Health Risk Related to Pesticides Exposure in Agriculture System in Thailand: A Systematic Review

Mr. Edward Patrick Rivera

จุฬาลงกรณ์มหาวิทยาลัย
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ความเสี่ยงทางสุขภาพที่เกี่ยวข้องกับการสัมผัสสารกำจัดศัตรูพืชในระบบเกษตรกรรมประเทศไทย: การทบทวนงานวิจัยอย่างเป็นระบบ

นายเอ็ดเวิร์ด แพทริค ริเวียรา

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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By	Mr. Edward Patrick Rivera
Field of Study	Public Health
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เอ็ดเวิร์ด แพทริค ริเวียรา : ความเสี่ยงทางสุขภาพที่เกี่ยวข้องกับการสัมผัสสารกำจัดศัตรูพืชในระบบเกษตรกรรม ประเทศไทย: การทบทวนงานวิจัยอย่างเป็นระบบ (Health Risk Related to Pesticides Exposure in Agriculture System in Thailand: A Systematic Review) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. วัฒน์สิทธิ์ ศิริวงศ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: Prof. Mark G. RobsonPh.D., หน้า.

ช่วงทศวรรษปัจจุบันการใช้สารกำจัดศัตรูพืชในเกษตรกรรมของประเทศไทยเพิ่มขึ้น เนื่องจากประเทศไทยเป็นแหล่งส่งออกสินค้าประเภทอาหาร จากการศึกษาพบว่า ผลกระทบต่อสุขภาพจากการใช้และการสัมผัสสารกำจัดศัตรูพืชของเกษตรกรปลูกข้าว พริก ข้าวโพด และครอบครัวของเกษตรกรนั้นยังขาดการรวบรวม ดังนั้นการศึกษารวมเอกสารงานวิจัยที่เกี่ยวข้องอย่างเป็นระบบนี้มีจุดประสงค์เพื่อการเปรียบเทียบผลกระทบสุขภาพจากการสัมผัสสารกำจัดศัตรูพืชต่อเกษตรที่ปลูกพืชทั้งสามชนิด จากการค้นคว้ารวบรวมงานวิจัยของจุฬาลงกรณ์มหาวิทยาลัย กรุงเทพมหานคร ประเทศไทย ที่ได้รับการตีพิมพ์ในวารสารต่างๆ มีการเปรียบเทียบผลกระทบสุขภาพจากการสัมผัสสารกำจัดศัตรูพืชผ่านเส้นทางสัมผัสต่างๆได้แก่ ทางผิวหนัง ทางการหายใจ และการบริโภค จากบทความต่างๆที่ได้รวมรวม ตลอดจนมุมมองด้านความเสี่ยง การปฏิบัติตน และการป้องกันตัวจากการสัมผัส บทความต้นฉบับที่รวบรวมมานั้นได้ทำการศึกษาวิเคราะห์รายละเอียดการสัมผัสสารกำจัดศัตรูพืชกลุ่มออร์แกนโนฟอสเฟต โดยมีบทความจำนวน 6 บทความเกี่ยวข้องกับความเสี่ยงสุขภาพและพฤติกรรมเสี่ยงในการสัมผัสสารกำจัดศัตรูพืช และ อีก 6 บทความศึกษาวิเคราะห์ทั้งการสัมผัสสารกำจัดศัตรูพืชกลุ่มออร์แกนโนฟอสเฟตและพฤติกรรมเสี่ยงต่อสุขภาพ นอกจากนี้พบว่าการศึกษาชนิดภาคตัดขวางเป็นรูปแบบการศึกษาที่นิยมทำในงานวิจัยด้านนี้ มี 6 งานวิจัยเน้นการสัมผัสสารสารกำจัดศัตรูพืชและผลกระทบต่อชาวนาและครอบครัว มี 7 งานวิจัยเน้นการสัมผัสสารสารกำจัดศัตรูพืชและผลกระทบต่อเกษตรกรปลูกพริกและครอบครัว และ มี 2 งานวิจัยในเกษตรกรปลูกข้าวโพดซึ่งยังขาดงานด้านนี้ การศึกษาการสัมผัสสารกำจัดศัตรูพืชกลุ่มออร์แกนโนฟอสเฟตส่วนใหญ่บงชี้ว่าเกษตรกรได้รับผลกระทบสุขภาพโดยตรงและเด็กในครอบครัวได้รับผลกระทบทางอ้อม และเกษตรกรที่ได้รับผลกระทบสุขภาพส่วนใหญ่มีการใช้อุปกรณ์ป้องกันตัวอย่างไม่เหมาะสม โดยในงานวิจัยต่างๆได้แนะนำให้มีข้อแนะนำและการจัดการโดยการให้ความรู้ เปลี่ยนแปลงทัศนคติและการปฏิบัติตนในการใช้สารกำจัดศัตรูพืชของเกษตรกรอย่างเหมาะสม นอกจากนี้ผลการประเมินความเสี่ยงโดยใช้ระดับดัชนีบ่งชี้อันตราย (Hazard Quotient, HQ) ในเกษตรกรปลูกพริกนั้นมีความเสี่ยงจากการสัมผัสสารโพรฟีโนฟอส (HQ > 1) และพบว่าระดับดัชนีบ่งชี้ทางชีวภาพ (AChE และ PChE) ในเลือดของชาวนาสูงกว่าเกษตรกรปลูกพริกและข้าวโพด

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ปีการศึกษา 2558	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
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EDWARD PATRICK RIVERA: Health Risk Related to Pesticides Exposure in Agriculture System in Thailand: A Systematic Review. ADVISOR: ASSOC. PROF. WATTASIT SIRIWONG, Ph.D., CO-ADVISOR: PROF. MARK G. ROBSON, Ph.D., pp.

Agricultural use of pesticides has increased in Thailand in recent decades due to Thailand's major role as a leading exporter of food. There is evidence of the adverse effects of pesticide exposure and health risk on Thai rice, chili and maize farmers, however, limited information is available about which cropping systems pose the greatest exposure risk to farmers and their families. This systematic review is aimed at comparing the scientific articles published to date by Chulalongkorn University, Bangkok Thailand on potential differences of pesticide exposure of agricultural systems. Articles were compared focusing on adverse health effects from different pathways of exposure such as dermal, inhalation and ingestion, as well as risk perception and proper prevention practices by farmers themselves. Original articles were identified which analyzed exposure to OP pesticides, 6 analyzed exposure due to health risk and health risk behavior, and 6 analyzed both exposure to OP pesticides and Health Risk behavior. Cross sectional studies were the most frequent design. Six of the studies focused on rice farming systems and the effects on farmers and their families. Seven studies focus on chili cropping systems and the effects on farmers and their families. Only 2 articles presented data on maize farming which suggests that the paucity of studies in maize there is still a knowledge gap between the association between health risks and pesticide exposure in maize cropping systems. Most studies on organophosphates show that farmers do suffer from adverse health effects while children are also exposed indirectly. Most studies reflect on the results of pesticide exposure being the result of improper use of personal protective equipment (PPE) and suggest guidelines and management strategies be implemented to increase the knowledge attitude and practices of farmers. In conclusion, HQ levels in most chili studies suggest that residue of Profenofos on chilies was higher than the acceptable level suggested by the hazard quotient (HQ > 1) and exceed acceptable risk however based on AChE and PChE levels in farmers the research suggests that rice farmers have a higher health risk of adverse health effects than chili and maize farmers.

Field of Study: Public Health	Student's Signature ....
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	Co-Advisor's Signature ....

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CHAPTER I

INTRODUCTION

1.1 Background and rational

Pesticides pose serious health concerns and risk in Thailand. These risks are arising due to the exposure of farmers when either mixing or applying pesticides and even working in treated fields. Exposure from residues on food and in communal drinking water for general populations has also become a huge cause for concern. Accidental poisoning has been the result of these activities and the routine uses of pesticides have posed a major health risk to rice, chili and maize farmers in Thailand. Farmers in developing countries face great risks of exposure due to the misuse of toxic chemicals. For one, these chemicals are normally banned or restricted in other countries with the addition of incorrect application techniques, poorly maintained or totally inappropriate spraying equipment, inadequate storage and misguided use of personal protective equipment , and often the reuse of old pesticide containers for food and water storage increase exposure. Exposure to pesticides poses a continuous health hazard, especially in the agricultural working environment which is why we will focus on Thailand.

Thailand is one of the world's largest food exporters and as a country with its GDP relying on agriculture; Thailand relies largely on pesticide use. The last decade has been a huge change for agriculture in The Kingdom, as it has seen an enormous increase on pesticide use mainly to increase yields and protect its crops. In 2009, agricultural products accounted for 9% of Thailand's gross domestic product (GDP), but their production used 40% of the workforce and 40% of the land area (Panuwet et al., 2012)

Agriculture is important for the Thai economy and for the labor forces specifically the 3 major crops rice, chili and maize. The total production of rice in Thailand has increased from 29.5 million tons in 2003 to 37.9 million tons in 2012, and at the present time 25.7 million acres of paddy fields are under cultivation. As a result, increasingly more pesticide is being used to increase this already massive production of rice. The most common types of pesticides imported into Thailand are herbicides, followed by insecticides and fungicides.

Organophosphates and carbamates protect crops from insects and are usually wildly found among insecticides in chili and rice cropping systems. With the increasingly growing use of pesticides in Thai agricultural practices we have seen many health related risks associated with the health of occupational farmers. For example The Disease Control Department of northern Thailand reported that 13.54 per 100,000 people in northern Thailand are hospitalized due to pesticide poisoning from farming. Most poisoning cases are related to the use of OPs, followed by herbicides and carbamates (Sapbamrer & Nata, 2014).

Pesticide exposure may cause acute health effects. The acute effects include dizziness, blurred vision, nausea, vomiting and some muscular weakness and numbness. However there is a gap in this research for low level exposure due to inconsistency of assessments.

Several publications exist for health symptoms among farmers. However, the gap in the research points to the association between symptoms and agricultural tasks on a farm because they have never been well established. Most studies have been done on exposure without taking into consideration the actual tasks that some farmers are responsible for. If you look at the relationship between exposure and tasks we can concur that different tasks account for different exposure concentrations and time frames. Some of the tasks performed in the fields consist of spraying, mixing pesticides, scattering seeds and harvesting crops. The risks and consequences of being directly exposed to pesticides may differ according to the task and doses used in that task, resulting in different symptoms. Therefore, the aim of this study investigated the potential health risks related to pesticide exposure in agriculture systems, compare exposure occurrences between different cropping systems and compare the difference in exposure in different cropping systems.

1.2 Knowledge gap

Unless vigorously applied, pesticides it is usually difficult to find results in significant aerosol formations and the amount of pesticides inhaled is likely to be low. Due to improved control technologies and the lowering of occupational exposure limits inhalation has decreased however dermal exposure has increased. Total exposure has become more easily measurable due to advances in biological monitoring. Therefore, data from inhalation ingestion and from the dermal pathways of exposure are necessary to highlight the need for accurate estimates of exposure over a wide range of circumstances or scenarios. Improved methods for analyzing pesticides and more precise ways of extrapolating the data should be taken into account when bridging the research gaps in pesticide exposure. A Systematic review on this subject can compare data of exposure routes, knowledge, attitude and practices (KAP) and which agricultural systems have the most risk on farmers.

1.3 Research Questions

By summarizing the impact of exposure and understanding the issues which farmers go through, it is hoped that the data obtained might be used to optimize and or develop services which help in educating Thai farmers and improve their working environment. Furthermore it may be reassuring for farmers to realize that the programs have been set in place to assure the improvement of occupational safety. This systematic review may act as a catalyst for Thai farmers and the ministry of agriculture on reducing pesticide exposure.

The issues associated with exposure are equally as significant as the educational deprivation and health risk posed by exposure but although this assessment is not intended to focus on the education aspect of exposure, it does unavoidably emerge through the themes.

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Research Questions:

1. Which cropping system posed the greatest exposure risk to farmers and their families?
2. Which cropping systems used practices to prevent and reduce pesticide exposure?

1.4 Outline of Assessment

Chapter two reviewed the literature corresponding to this topic. This chapter discussed the exposure health risk and agricultural practices of Thai rice, chili and maize farmers in Thailand as the definitions of each topic of research. It discussed the health risk impact of exposure as well as the level of exposure in relation to agricultural practices. In addition it examined the impact of limited knowledge and resources have on a farmer's standard of living and hence increasing their potential of being exposed to pesticides.

Chapter three presented the research methods used in this assessment. It discussed the aim of the research study, the data collection methods used; and also discussed the ethical considerations and finally, the limitations which this assessment posed.

Chapter four presented the findings obtained from the data collection and analysis.

Chapter five put forward an interpretation of the findings obtained, why the findings are relevant to the research.

Chapter six concluded with a brief summary of the complete research study along with a series of recommendations that will help reduce exposure to be made aware of by both Thai Farmers and the Ministry of Agriculture in Thailand.

