2.48*10^{-6}$	$2.24*10^{-5}$	
11	$6.89*10^{-12}$	$3.94*10^{-11}$		$2.48*10^{-7}$	$1.41*10^{-6}$	
12	$8.85*10^{-10}$	$6.70*10^{-9}$		$1.21*10^{-5}$	$9.13*10^{-5}$	
13	$6.28*10^{-9}$	$1.15*10^{-7}$		$8.37*10^{-5}$	$1.53*10^{-3}$	1.02
14	$7.20*10^{-11}$	$9.52*10^{-10}$		$1.54*10^{-6}$	$2.02*10^{-5}$	

Both the absorbed doses per event and the daily average doses of the respondents obtained by the dermal absorption rate method were found to be 4 to 5order of magnitude lower than those computed by the dermal absorption factor method. These findings suggest that usage of dermal absorption rate of 456 ng/cm²-hour is very likely to lead to a gross underestimation of the actual amount of Chlorpyrifos absorbed via the skin.

Unfortunately, after searching many databases, the researcher could only find Griffin's study reported dermal absorption rate in figures (Griffin, 1999). Yet, while an absorption factor of 50% (0.5) for Profenofos was obtained from the EPA registrant database (EPA, 1998), no dermal absorption rate in terms of mg/cm²-hour

was officially reported as best as the researcher could find.

The highlights of the lack of comprehensive data in risk assessment led the researcher to investigate further. In the calculation of the ADD_{dermal} contact with soil, in using only the concentration of mg of pesticide in 1 Kg of soil without the need of the weight of the different individual lumps of soil, a soil-to-skin adherence factor, the dermal absorption factor of the pesticide, and a conversion factor of 10^{-6} Kg/mg are called for:

$ADD_{dermal,\ soil}$ = Cs * SA * AF * ABS * EV * EF * ED * CF / BW * AT (EPA, 1997)

Where SA = skin surface

AF = Soil to skin adherence factor (0.2mg/cm^2-event)

CF = Conversion factor (10^{-6} Kg/mg)

The other variables in abbreviations are the same as those in the hand ADD_{dermal}.

AF is not required in hand ADD_{dermal} equation calculation. In order to fulfill the unit mg/cm^2, the dermal absorption rate is used instead. ABS is the percentage of absorption (unitless, also a form of absorption rate), it would be redundant to put it in the equation. The researcher would like to find out if the following would work directly by using just Cs in mg/Kg which is an uncertainty, such that the knowledge of the weights of the 2 pieces of gauzes is not required. For Chlorpyrifos:

$$ADD_{dermal} = Cs\ (\underline{mg})/Kg * SA * \underline{456*10^{-6}\ mg}/cm^2\text{-}h * \underline{hours}/day * EF * ED * CF\ \underline{(10^{-6}\ Kg)}/mg$$

Interesting outcomes from the computation are obtained shown in figure 12.

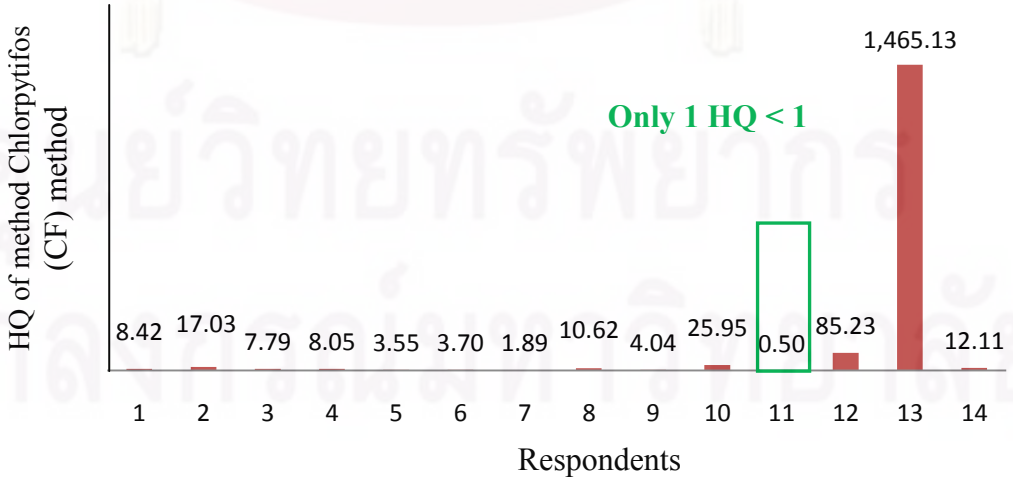


Figure 12: The computed HQs of Chlorpyrifos by dermal absorption rate with a correction factor (CF) method.

Contrary to the results obtained by the previous methods, all HQs are >1 except one finding. The maximum HQ was found in the same farmer number 28 as with the previous methods, but with a magnitute of almost 1500 times more.

In the study of 33 vegetable farmers in a pesticide intensive sub-district in Songkla Province from Jaipieam, the mean hand HQ_{dermal} for Chlorpyrifos was 0.021, with a maximum HQ of 0.151 in dry season, whereas the mean HQ was 0.026 with a maximum of 0.260 from wet season. The mean hand HQ_{dermal} for Profenofos was 3.692, with a maximum HQ of 22 in dry season, whereas the mean HQ was 9.077 , with a maximum HQ of 132.16, respectively (Jaipieam, 2008). In summary, the trend of the HQs obtained from dermal absorption factor (ABS) with the estimated total weights of the 2 gauze, is consistent with Jaipieam's findings. In using the absorption rate for calculation, working hours per day need be used instead of EV that is in event/day as suggest in the equation from EPA. Simply applying the absorption rate and a conversion factor in soil study to this study might overestimnate HQs, and in turn, overpredict the risk.

For chemical mixture of similar chemical group, the HQ_s are combined to form a Hazard Index (HI), assuming that the effects of the different compounds and effects are additive.

$$HI = \sum HQ_{\text{Chlorpyrifos , Profenofos}}$$

Since all HQs for Profenofos are all > 1, HIs are all >1. All 14 respondents are at risk from hand contact from the application of Chlorpyrifos and Profenofos.

4.4.3 Risk assessment analysis

According to risk determination, only one farmer was at risk for hand dermal contact to Chlorpyrifos, whereas all farmers were at risk to hand dermal contact to Profenofos. It is within expectation as the dermal absorption of Profenofos is 50% versus 3% for Chlorpyrifos. However, when the farmers applied both pesticides, they are all at risk to the mixtures of these two pesticides. Since the sample size is very small, binary regression analysis cannot be carried out as originally proposed. By the same token, since all 14 farmers are all at risk from Chlorpyrifos and Profenofos hand dermal contact, test of association cannot performed either. In view fo f these, the hazard of indices with repect to the farmers' pesticide exposure years and working patterns are briefly discussed. The hazard indices obtained are shown in figure 13,

and the farmers‘ working durations are tabulated in table 14.

