HEALTH RISK ASSESSMENT RELATED TO PESTICIDE EXPOSURES AMONG YOUNG CHILDREN: A CASE STUDY IN AGRICULTURAL COMMUNITY, SAKON NAKHON PROVINCE, THAILAND

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จุฬาลงกรณ์มหาวิทยาลัย
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บทคัดย่อและแฟ้มข้อมูลฉบับเต็มของวิทยานิพนธ์ตั้งแต่ปีการศึกษา 2554 ที่ให้บริการในคลังปัญญาจุฬาฯ (CUIR)
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การประเมินความเสี่ยงจากการสัมผัสสารกำจัดศัตรูพืชของเด็กเล็ก: การศึกษาในสังคมเกษตรกรรม จังหวัดสกลนคร ประเทศไทย

นางสาวสาธินี ศิริวัฒน์

จุฬาลงกรณ์มหาวิทยาลัย
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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
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By	Miss Satinee Siriwat
Field of Study	Public Health
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สาธินี ศิริวัฒน์ : การประเมินความเสี่ยงจากการสัมผัสสารกำจัดศัตรูพืชของเด็กเล็ก: การศึกษาในสังคมเกษตรกรรม จังหวัดสกลนคร ประเทศไทย (HEALTH RISK ASSESSMENT RELATED TO PESTICIDE EXPOSURES AMONG YOUNG CHILDREN: A CASE STUDY IN AGRICULTURALCOMMUNITY, SAKON NAKHON PROVINCE, THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร.วัฒน์สิทธิ์ ศิริวงศ์, 152 หน้า.

เด็กที่อาศัยอยู่ในพื้นที่เกษตรกรรมได้รับสัมผัสสารกำจัดศัตรูพืชจากพื้นที่อยู่อาศัยและกิจกรรมของเด็กอาจนำไปสู่อันตรายต่อสุขภาพ การวิจัยครั้งนี้มีจุดประสงค์เพื่อประเมินความเสี่ยงต่อสุขภาพและศึกษาปัจจัยด้านสิ่งแวดล้อมและพฤติกรรมที่เกี่ยวข้องกับการได้รับสัมผัสสารกำจัดศัตรูพืชและผลต่อสุขภาพในเด็กเล็กที่อาศัยอยู่ในสังคมเกษตรกรรม การศึกษาภาคตัดขวาง ได้ดำเนินการศึกษาในเด็กเล็กจำนวน 65 คน (อายุ 12-36 เดือน) ผู้ปกครองถูกสัมภาษณ์แบบตัวต่อตัว เก็บตัวอย่างสารกำจัดศัตรูพืชตกค้างบน มือ เท้า ของเล่นเด็กและพื้น/แคร่ไม้ เก็บตัวอย่างเลือดเพื่อวัดระดับโคลีนเอสเทอเรสในเลือดเด็ก จากการศึกษาพบว่า เด็กมีอายุเฉลี่ย 19.9 ± 5.9 เดือน สารกำจัดศัตรูพืชตรวจพบมากที่สุดบนมือ ของเล่น พื้น/แคร่ไม้และเท้าตามลำดับ ความเข้มข้นของสารกำจัดศัตรูพืชพบสูงสุดบนของเล่นเด็ก ความเข้มข้นของสารกำจัดศัตรูพืชบนมือและเท้ามีความสัมพันธ์เชิงบวกกับความเข้มข้นของสารกำจัดศัตรูพืชบนพื้น/แคร่ไม้และของเล่น (Spearman's rho=0.452-0.691, $p<0.01$) การใช้สารกำจัดแมลงในบ้านมีความสัมพันธ์กับความเข้มข้นของไซเปอร์เมธรินบนมือและเท้าของเด็ก ($p<0.05$) ระดับโคลีนเอสเทอเรสในเลือดของเด็กเล็กมีค่าต่ำกว่าในการศึกษาที่ผ่านมา การวิเคราะห์การถดถอยเชิงเส้นพบว่าความถี่ของการล้างมือ/เท้า (β = -0.236, p = 0.067) และการอาบน้ำ (β = -0.240, p = 0.056) มีความสัมพันธ์กับการลดลงของคลอร์ไพรีฟอสมือและเท้าของเด็ก อาการทั่วไป (คลื่นไส้ อาเจียน เบื่ออาหาร) มีความสัมพันธ์กับระดับพลาสม่าโคลีนเอสเทอร์เรสอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การประเมินความเสี่ยงต่อสุขภาพของเด็กเล็ก พบว่าอาจจะไม่ได้รับความเสี่ยงจากการรับสัมผัสสารกำจัดศัตรูพืชชนิด คลอร์ไพรีฟอส ไซเปอร์เมธรินและเปอร์เมธรินบนมือและเท้าของเด็ก เนื่องจากค่าดัชนีบ่งชี้อันตรายอยู่ในเกณฑ์ที่ยอมรับได้ (HI<1) เด็กสามารถสัมผัสสารกำจัดศัตรูพืชผ่านทางกิจกรรมและพฤติกรรมในสภาพแวดล้อมที่อยู่อาศัย การสัมผัสสารกำจัดศัตรูพืชจะส่งผลกระทบซึ่งเป็นอันตรายต่อสุขภาพ ควรลดเหตุการณ์ที่มีความสัมพันธ์กับการสัมผัสสารกำจัดศัตรูพืชเพื่อสภาพแวดล้อมที่ดีขึ้นของเด็กที่อาศัยอยู่ในพื้นที่เกษตรกรรม