General objective

- To review pesticide exposure in Thai farmers and the role of agricultural practices of exposure.

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1.5 Specific objectives

PHASE I:

To summarize pesticide exposure of cropping practices among Thai rice, maize and chili farmers.

PHASE II:

1. Compare the association between pesticide exposure use and agricultural tasks.
2. Compare what potential health risks are most common and what is least common.
3. Compare the relationship between exposure to farmers and the potential health risk on their families.
4 Compare exposure occurrences between difference cropping systems in difference regions of Thailand.

1.6 Research Hypothesis

1. There is the difference in exposure in different cropping systems.
2. Rice cropping systems presents the most risk of potential health risk for farmers and their families.

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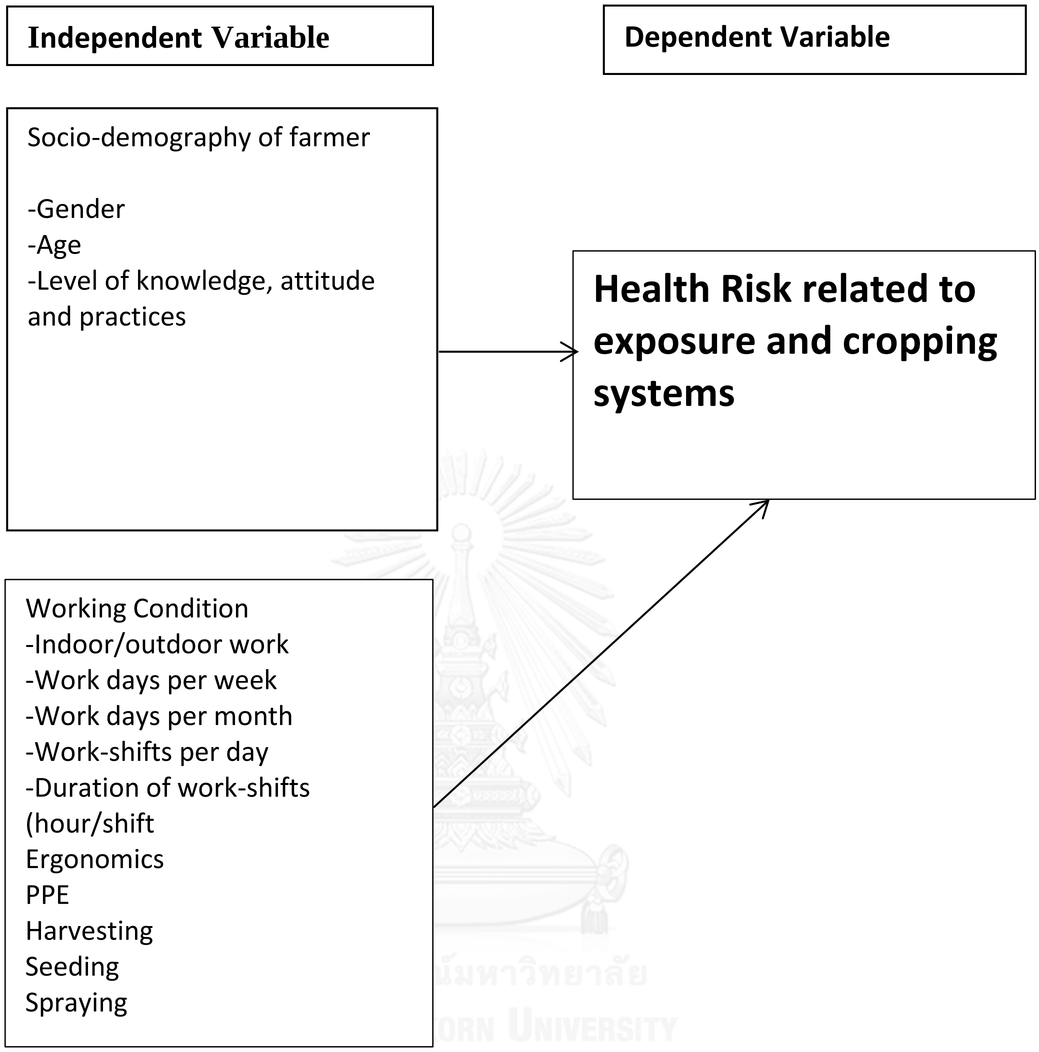
1.7 Conceptual Framework



1.8 Operational definition

Pesticide- refers to any substance that is used to kill, repel and control what people consider to be pests. These pesticides include Herbicide for fighting against unwanted weeds, fungicide for the control of mildew and mold and insecticide to kill unwanted bugs that can potentially eat crops.

Pesticide Exposure – refers to the way farmers receive pesticides within the body whether it be through inhalation or through direct contact on the skin. This study would show the effects of exposure to the farmers and what symptoms they receive based on the level of exposure.

Agricultural Tasks- Refers to the responsibilities each person on a farmers conducts depending on their duties. As an example some farmers mix pesticides, others may seed, harvest and spray pesticides. This is important to know because each case of exposure depends on the level of concentration to each farmer based on their duty and length of time working directly with the pesticide.

Health Risk - Refers to exposure of that is going to increases the likelihood of developing a symptom of exposure, in this case we are looking into common pesticide exposure symptoms such as respiratory difficulty, vomiting, blurred vision, muscle spasms.

Thai Farmers- refers to the people that are exposed to pesticide exposure through their responsibilities on a rice paddy, maize or chili farm.

This study targets rice farmers who have different agricultural tasks such as seeding, mixing and spraying.

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Personal Protective Equipment (**PPE**) refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from exposure.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to review the literature available on this research study of exposure, agricultural practices and potential health risk. It will examine the central role cropping systems pose on Thai farmers and families. In addition, it will examine the agricultural practices and exposure contributing to health risk and present different theories developed on the effects of exposure. Finally it will explore which cropping system use practices reduce pesticide exposure.

2.2 Type of Pesticide

2.2.1 Organophosphates: Most often sprayed on Rice and Chili farms organophosphates disrupt the enzyme that regulates acetylcholine this effects the nervous system as acetylcholine is a neurotransmitter. Organophosphates are any organic phosphorus containing compound, especially when dealing with neurotoxic compounds. In Pesticide use they are potent inhibitors that are capable of causing severe toxicity following exposure. The toxicity can cause problems with the nervous system. Exposure can come in the form of inhalation or ingestion. (EPA, 2010). Most organophosphates are insecticides they were used in WWII as nerve agents since it was discovered, in 1932, to have the similar effects on humans as they had on insects. The intensive use along with unorthodox application practices has had consequences on human health.

2.2.2 Carbamate Pesticide: Affect the nervous system neurotransmitters. Effects are usually reversible. There are several subgroups within carbamates. These are also found in insecticides sprayed predominately on rice and chili farms. (EPA, 2010)

2.2.3 Pyrethroids Pesticides: Developed as a synthetic version of a naturally occurring pesticide pyrethrin found in chrysanthemums. Some pyrethroids are toxic to the nervous system and have been modified to increase their stability in the environment. (EPA, 2010)

2.3 Cropping Systems

2.3.1 Maize

In most of the Lower Northeast, Upper Northeast, and some parts of the Lower North, farmers planted only one crop of maize per year during the early rainy season from April to June. Table 1 shows the cropping system of 13 provinces growing maize each year.

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2.3.2 Rice

Table 2 shows cropping systems of these 4 sites Pimai, Ubon, Kampangphet and Prae. Chosen sites were based on national priority, relatively large size and technology that can improve the cropping systems.

Table 1 cropping system of 13 provinces growing maize each year. (Ekasingh, 2004)

Province	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
Chiang Rai												
Tak												
Petchabun Uthai Thani												
Loei												
Nakorn Ratchaseema									Second Maize Crop			
Kamphangpet									Second Maize Crop			
Nakornsawan												
Pitchit Lopburi									Second Maize Crop			
Sra Kaew									Second Maize Crop			
Chiang Mai												

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Table 2: cropping systems of 4 sites Pimai, Ubon, Kampangphet and Prae.

(Ekasingh, 2004)

Site	**Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec**
Pimai	
Ubon	
Kampangphet	
Prae	

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2.4 Health effects

The American Medical association recommends limiting the pesticide exposure and making safer alternatives as pesticides can be dangerous to consumers, workers, communities, transport and during manufacture.

Surveillance systems that characterize potential exposure problems related to pesticides or related illnesses are currently inadequate. (Association, 1994)

Farmers Exposure to Pesticide

The main route of exposure for farmers are exposures by absorption through exposed skin such as the face, hands, forearms, neck, and chest shortly after re-entering treated fields. This exposure is sometimes enhanced by inhalation in settings including spraying operations. Hence, the reason exposure to pesticide has been associated to a range of acute adverse health effects such as respiratory difficulty. According to the World Health Organization and the UN environmental program it is estimated that 3 million agricultural workers experience severe poisoning from pesticides in which 18,000 die. A study show that as many as 25 million workers in developing countries may suffer from mild pesticide poisoning yearly. There have been many studies associating potential health risk and pesticides in which they result in prostate cancer, Leukemia soft tissue sarcoma and Non-Hodgkin's lymphoma. (NIOSH, 2015)

Due to the decreased severity of environmental degradation organophosphates have extensively increased in use. However these are associated in with acute health problems with rice and chili farmers that work with these chemicals on a daily basis. Such problems consist of abdominal pain, dizziness, headache, nausea, and vomiting as well as skin and eye irritation. Based on many peer reviewed research it has been found that there is a significant link between pesticide exposure and neurological outcomes and cancer. In addition many studies have found the association between pesticide exposure and long term health problems such as respiratory problems, memory disorders and depression but the two most significant being cancer and neurological outcomes (EPA, 2010)

Types of exposure:

Dermal or skin absorption is the most common route of poisoning in pesticides. As long as a pesticide remains in contact with the skin absorption is continuous. Depending on which body part is exposed determines the rate at which absorption occurs. This case of absorption may occur as a result of improper handling of the pesticides being used for example an accidental splash, spill or drift when mixing may occur. In addition when mixing concentrated pesticides that contain a high percentage of active ingredients. Residues on improperly cleaned equipment can also account for exposure so it’s always important to be aware to clean used equipment after use. Residues can be inadvertently moved from a hand to a face where the relative absorption rate is higher as the eyes absorb pesticides easily and rapidly.

With pesticides being so wildly used and with may pathways of exposure, the most severe poisoning usually result when pesticides are taken in through the mouth. Pesticides can be ingested and are most often accidental. Due to the lack of awareness in most cases the most frequent cases of accidental oral exposure occur due to the fact that pesticides have been taken from the original labeled container and places in an unlabeled separate container. Improper labeling can result in pesticides ending up in containers that are used for food or drink in which residue may still be in that container or direct oral contact may take place accidentally. Workers that handle pesticides or application equipment can also have also consumed excessive levels of pesticide if they have not properly washed their hands before eating or even smoking (Damalas, 2011).

Inhaling vapors, airborne droplets, or powders expose your lungs to pesticide intoxication and can cause serious damage to the nose and throat as well. If vapors and small particles cause the most serious risk as the hazard of poisoning from respiratory exposure is rapid. Farmers working with powders can be in danger as they can easily be inhaled during mixing operations which may contain concentrated pesticide active ingredients. When exposed to air many pesticides may give off a hazardous vapor and fumigants like this are used because of how desirable they are for pest control. Table 3, 4, 5shows acute toxicity of pesticides

Table 3- Acute toxicity of pesticides according to WHO classification (Sapbamrer & Nata, 2014).

Class	Classification	LD$_{50}$ for the rat (mg/kg b.w.) Oral		Dermal	
		Solids	Liquids	Solids	Liquids
Ia	Extremely hazardous	<5	<20	<10	<40
Ib	Highly hazardous	5–50	20–200	10–100	40–400
II	Moderately hazardous	50–500	200–2,000	100–1,000	400–4,000
III	Slightly hazardous	>501	>2,001	>1,001	>4,001
U	Unlike to present acute hazard	>2,000	>3,000	–	–

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Table 4-Acute toxicity of pesticides according to the EPA classification (Sapbamrer & Nata, 2014).

Class	**Signal words**	**Acute toxicity to rat**		
		Oral LD_{50} (mg/kg)	**Dermal LD_{50} (mg/kg)**	**Inhalation LC_{50} (mg/L)**
I	DANGER	<50	<200	<0.2
II	WARNING	50–500	200–2,000	0.2–2.0
III	CAUTION	500–5000	2,000–20,000	2.0–20
IV	CAUTION (optional)	>5,000	>20,000	>20

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Table 5- Acute toxicity of pesticides (eye and skin effects) according to the EPA classification (Sapbamrer & Nata, 2014).