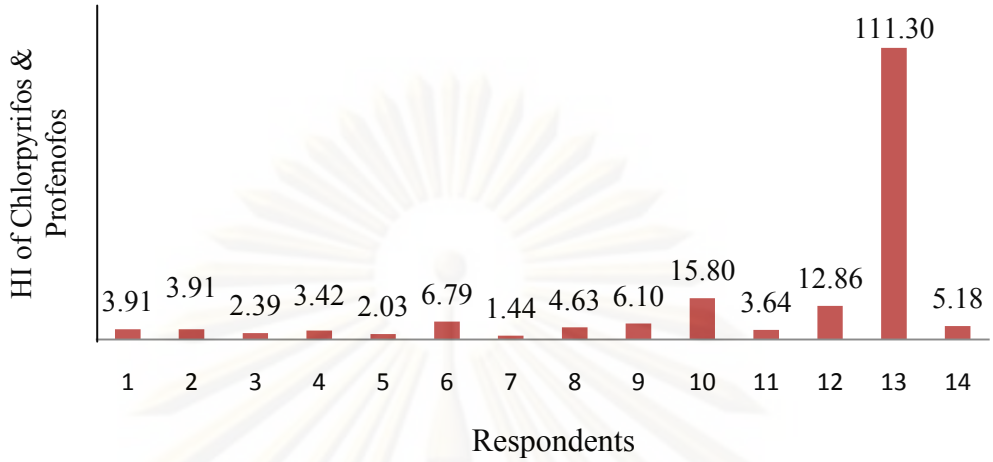


Figure 13: HIs of Chlorpyrifos and Profenofos.

Table 14: Working characteristics of the 14 respondents

Farmers	1 (s)	2 (s)	3	4	5 (s)	6 (s)	7	8 (e)	9	***10***	***11***	12	***13***	14 (e)
Age(year)	33	30	29	40	57	54	45	43	55	57	-	62	61	47
Exposure years	6	1	5	10	30	10	5	4	30	15	10	40	50	20
Workday/ week	5	2	7	4	2	5	5	4	5	7	4	7	7	5
Working hours/day	2	6	5	3	2	1	1	4	1	3	1	2	5	3

Annotations: Bold and *Italic*: femeles Filled: farmers who did not mix pesticides

(s): smokers (e): ex-smokers

From the interviews, subject 13 had the longest exposure duration of 50 years, and she worked 5 days a week, 5 hours a day. Farmer 12 had 40 years of pesticide, but his HI is less than farmer 10 who had 15 years of exposure duration. They both worked 7 days a week, but subject 10 (female, 57 years old) worked 3 hours a day, while subject 12 only worked 2 hours a day. Moreover, farmer 2 had the shortest duration of only 1 year of pesticide exposure, but his HI was higher than several other farmers. Strikingly, farmer 2 tied with subject 1 who had 6 years of pesticide exposure. However, subject 1 worked 5 days a week, and 2 hours a day, while subject 2 worked 2 days a week, but 6 hours a day. Subject 7 had the lowest HI; he had 5 years of exposure years, 5 working days a week, and only worked 1 hour a day. In

fact, subject 7 did not mix pesticides. As a matter of fact, 5 subjects (number 5, 6, 7, 9, and 11) responded that they did not mix pesticides, but not all of them had lower HIs compared to those who mixed pesticides. Since there is no loading, it means the 5 subjects only sprayed pesticides, and the rest of the 9 subjects either only mixed or worked by both mixing and spraying. More detailed interviews should have been done to identy farmers who mixed and farmers who both mixed and sprayed pesticides. In brief, risk was found to be highly variable with exposure all in terms of years, weeks and hours, as well as the farmers' job classes. From the data of the two female farmers, female farmers would be more susceptible to risk of Chlorpyrifos and Profenofos. Smoking status and individual's well being would be important factors as well.

4.4.4 Concentration analysis

Accurate detection of pesticides from hand-wipes requires efficient extraction, separation, and detection. Accuracy always starts from the first step -- efficient pesticide extraction. The sample clean up and extraction process in this study utilized a _modified' 2-step QuEChERs method. QuEChERs stand for Quick, Easy, Cheap, Effective, Rugged and Safe. The technique was developed by Anastassiades basically for extracting pesticides from food (Anastassiades, 2003). The method is accepted by USDA (US Department of Agriculture). The food samples are usually homogenized using a blender or a mortar and testle. Since the sample is homogenized, typically a small amount of sample is required for extraction. Addition of magnesium sulfate serves to salt out (remove) water from the sample to induce phase separation between water and acetonitrile with the pesticides of interest being extracted into the organic (acetonitrile) phase. The extraction step is followed by a dispersive solid phase extraction. In this step, a primary secondary amine is added to remove fatty acids, organic acids, and anthocyanine pigments from the food samples. To use this method in extracting pesticides from gauze pads, it is difficult to envision the 1 g of gauze sample as homogenized, and the addition of a primary secondary amine seems not necessary. Addition of extra chemical may even introduce interference in subsequent separation and detection steps.

CHAPTER V
CONCLUSION, CONTRIBUTION, LIMITATION, RECOMMENDATION, AND FUTURE STUDY

5.1 Conclusion

Observations and interviews of the 29 respondents at the Rangsit Agricultural Area revealed some of the general characteristics of the rice farmers in the community. The majority of them were in the age ranges of 51 to 60, and 41 to 50. More than half of them had education level of Pratron grade 5 or 6. They either grew rice by themselves or hired someone to grow rice or both. The community is a pesticide intensive area. The mean working years of the respondents was 19.2 years, mean frequency use of pesticide was 1.52 times per day, the mean working hours per day was 3.29 hours**,** and the mean working days was 4.45 days per week. Neurological signs and symptoms that could be related to organophosphate pesticides existed among the community. The respondents generally could not identify the names of the pesticides which could cause their symptoms. The majority of them were not smokers. The most common pesticides used by the 29 respondents were Chlorpyrifos followed by Dicroptophos and Quinalphos. Two subjects reported that they first personally used Chlorpyrifos more than 20 years ago. Peer influence or peer norm was an important factor in pesticide purchasing. Interestingly, none of the respondents reported that they followed the suggestion from neighbors in mixing pesticides. Water was the most common solvent in mixing pesticides, and fertilizers, hormones, other pesticides and fungicides were often added in their mixing practices. When mixing pesticides, they tended to mix more than the instructions called for. When the previous pesticide application was ineffective, they tended to change to new ones, or, quite often, they mixed higher dosages of pesticides. When they sprayed, the majority sprayed banded instead of furrow. After application of pesticides, they typically washed themselves at the end of the day. Some of them washed their hands and/or arms only after mixing, and washed themselves completely after spraying. This information indicated that some respondents had the knowledge that mixing was more risky than spraying. None of the 29 participants wore gloves on the days of data

collection, although some of them reported wearing plastic gloves. All of them wore long-sleeved shirts and long pants; however, most had bare feet. Their ideas of —protective equipment" were cloth face protection, hats, or cloth coveralls. All in all, the surveyed farmers used at least one type of hazardous pesticides; often mixed more pesticides than recommended in each spray and even more if the previous application was ineffective, which shows that the sampled farmers are of particular concern since they were experiencing extensive potential exposure to harmful pesticides.