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต .....

ปีการศึกษา 2559 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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KEYWORDS: CHLORPYRIFOS / CYPERMETHRIN / HEALTH RISK / BLOOD CHOLINESTERASE / YOUNG CHILDREN / AGRICULTURAL AREA

SATINEE SIRIWAT: HEALTH RISK ASSESSMENT RELATED TO PESTICIDE EXPOSURES AMONG YOUNG CHILDREN: A CASE STUDY IN AGRICULTURALCOMMUNITY, SAKON NAKHON PROVINCE, THAILAND. ADVISOR: ASSOC. PROF. WATTASIT SIRIWONG, Ph.D., 152 pp.

Children living in agricultural areas are subject to pesticide exposures in their living areas and through their activities led to adverse health. The aim of this study is to assess the health risk and investigate the environmental and behavioural factors associated with pesticide exposure and resultant adverse health effects in young children living in an agricultural community. A cross-sectional study was conducted in 65 young children (age of 12-36 months). The parents were interviewed face-to-face. Childrens' hands and feet, toys, and floors/wood beds were wiped for pesticide residue. Blood samples were collected and blood cholinesterase activity was measured. This study found that the average age of participants was 19.9±5.9 months. Percent of pesticide detections were highest on hands, toys, floors/wooden beds, and feet respectively. The highest pesticide concentration was detected on children's toys. Pesticide concentrations on hands and feet were positively correlated to concentrations on floors and toys (Spearman's rho=0.452-0.691, $p<0.01$). Using insecticide in houses were related to cypermethrin concentrations on children's hands and feet ($p<0.05$). Blood cholinesterase levels among young children were lower than those in previous studies. Linear regression analysis revealed that more frequent hands/feet washing (β=-0.236, p=0.067) and showering (β=-0.240, p=0.056) was negatively associated with chlorpyrifos residue on childrens' hands and feet. General symptoms (nausea, vomiting and anorexia) were significantly related to PChE ($p<0.05$). Health risk assessment of young children were not concerned from dermal exposure via children's hands and feet from pesticide exposure to chlorpyrifos, cypermethrin and permethrin, that the HI of young children were lower than the acceptable level (HI<1). Pesticide exposures can be found in the child's residential environment as well as through their activities and behaviours. These exposures can cause several adverse health effects. The circumstances associated with pesticide exposure should be reduced to improve the environment of children living agricultural areas.

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

Academic Year: 2016 Advisor's Signature .....

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CHAPTER I
INTRODUCTION

1.1 Background and rational

Agriculture is the primary occupation in Thailand, 46.54 % of the land area is in agriculture. Most of agriculture area (63.85%) is located in the northeastern part of Thailand [1]. Pesticides are used in agriculture to control weeds, insect and diseases [2]. In 2010-2015, Thailand pesticide imports exceed 130,000 tons per year [3]. Organophosphate (OP) and pyrethroid (PYR) have been become the most abundantly use insecticide group in Thailand [4]. OP insecticides are a group of chemical compounds that are highly toxic and used for the control insects for crop in agriculture [5]. PYR concentrations may be used especially high in home or residence [6]. Data from Bureau of Occupational and Environmental Diseases, (2014) showed that 34.3 % of Thai farmers were exposed to pesticide in high risk level [7]. There were no documented studies for farm children.