Class	Signal words	Eye effects	Skin effects
I	DANGER	Corneal opacity not reversible within 7 days	Corrosive
II	WARNING	Irritation persisting for 7 days	Severe irritation at 72 hours
III	CAUTION	Irritation reversible within 7 days	Moderate irritation at 72 hours
IV	CAUTION (optional)	No irritation	Mild or slight irritation at 72 hours

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Perception of exposure:

When looking into the ways that Thai farming practices are administered we have to realize that perception comes into play when dealing with agricultural practices. Perception is important to understand as is the way that farmers interpret the situation they are facing on a daily basis while handling pesticides. Based on experience perception may be substantially different from farmer to farmer due to different farming practices and knowledge. Even though farmers may face the same circumstances they may think about it differently. Research shows that maize farmers may have high knowledge, positive attitude, good practices, but the maize farmers still had herbicides poisoning symptoms (Denpong., 2012).

Perception of Occupational Risk

Occupational risk is regarded as the possibility of a worker suffering a particular work-related injury. Occupational risks are associated with causes due to human nature, individual behavior and methodologies in performing work, technical nature working environment, equipment, tools, machines and materials. Occupational risks often arise associated with industrial accident and environmental impact risks. With few studies completed that focus on health risk perception among rice farmers. It is crucial to investigate occupational risk perception and factors affecting occupational risk perception among farmers in order to emphasize the actions to prevent injury and illness at work. Understanding potential health risk perception is a first step in developing a program to minimize occupational exposure. Occupational risk perception should play an important role to encourage rice, chili and maize farmers to be aware of their occupational hazards. The health risk perception of equipment use, ergonomics, and working condition play a huge part in occupational risk perception and should be examined more closely in future studies in order to bridge the gap in the association between hazards and perception. Some risk perception items should be raised because many farmers, although aware of the risk, perceive that some actions do not cause damages to their health or cause moderate or low risks. This perception should be corrected because it might be the cause of injury and illness at work e.g. jump of the tractor before complete standstill, never maintain machines, not check sharp equipment carefully before working, mixing pesticide more than one kind, after mixing pesticides, not keep in its original package, not changing clothes after coming home, and mixing work clothes with other clothes (Santaweesuk, Chapman, & Siriwong, 2014).

2.5 Potential health risks.

Acute effects from occupational exposure to pesticide will most likely cause headache, dizziness, vomiting, respiratory difficulty, numbness in the muscles. It also can cause skin and eye problems such as blurred vision. According to the Canadian center for Occupational and health safety, some health effects from pesticide exposure may occur right away, as you are being exposed. Some symptoms may occur several hours after exposure. Some symptoms of pesticide exposure will go away as soon as the exposure stops. Others may take some time to go away. For people exposed to pesticides on a regular basis, long-term health effects are a concern. (CCOHS, 2016)

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2.6 Personal Protective Equipment (PPE)

According to the US EPA, use of PPE is specified under the Worker Protection Standard (WPS). PPE can be safety clothing or equipment for a specified circumstance or area where the nature of work or the conditions of work require wearing PPE to minimize risk. (EPA, 2010)

PPE required for early entry to treated areas (that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water), are:

1. Eyes - safety glasses, goggles
2. Faces - face shields
3. Heads - Chemical-resistant headgear
4. Feet - Chemical-resistant footwear plus socks
5. Hands and arms-Chemical-resistant gloves
6. Bodies - Coveralls over long-sleeved shirt and long pants

2.7 Pesticide measurement in the farmers

Urinary biomarkers are able to evaluate pesticide exposure in the human body and determine. There are some limitations to the test but it is the best way to measure as it is non- invasive. Predominately these are used to measure the level of carbamates and organophosphates in Chili and Rice farmers (EPA, 2010).

2.8. Previous Research

The study "Health Risk of Occupational Hazards among Rice Farmers in Nakhon Nayok Province, Thailand pertaining to rice farmers in the Nahkhon Nayok Province of Thailand has focused on occupational risk perception and the factors affecting occupational risk.(Sapsatree Santaweesuk & 2013). Data was ranked using a Likert scale from 0 (no risk) to 10 (high risk) collected from 145 rice farmers using a structured face to face interview questionnaire. Farmers were questioned on 36 items in terms of potential health risks of occupational hazards of equipment use, pesticide use working conditions and ergonomics. The result showed that pesticide risk perception was high and the health risk perception was also high in equipment use, ergonomics and working condition. Taking these factors into account risk perception can be compared and contrasted amongst other farming systems such as Maize and chili. In the study the respondents were female (51.7%) and male

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(48.3%). The mean age was 50.2 years; the majority were married (82.8%). Most graduated primary school about (77.9%). In this study the dependent variable was Health risk perception and he results showed that the mean score was 6.9. The respondents perceived occupational health risk at moderate level and high level in the same number (46.7%) and 4.8% perceived health risk at the low level. Respondents perceived health risk of occupational hazards on moderate level ($\bar{x}$ = 6.90). The pesticide risk perception was high level ($\bar{x}$ = 8.07), ranking it as the first of health risk perception. The health risk perception of equipment use, ergonomics, and working condition were also moderate level.

The study “Herbicide Exposure to Maize Farmers in Northern Thailand: Knowledge, Attitude, and Practices (Denpong., 2012)” concerning Maize farmers out of 555 households that owned maize farms 407 participated in a survey. Sixty percent of the subjects graduated from primary school. The total response rate was 73.3%. The results were found that 79.9% was male and 70.8%. 36.1% reported health effects after spraying although 48.6% of maize farmers had high knowledge level, 69.3% had positive attitudes, and 93.9% had good practices. In the study significance in data was determined to have a statistically significant association ($p < 0.05$) were found between the knowledge and the attitudes (r =0.37), the knowledge and the practices (r=0.24), and the attitude and the practices (r=0.2). However, even with this significance and high knowledge, positive attitude and good practices, the majority of Maize farmers still had symptoms of herbicide poisoning. The most important finding is that farmers are more reluctant to use PPE based on the premise that PPE can result in discomfort while applying pesticides.

The Study "Health Risk Assessment Related to Dermal Exposure of Chlorpyrifos: A Case Study of Rice Growing Farmers in Nakhon Nayok Province, Central Thailand (Lappharat et al., 2014)" Shows that farmers are exposed to high levels of chlorpyrifos and that the hazard quotient exceeds acceptable levels. The dermal samples collected immediately after pesticide application show that on males the highest amount of residue was found on the lower leg and the least amount of residue was found on the chest underneath the clothes. For female farmers, the highest amount of residue was found on the chest outside of the clothes and the least amount was on the chest under the clothes. The difference in concentrations and locations between males and females could be a result of differences in body size and posture during spraying of pesticides. (Lappharat et al., 2014). An important finding of a comparison among to different regions of Thailand, one in Rangsit and the other in on Chili farmers in Ubon Rathchathani , suggest that pesticide application during different farming practices may affect the level of exposure among farmers.

The study "Inhalation Exposure of Organophosphate Pesticides by Vegetable Growers in the Bang-Rieng Sub district in Thailand (Jaipieam, 2009)" investigated inhalation exposure to organophosphate pesticides in which Chlorpyrifos, dicrotophos, and profenofos were found in all the vegetable grower's air samples. Vegetable farmers in Bang-Rieng, Thailand do not wear proper protective equipment therefor it was found that 39% and 87% of vegetable growers are at risk of inhalation exposures to chlorpyrifos and dicrotophos organophosphate insecticides that exceeded EPA recommendation. A Higher percentage of agricultural workers in

Thailand were exposed to organophosphate pesticides than US agricultural workers. In the United States the agricultural workers are more willing to wear proper protective equipment and have better engineering control. When compared to previous studies in Thailand it was found that exposure in vegetable farmers were slightly less than exposure in rice farmers. Vegetable farms are usually smaller than rice farms so this may be the result of decreased exposure. Overall this study provides a baseline for local and national governments when it comes to making decisions promoting the health of farmers as well as providing farmers with adequate advice on providing adequate advice on exposure protection.

The study, "Health symptoms related to pesticide exposure and agricultural tasks among rice farmers from northern Thailand (Sapbamrer & Nata, 2014)", analyzed data of farmer characteristics, practices, attitudes, and protective behavior to pesticide exposure. The study found that the major symptoms among rice farmers spraying and mixing pesticides were dry throat and cramps. It is suggested that respiratory tract symptoms may be due to the use of inadequate protective equipment such as cloth masks while spraying. In addition the major symptom for farmers scattering seed and harvesting was numbness. All in all the finding suggest that occupational pesticide exposure and agricultural tasks in the paddy field may be associated with the increasing prevalence of respiratory tract and muscle symptoms as a potential health risk.

Interestingly in a comparison study on Neurotoxicity of pesticides showed study in 214 Indonesian farmers reported symptoms after the spraying of pesticides. The most frequent symptoms being fatigue (60 %), muscle stiffness (54 %), dry throat (30

%), muscle weakness (23 %), dizziness (21 %), difficulty in breathing (18.5 %), and chest pain (13.6 %) (Sapbamrer & Nata, 2014).

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CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Design

The design of this study is a qualitative study. Recording data collected from different methods of collection such as focus groups, interviews and observations. The purpose of this study is to present an assessment of the different Thai cropping systems and how they associate with health risk of pesticide in agriculture systems. Agricultural practices factor into how much exposure farmers and their families are susceptible to and how exposure is related to potential health risk. A systematic review of articles in the PubMed, and Science Direct was carried out using the following search words or text word combinations: "Health Risks" "Risk Behavior", "Pesticide Exposure, Thai vegetables, "chilies", "maize" and "rice."

3.1 Study Area and Study Population

The articles selected for the review met the following inclusion criteria: (a) original articles; (b) published after January 2009; (c) written in English; (d) carried out in Thai farmers and their families; (e) evaluating the summaries of pesticide exposure on agriculture systems.

3.2 Measurement tools:

This study relies on the measurements already collected from previous studies.

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3.3 Data collection

As this was a systematic review, a summary of data was collected from 36 different articles pertaining to pesticide exposure, Thai agriculture and Risk assessments. The qualitative data used to complete this systematic review were collected through open-ended interviews, focus group discussions, and observation. An open-ended interview schedule was used to guide the interviews and focus group discussions. The interviews and focus group discussions were performed by a research team whose members were trained in interviewing techniques and briefed on the interview and discussion topics. The research team members included professors of public health and health sciences, medical doctors and health care workers, nurses, and health care volunteers who had worked and lived in the study area over the study period.

3.4 Data analysis

Studies that met the inclusion criteria were sorted into categories based on exposure type (application) and compared using the following criteria: (a) exposure pathways; (b) pesticide type; (c) gender of participants; (d) exposure assessment; (e) levels of exposure to compounds; (f) effects observed (g) frequency of spraying

3.5 Ethical consideration

All of the data used in this Systematic Review already had prior approval by the Ethics Review Committee. This is secondary data no direct data was collected therefore addition ethical review is not required.

3.6 Limitations

Based on the study being an assessment of and a summary of previously collected data one must be cautious in generalizing from the findings. While undertaking this study, some the limitations are most notably when conducting any type of research it is beneficial to carry out the research on a larger and more in-depth scale in order to allow a more comprehensive analysis of the study. Fortunately no participants were required to directly conduct the study but it was most important that data was properly presented in the context that it was collected in by other authors. Another limitation relates to researcher bias which is always a risk in any type of research study, more so, the less structured the data collection is. Researcher bias is impossible to eliminate but the validity of the data researched are what makes this the researcher confident enough to have achieved valid findings, which can be used for larger populations. All in all the data used can leave room for interpretation than numerical data would.

3.7 Expected benefit

1. With an assessment representing a combination of collective data on 3 of the main crop systems in Thailand it will give a better understanding on to how approach future studies with access to consolidated data for reference.
2. The study can help identify what are the main factors of exposure are that are causing farmers to be more at risk to health risk exposure on a grand scale overall in Thailand. The result will be intended as a source of information to influence policy making and appropriate regulation.
3. Identifying how agricultural practices increase exposure can be a catalyst for change in those practices as well as a source of guidance.
4. By consolidating information on exposure it will give future quantitative study a better idea on how to approach risk assessments.
5. The research can be used as a guideline to conduct more research in the health risks of pesticide use as well as education for the people that are affected by the risk.

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CHAPTER IV
RESULTS

4.1 General information

Thirty six articles were identified using the inclusion criteria described in the previous chapter, 9 of which analyzed exposure to OP pesticides, 6 analyzed exposure due to health risk and health risk behavior, and 6 analyzed both exposure to OP pesticides and Health Risk behavior. Cross sectional studies were the most frequent design. Six of the studies focused on rice farming systems and the effects on farmers or their families. Seven studies focus on chili cropping systems and the effects on farmers and their families. Tables 6, 7 and 8 show no gender disparity among farmers of rice, chili, and maize cropping systems.

Table 6 Proportion of gender disparity in different cropping systems in rice crop.