Risk assessment was determined on the 14 respondents who sprayed Chlorpyrifos and Profenofos. By using the dermal absorption factor method, which was tested to reflect the dermal absorption more realistically compared to the dermal absorption rate method, it was found they only one subject (HQ >1) was at risk with hand dermal contact with Chlorpyrifos, while all of the subjects (all HQs >1) were at risk with hand dermal contact with Profenofos. The trend of the HQ results agreed with Jaipieam's findings in a similar study of hand dermal risk assessment which studied risk assessment on both dry and wet seasons (Jaipieam, 2008). As compare with Jaipieam's study, since the paddy fields at the Rangsit Agricultural Area are adjacent to the Klong 7 with its own irrigation system, rice crops do not depend upon seasonal effects too much as those vegetable fields in the Bang Rieng Area. However, if this study were to be studied in wet season, higher HQs would be expected as hotter and wetter climate may increase pest growth. As a summation, the sampled farmers were at risk of hand contamination with the mixture of Chlorpyrifos and Profenofos. Qualitative analysis demonstrated that risk was found to be highly variable with exposure all in terms of farmers' years of exposure, weeks and hours of work, as well as the farmers' job classes. Smoking status, gender, and general well beings of individuals might be contributing factors as well.

5.2 Contribution of the study

This study provided a small scale investigation of the characterization of farmers in their intensive usage of pesticides, as well as a risk assessment of two common organophosphate pesticide skin exposures through the hands among some of the rice farmers in Rangsit Agricultural Area. This information can be added to the existing literature. Thus it is useful for risk management and risk communication in the Rangsit community. The information might be further useful for local and

national government relevant to rice farmer health risks. In addition, the results obtained from this study could be discussed at both community and individual (particularly farmer 13) levels and used to provide information on occupational health indicators and provide recommendations such as methods to reduce exposure. Findings of the study could be used in formulating strategies concerning pesticide use, including promoting Integrated Pest Management (IPM) approach in agriculture. These finding could also be used to design behavioral intervention programs to assist farmers in protecting themselves from unwanted health effects. Findings of the study also provide baseline information for researchers who wish to pursue further epidemiological studies on effects of pesticides on women farmers.

5.3 Limitation

Several limitations in the study should be noted. In this study, due to budget and time constraints, availability of farmers, farmers‘ spraying schedules and schedules of interviewers, a small sample size of only 29 subjects was recruited for interviews, and only 14 hand-wipe samples from subjects who sprayed Chlorpyrifos and Profenofos were studied for risk assessment calculations. Despite my proposed stratified random sampling from all neighborhoods (moos) of the community, the subjects were selected from several moos as best as the village headman could find. It remains possible that residual confounding from unidentified sources could have occurred. A large enough sample of applicators was not available for analysis resulting in statistical power restriction. As a consequence, the findings from this study might not be generalized to other communities. In addition, a small sample size renders binary regression and association studies of risk and independent variables impossible; links cannot be established with the limited data set. Notably, this study only looks at hands, which is a very small percentage of dermal exposure. Moreover, this is a one-time study, it cannot address daily variation. To continue, the rice farmers may be acutely aware that performance is under scrutiny thus their behavior is not likely to be typical, which may contribute to observational bias. For instance, the 15 subjects sprayed Abamectin on the first day of data collection. However, in the interviews about pesticides usage, only 4 of them named Abamectin. Furthermore, due to limited timeframe, samples were sent to the Central laboratory, resulted in the inability to validate a new method. Besides, apart from concentration uncertainty, limitation of

detection and quantitation, the recoveries from extraction and GC, linear range, reproducibility, and method detection limit were not reported by the time the thesis was written. Consequentially, error analysis could not be performed. Thus, the quality of the HQ results calculated could only be as good as the quality of the concentrations of Chlorpyrifos and Profenofos could get. Also, the researcher‘s questionnaire should have been improved to investigate more on the job classes of the farmers and to provide more open ended questions and fixed wordings to understand the community better and to reduce interviewers‘ bias. Finally, the interviewers were not professional interviewers by training, bias may occur in conducting interview questionnaire, and missing data existed.

5.4 Recommendation and suggestions

Reducing pesticide exposure in farm workers remains a significant challenge to occupational health. Family farms are often isolated workplaces with only a few workers, which make health and safety outreach, monitoring, and enforcement especially difficult. Since periodic monitoring or site visits remain infeasible, use of long-sleeve shirts, long pants, and shoes plus socks are assumed for all applicators and are not counted as separate gear items. Depending on the chemical, other required gear may have included chemical resistant gloves, footwear, and apron, protective eyewear; and /or approved respirator. Responsibility for safe handling is left to the applicator Therefore, the approaches necessary to minimize hazardous exposures should include more targeted community level public health initiatives which include education and training. For instance, educational intervention to increase personal protective equipment use and reduce direct pesticide exposure hazards in the community. Farm pesticide-safety interventions should be designed to include multiple sessions, with knowledge of pesticide-associated health risk, epidemiologic data illustrated with slides to demonstrate how pesticide contact the body during the use of different levels of protective equipment, the importance of preventing pesticides from entering the body through inhalation, absorption, and ingestion should be emphasized. The non-carcinogenic effects of Chlorpyrifos and Profenofos, such as weakness, chest tightness, nausea and vomiting, abdominal cramps, tremor, and salivation should be discussed. Since peer norm is common in the community in dealing with unfamiliar information, A respected farmer from the

area, identified through nomination would be asked to speak to the group on how he/she had incorporated safe handling into his pesticide application routines to endorse the desired behavioral change would exercise peer influence directly to encourage behavioral change among the peer group. In addition, self training to increase self-efficacy beliefs would be helpful, as time is spent to demonstrate the proper use of protective gear and safe handling to how applicators can make minor adjustments in their applications routines to easily incorporate these practices. To render protective equipment handy, placing an extra set of plastic apron, or extra pairs of rubber gloves in several places such as in the barn, tractor, or in a storage box in the field for easy access are recommended. Similarly, each of the participants should be given the opportunity to experiment with the protective equipment. This includes practicing a brief check to make sure that all parts of the body are covered, and timing each other to illustrate how one can gear up properly in only a few minutes. The objective of this component is to give applicators time to acquire the skills necessary to practice safe handling procedures. Training should be in boosters to ensure maintenance of behavioral changes over time.

Having said that, one argument of this study is that they are at risk possibly not because they are not aware of adverse health effects of pesticides or they are careless, but are constrained not only by their access to accurate knowledge, but also and more importantly by other conditions such as social, cultural and economic conditions that sometimes beyond their control. Policies and education programs that do not consider these factors would fail to assist farmers in protecting themselves from harmful effects of pesticides. Specifically, policies that only focus on regulating overuse of pesticides without paying due attention to supporting farmers in improving their economic conditions, either through improving rice productivity or other means, would fail. Without addressing the underlying conditions, the farmers would resort to pesticides—the only mean available to them, despite their awareness of its unwanted effects—to achieve what are more important to them than their own health.

For extraction steps, less is more. Simple one step liquid extraction aided by sonication is preferred to multi-step extraction. If conditions permit, accelerated solvent extraction is most preferably for solid environmental sample matrices. Besides, ethylacetate is more environmentally than acetonitrile. Of major interest,

environmental researches often appeal to authority like USEPA reference guidelines. Although environmental regulations in the United States are primarily written by the Federal government, the authority to implement and monitor compliance with the regulations is retained by the individual states, referred to as primacy. Recognizing the need for controlling the quality of environmental data being generated, in the late 1990, EPA formed a committee known as the National Environmental Laboratory Accreditation Conference (NELAC) to promote mutually acceptable performance standards for the operation of environmental laboratories (EPA, 2007). Prior to NELAC, the existing state programs varied widely in scope and requirements. Some states had only agriculture, or only drinking water laboratory accreditations, while a few had accredited laboratories for wastewater, air, and solid and hazardous waste. Quality control is not the whole answer to assuring acceptable data quality. NELAC specifies a standardized quality system, which includes requirements for management qualifications, documentation of policies and procedures, calibration and maintenance of equipment, quality control, qualifications and training of personnel, maintaining sample integrity, management of audit findings, corrective actions, customer complaints, records, supplies and subcontracting, and review of the entire system by management to ensure that it is performing as expected. The burden of proof of the applicability and quality of testing lies primarily with the laboratory. NELAC is building a foundation to ensure that future environmental data are traceable, reproducible, and of known quality. This will facilitate interpretation of results, and will minimize the risk of making decisions based on data of doubtful authenticity. At present, NELAC is working toward all 50 states for this accreditation. With the potential of developing an excellent scientific program in Thailand, improvement and standardization in environmental analysis is recommended in this direction.

5.5 Future Studies

Although risk assessments have been reported in other studies on agricultural workers in Thailand, this study focuses on understanding and assessment of the risk of Chlorpyrifos and Profenofos dermal contamination of the rice farmers in the Rangsit Agricultural Area in central Thailand. In future studies, a larger sample size of rice farmers should be recruited in order to expand our understanding in the multi-independent variables relationship of the risk. Also, intervention of personal

protection equipment use and its outcomes could be beneficial and meaningful studies to carry out. Furthermore, study on the multi-route exposure such as inhalation and consumption of Chlorpyrifos and Profenofos may provide more comprehensive evaluation of potential risk associated with the rice farmers‘ exposures to these two Organophosphates. In addition, cost effective analysis on the rice farmers in the community would also be a very interesting research to approach and help the respondents. Furthermore, current research studies focus mainly in male farmers, more research data on women pesticide applicators at both national and regional levels are yet to be collected to raise community awareness, and on further epidemiological studies on reproductive health effects of pesticide exposure. Above all, method and researches are absolutely required to close many gaps in exposure measures to provide a reliable and unified database for the purpose of meaningful risk evaluation and policy making.

REFERENCES

English

Anastassiades, M., Lehotay, S.J., Stajnbaher, D., and Schenck, F.J. (2003). Fast and Easy Multiresidue Method Employing Acetonitrile Extraction/ Partitioning and –Dispersive Solid Phase Extraction" for the Determination Of Pesticides Residues in Produce. Journal of Accociation of Analytical Community International. 86(22): 412-431.

AOAC. (2003). Validation: An Invisible Component Measurement. Available from: http://aoac.org/dietsupp6/DietarySupple. [2009, November 6]

Arcury, T.A., Quant, S.A., Barr, D.B., Hoppin, J.A., McVauley, L., Gzywacz, J.G., and Robson, M.G., et al (2006). Farm Worker Exposure to Pesticides: Methodologic Issues for the Collection of Comparative Data. Environmental Health Perspective. 114 (6): 923-928.

Alavanja, M.C.R. (1996). Farmer Applicator Questionnaire Coded Manual: Agricultural health Study OMB # 0925-0406). Washington DC: National Institute of Health, USA.

ATSDR. (2009). ATSDR Toxicological Profiles. In Agency for Toxic Substances and Disease Registry. Available from: http://www.atsdr.cdc.gov/toxpro2.html. [2009, October 8]

Azarroff, L.S., Neas, L.M. (1999). Acute Health Effects Associated with Nonoccupational Exposure in El Salvador. Environmental Research. 80: 158-164.

Barr, D.B. , Chief, Pesticide Laboratory, National Center for Environmental Health, Center for Disease Control and Prevention, USA. Interview on 13 October 2009.

Bierman, E.P.B., Brouwer, D.H., Van Hemmen, J.J. (1998). Implementation and Evaluation of the Fluorescent Tracer Technique in Greenhouse Exposure Studies. Annals of Occupational Hygiene. 42: 467-475.

Bravo, R., Driskell, W.J., Whitehead, R.J., Needham, L.L., Barr, D.B. (2002). Quantification of Dialkyl Phosphate Metabolites or Organophosphate Pesticides in Human Urine Using GC-MS-MS with Isotopic Standards. Journal of Analytical Toxicology. 26: 245-252.

Costa, L.G. (2006). Current Issues in Organophosphate Toxicology. Clinical.Chimica Acta. 366(1-2): 1-13.

De Silver, H.J., Samarawickrema, N.A., Wickremasinghe, A.R. (2006). Toxicity Due

To Organophosphorus Compounds: What about Chronic Exposure? Transaction of the Royal Society of Tropical Medicine and Hygiene. 100: 803-806.

Dosemeci, M., Alavanja, M.C.R. (2002). A Quantitative Approach for Estimating Exposure to Pesticides in the Agricultural Health Study. Annals of Occuptional Hygiene. 46(2): 245-260.

Duggan, A., Chamley, G. (2003). Di-alkyl Phosphate Monitoring Data: Assessing Cumulative Exposure to Organophosphate Pesticides. Regulatory Toxicology And Pharmacology. 37: 382-395.

Durham, W.F., Wolfe, H. R. (1962). Measurement of the Exposure of Workers to Pesticides. Bulletin of World Health Organization. 26: 75-91.

EPA. (1986). Guidelines for the Health Risk Assessment of Chemical Structures. Fed Reg 51(185): 34014-34025. Washington, DC: USEPA Office of Research and Development.

EPA. (1992). Guidelines for Exposure Assessment. In Federal Regulation Series. Available from: http://epa.gov/osa/raf/publications/ pdfs/GUIDELINES_EXPOSURE_ASSESSMENT.pdf. [2009, October 17]

EPA. (1996). Proposed Guidelines for Carcinogen Risk Assessment. (Report Number 600/P-92/003C). Washington, DC: USEPA Office of Research and Development.

EPA. (1997). Chapter 6 in Dermal Exposure. In Exposure Factors Handbook. Available from: http://cfpub.epa.gov.ncea..cfm.recordisplay.cfm. [2009, November 9]

EPA. (1998). Profenofos (PC Code 111401). FQPA Update of the HED Chapter of the Reregistration Eligibility Decision Document.Case No. 2540. Washington. DC: US EPA, Office of Pesticide Programs.

EPA. (1999. Chlorpyrifos**:** HED Preliminary Risk Assessment for the Reregistration Eligibility Decision (RED) Document. Chemical No. 059101. Barcode: D260163. Washington. DC: US EPA, Office of Pesticide Programs.

EPA. (2000). Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures. Available from: http://www.epa.gov/raf/publications/sub-guidance/hra-chem-mix.htm. [2009, October 10]

EPA. (2007). National Environmental Laboratory Accreditation Conference. Available from: http://www/epa/gov/NELAC. [2009, December 25]

EPA. (2009). The Integrated Risk Information System (IRIS) Prepared and maintained by The EPA's National Center for Environmental Assessment. Available from: http://www.epa.gov/NCEA/iris/Index.html. [2009, December 25]

EXTOXNET. (1996). Extension Toxicology Network Pesticide Information Profile maintained and archived at Oregon State University. Available from: http://extoxnet,orst.edu/pips/abanectin.htm. [2010, March 15]

Fenske, R.A.(1988). Visual Scoring System for Fluorescent Tracer Evaluation of Dermal Exposure to pesticides. Bulletin of Environmental Contamination and Toxicology. 41: 727-736.