General Information	**Rice Growing Farmers**				**Total**
	Male		**Female**		
GENDER Reference	**N**	**%**	**N**	**%**	**N**
NAKHON NAYOK PROVINCE (Sapsatree Santaweesuk & 2013)	74	51.7	71	48.3	145
BAN TOM SUBDISTRICT (Sapbamrer & Nata, 2014)	90	49	92	51	182
KHLONG LUANG DISTRICT (Raksanam, Taneepanichskul, Robson, & Siriwong, 2014)	55	55	45	46	101
SUB-DISTRICT PHIMAI DISTRICT (Sombatsawat, 2014)	33	100	0	0	33

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TABLE 7 Proportion of gender disparity in different cropping systems in chili crop.

General Information		Chili Growing Farmers				Total
		Male		Female		
GENDER	Reference	N	%	N	%	N
UBON RATCHATHANI PROVINCE	(Ooraikul S., 2011)	45	41	65	59	110
HUA RUA SUB-DISTRICT	(Taneepanichskul, 2012)	26	74.3	9	25.7	35
UBONRATCHATHANI PROVINCE	(Norkaew, 2013)	25	65	13	35	38
Hua Rua sub-district, Mueang district	(Norkaew, 2013)	175	53	155	47	330
UBON RATCHATHANI	(Norkaew, 2015) (Parkinsonism 50 to 59 years old)	36	38	54	62	90
HUA RUA SUB-DISTRICT MUANG DISTRICT	(Kukreja, 2013) (Parkinsonism Study AGE AVG above 50yrs)	-	-	-	-	271

TABLE 8 Proportion of gender disparity in different cropping systems in maize crop

General Information	Maize Growing Farmers				Total
	Male		Female		
GENDER	N	%	N	%	N
Nan province (Denpong, 2010)	326	80	81	20	407
Namtok sub District (Denpong, 2012)	325	80	82	20	407

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4.2 Summary of systematic review references pertaining to rice, chili and maize and other agriculture.

4.2.1 Rice:

Health symptoms related to pesticide and agricultural tasks among tice farmers from North Thailand (Sapbamrer & Nata, 2014)

This cross-sectional study was put in place to investigate occupational pesticide exposure and agricultural tasks in rice farmers. The focus was to study the health symptoms caused by the exposure. One hundred and eighty two rice farmers who were the exposed subjects and 122 non-farmers (control group) were interviewed in order to gain method data on demographic variables and health symptoms. Whole blood acetyl cholinesterase (AChE) activity was measured during August and October of 2012 resulting in rice farmers having significantly lower median AChE activity than the controls (9,594 vs. 10,530 U/L,) and a significantly higher prevalence of difficulty in breathing and chest pain. The prevalence of dry throat and cramp was associated with those farmers who sprayed and mixed pesticides (OR 2.5 and 2.6 for dry throat, OR 2.5 and 2.9 for cramp, respectively; P\0.01). The prevalence of numbness and diarrhea was associated with those farmers who scattered seed (OR 2.2, P\0.01 and OR 3.6, P\0.05, respectively). The prevalence of numbness and increasing anxiety was also associated with those farmers who harvested crops (OR 3.6, P\0.01 and OR 3.0, P\0.05, respectively). The findings would invite the notion that there may be an association between occupational pesticide exposure agricultural tasks in the paddy field and the increasing prevalence of respiratory tract and muscle symptoms. Further investigation should be taken in more detail in order to further the study.

Blood Cholinesterase level as a biomarker of organophosphate and carbamate pesticide exposure effect among rice farmers in Tarnlalord sub-district Phimai district Nakhon Ratchasima Province Thailand (Sombatsawat, 2014).

This is a cross sectional study that aims to measure blood cholinesterase levels of acetyl cholinesterase (AChE) and plasma cholinesterase (PChE) 3 times during dry-season and to assess health effects of organophosphate and carbamate pesticides exposure among rice farmers in Tarnlalord Sub-District, Phimai District, Nakhon Ratchasima Province, Thailand. The farmers were interviewed using a face to face questionnaire and blood cholinesterase level tested by Test-mate ChE (Model 400). Thirty three male farmers participated in the study. The study design was a cross-sectional study using face to face questionnaire interview and blood cholinesterase level tested by Test-mate ChE (Model 400). The participants were 33 male farmers. The first blood collection was taken 24 hours after pesticide application and showed that the ChE levels of 72.70% of the farmers were abnormal. The second blood collection was taken 15 days after the first collection which showed that 48.50% of farmers ChE levels were abnormal and finally the third collection took place after 30 days of the first collection. The third collection showed the ChE levels of 42.40 were abnormal. Gastrointestinal systems, urinary systems, eye, skin and central the central nervous system were all reported by farmers as to where they believed their adverse health effects were occurring. As you can see by the activity of AChE and PChE levels statistically significant associations between first second and third applications are apparent. Using Chi Square AChE levels with 24 hours after first application suggest a significant association in eye symptoms. AChE and PChE level were abnormal but with time began to recover to normal level. It is recommended that rice farmers use appropriate protective practiced and prevention from pesticide exposure such as of personal protective equipment (PPE) and pesticides handling to reduce adverse health effects from pesticides exposure.

4.2.2 **Non- Occupational risk on children of rice farmers due to pesticide exposure**

Due to residues of pesticides the children of Thai farmers have become susceptible to exposure. The fact of the matter is that children also become exposed due to the fact that farmers, specifically rice farmers, tend to live on or extremely close to the farm which enables children access to play around farms resulting in exposure.

Neurobehavioral effects of exposure to organophosphates and pyrethroid pesticides among Thai children (Fiedler et al., 2015).

Since pesticide use for crop production has grown so rapidly in the last decade there has been greater potential to exposure for farmers and this also is true for the families living close to or even on the farms. This study focuses on exposed and controlled groups of children on rice farming community as well as an aquaculture shrimping community. Twenty four children from a rice farm (exposed) and 29 from aquaculture (control) participated in the study. A Neurobehavioral test battery was administered to the participating children. The battery was given three times in 6 month intervals, once during a preliminary orientation, the second time during the season of high pesticide use and the third and final test was given in the low pesticide use season. Only the second and third sessions of the tests were used in the result analysis. Urinary metabolites of organophosphates (OPs) and pyrethroids (PYR) were analyzed from first morning void samples collected the day of neurobehavioral testing. During both seasons it was shown that the rice farm children has significantly higher concentrations of dialkylphosphates (DAPs) (common metabolites of OPs) and TCPy (a specific metabolite of chlorpyrifos) than aquaculture farm children, however TCPy was significantly higher during the low season rather than the high pesticide use season for both participant groups. During the high exposure season rice farm children had a significantly higher DCCA which is a metabolite of PRY, than aquaculture children. Although concentrations were present there were no significant adverse neurobehavioral effects observed between both groups in either season. DAPs, TCPy, and PYR were not significant predictors of adverse neurobehavioral performance during either season. Increasing DAP and PYR metabolites predicted some relatively small improvement in latency of response. The small sample size and inability to characterize chronic exposure it is a good idea that any significant difference should be cautiously regarded however small to moderate adverse effects of pesticide exposure should not and cannot be ruled out for neurobehavioral performance.

Organophosphate pesticide exposure in school aged children living in rice and aquacultural farming regions of Thailand (J. Rohitrattana et al., 2014).

Due to the previous studies of children residing in agricultural areas having higher exposure to Organophosphates (OPs) than children in other residential areas the object of this study was to determine the environmental conditions and activities that predict urinary biomarkers of OP exposure among children living in Central Thailand's farming regions. The study was conducted in October 2011 where 53 children ranging from 6 to 8 years of age were recruited to participate. These children were from Pathum Thani Province and 24 lived in rice farming communities at Khlong Luang District where Ops are the frequently used pesticides. Among the rest were 29 children living in aqua cultural farming communities at Lum Luk Ka district where OPs are not used at all. These 29 children had been recruited to serve as controls for the pathways of exposure such as residential dietary and other than occupational exposures present in rice farming. An assessment was done on household environment and activities by the children using a parental structured interview. Urine sampled collected in the early morning for OP urinary metabolites. Children in the rice farming community were found to have significantly higher level of urinary OP metabolites. The results from linear regression analysis revealed that the frequency of OP application on rice farms (}.DAP: P = .001; TCPy: P = .001) and living in a rice farming community (}.DAP: P = .009; TCPy: P < .001) were significant predictors of urinary DAP metabolite levels in participants. Increasing TCPy levels were significantly related to proximity to rice farm (P = .03), being with parent while working on a farm (P = .02), playing on a farm (P = . 03), and the presence of observable dirt accumulated on the child's body (P = .02**)** (Rohitrattana, 2014) Farming activity, household environments, and child behaviors strongly influenced OP metabolite levels among children who live in rice farming communities meaning these are the primary pathways to children being exposed to OPs.

Pyrethroid insecticide exposure in school aged children living in farming regions of Thailand (Rohitrattana, 2014).

This study was a cross sectional study done during the wet season and dry seasons in Thailand aimed to compare the levels of pyrethroid (PRY) exposure between children living in rice where high intensity PRY is used. Different amounts are applied in different seasons hence the study incorporated both the wet and the dry. As a control, children from an aqua cultural area in which low intensity PRY are applied participated in the study. To identify factors associated with PRY exposure environmental conditions and common activities of children were observed. Fifty three children ages 6-8 were recruited from rice farming and aqua cultural areas with a parental structured interview method used to gather information about PRY use, household environments and participants' daily activities. Urine samples were collected first thing in the morning for PYR urinary metabolite measurements such as 3-phenoxybenzoic acid [3-PBA] and cis/trans- 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid [DCCA]) measurements. During home visits, hand wipe samples were collected to measure PYR residues for dermal exposure measurements. PRY metabolites were not significantly different between both groups of children during both seasons however both had slightly increased urinary PRY metabolites during the wet season compared to dry season. After the analysis of linear regression results it was determined that the conditions and activities may be used to predict trends PYR exposure. Increased concentrations of PYR metabolites were likely to be related to frequency of PYR use in farms (β=0.004) and households (β=0.07), proximity to rice farms (β=0.09), playing in rice farms (β=0.11), and oral exposure from objects exposed to PYR (β=0.08). PYR exposure among children living in agricultural areas may be the result of significant use of PYR use in the rice farms and households based on the findings of this study. It is important that a much larger sample size be necessary in a subsequent study to further explore the association between long term exposure and health effects on children.

4.2.3 Chilies

Risk assessment of organophosphate pesticides for chili consumption from chili farm area, Ubon Ratchathani Province, Thailand (Ooraikul S., 2011).

This cross sectional study focused on a human health risk assessment related to chili consumption. It was conducted in October 2010 to February 2012 in Hua Rua sub district, Muang district Ubon Rathcathani at the Hua Rua agricultural community. The study consisted of 110 local people in which 45 were male and 65 were women. In order to collect socio-demographic and dietary information a survey was completed by face to face questionnaire. The average age ranged spanned from 15years old up to 79 years old and average weight 57 ± 10 kg. The average Thai generally consumes (0.005 kg/day) of chilies but this study found that the average was a lot higher in this community about (0.005 kg/day). In order to conduct a pesticide analysis 33 chili samples were collected from farms after the 7th day of application of pesticides. QuEChERS technique was used in order to extract chili samples and quantified by gas chromatography. The most common organophosphates detected were Chlorpyrifos and profenofos in the range of < 0.010-1.303 mg/kg and 0.520-6.290 mg/kg. Acceptable risk ratios were set at a Hazard quotient of < 1.0 but profenofos exceeded an acceptable risk ratio of HQ > 1.0. Average daily dose (ADD) of chlorpyrifos and profenofos were 1.07 × 10-4 mg/kg-day and 8.00 × 10-4 mg/kg-day. Non-carcinogenic adverse health effects may be caused from profenofos residues in chilies. The Hua Rua community is subject to acquiring an appropriate risk communication for pesticide residues the study suggests.

Indirect exposure of farm and non-farm families in an agricultural community, Ubonratchathani Province, Thailand (Norkaew, 2013).

Adverse effects on human health have become a rising concern in Thailand's agricultural communities due to the frequency of high use of pesticide products. Direct exposure is a problem but indirect exposure should also be given attention. Residential pesticide exposure of farms and non-farm communities in the agricultural community of Ubonratchathani province was the focus of this assessment. During April 2012 a total of 108 households of farm and non-farm families were recruited after signing a consent form before any data was collected. A 24 hour indoor air sampler and wiping surface residues was used to collect Organophosphate pesticide concentrations. Results from the air samples within the farm family study group showed that Chlorpyrifos pesticides were detected with an average 1.28x10-3 mg/m3, Non-farm families 1.15x10-3 mg/m3. Chlorpyrifos and pirimiphos-methyl in the farm family study group was detected in surface residue samples with an average of 0.047 mg/cm2 and 0.032 mg/. In non-farm families, chlorpyrifos and pirimiphos-methyl were detected with an average of 0.029 mg/cm2 and 0.024 mg/cm2. Indoor environments had been contaminated by farm used pesticides which was determined and tracked in by clothes that were not properly washed after application as well as air drift and shoes. By their main occupation in the community the study described that families who live in the community are possibly exposed due to indirect pesticide exposure.