Fenske, R.A. (2000). Dermal Exposure: A decade of Real Progress. Annals of Occupational Hygiene. 44: 489-492.

Fenske, R.A., Leffingwell, J.T., Spear, R.C. (1985). Evaluation of Fluorescent Tracer Methodology for Dermal Exposure Assessment in Dermal Exposure Related to Pesticide Use. In Honeycutt, R.C., Zweig, G., Ragsdale, N.N (Eds). American Chemical Society Symposium Series. (pp.377-393). Washington DC: American Chemical Society.

Fenske, R.A., Leffingwell, J.T., Spear, R.C., Wong, S.M. (1986). A Video Imaging Technique for Assessing Dermal Exposure-Fluorescent Tracer. American Indian Hygiene Association Journal. 47: 771-775.

Fenske, R.A., Schulter, C., Lu, C.m Ellen, E.H. (1998). Incomplete Removal of the Pesticide Captan from Skin by Standard Handwash Exposure Assessment Procedures. Bulletin of Environmental Contamination and Toxicology. 67: 194-201.

Franklin, C.A., Fenske, R.A., Greenhalgh, R., Mathieu, L., Denley, H.V., Leffingwell, J.T., and Spear, R.C., et al. (1981). Correlation of Urinary Pesticide Metabolite Excretion with Estimated Dermal Contact in the Course of Occupational Exposure to Guthion. Journal of Toxicology and Environmental health. 7: 715-731.

Franklin, C.A., Muir, N.I., Moody, R.P. (1986). The Use of Biological Monitoring in Estimation of Exposure During Application of Pesticides. Toxicology Letter. 33: 127-136.

Franklin, C.A., Worgan, J.P. (Eds). (2005). Occupational and Residential Exposure Assessment for Pesticides. West Sussex: John Wiley & Sons.

Gallo, M.A., Lawryk, N.J. 1991. Organic Phosphorus Pesticides. In Hayes, W.J., and Raws, E.R. (Eds). Handbook of Pesticide Toxicology Volume 2: Classes of Pesticides, pp.917-1091. California: Academic Press.

Geer, L.A., Cardello, N., Dellarco, M.J., Leighton, T.J., Zendzian, R.P., Roberts, J.D., and Buckley, T.J. et al. (2004). Comparative Analysis of Passive Dosimetry biomonitoring for Assessing Chlorpyrifos Exposure in pesticide Workers. Annals of Occupational Hygiene. 48(8): 683-695.

Geno, P.W., Camann D.E., Harding H.J., Villalobos, K., Lewis, R.G. (1996) Handwipe Sampling and Analysis Procedure for the Measurement of Dermal Contact with Pesticides. Archives of Environmental and Toxicology. 30: 132-138.

Griffin, P., Mason, H., Heywood, K., Cocker, J. (1999). Oral and Dermal Absorption of Chlorpyrifos: a Human Volunteer Study. Occupational Environmental Medicine. 56: 10-13.

Gupta, R.C. (2006). Toxicology of Organophosphate and Carbamate Compounds. New York: Elsevier Inc.

Hirai, Y., Tomokini, K. (1993). Levels of Chlordane, Oxychlordane, and Nonachlor on Human Skin and in Human Blood. Bulletin of Environmental Contamination and Toxicology. 50: 316-324.

Jaipieam, S. (2008). Risk Assessment of Multi-Route Exposure to Organophosphate Pesticide of Vegetable Growers (A Case Study at Bang Reing Sub- District, Khuan Nieng District, Songkla Province). Ph.D. Dissertation, College of Environmental Management, Chulalongkorn University.

Kushik, J., Chandrabhan, D. (2003). Sources of Exposure and Public Health Implications of Organophosphate Pesticides. PAHO Pan American Jouranl of Public Health. 14(3): 171-185.

Lopez, L., Blanco, L. (2009). Insecticide Residues on Hands: Assessment and Modeling with Video Observations of Determinants of Exposure – A Study among Subsistence Farmers in Nicaragua. Journal of Occupational and Environmental Hygiene. 6: 157-164.

Lu, C., Fenske, R.A. (1999). Dermal Transfer if Chlorpyrifos Residues from Residential Surfaces: Comparision of Hand Press, Hand Drag, and Polyurethane Foam Roller Measurements after Broadcast and Aerosol Pesticide Applications. Environmental Health Perspectives. 107(6): 463-467.

Nolen, R.J., Rick, D.L., Freshour, N.L., Saunders, J.H. (1984). Chlorpyrifos: Pharmacokinetics in Human Volunteers. Toxicology Applied Pharmacology. 73: 8-15.

O'Neil, M.J., Smith A. (Eds). (2001). The Merck Index, an Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station: Merck & CO., Inc.

Patchuay, C., Visuthismajarn, P., Vitayavirasak, B., Hore, P., Robson, M. G. (2006). Biological Monitoring of Organophosphate Pesticides in Preschool Children in an Agricultural Community in Thailand. International Journal of Occupational and Environmental Health. 12: 133-141.

Pohl, C. (2002). Determination of Pesticides in Large-Volume Food Samples Using Acceleration Solvent Extraction. (Application Note 343). Sunnyvale: Dionex Corporation.

Quandt, S.A., Arcury, T.A., Rao, P. (2004). Agricultural and Residential in Wipe Samples from Farmworker Residences in North Carolina and Virginia.

Robson, M.G., Toscano, W.A. (Eds). (2007). Risk Assessment for Environmental Health. San Francisco: Jossey-Bass, A Wiley Imprint.
Environmental Health Perspectives. 112(3): 382-387.

Sartorelli, P. (2002) Dermal Exposure Assessment in Occupational Medicine. Occupational Medicine. 52(3): 151-156.

Satoh, T. (2006). In Global Epidiomology of Organophosphate and Carbamate Poisonings. Toxicology of Organophosphate and Carbamate Compounds (pp.647-660). New York: Elsevier Inc.

Semple, S. (2004). Dermal Exposure to Chemicals in the Workplace: Just How Important is Skin Absorption? Occupational Environmental Medicine. 61: 376-382.

Siriwong, W. (2009). Lecture Figure in Environmental Risk Assessment Course. College of Public Health Sciences, Chulalongkorn University Bangkok, Thailand, 12, October 2009.

Siriwong, W., Thirakhupt, K., Sitticharoenchai, D, Borjan, M., Keithmaleesatti, S., Burger, J., and Robson, M. et al.(2009). Risk Assessment for Dermal Exposure of Organochlorine pesticides for Local Fishermen in the Rangsit Agricultural Area, central Thailand. Human and Ecological Risk Assessment. 15: 636-646.

Siriwong, W., Sitticharoenchai, D., Robson, M., Borjan, M., and Thirakhupt K.P. (2008). Organochlorine Pesticide Residues in APlankton, Rangsit Agricultural Area, Central Thailand. Bulletin of Environmental Contamination and Toxicology. 81(6): 608-612.

Skoog, D.A., Leary, J.J. (1992). Principles of Instrumental Analysis. New York: Saunders College Publishing.

Soutar, A., Semple, S., Aitken, R. (2000). Use of Patches and Whole Body Sampling For the Assessment of dermal Exposure. Annals of Occupational Hygiene. 44:

511-518.

Stallones, L., and Beseler, C. (2002). Pesticide Illness, Farm Practices, and Neurological Symptoms among Farm Residents in Colorado. Environmental Research section A. 90: 89-97.

Teschke, K., Marion, S.A., Fenske, R.A. (1994). Strategies for Determining Occupational Exposures in Risk Assessment: A Review and a Proposal for Fungicide Exposures in the Lumber Industry. American Indian Hygiene Association. 55: 443-449.

Tirado R., Englande, A.j., Promakasikorn, L., and Novotny, V. (2008). Use of Agrochemicals in Thailand and its Consequences for the Environment. (Technical Note 03/2008). Exeter: Greenpeace Research Laboratories.

Vermeulen, R., Stewart, P., Kromhout, H. (2002). Dermal Exposure Assessment in Occupational Epidemiologic Research. Scandinavian Journal Work of Environmental Health. 28: 371-385.

Zamroni. (2006). Thailand‘s Agricultural Sector and Free Trade Agreement. Asia Pacific Trade and Investment Review. 2(2): 51-69.

APPENDICES

APPENDIX A

Questionnaire (English Version)

Survey Objective: This project helps to assess if you are likely to suffer ill health effects from long term organophosphate pesticide spraying.

Information to read to respondent:

This study will provide investigation results of organophosphate pesticide skin exposure through the hands among rice farmers in Rangsit Agricultural Area. This information can be added to the existing Thai Farmer database. Thus it is useful for risk management and risk communication in the Rangsit community. The information can be further useful for local and national government relevant to rice farmer health risks. In addition, the results obtained from this study will be discussed with the community and used to provide information on occupational health indicators and provide recommendations such as methods to reduce exposure. Participation in the study is voluntary and the participant has the **right to deny** and/or **withdraw** from the study at any time.

For Office Use only:

Interviewer‘s name _____

Date _____

Farmer‘s code _____

Part I General Information

1. Name _____ Surname _____
   Address _____Moo _____ Klong 7, Rangsit Agricultural Area
2. Gender Male □ Female □
3. Age _____ years old
4. What is the highest schooling you have completed? (Check only one item)
   1. □ No formal education
   2. □ Had education, but not above Pratom Grade 4
   3. □ Pratom grade 5 or 6
   4. □ Matayom 1-3 or Matayom Seuksa 1-3

5. □ Matayom 4-6 or Matayom Seuksa 4-6
6. □ Certificate / Diploma
7. □Bachelor or Higher Degree

5. How many years have you applied pesticides in the farm?

   _____ years

6. How many times do you use pesticides in a day?

   _____time(s)/day

   Working hours in the farm

   _____ hours/day

   Working day in the farm

   _____days/week

7. How many members in your family (including you) are farmers?

   _____ person(s)

8. Present working characteristics (can check more than one)

   □ Grow rice by yourself

   □ Hire other person(s) to grow rice

   □ Employee in rice growing

9. Last year, how many rais were planted on the farm(s) where you worked (whether or not you owned the farm)?

   □ _____rais

Part II General Health Information

1. How tall are you? _____ cm
2. How much do you weigh now? _____ Kg

3. During the last 12 months have you experienced the following while and/or after applying pesticide?

Symptoms	Never	Almost never	During using	Shortly after use(within 24 hours after application)	When not using
Dizziness					
Nausea/vomiting					
Abdominal cramp					
Blurred vision					
Tearing					
Numbness or pins-and needles in your hands or feet					
Weakness in your arms or legs					
Involuntary twitches or jerks, in your arms or legs					
Chest pain					
Difficulty of breathing					

4. Do you know what causes those signs and symptoms?

   Yes □ No □

5. Do any of these symptoms seem to get worse after smelling chemical odors from pesticides, paint, perfume, or exhaust?

   Yes) □ No □

6. If you experience those symptoms, or those symptoms seem to get worse, after smelling odors from pesticides, do you know the names of such pesticides?

   Yes □ No □

Part III Pesticide Use, Exposure Information, and Work Practices

1. What instrument(s) and application method(s) do you generally use when you apply pesticides? (can check more than one).

   □ Don't usually apply pesticides

   □ Boom on tractor, truck, or trailer

   □ Hand spray gun

   □ Backpack sprayer

   □ Mist blower/fogger

   Others _____

   When you spray, you spray in furrow □ banded □

2. Who would you listen to when you decide to purchase pesticide? (check only one choice).

   □ Neighbor

   □ Agricultural officer

   □ Shopkeeper's advice

   □ Advertisement

   □ Sales representative

3. When you personally mix pesticides, what additives do you generally use? If possible, please name the additive(s) when answer is yes.

   Don't mix pesticides □

   Don't usually use additives □

   Solvents Yes □ _____ No □

Water Yes □ No □

Fertilizer Yes □ _____ No □

Other Pesticides

Yes □ _____No □

Surfactants, crop oil concentrates

Yes □ _____No □

4. How do you usually mix the pesticides? (check only one choice).

□ Follow the instruction

□ Mix more than the instruction

□ Follow suggestion in the neighborhood

□ Same technique for all brands

□ Depends on type (mix more than one type of pesticides)

5. What type of protective equipment do you usually use when you personally handle pesticides? (can check more than one).

□ Never use protective equipment

□ Cartridge respirator, gas mask

□ Dust mask

□ Cloth protecting face

□ Hat

□ Goggles

□ Chemically resistant gloves e.g., neoprene or nitrile gloves

□ Fabric/leather gloves

□ Apron (cloth □ plastic □)

□ Rubber boots

□ Cloth coveralls

□ Others Please describe briefly

_____

6. When mixing or applying pesticides, how long do you usually work with the same pair of gloves before exchanging them for a new set? (check only one choice)

□ Don't wear gloves

□ Change each time

□ Change at least once per month

□ Change 1 to 4 times per season

□ Don't change gloves until they are worn out

7. When do you spray pesticides? (can check more than one)

□ Early morning

□ At noon

□ Late afternoon

□ Depends on sprayer

_____

8. If you finish mixing and/or applying pesticides in the morning, when do you usually wash yourself?

□ Hands/arms only right away

□ Complete bath/shower right away

□ Complete bath/shower at lunch

□ Hands/arms only at end of day

□ Complete bath/shower at end of day

□ Other _____

9. If your last pesticide application is ineffective, what would you do with the first pest control? (check only one choice).

□ Change to new one

□ Mix higher dosage pesticides

□ Mix more than one type of pesticides

□ Spray again with the same concentration

□ Do nothing

□ Other _____

10. Do you smoke?

□ Yes, _____cigarettes/day

□ No

□ Ex-smoker

11. Do you smoke while you are working in the farm?

□ Usually

□ Sometimes

□ Rarely

□ Never

12. Do you eat your meals in the field?

□ Usually

□ Sometimes

□ Rarely

□ Never

13. For the following pesticides, first answer question in Column A. If you answered ~~"y~~es" then answer the questions in Column B, C and D for that pesticide. If you answered ~~"N~~o" then go to the next pesticide. Be sure to answer Column A (~~"Y~~es" or ~~"N~~o") for each pesticide listed.