Parkinsonism and related factors among farmers living in chili farm area in Hua Rua sub-district Muang district Ubonratchathani Thailand (Sunit Kukreja, 2015).

Two hundred and seventy one participants were selected for this study addressing the potential symptoms of Parkinsonism due to pesticide exposure. Previous studies had reported that pesticide exposure may cause symptoms of Parkinson's. To conduct this study the participants chosen consisted farmers with the average age of 50 and above that were both current and former workers. Chi square was used in order to analyze the risk factors to determine the association with the risk of Parkinsonism. The strongest risk factors were age and the pesticide combinations used as well as organophosphates and herbicides. Other risk factors included medical history, years living in the area, farm size, farming experience and activities with pesticides and pesticide preparation at home. The loss of dopamine is an underlying mechanism specific to Parkinson's disease and suggested by this study. Long term exposure to organophosphates and herbicides had begun to cause symptoms of Parkinsonism but future studies will be required to understand the mechanisms of PD in order to establish a causal relationship specific to factor or pesticide.

An association between organophosphate pesticides and exposure and parkinsonism amongst people in an agricultural area in Ubon Ratchathani Province, Thailand (Saewanee, 2015).

Since the prevalence of Parkinsonism and pesticide exposure studies are scarce, populations in agricultural communities lack the understanding between the association of pesticide exposure and factors of risk for Parkinsonism. This study investigated the potential association between organophosphate pesticides exposure and Parkinsonism. The study was cross sectional and consisted of 90 elderly people at an age range of 50-59 years old living in agricultural areas in Tambon Hua-Rua Health Promoting Hospital in April 2014. The participants were 60% female and 82% of all were farmers. Information was gathered using screening questionnaires for Parkinson's disease and levels of both blood enzymes erythrocyte cholinesterase (AChE), and plasma cholinesterase (PChE) were used as measurement tools using a Test-mate ChE (Model 400). Using an 11 item questionnaire the results showed that most of the participants applied insecticides on their farms and out of these about 17 participants (19%) reported that they lost balance when turning. Seventeen percent of participants said that they needed to move slowly or stiffly as well. Questionnaires seem very useful when establishing a way of screening for Parkinsonism. AcHE and PChe levels were set with a cutoff score of 5 or higher to establish prevalence of abnormal AChE. The study suggested that prevalence of abnormal AChE levels was 28.9% (95%CI=19.81-39.40) and 17.8% of PChE levels (95%CI=10.52-27.26). In order to predict parkinsonism AChE, and PChE level, with a cutoff score of 5 had to be a sensitivity of 0.31, specificity of 1.00, positive predictive value (PPV) of 1.00 and negative predictive value (NPV) of 0.78 for AChE. While PChE which the score value of 5 or more had a sensitivity of 0.19, specificity of 0.93, PPV of 0.38 and NPV of 0.84. In conclusion the study suggested that there had been an association to Parkinsonism and pesticide exposure.

Risk assessment of chlorpyrifos (organophosphate pesticide) associated with dermal exposure in chili-growing farmers at Ubonrachathani Province, Thailand (Taneepanichskul, 2010).

During the growing season of December 2009 to January 2010 a risk assessment was conducted to measure the exposure of Chlorpyrifos (Organophosphate Pesticide) in Chili-growing farmers in at Hua-Rua sub-district, Muang district, Ubonratchathani province, Thailand. The assessment focused on dermal exposure to residues of pesticide by collecting chlorpyrifos residue on chili-growing farmers' hands after spraying were collected using hand-wiping techniques. The study was done on 35 farmers, 26 of whom were men and 9 whom were women and the average age for the sample size was 40-50years old which was measured by simple random sampling. Hand surface areas were established with men having 0.088 m2 and females were at 0.075 m2. Chlorpyrifos were analyzed by using gas chromatograph with a selective detector; flame photometric detector (FPD) was 6.95 ±18.24 mg/kg/two hands (0.01 – 98.59 mg/kg/two hands). Calculating an average daily dose (ADD) was used to evaluate health risk of the chili growing farm community, which was done by using (RME) reasonable maximum exposure at 95th percentile of Chlorpyrifos concentration in order to health awareness and prevention. Farmers were given an (ADD) of 2.51 × 10-9 mg/kg/day which resulted in male farmers having a high ADD at (2.57 × 10-9 mg/kg/day) compared to female farmers with and ADD of (2.41 x 10-9 mg/kg/day). The Hazard Quotient (HQ) for risk characterization was implemented to indicate acceptable levels of exposure at 1.0 (HQ = 1.67 × 10-6). Furthermore, male and female farmers were lower than the acceptable level, 1.71 × 10-6 and 1.61 × 10-6. It was determined although unacceptable the farmers were not at risk to non-carcinogenic effects from dermal exposure however other routes such as inhalation and oral exposure should be considered. An evaluation should be done as the farmers did address the fact that they had been having acute and repeat effects after applying organophosphate pesticides.

Organophosphate pesticide exposure and dialkyl phosphate urinary metabolites among chili farmers in Northeastern Thailand (Taneepanichskul, 2014).

During the chili growing season between March and April 2012 exposure and urinary metabolites of Chlorpyrifos and profenofos were studied in an agricultural area in the northeastern part of Thailand. An assessment to study pesticide exposure concentrations through dermal and inhalations were designed for this study to find the relationship between urinary metabolites and means of exposure. The study tools used to conduct the assessment were dermal patches, dermal wipes and air samples that had been collected from 38 chili farmers in the area. Urine samples were taken during pre and post applications of pesticides as a biological monitoring indicator. Residues were detected on all dermal pathways from hand to face wipes however no significant residues were found on the feet. All personal air samples detected pesticide residues but correlation was not found

between dermal and inhalation exposure. There was however a relationship between the first pre application and morning void and post application morning void when it came to urinary metabolites. It was found that both pesticide exposure and urinary metabolites have been relevant to dermal exposure
(r= 0.405; p<0.05). Public health education and training programs could be suggested in this area as a way to inform farmers of the risk of being exposed to pesticides as well as appropriate use of (PPE) to properly use pesticides.

4.2.3 MAIZE

Herbicide Exposure to Maize Farmers in Northern Thailand: Knowledge, Attitude, and Practices (Denpong., 2012).

This study was conducted on maize farmers in the Nanoi district of Nan Province, herbicides are heavily used by maize farmers so a knowledge attitude and practices (KAP) study was necessary to evaluate the association it has with pesticide exposure. The study consisted of 80% males and 205 female between the ages of 35-53 years old. Overall out maize farmers 36.1% reported adverse effects to being exposed after the first spraying of pesticides. Out of the total farmers 48.6% had a high knowledge level, 69.3% had positive attitudes and 93.9% demonstrated adequate practices. With P value being set at (p< 0.05) the knowledge and the attitudes (r =0.37), the knowledge and the practices (r=0.24), and the attitude and the practices (r=0.2) a significant association was found. The maize farmers were found to still have herbicide poisoning symptoms although having high knowledge, positive and adequate practices which resulted in a qualitative double checking method. When maize farmers applied herbicides, it was found that they did not use personal protective equipment as a result of discomfort. Some maize farmers used them improperly as well. The risk communication and implementation of personal protective equipment are necessary for decreasing farmers risk to herbicide exposure and encouraging their concern for adverse health effects because the results found were completely opposite the results obtained by face to face interviews from farmer reports.

Risk reduction of paraquat exposure through risk communication model in Maize farmers at Namtok sub-district, Nanoi district, Nan Province, Thailand (Denpong, 2010).

This cross sectional study was conducted to evaluate the effectiveness of risk communication in Maize farmers in the Namtok sub district, Nanoi district of Nan province. Data was collected by face to face interviews with questionnaires as well as participatory observations in the first phase. The second phase of data collection consisted of quasi-experimental. Experimental group work was done to develop a Risk communication model based on the risk communication principle. The model comprised of 4 components including public meeting workshop, production and distribution media, home visit and Personal Protective Equipment (PPE.) A public meeting workshops consisting of sessions included focus group discussions, susceptibility to paraquat exposure, environmental effect of paraquat, toxicity and health effect of paraquat, peer norms for safe paraquat handling and skill training to increase self-efficacy beliefs. Evaluated effectiveness of communication model was the last phase of the study, the majority of maize farmers had high knowledge, positive attitudes and good practices. However, maize farmers still showed symptoms of being poisoned by pesticide exposure due to not using personal protective equipment (PPE) or not using it properly all together. In Phase 2 of the study it showed that paraquat residues in human serum were less than 0.21 mg/l in both groups. Paraquat residues more than 0.21 mgll were detected in 4 cases (7.8%) of experimental group and 11 cases (19.0%) of control group, after intervention. After intervention, knowledge, attitude, and practice between groups showed a significant difference. The difference of mean of knowledge, attitude, and practice of paraquat and exposure between groups was strongly different as well. The difference in PPE use in groups was significantly different when referring to hat, scarf, goggles, glove and mask use. Full compliance of PPE use showed a significant difference between group both before and after intervention ($p<0.05$). The proportion of paraquat poisoning toxic symptoms between group after intervention were significantly different in burn nose, eye irritation, tear drop, and mucus symptoms ($p<0.05$). In conclusion this study shows that the risk communication model may not significantly decrease residue or poisoning of paraquat symptoms after intervention in both the experimental and control groups when compared. However the model was affective in increasing the knowledge, attitude, and practice of paraquat use and exposure and significantly increases full compliance of PPE use after intervention in the experimental group when compared with the control group. If maize farmers follow recommendations for safe working practiced then occupational exposure may not pose a health risk, however, future risk communication studies in this area should be continued.

4.3 Perception of pesticide exposure

4.3.1 RICE

Health risk perception of occupational hazards among rice farmers in Nakhon Nayok Province, Thailand (Sapsatree Santaweesuk & 2013).

Occupational risk levels are unacceptable in Thailand among rice farmers. In order to accommodate working conditions health risk perception is important to preventative health. In this study rice farmers were subject to investigation on how risk perception affects their daily duties and effect exposure. Occupational risk perception was investigated as well as factors affecting their occupational risk perception. The study was cross sectional which was carried out in two communities in the Nakhon Nayok Province and consisted of a multistage random sampling. One hundred and forty five rice farmers were selected by choosing 1 person per each rice farmer household. Furthermore the data that was collected came from using a structured face to face interview questionnaire. Potential health risks of occupational hazards in four sides such as equipment use, pesticide use, ergonomics, and working conditions were some of the items evaluated among the 36 items under evaluation. In order to analyze such items the Likert scale model was used scaling risk from 0 (no risk) to 10 (high risk). After analysis it showed that rice farmers perceived health risk of occupational hazards on moderate level ($\bar{x}$= 6.90). However pesticide risk was at a high level of ($\bar{x}$= 8.07), ranking it as the first of health risk perception. The health risk perception of equipment use, ergonomics, and working condition were also moderate level ($\bar{x}$= 6.85, 6.19, and 6.54). Due to the result of simple linear regression it was found that two variables affect health

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risk perception at a significance level of 0.05. The current occupations of farmers as well as the farm size were variables that were negatively influenced by occupational health risk perception. This study assists in determining how important it is to understand the potential health risk perception of farmers in order to take the necessary steps in developing programs that will aid in the minimizing occupational hazards. When committing to an intervention program and risk management strategies the study would suggest that different levels of health risk perception be a priority in order to develop programs successfully.

Health risk behaviors associated with agrochemical exposure among rice farmers in rural community, Thailand: A community based ethnography (Raksanam et al., 2014).

Health beliefs and behaviors associated with agrochemical exposure among rice farmers was the study objective. Data was collected from 101 rice farmers in Khlong Seven community between January and June 2010 using a public risk assessment along with a Health Belief Model and community based ethnography resulting in data; comprised observations were made though unstructured and semi structured interviews, focus groups discussions. The perceived susceptibility to, severity of, benefits of and barriers to using agrochemicals safely all showed to be at moderate levels in farmers. Misuse of pesticides including beliefs of farmers regarding pesticide toxicity were major risk factors related to agrochemical exposure. Among other factors were the use of faulty spraying equipment and the lack of proper maintenance of equipment, PPE and lack of clothing. Intervention programs are suggested as a necessary action in order to improve safety regarding agrochemicals in the Khlong Seven rice community.

4.3.2 Chilies

Pesticide risk behavior and knowledge of chili and tomato farmers (Praneetvatakul, 2015).