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Dicrotophos (Bicron)	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Chlorypyrifos (AV ban)	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Phenthoate (Dasan)	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Triazophos (Cover)	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Qunalphos	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Name of Pesticide	A. Have you ever personally mixed or applied this pesticide?	B. How many years did you personally mix or apply this pesticide?	C. In an average year when you personally used this pesticide, how many days did you use it?	D. When did you *first* personally use this pesticide?
Others Name of pesticide _____	Yes □ No □	□ 1 year or less □ 2-5 years □ 6-10 years □ 11-20 years □More than 20 years	□ Less than 5 days □ 5-9 days □ 10-19 days □ 20-39 days □ 40-59 days □ 60-150 days □ More than 150 days	□ Before 1960 □ In the 1960s □ In the 1970s □In the 1980s □ In the 1990s □ In the 2000s □ Mark here if you used this pesticide last year

Questionnaire (Thai Version)

For Office Use only:

Interviewer‘s name _____

Date _____

Farmer‘s code _____

Part I ส่วนที่ 1 ข้อมูลทั่วไป

1. (ชื่อ) _____ (นามสกุล)_____

   (ที่อยู่) _____ (หมู่ที่) _____ (คลอง 7 พื้นที่เกษตรกรรมรังสิต)

2. (เพศ) (ชาย) □ (หญิง) □

3. (อายุ) _____ (ปี)

4. การศึกษาสูงสุดของท่าน คือ (โปรดเลือกเพียง 1 ข้อ)

   1. □ (ไม่ได้เรียน)
   2. □ (ต่ำกว่าชั้น ป. 4)
   3. □ (จบชั้น ป. 6)
   4. □ (จบชั้น ม. 3)
   5. □ (จบชั้น ม. 6)
   6. □ (ประกาศนียบัตร)
   7. □ (ปริญญาตรี หรือ สูงกว่า)

5. ท่านใช้สารกำจัดศัตรูพืชในนามากี่ปี

   _____ (ปี)

6. ท่านใช้สารกำจัดศัตรูพืชกี่ครั้งใน 1 วัน

   _____ (ครั้ง/วัน)

   ท่านทำงานในนากี่ ช.ม./วัน

   _____ (ช.ม./วัน)

   ท่านทำงานในนากี่วัน/สัปดาห์

   _____ (วัน/สัปดาห์)

7. ท่านมีสมาชิกกี่คนในครอบครัวที่เป็นชาวนา (รวมท่านด้วย)

_____ (คน)

8. ปัจจุบันท่านทำนาอย่างไร (เลือกได้มากกว่า 1 ข้อ)

□ (ปลูกข้าวด้วยตัวเอง)

□ (จ้างคนปลูกข้าว)

□ (ใช้คนงานในนา)

9. เมื่อปีที่ผ่านมาท่านทำนากี่ไร่โดยประมาณ (ไม่ว่าจะเป็นนาของท่านเองหรือไม่)

□ _____ (ไร่)

Part II ส่วนที่ 2 ข้อมูลด้านสุขภาพ

1. (ท่านสูงเท่าใด)_____ (เซนติเมตร)

2. (ท่านหนักเท่าใด)_____ (กิโลกรัม)

3. ในปีที่ผ่านมาท่านมีอาการดังต่อไปนี้หรือไม่

(อาการ)	(ไม่เคย)	(เหมือนจะไม่เคย)	(เคยขณะฉีดพ่น)	(เล็กน้อยหลังจากฉีดพ่นภายใน 24 ชม.)	(เคยเมื่อไม่ได้ฉีดพ่น)
(วิงเวียนศีรษะ)					
(คลื่นไส้/อาเจียน)					
(มีอาการเกร็งช่องท้อง)					
(มีอาการมองเห็นพร่ามัว)					
(มีน้ำตา)					
(มีความรู้สึกมึนงงและ					

เหมือนมีเข็มมาทิ่มแทง บริเวณมือและเท้า)					
(แขนขาอ่อนแรง)					
(แขนขากระตุก)					
(เจ็บบริเวณหน้าอก)					
(เจ็บบริเวณหายใจ ลำบาก)					

4. ท่านทราบสาเหตุของอาการต่างๆข้างต้นหรือไม่

(ทราบ) □ (ไม่ทราบ) □

5. ท่านรู้สึกว่ามีเกิดอาการผิดปกติหลังจากได้กลิ่นสารเคมี ได้แก่ สารกำจัดศัตรูพืช สี น้ำหอม กลิ่นไอเสีย

(รู้สึก) □ (ไม่รู้สึก)

6. เมื่อท่านรู้สึกว่ามีเกิดอาการผิดปกติหลังจากได้สูดดมสารกำจัดศัตรูพืช ท่านทราบชื่อของกำจัดศัตรูพืชหรือไม่

(ทราบ) □ (ไม่ทราบ) □

Part III ส่วนที่ 3 ข้อมูลการใช้สารกำจัดศัตรูพืช การได้รับสัมผัส และการปฏิบัติตน

1. ในการฉีดพ่นสารกำจัดศัตรูพืชท่านใช้วิธีใดต่อไปนี้ (เลือกได้มากกว่า 1 ข้อ)

□ (ไม่ฉีดพ่นสารกำจัดศัตรูพืช)

□ (ฉีดพ่นด้วยรถแทรกเตอร์)

□ (ฉีดพ่นด้วยเครื่องฉีดพ่นแบบมือ)

□ (ฉีดพ่นด้วยเครื่องฉีดพ่นแบบสะพายหลัง)

□ (ฉีดพ่นด้วยเครื่องฉีดพ่นแบบควัน)

(ฉีดพ่นด้วยเครื่องมือชนิดอื่น) _____

เมื่อท่านฉีดพ่น ท่านฉีดพ่นลงในร่องนา □ ฉีดพ่นเป็นแนว □

2. ท่านตัดสินใจซื้อสารกำจัดศัตรูพืชโดยคำแนะนำจากใคร (เลือกได้มากกว่า 1 ข้อ)

□ (เพื่อบ้าน)

□ (เกษตรอำเภอ/ตำบล)

□ (ผู้จำหน่าย)

□ (โฆษณา)

□ (ตัวแทนจำหน่าย)

3. ท่านผสมสารกำจัดศัตรูพืชอย่างไร(โปรดระบุชื่อหากตอบใช่)

□ (ไม่ผสมสารกำจัดศัตรูพืชเข้าด้วยกัน)

□ (ไม่ผสมสารอื่นๆ)

(ผสมตัวทำละลาย) (ใช่) □ _____ (ไม่ใช่) □

(ผสมน้ำ) (ใช่) □ (ไม่ใช่) □

(ผสมปุ๋ย) (ใช่) □ _____ (ไม่ใช่) □

(ผสมสารกำจัดศัตรูพืชตัวอื่น)

(ใช่) _____ (ไม่ใช่)

(ผสมสารลดแรงตึงผิว น้ำมัน)

(ใช่) □ _____ (ไม่ใช่) □

4. โดยปกติท่านผสมสารกำจัดศัตรูพืชอย่างไร (โปรดเลือกเพียง 1 ข้อ)

□ (ตามคำแนะนำข้างฉลาก

□ (มากกว่าคำแนะนำข้างฉลาก)

□ (ตามคำแนะนำของเพื่อนบ้าน)

□ (ผสมสารกำจัดศัตรูพืชเหมือนกันทุกชนิด)

□ (ผสมสารกำจัดศัตรูพืชหลายชนิดเข้าด้วยกัน)

5. ท่านใช้อุปกรณ์ป้องกันตัวเองในระหว่างฉีดพ่นสารกำจัดศัตรูพืชชนิดใดบ้าง (เลือกได้มากกว่า 1 ข้อ)

□ (ไม่ใช้เลย)

□ (หน้ากากแบบมีตัวกรอง)

□ (หน้ากากกันฝุ่น)

□ (ผ้าปิดหน้า)

□ (หมวก)

□ (แว่นตา)

□ (ถุงมือทนสารเคมี)

□ (ถุงมือผ้าหรือหนัง)

□ (ผ้ากันเปื้อน) (ผ้า □ พลาสติก □)

□ (รองบูธ)

□ (ใส่เสื้อผ้าปกคลุมทั้งตัว)

□ (อื่นๆโปรดระบุ)

_____

6. เมื่อท่านผสมสารกำจัดศัตรูพืช ท่านใช้ถุงมืออย่างไร (ตอบได้มากกว่า 1 ข้อ)

□ (ไม่ใส่ถุงมือ)

□ (เปลี่ยนถุงมือใหม่ทุกครั้ง)

□ (เปลี่ยนถุงมือใหม่ทุกเดือน)

□ (เปลี่ยนถุงมือใหม่ 1-4 ครั้งต่อฤดูการเพาะปลูก)

□ (เปลี่ยนถุงมือใหม่เมื่อถุงมือเดิเสื่อมสภาพ)

7. ท่านฉีดพ่นสารกำจัดศัตรูพืชเวลาใดเป็นประจำ (ตอบได้มากกว่า 1 ข้อ)

□ (เช้าตรู่)

□ (เที่ยงวัน)

□ (ตอนเย็น)

□ (ไม่แน่นอนตามความสะดวก)

_____

8. ถ้าท่านผสมสารกำจัดศัตรูพืชในตอนเช้า หลังจากผสมหรือฉีดพ่นสารท่านทำความสะอาดตัวเองอย่างไร

□ (ล้างมือและแขนโดยทันที)

□ (อาบน้ำโดยทันที)

□ (อาบน้ำตอนเที่ยง)

□ (ล้างมือและแขนในตอนเย็น)

□ (อาบน้ำตอนเย็นเมื่อเสร็จสิ้นงาน)

□ (อื่นๆโปรดระบุ)

_____

9. ถ้าการฉีดพ่นสารกำจัดศัตรูพืชไม่สามารถควบคุมแมลงศัตรูพืชได้ ท่านจะทำอย่างไร (ตอบได้มากกว่า 1 ข้อ)

□ (เปลี่ยนสารกำจัดศัตรูพืชตัวใหม่)

□ (ผสมสารให้ความเข้มข้นมากขึ้นกว่าเดิม)

□ (ผสมสารตัวเดิมร่วมกับสารชนิดอื่น)

□ (ฉีดพ่นซ้ำอีกครั้งด้วยความเข้มข้นเดิม)

□ (ไม่ทำอะไรเลย)

□ (อื่นๆโปรดระบุ)_____

10. ท่านสูบบุหรี่หรือไม่

□ (สูบ_____มวนต่อวัน)

□ (ไม่เคยสูบ)

□ (เลิกสูบ)

11. ท่านสูบบุหรี่ระหว่างฉีดพ่นสารหรือไม่

□ (สูบเป็นประจำ)

□ (สูบบางครั้ง)

□ (สูบบ้าง)

□ (ไม่สูบ)

12. ท่านกินอาหารในนาหรือไม่

□ (กินเป็นประจำ)

□ (กินบางครั้ง)

□ (กินบ้าง)

□ (ไม่กินเลย)

13. โปรดตอบคำถามต่อไปนี้ ถ้าท่านตอบคำถามใช้ข้อ ก. ว่าใช่ โปรดตอบข้อ ข. ค. และ ง. ถ้าท่านตอบไม่ โปรดทำข้ออื่นต่อไป

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
ไดโครโทฟอส (ไบครอน)	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
คลอไพรีฟอส (เอวีแบน)	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
ฟรีโทเอท (แคนซาน)	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
ไตรโซฟอส (โคฟเวอร์)	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
(ควินนาฟอส)	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

สารกำจัดศัตรูพืช	A. ก. ท่านเคยผสมหรือฉีดพ่นสารชนิดนี้หรือไม่	B. ข. ท่านใช้สารชนิดนี้มากี่ปี	C. ค. ใน 1 ปีท่านใช้สารชนิดนี้กี่วัน โดยเฉลี่ย	D. ง. ท่านใช้สารชนิดนี้ตั้งแต่ปีใด
(อื่นๆ) สารกำจัดศัตรูพืช _____	(ใช่)□ (ไม่ใช่) □	□ (1 ปีหรือน้อยกว่า 1 ปี) □ (2-5 ปี) □ (6-10) ปี) □ (11-20 ปี) □(มากกว่า 20 ปี)	□ (น้อยกว่า 5 ปี) □ (5-9 วัน) □ (10-19 วัน) □ (20-39 วัน) □ (40-59 วัน) □ (60-150 วัน) □ (มากกว่า 150 วัน)	□ (ก่อน พ.ศ. 2503) □ (ช่วง พ.ศ. 2503-2513) □ (ช่วง พ.ศ. 2513-2523) □(ช่วง พ.ศ. 2523-2533) □ (ช่วง พ.ศ. 2533-2543) □ (ช่วง พ.ศ. 2543-2553) □ (ขีดที่นี่ถ้าท่านเพิ่งใช้เมื่อปีที่ผ่านมา)

APPENDIX B

Pictures of activities of rice farmers, interviewers, and the researcher

APPENDIX C

Timeline

RESEARCH PROCESS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Literature Review	→							
Writing Proposal		→	→					
Proposal Exam			→					
Revise Proposal, translation, pending Ethics Committee's Approval				→	→	→		
Prepare Items for Data Collection				→	→	→		
Data Collection						→		
Data Analysis						→	→	
Writing Report							→	
Submit for Final Exam							→	
Thesis Defense							→	→
Revision								→
Submit Final Thesis								→

APPENDIX C

Administration Cost

Expenditure	Amount (Baht)
1. Student's stipend	
Research fees	10000
2. Payment	
Questionnaire forms, informed consent forms, Participant's information sheets	1000
Laboratory analysis	16478
Transportations	2400
Meals and miscellaneous	1600
Copy print proposal and thesis	3000
3. Material	
Chemical and instrument	1000
Office material	500
Publication	4000
4. Compensation for participants	9800
Total	**49778**

VITAE

Ms. Un Mei Pan is an American Macanese. She was born in Macau, a former Portuguese colony. She received her Bachelor of Science in Chemistry in 1997, and her Master of Science in Biochemistry in 2002 from the University of Maryland, USA. She is also a registered nurse in USA specializing in renal nursing. Her graduate research in Maryland focused on biophysical-chemical studies on Alzheimer Tau protein structure. Her other works include development of electro-analytical detection methods for ions and vitamins, as well as indexing biomedical journals for PubMed, an online database at the United States National Library of Medicine. She is a member of American Chemical Society, Society of Electro-analytical Chemistry, and American Association for the Advancement of Science. In her spare time she enjoys movies, rubber (American bridge game), belly dancing, bowling, Chinese landscape painting, and learning new languages. During her stay in Thailand, she pursued her study for a Master of Public Health in Environmental and Occupational Health at the College of Public Health Sciences, Chulalongkorn University from 2009 to 2010.