Data was gathered from 200 Thai farmers growing hot chili peppers and tomatoes. The study was done in order to analyze the relationship between pesticide use, risk behavior of the farmers and the knowledge of the potential pesticide risk. A pesticide risk beliefs inventory was used to measure pesticide risk knowledge. Farmers were given hypothetical situations on making pesticide use decisions in order to measure risk behavior. Low levels of pesticide knowledge and higher levels of risk aversion were shown to be positively associated with pesticide use as farmers were highly risk averse. Farmers preferred to incur a high cost of pesticide to quickly eliminate pests. Lowering pesticide use can immediately contribute to less exposure but the only way is to enhance farmer knowledge about the pesticides they are using and the pesticide risk.

Pesticide application and safety behavior among male and female chili-growing farmers in Hua Rua sub-district , Ubon Ratchathani Province, Thailand (Taneepanichskul 2012).

With the wide spread use of pesticides it is important to understand the determinants that cause acute and chronic health effects from pesticide exposure. Farmers' behaviors are important to understand mainly to effectively reduce exposure. This study focuses on safety behavior related to pesticide exposure on chili growing farmers. A standardized questionnaire was designed in order to collect data on the safety behavior and use of pesticides. Gender was an independent variable used to study assessed safety behavior of 35 randomly selected chili growing farmers. Face to face interviews were administered to investigate the general characteristics, frequencies of spraying and safety behavior such as the pesticides used in Hua Rua sub district of Ubon Rathchathani province. Of the farmers 74.3% were male and 25.7% were female. Personal Protective Equipment such as gloves, boots and masks were rarely used due to the fact that most workers found it interferes with their tasks and can be uncomfortable. It was shown that 85.7% of the workers sprayed pesticides about once a week and nearly 80% did not wash or clean their equipment properly after pesticide application. After observation it is suggested that chili farmers in this area might be exposed to pesticides due to their lack of PPE use and their behavior towards not properly identifying the risk of improper use. This could be contributed to their increased health risk and further studies focusing on pesticide residues should be carried out as the study suggests. In order to protect themselves the study suggests that risk communication should be applied to increase farmer awareness of the exposure they are susceptible to.

Knowledge, attitude, and practice (KAP) of using personal protective equipment (PPE) for chili-growing farmers in Hua Rua sub-district, Mueang district, Ubonrachathani province, Thailand (Norkaew S., 2010).

This study focuses on the knowledge level of farmers and their abilities to use pesticide properly and their attitude towards the potential exposure of those pesticides. The aim is to observe the knowledge, attitudes, and practices on using personal protective equipment while evaluating the knowledge, attitudes, and practices associated with pesticide use. Lastly, the findings are dedicated to provide recommendations and an outline of guidelines to reduce chili farmers from pesticide exposure. The location of the study is in Hua Rua sub district Ubonrachathani Province, Thailand. Face to face interviews were used to gather information regarding Knowledge, attitude, and practices from 330 chili growing farmers. Of all participants 53% were male with ages in the range of 31-40 years which consisted of 71% being educated at a primary school and most applied pesticides by themselves. It seems as the local government authorities and the communities are aware of the potential risk of pesticide exposure as 89.4% of farmers recognized that it was necessary to wear proper personal protective equipment (PPE). The awareness pertaining to pathways such as inhalation, dermal and ingestion was at 83.3% however 45.5% were aware that they should be spraying in the windward direction. It was common for participants to check equipment before use and wearing clothes properly while spraying. However, 54.5% of farmers' attitudes showed no concern about pesticide use and the potential risk of exposure. About 85% of Farmers displayed fair practice levels. Using Spearman's rank correlation coefficient 0.216, 0.285, and 0.305 respectively, p-value < 0.001) the significant association between knowledge and attitude, knowledge and practice, and attitude and practice were low positive correlation.

4.4 Pesticide exposure in other vegetable farming communities.

Exposure assessment of traditional and IPM farmers on using pesticides: A case study at Bang Rieng Sub District, Khuan Nieng District, Songkhla Province (Jirachaiyabhas., 2004).

This case study in Bang Rieng sub district of Khuan Nieng district in Songkhla Province evaluated the exposure to pesticides quantitatively of farmers in this area. In addition, it focused to gauge the concentration of organophosphate pesticides such as chlorpyrifos ad methyl-parathion while farmers sprayed pesticides. Exposure was measured in 33 traditional and 40 integrated pest management (IPM) farmers of Bang Rieng. AN exposure assessment was used to compare results which showed significant difference in the level of exposure between the traditional farmers, who had the average pesticide exposure scores of 58.30 points and the IPM farmers, whose average scores were 53.50 points, ($p < 0.015$). Personal sampling was implemented during pesticide spraying periods and 33 air samples were collected using this method. Higher levels of exposure were found in traditional farmers with the mean concentration of 0.1865 mg/m3 compared to the IPM farmers who were exposed to a mean pesticide concentration of 0.037 mg/m3 . All in all the exposure assessment showed that traditional farmers were exposed to a greater amount of the pesticides through inhalation pathways compared to the IPM farmers originally estimated that the farmers would be exposed to 186-19,616.6 mg of the organophosphate pesticide through inhalation throughout their lifetime (65 years).

Inhalation Exposure of Organophosphate Pesticides by Vegetable Growers in the Bang-Rieng Sub district in Thailand (Jaipieam, 2009).

Inhalation exposure to organophosphate pesticides along with the evaluation of the associated health risks to vegetable growers was investigated in this study. Air samples were collected in Bang Rieng agricultural community using sampling pumps with sorbent tubes which were placed in the breathing zones of vegetable growers. Residues of chlorpyrifos, dicrotophos and profenofos were analyzed during the wet and dry seasons from 33 vegetable growers and 17 reference subjects. As a result median concentrations of OPPs in the air of farm areas were in the range of 0.022–0.056 mg/m3 and air in nonfarm areas in the range of <0.0016– <0.005 mg/m3. The vegetable growers were found to have higher concentrations of all 3 pesticides compared to those of the reference during both seasons. Acute adverse effects from inhalation of chlorpyrifos and dicrotophos may be putting vegetable growers at risk during pesticide application, mixing and loading. Appropriate strategies were suggested to be implemented concerning risk reduction and management in this community.

Organophosphate Pesticide Exposures of Traditional and Integrated Pest Management Farmers from Working Air Conditions: A Case Study in Thailand (Jirachaiyabhas, 2004).

An exposure assessment and comparison was made on levels of pesticide exposure of traditional and integrated pest management (IPM) farmers in this study in order to examine the concentrations of organophosphate pesticides such as chlorpyrifos and methyl parathion. The study was done in Tambon Bang Rieng by measuring the ambient air breathed by farmers in this area. A total of 33 air samples were collected during the time pesticides were being sprayed which showed that traditional farmers were exposed to higher levels of the pesticides with an average concentration of 0.19 mg/m3 , compared with 0.037 mg/ m3 for the IPM farmers. As seen in the previous study it was concluded that traditional farmers had more pesticide concentrations by inhalation than the IPM farmers.

Pesticide Exposures among Hmong Farmers in Thailand (Kunstadter et al., 2001).

This study examines three highland communities and Hmong in urban Chiang Mai. The methods of application of pesticide used by most rural participants in this study were by back pack, machine sprays and by hand to control insects, weeds and fungus. Language skills among Hmong farmers vary which showed that Hmong women have a limited ability in speaking Thai compared to that of the men farmers. This has contributed to the information gap concerning hazards of exposure and the use of personal protective equipment. Amongst the 582 Hmong farmers screened the results showed that 20-69% had potentially risky or unsafe levels of unsafe levels of cholinesterase inhibition, an indicator of exposure to organophosphate and carbamate pesticides. Since it was found that exposure rates between both farmers who apply pesticides and those who do not were high, it's suggested that different routes of exposure other than direct contact are also associated with exposure among these communities.

Assessment of farmer and non-farmer health effects related to organophosphate pesticide exposure using blood cholinesterase activity as a biomarker in agricultural area Ongkharak District Nakhon Nayok Province Thailand (Wilaiwan., 2014)

This cross sectional study consisted of 35 farmers and 35 non- farmers in Sisa Krabue sub district, Ongkharak district, Nahkon Nayok with the aim to assess health effects caused by organophosphate exposure. Measurement tools used for measuring blood cholinesterase levels of both blood enzymes and plasma cholinesterase were questionnaires and Test-mate ChE (Model 400). Participants in this research accounted for 40% male and 60% female with an average age of 42.40 years of age. As a result of the study AChE level of farmers were likely to be lower than that of the non-farmers and PChE levels in the farmer group was significantly lower than those of the non-farmer group. Farmers showed more risk than that of non-farmers and showed that gender was associated with AChE levels however there was a low negative correlation between AChE levels and PChE. Other factors were examined such as drinking alcohol, smoking and years of using pesticides showed a significant association with PChE levels. Increase eye symptoms central nervous system symptoms and glands were significantly associated with PChE in farmers with only AChE associated with central nervous system symptoms. A knowledge, attitude and practices assessment should be provided in order to establish awareness for appropriate prevention from health effects caused by pesticide exposure.

Organophosphate Pesticide Residues in Drinking Water from Artesian Wells and Health Risk Assessment of Agricultural Communities, Thailand (Jaipieam., 2009)

Participants in this study were given a survey to complete, as organophosphates were located in artesian wells in a Thai agricultural and non-agricultural community during both the wet and dry seasons. In addition to the study 100 water samples were collected for analysis. For Organophosphate pesticide analysis a gas chromatography flame photometric detector was used. On average the concentration of OP in the agricultural communities in both the dry and went season was higher than in the non-agricultural communities. The communities were exposed to OP residues under oral chronic reference dose and the study suggests that agricultural communities may be exposed at greater levels than that of non-agricultural communities during both the wet and dry seasons.

4.5 Health risk, pesticide exposure and perception in farmers

On rice and chili farms most farmers use organophosphates on their crops and normally apply more than what is recommended whereas maize farmers tend to spray herbicides on their farms. In rice farms, studies suggest that occupational pesticide exposure and agricultural tasks in the paddy field may be associated with the increasing prevalence of acute adverse health effects such as dizziness, fatigue and respiratory infection. Some farmers reported their adverse health effects related to gastrointestinal system, urinary system, eye, skin, and central nervous system. Major risk factors related to agrochemical exposure resulted from the misuse of pesticides, or improper use of personal protective equipment (PPE). The farmers beliefs regarding pesticide toxicity along with lack of appropriate clothing increase health risk not only among farms but families as well. Findings suggest that PYR use in rice farms and households may be significant sources of PYR exposure among children living in agricultural areas (Rohitrattana, 2014). Metabolite levels among children who live in rice farming communities were strongly influenced by farming activity, such as not washing clothing properly. Household environments, and child behaviors, also suggest that these are primary pathways to indirect exposure to children living near rice farms (Rohitrattana, 2014). Overall the original hypothesis was the rice farmers were at higher risk from pesticide exposure than chili and rice farmers. Based on results compared from AChE and PChE levels in farmers it is suggested that rice is farmers indeed have a higher risk of pesticide exposure resulting in adverse health effects.

Studies on chili farms suggest that the lack of Knowledge, Attitude and Practice (KAP) has put chili farmers at high risk of pesticide exposure. Chili plants are large sometimes growing above the farmer in 1 study organophosphates such as chlorpyrifos and profenofos residues were detected on dermal patches, face wipes, and hand wipe samples suggesting that farmers are not properly using pesticides nor (PPE) Chili farmers participating in the studies only rarely used protective equipment which most applied pesticides weekly. Use behavior would suggest that chili-growing farmers may have high risk of exposure. The lack of Knowledge, Attitude and Practice (KAP) among chili farmers has shown the long term exposure to pesticides particularly organochlorine and all groups of herbicides had begun to cause the symptoms of Parkinsonism among the some farmers (Saewanee, 2015). KAP studies have not only suggested exposure to farmers but and also indirect pesticide exposure have contaminated the indoor environment of households.

The paucity of maize studies suggest that much more research needs to done on the subject. However what can be suggested from current studies is that the majority of maize farmers have high knowledge, positive attitude, good practices, but the maize farmers still had herbicides poisoning symptoms (Denpong., 2012).

Due to discomfort most maize farmers did not use personal protective equipment which is a risk behavior common amongst most farmers in Thailand (Denpong., 2012). Results of study populations in chosen articles are summarized in Table 9

Table 9 Results of study populations of rice, chili and maize farmers

Summary of studies investigating rice cropping system exposures to pesticides		
First author (year)	Study population	Study Results
		PYRETHROIDS
(Fiedler et al., 2015)	Twenty-four children from a rice farming community (exposed) and 29 from an aquaculture (shrimp) community (control)	DAPs, TCPy, and PYR were not significant predictors of adverse neurobehavioral performance.
(Rohitrattana, 2014)	53 participants aged between 6 and 8 years old were recruited from rice farms and aquacultural areas.	Both participant groups had slightly increased urinary PYR metabolites during the wet season compared with the dry season. PYR use in rice farms and households may be significant sources of PYR exposure among children living in agricultural areas.
		ORGANOPHOSPHATE
(Sapbamrer & Nata, 2014)	182 rice farmers (exposed subjects) and 122 non-farmers (controlled group)	Occupational pesticide exposure and agricultural tasks in the paddy field may be associated with the increasing prevalence of respiratory tract and muscle symptoms.
(Sombatsawat, 2014)	33 male farmers and average age, 46 years old.	Reported their adverse health effects related to gastrointestinal system, urinary system, eye, skin, and central nervous system. Twenty four hours after first application, significant association in eye symptoms Rice farmers applied pesticides at the beginning; both AChE and PChE level were abnormal and self-recovering to normal level by time.
(J. Rohitrattana et al., 2014)	53 6–8- year-old participants, 29 participants, living in aquacultural farming communities	Frequency of OP application on rice farms and living in a rice farming community were significant predictors of urinary DAP metabolite levels. Primary pathways- related to proximity to rice farm, being with parent while working on a farm, playing on a farm, and the presence of observable dirt accumulated on the child's body.
		RISK BEHAVIOR/PERCEPTION
(Raksanam et al., 2014)	101 rice farmers in Khlong Seven community	exposure resulted from the misuse of pesticides, erroneous beliefs of farmers regarding pesticide toxicity, the use of faulty spraying equipment, the lack of proper maintenance of spraying equipment, or the lack of protective gear and appropriate clothing.

(Sapsatree Santaweesuk & 2013)	145 rice farmers	Farmers perceived health risk of occupational hazards on moderate. The pesticide risk perception was high, first of health risk perception. current occupation and farm size variables for exposure
(Ooraikul S., 2011)	110 local people (45 males and 65 females)	Risk characterization of chlorpyrifos did not exceed an acceptable risk ratio (hazard quotient, but risk characterization of profenofos exceeded an acceptable risk ratio. Local people in this area might be getting non-carcinogenic adverse health effects from profenofos residues in chili.
(Taneepanichskul, 2014)	38 chili farmers	The main relationship between pesticide exposure and urinary metabolite was found to have been relevant to dermal exposure Chlorpyrifos and profenofos residues were detected on dermal patches, face wipes, and hand wipe samples
(Taneepanichskul, 2010)	35 farmers (26 men and 9 women)	HQ of farmers was lower than the acceptable level). Both of the HQ for male and female farmers were lower than the acceptable level.
(Taneepanichskul, 2012)	35 male farmers and average age, 46 years old.	Chili-growing farmers in this area might be exposed to pesticides due to their pesticide using behavior. Most participants only rarely used protective equipment.
(Norkaew, 2013)	108 households of farm and non-farm families	Pesticides used in farms have contaminated the indoor environment and can be tracked in by clothes, shoes and air drift. Chlorpyrifos pesticides were detected in air samples, Chlorpyrifos and pirimiphos-methyl were detected in surface residue samples
(Saewanee, 2015)	Ninety elderly people living in agricultural areas, 50 to 59 years old	Described an association between pesticides exposure and Parkinsonism. Prevalence of abnormal AChE and of PChE levels
		ORGANOCHLORINE
(Sunit Kukreja, 2015)	271 participants that consisted of elderly farmers with average of 50 and above, both current and former,	Combination and use of organochlorine and herbicides were the strongest risk factors Parkinsonism. Long term exposure to pesticides particularly organochlorine and all groups of herbicides had begun to cause the symptoms of Parkinsonism among the farmers.

(Praneetvatakul, 2015)	200 Thai farmers growing hot (chili) pepper and tomato	**RISK BEHAVIOR** Pesticide use is positively associated with lower levels of pesticide knowledge and higher levels of risk-aversion.

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Summary of studies investigating maize cropping system exposures to pesticides

First author (year)	Study population	Study Results
		ORGANOPHOSPHATES
(Denpong., 2012)	407 participated in the survey	maize farmers have high knowledge, positive attitude, good practices, but the maize farmers still had herbicides poisoning symptoms. Did not use the personal protective Equipment
(Denpong, 2010)	407 farmers	Paraquat poisoning toxic symptoms between group after intervention were significantly different in burn nose, eye irritation, tear drop, and mucus symptoms Affective in increasing the knowledge, attitude, and practice of paraquat use and exposure and significantly increases full compliance of PPE use after intervention
(Jaipieam, 2009)	33 vegetable growers	Indicate that the vegetable growers may be at risk for acute adverse effects via the inhalation of chlorpyrifos and dicrotofos during pesticide application, mixing, loading, and spraying.
(Jirachaiyabhas, 2004)	Thirty-three air samples were collected during pesticide spraying.	Traditional farmers 'absorbed more of pesticide via Inhalation than did IPM farmers.
(Kunstadter et al., 2001)	Three highland communities and Hmong in urban Chiang Mai were studied. 582 Hmong adults.	20-69% of 582 Hmong adults with risky or unsafe levels of cholinesterase inhibition, exposure to organophosphate and carbamate pesticides. Exposure rates are as high among those' who do not actually apply pesticides as among those who do. exposure by routes in addition to direct contact
(Jaipieam., 2009)	100 water samples were collected and subjects were asked to complete a survey.	Agricultural communities were exposed to pesticide residues under the oral chronic reference dose. People in agricultural communities may be exposed to significantly greater levels of pesticides than non-agricultural populations during the dry and wet seasons
(Wilaiwan., 2014)	farmers (n=35) and non-farmers (n=35)	The farmers were significantly associated with increase eye symptoms, central nervous system (CNS) symptoms, respiratory system symptoms, and glands. The AChE level was significantly associated with CNS symptoms The PChE level was significantly associated with eye symptoms, CNS symptoms, respiratory system symptoms,

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		and glands symptoms
(Jirachaiyabhas., 2004)	33 traditional and 40 integrated pest management (IPM) farmers Thirty-three air samples were collected	Significant difference in the level of exposure between the traditional farmers and the IPM farmers Traditional farmers were exposed to higher levels of the pesticide(s)

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CHAPTER V
DISCUSSION, CONCLUSION, AND RECOMMENDATION

5.1 Discussion

This study was a systematic review about the health risks of pesticide exposure in agriculture systems in Thailand. Participants came from farming and non-farming communities across the country from different cropping systems. Many factors were addressed such as pathways of exposure, farmer perceptions, and risk behaviors among farmers of the three major cropping systems; rice, chili and maize. Thailand having a major role in exporting food is drastically increasing their dependency on pesticide exposure most of which are not regulated and improperly applied to agriculture resulting in higher risk of exposure. Organophosphates are prevalent on rice and chili farms and most studies on organophosphates show that farmers do suffer from adverse health effects while children are also exposed indirectly. Contamination of Indoor environments by farm used pesticides were determined to be the result of improper methods of washing and putting away spraying equipment and clothes. It is suggested that possible indirect pesticide exposure to families that live in the vicinity comes from these bad habits of not properly washing equipment or clothes and can also result in indirect exposures in the household. Furthermore studies have shown the main pathway for children may be from activities done around farms which track dirt into households as a result cause children in rice farming communities to have higher urinary OP metabolites than children in non-farming communities. Maize farms

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rely of herbicides however not much research has been done in the field creating a knowledge gap of pesticide exposure and it's relation to health risk on maize farmers. Knowledge, attitudes, and practice (KAP) is suggested to be one of the most important factors to be researched for a better understanding on what causes high prevalence of pesticide exposure. Most studies reflect on the results of pesticide exposure being the result of improper use of personal protective equipment (PPE) and suggest guidelines and management strategies be implemented to increase the knowledge attitude and practices of farmers. Continued studies should be done on KAP, as it is suggested to be the catalyst of change in the rate of pesticide exposure and chance of exposure. In conclusion the research suggest that rice farmers have a higher health risk than chili and maize farmers based on AChE and PChE levels in farmers. Agricultural communities may be exposed at greater levels than that of non-agricultural communities during both the wet and dry seasons so further research should be done with control groups to show the disparity between farming community pesticide exposure and non-farming communities.

5.2 Conclusion

Participants in this study were all secondary data collections from multiple studies pertaining to rice, chili, and maize. In some studies we have even concluded men having a higher average daily dose (ADD) of pesticide exposure than women, however looking at demographic data such as gender we can conclude that there is no disparity between men and woman being exposed as both groups are equally exposed.

With the growing demand of crops Northern Thailand is the largest maize producing region, accounting for about 49% of the national acreage, followed by the Northeast Region with 26%. The Central Region accounts for 24% of the total maize area. Thailand has plans to further increase the land available for rice production, with a goal of adding 500,000 hectares to its already 9.2 million hectares of rice-growing areas. Pesticide exposure in the last decade has increased drastically along with the rising demand of crop out. Looking at the comparison among rice, chili and maize it can be suggested that the pesticide residues on chili exceed the acceptable levels suggested by the hazard quotient (HQ > 1). However, looking into comparisons of studies between AChE and PChE levels in rice and chili it can be suggested that rice farmers are at a higher risk of exposure than chili and maize farmers. The original hypothesis stating rice farmers were at higher risk than chili and maize farmers can be suggested by the comparison of AChE and PChE as a biomarker. Studies in which biomarkers of OP exposure were collected observed adverse neurobehavioral effects associated with lower AChE activity and neurologic symptoms such as dizziness and blurred vision. AChE activity was significantly lower median in rice farmers but significantly higher prevalence of difficulty in breathing and chest pain. In one study both AChE and PChE levels were abnormal and self-recovering to normal levels with time. Collectively most rice, chili and maize farmers do not use personal protective equipment to the best of their ability to accommodate the increase of pesticide applications on crops which leaves opportunity for pesticide exposure. The use of gloves, masked and proper clothing is essential to reducing pesticide exposure in farming communities yet we have not seen this practice becoming a priority. Spraying happens all year round in multiple applications and the neglect in proper PPE use is not only an occupational hazard but also an environmental one with indirect consequences on farmers' families as well. Predominately seen in the rice studies children are becoming exposed due to the practices of not properly cleaning farming equipment prior to being used. Rice farming families tend to live closer to paddies and child behaviors have influenced OP metabolite levels.

Knowledge, attitude and practices along with PPE are essentially important to decreasing pesticide exposure among all cropping systems in Thailand. It is suggested that with this data a public health education center for programs be implemented in Universities in Thailand. Programs like this are already modeled and work very well in the United States and European Union which produce similar agriculture.

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5.3 Recommendations

1.) Intervention is needed to increase Knowledge, Attitude and Practice (KAP) of all farmers in Thailand specifically rice, chili and maize farmers.
2.) Due to the paucity of studies in Maize it is suggested that there be more focus on maize cropping systems in Thailand to grasp a more clear association between health risks and pesticide exposure.
3.) Indirect exposed groups, such as children, should be included for additional rice, chili and maize studies.
4.) A University center for agricultural health should be established in Thailand to address the increased use of pesticides and fertilizers and other agricultural inputs.

Appendix

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TableA1 Occurrences, Signs, and symptoms of pesticide exposure via skin

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Irritation, Rash, Blistering, or Erosion (without sensitization)	Copper, organotin, cadmium compounds Metam sodium Paraquat Diquat Sodium chlorate Phosphorus Sulfur Glyphosate Propargite Sodium hypochlorite Quaternary ammonia Thiram Chlordimeform Cationic detergents Hexachlorphene Ethylene oxide Formaldehyde Acrolein Methyl bromide Ethylene dibromide Dibromochloropropane Dichloropropane Endothall Aliphatic acids	Pentachlorophenol Picloram Chlorophenoxy compounds Captan Rotenone Diethyltoluamide Creosote Fungicides Herbicides with irritant properties Petroleum distillate
Contact dermatitis	PCP Paraquat DEET Chlorhexidine Creosote Hexachlorphine Pyrethrins Chlorothalonil Thiram Thiophthalimides	
Flushing	 Cyanamide Nitrophenols	Thiram plus alcohol
Dermal sensitization	 Propachlor Propargite Ethylene oxide	Anflazine Chlorothalonil Barban Captafol Formaldehyde
Beefy red palms, soles	Borate	
Urticaria	 Chlorhexidine PCP DEET	 Fluoride Pentachlorophenol
Bullae	Liquid fumigants	Hexachlorobenzene

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TableA1 Occurrences, Signs, and symptoms of pesticide exposure via skin **(Continued)**

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Pallor	Organochlorines Fumigants Sodium fluoride Creosote	Coumarins Indandiones
Cyanosis	Sodium chlorate Paraquat Cadmium dusts Sodium fluoroacetate Strychnine Crimidine Nicotine Organochlorines	Organophosphates Carbamate insecticides Agents that cause shock, myocardiopathy, severe arrhythmias or convulsions
Yellow stain	Nitrophenols	
Keratoses, brown discoloration	Inorganic arsenicals	
Ecchymoses	Coumarins Indandiones	Phosphorus Phosphides
Jaundice	Carbon tetrachloride Chloroform Phosphorus Phosphides Phosphine Paraquat Sodium chlorate	Inorganic arsenicals Diquat Copper compounds
Excessive hair growth		Hexachlorobenzene

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Loss of hair	Thallium	Inorganic arsenicals
Loss of fingernails		Paraquat Inorganic arsenicals
Brittle nails, white striations		Inorganic arsenicals Thallium
Sweating, diaphoresis	Organophosphates Carbamate insecticides Nicotine Pentachlorophenol Naphthalene Aminopyridine	Copper compounds

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Table A2 Occurrences, Signs, and symptoms of pesticide exposure via eyes

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Conjunctivitis (irritation of mucous membranes, tearing)	Copper compounds Organotin compounds Cadmium compounds Metam sodium Paraquat Diquat Acrolein Chloropicrin Sulfur dioxide Naphthalene Formaldehyde Ethylene oxide Methyl bromide Endothall Toluene Xylene	Thiophthalimides Thiram Thiocarbamates Pentachlorophenol Chlorophenoxy compounds Chlorothalonil Picloram Creosote Aliphatic acids
Tearing	Organophosphates Carbamate insecticides Chloropicrin Acrolein	Pentachlorophenol Pyrethrins
Yellow schlerae	Nitrophenols	Agents that cause jaundice (see above under Skin)
Keratitis	Paraquat	
Ptosis	Thallium	
Diplopia	Organophosphates Carbamate insecticides Nicotine	
Photophobia		Organotin compounds
Constricted visual fields	Organic mercury	
Optic atrophy		Thallium
Miosis	Organophosphates Carbamate insecticides	Nicotine (early)
Dilated pupils	Cyanide Fluoride	
Unreactive pupils	Cyanide	

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Table A3 Occurrences, Signs, and symptoms of pesticide exposure via nervous system.

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Paresthesia (chiefly facial, transitory)	Organophosphates Cyanopyrethroids Phosphides Organochlorines Thiabendazole	Nicotine (late)
Paresthesia of extremities	Inorganic arsenicals Organic mercury Sodium fluoroacetate Carbon disulfide Thallium	Pyrethroids (transitory)
Headache	Organophosphates Carbamate insecticides Nicotine Inorganic arsenicals Organic mercury Cadmium compounds Organotin compounds Copper compounds Thallium Fluoride Borates Naphthalene Phosphine Halocarbon fumigants Creosote Diquat Cholecalciferol Cyanamide	Organochlorines Nitrophenols Thiram Pentachlorophenol Paraquat Diethyltoluamide
Behavioral mood Disturbances (confusion, excitement, mania, disorientation, emotional lability)	Organic mercury Inorganic arsenicals Organotin compounds Thallium Nicotine Sodium fluoroacetate Diquat Cyanide Nitrophenols Aminopyridine Carbon disulfide Methyl bromide	Organophosphates Carbamate insecticides Pentachlorophenol Sodium fluoride Diethyltoluamide Organochlorines
Depression, stupor, coma, respiratory failure, often without convulsions	Organophosphates Carbamate insecticides Sodium fluoride Borate Diquat	Inorganic arsenicals Metaldehyde Sulfuryl fluoride Halocarbon fumigants Phosphorus Phosphine Paraquat Chlorophenoxy compounds Diethyltoluamide Alkyl phthalates

Table A3 Occurrences, Signs, and symptoms of pesticide exposure via nervous system. (continued)

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Seizures/Convulsions (clonic-tonic) sometimes leading to coma	Organochlorines Strychnine Crimidine Sodium fluoroacetate Nicotine Cyanide Acrylonitrile Metaldehyde Thallium DEET Chlorobenzilate Carbon disulfide Phosphine Povidone-iodine Hexachlorophene Sodium chlorate Creosote Endothall Fluoride	Nitrophenols Pentachlorophenol Inorganic arsenicals Organotin compounds Diquat Borate Sulfuryl fluoride Methyl bromide Chlorophenoxy compounds Organophosphates Carbamate insecticides Aminopyridine
Muscle twitching	 Organophosphates Carbamate insecticides Nicotine Sulfuryl fluoride	 Organic mercury Chlorophenoxy compounds
Myotonia		Chlorophenoxy compounds
Tetany, carpopedal spasms	 Fluoride Phosphides Phosphorus	
Tremor	 Organic mercury Thallium Organophosphates Carbamate insecticides Nicotine Metaldehyde Borates	 Pentachlorophenol Nitrophenole Thiram
Incoordination (including ataxia) Paralysis Paresis, muscle weakness	Halocarbon fumigants Organophosphates Carbamate insecticides Carbon disulfide Nicotine Thallium Inorganic arsenicals Organophosphates Carbamate insecticides Nicotine	Organic mercury Organochlorines Organic mercury Diethyltoluamide
Hearing loss	Organic mercury	

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Table A3 Occurrences, Signs, and symptoms of pesticide exposure via nervous system. (continued)

Manifestation	Poisoning characteristics	Occurrence of Agents
Hypotension shock	Phosphorus Phosphides Phosphine Sodium fluoride Sodium chlorate Borate Thallium Copper compounds Endothall Cyanamide	Inorganic arsenicals Nicotine (late) Creosote Alkyl phthalate Cycloheximide Formaldehyde Norbormide
Hypertension	Thallium (early) Nicotine (early)	Organophosphates

Table A4 Occurrences, Signs, and symptoms of pesticide exposure via cardiovascular system.

Manifestation	Poisoning characteristics	Occurrence of Agents
Cardiac arrhythmias	Sodium fluoroacetate Halocarbon fumigants Nicotine Sodium fluoride Ethylene oxide Sodium chlorate Thallium-ventricular Povidone-iodine Veratrum alkaloid (sabadilla)	Inorganic arsenicals Phosphorus Phosphides Phosphine Organochlorines Cyanide Acrylonitrile Fluoride
Bradycardia (sometimes to asystole)	Cyanide Organophosphates Carbamate insecticides	Nicotine
Tachycardia	Nitrophenols Pentachlorophenol Cyanamide	Metaldehyde Organophosphates

Table A5 Occurrences, Signs, and symptoms of pesticide exposure via respiratory System.

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Upper respiratory tract irritation, rhinitis, scratchy throat, cough	Naphthalene Paraquat Chloropicrin Acrolein Dichloropropene Ethylene dibromide Sulfur dioxide Sulfuryl fluoride Acrylonitrile Formaldehyde Cadmium dusts ANTU	Dry formulation of copper, tin, zinc compounds Dusts of thiocarbamate and other organic pesticides Chlorophenoxy compounds Aliphatic acides Rotenone
Sneezing	Sabadilla	
Runny nose	Pyrethrins Inorganic arsenicals Organophosphates Carbamate insecticides	Dry formulation of copper, tin, zinc compounds Dusts of thiocarbamate and other organic pesticides Chlorophenoxy compounds Aliphatic acides Rotenone
Pulmonary edema (many chemicals come packaged in a hydrocarbon vehicle, well known to cause pulmonary edema)	Methyl bromide Phosphine Phosphorus Phosphine Ethylene oxide Ethylene dibromide Acrolein Pyrethroids Sulfur dioxide Cationic detergents Creosote Methylisothiocyanate Cadmium	Organophosphates Carbamate insecticides Paraquat Phosphides
Pulmonary consolidation	Paraquat Cadmium dusts Methyl bromide	Diquat
Dyspnea	Organophosphates Carbamate insecticides Nicotine Paraquat ANTU Cadmium dusts Cyanamide Sulfuryl fluoride Pentachlorophenol Methyl bromide Sulfur dioxide Chloropicrin	Nitrophenols Cyanide Creosote Pyrethins

TABLE A6 Occurrences, Signs, and symptoms of pesticide exposure via gastrointestinal tract.

Manifestation	Poisoning characteristics	Occurrence of Agents
Nausea, vomiting, commonly followed by diarrhea	Organophosphates Carbamate insecticides Nicotine Arsenicals Fluoride Cadmium compounds Organotin compounds Copper compounds Sodium chlorate Borate Cyanide Chlorophenoxy compounds Phosphorus Phosphides Phosphine Carbon disulfide Chloropicrin Halocarbon fumigants Endothall Metaldehyde Thallium Red quill Diquat Naphthalene Methyl bromide Dibromochloropropane Veratrum alkaloid Thiram	Pentachlorophenol B.thuringiensis Cholecalciferol Thiram Ethylene dichloride Propane Ethylene oxide Cresol Many pesticides have some irritant property
Diarrhea (first)	Organophosphates Carbamates Pyrethroids Borates Sulfur Nicotine B.thuringiensis Thiram Cadmium	Cationic detergents Cresol Hexachlorophene Chlorophenoxy compounds
Diarrhea (bloody)	Fluoride Paraquat Diquat Thallium Coumarins Indandiones Endothall Arsenicals	Phosphorus Phosphides Cycloheximide

Table A6 Occurrences, Signs, and symptoms of pesticide exposure via nervous system via gastrointestinal tract and liver (continued)

Manifestation	**Poisoning characteristics**	**Occurrence of Agents**
Abdominal pain	Organophosphates Carbamate insecticides Paraquat Diquat Nicotine Methaldehyde Fluoride Borate Phosphorous Phosphides Inorganic arsenicals Cadmium compounds Copper compounds Thallium Organotin compounds	Chlorophenoxy compounds Aliphatic acids Sodium chlorate Creosote Endothall Aminopyridine Coumarins Indandiones Fumigants (ingested) Cycloheximide
Stomatitis	Inorganic arsenicals Paraquat Diquat Copper compounds	Thallium
Salivation	Organophosphates Carbamate insecticides Nicotine Aminopyridine Sodium fluoride Cyanide Cadmium compounds	
Ileus	Thallium Diquat	

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Table A7 Occurrences, Signs, and symptoms of pesticide exposure via the liver

Manifestation	Poisoning characteristics	Occurrence of Agents
Enlargement	Copper compounds Sodium chlorate Phosphine Carbon tetrachloride Cholorform	Inorganic arsenicals Phosphorus Phosphides Phosphine Organochlorines Cyanide Acrylonitrile Fluoride
Jaundice(see section on skin)		

Table A8 Occurrences, Signs, and symptoms of pesticide exposure via the kidneys

Manifestation	Poisoning characteristics	Occurrence of Agents
Proteinuria Hematuria Sometimes leading to oliguria Acute renal failure with Azotemia	Inorganic arsenicals Copper compounds Sodium fluoride Naphthalene Borate Nitrophenols Pentacholorphenol Sodium chlorate Sulfuryl fluoride Paraquat Diquat Arsine Ethylene dibromide	Cadmium compounds Phosphorus Phosphides Phosphine Chlorophenoxy compounds Creosote Organotin compounds
Dysuria, hematuria, pyuria	Chlordimeform	
Polyuria	Cholecalciferol	Fluoride
Wine-red urine (porphyrinuria	Hexachlorobenzene	
Smoky urine	Creosote	
Glycosuria		Organotin compounds
Ketonuria		Borate
Hemoglobinuria	Naphthalene Sodium chlorate Arsine	

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Table A9 Occurrences, Signs, and symptoms of pesticide exposure via the reproductive system.

Manifestation	Poisoning characteristics	Occurrence of Agents
Low sperm count	Dibromochloropropane	Kepone

Table 10 Occurrences, Signs, and symptoms of pesticide exposure via blood

Manifestation	Poisoning characteristics	Occurrence of Agents
Hemolysis	Naphthalene Sodium chlorate Arsine	Copper compounds Cresol
Methemoglobinemia	Sodium chlorate Creosote	Chlordimeform Cyanide Cresol Copper Arsine
Hypoprothrombinemia	Coumarins Indandiones	Phosphorus Phosphides Carbon tetrachloride
Hyperkalemia	Sodium chlorate Naphthalene Arsine	Sodium fluoride
Hypocalcemia	Fluoride	Thallium Phosphorus Phosphides
Hypercalcemia	Cholecalciferol	
Carboxyhemoglobinemia		Organotin compounds
Anemia	Naphthalene Sodium chlorate Arsine Inorganic arsenicals	
Leukopenia, Thrombocytopenia	Inorganic arsenicals	
Elevated LDH GOT, GPT, alkaline phosphatase, ALT, AST enzymes	Carbon tetrachloride Chloroform Phosphine	Inorganic arsenicals Phosphorus Phosphides Phosphine Sodium chlorate Nitrophenols Pentachlorophenol Thallium Organochlorines Chlorophenoxy compounds
Depressed RBC Acetylcholinesterase and plasma pseudocholinesterase	Organosphosphates	Carbamate insecticides

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APPENDIX

จุฬาลงกรณ์มหาวิทยาลัย
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