OP and PYR insecticide are developmental neurotoxicants [8]. OP acts as acetylcholineesterase (AChE) inhibitors, which prevent the breakdown of the neurotransmitter acetylcholine, increasing both its concentration and duration of action in the body [9]. PYR is acted primary on voltage- sensitive sodium channels in the nervous system [10]. The use of pesticides has been increased to concern about the potential side effect on human health and the environment [11]. The effect of symptom may include contact dermatitis, sweating, diaphoresis, lacrimation, diarrhea, salivation, and headache [5, 12].

Children are much more susceptible during different life stages owing to their dynamic growth and developmental processes as well as physiological, metabolic, behavioral differences and hygiene may result in significantly greater exposures to

environmental contaminants than adults [13, 14]. Children who live in agricultural community have much higher exposure to pesticide more than children in non- farm areas [15-17]. Distant of households to farm about 50 meter had significantly higher level of pesticide concentration [18]. Children are sensitive to pesticide exposure and are at greater risk of secondary pesticide exposure from agricultural area and their family [19]. Recreational activity in farming areas where pesticides have been used increase pesticide exposure in children. Hand-to-mouth and object-to-mouth (pica) behaviours in young children aged 1-3 years old can also lead to increased pesticide exposure [14, 20]. Young children spend much of their time on the floor or ground and are very likely to contact with pesticide residues in resident when playing inside and outside [13, 21]. Children have a greater skin surface area per kilogram body weight than adults [21]. The risk assessment process is generally viewed as three discrete components: risk assessment, risk management, and risk communication [22]. Potential pathways of exposure to consumer products or chemicals are released from consumer products during use occur via ingestion, inhalation, and dermal contact [23].

Biomonitoring measurements are used to estimate pesticide exposure consist of blood cholinesterase level, urinary metabolites concentration, and measurement of the parent pesticide in blood [9]. Biomarkers can be used to indicate that a person has been exposed and that the chemical has been absorbed into the body and can also provide a reality check to verify the realism and reasonableness of scenario based exposure assessments [14, 20].

OP and carbamate are a potent inhibitor of cholinesterase, including acetylcholinesterase (AChE), and plasma cholinesterase (PChE). AChE and PChE measurement has been widely used to monitor cholinesterase inhibiting pesticide exposure and toxicity in human who live in agricultural community. The effect of cholinesterase inhibiting pesticides on health can be acute or chronic [19]. The effect

of cholinesterase inhibiting activity is an appropriate method to assess past exposure to OP and carbamate insecticides [9, 19].

Several cross sectional studies have focused on urinary metabolite concentration from pesticide exposure among children [8, 15, 17, 24-32]. Previous studies in Thailand have shown that children (6-8 years old) living in rice production areas had significantly higher urinary metabolite concentrations of OP than aquaculture farm children [32, 33]. In addition, Thai children in pre-school (2-5 years old) and secondary school (12-13 years old) reported that they had significantly higher urinary metabolite concentrations of pesticide exposure than US children in the National Health and Nutrition Examination Survey [17, 28, 34]. Based on the earlier studies we can infer that Thai children are at significant risk from pesticide exposure, especially children who living in and around agricultural communities.

However, there is a lack of information about risk assessment and health effect from pesticide exposure among young children and a few studies have examined young children who living in residential, there are surrounded an agricultural community.

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1.2 Research questions

1. Is there difference of pesticide concentration, blood cholinesterase level and health symptoms between wet and dry seasons?

2. Are there any factors associated with pesticide concentration, blood cholinesterase level and health symptoms among young children (1-3 years old) living in agricultural community?

3. Is there health risk from pesticide exposure among young children (1-3 years old) in agricultural community?

1.3 Research objectives

1. To compare pesticide concentration, blood cholinesterase level and health symptoms between wet and dry seasons.

2. To identify factor associated with pesticide concentration, blood cholinesterase level, and health symptoms.

3. To assess health risk from pesticide exposures among young children (1-3 years old) in agricultural community, Sakon Nakhon province, Thailand.

1.4 Research Hypothesis

1. There are differences pesticide concentration, blood cholinesterase level, and health symptoms between wet and dry seasons.

2. Demographic information, activity behavior, environmental factors and pesticide concentration are associated with blood cholinesterase level, and health symptoms among young children (1-3 years old) in agricultural community.

3. There is health risk from pesticide exposure among young children (1-3 years old) in agricultural community.

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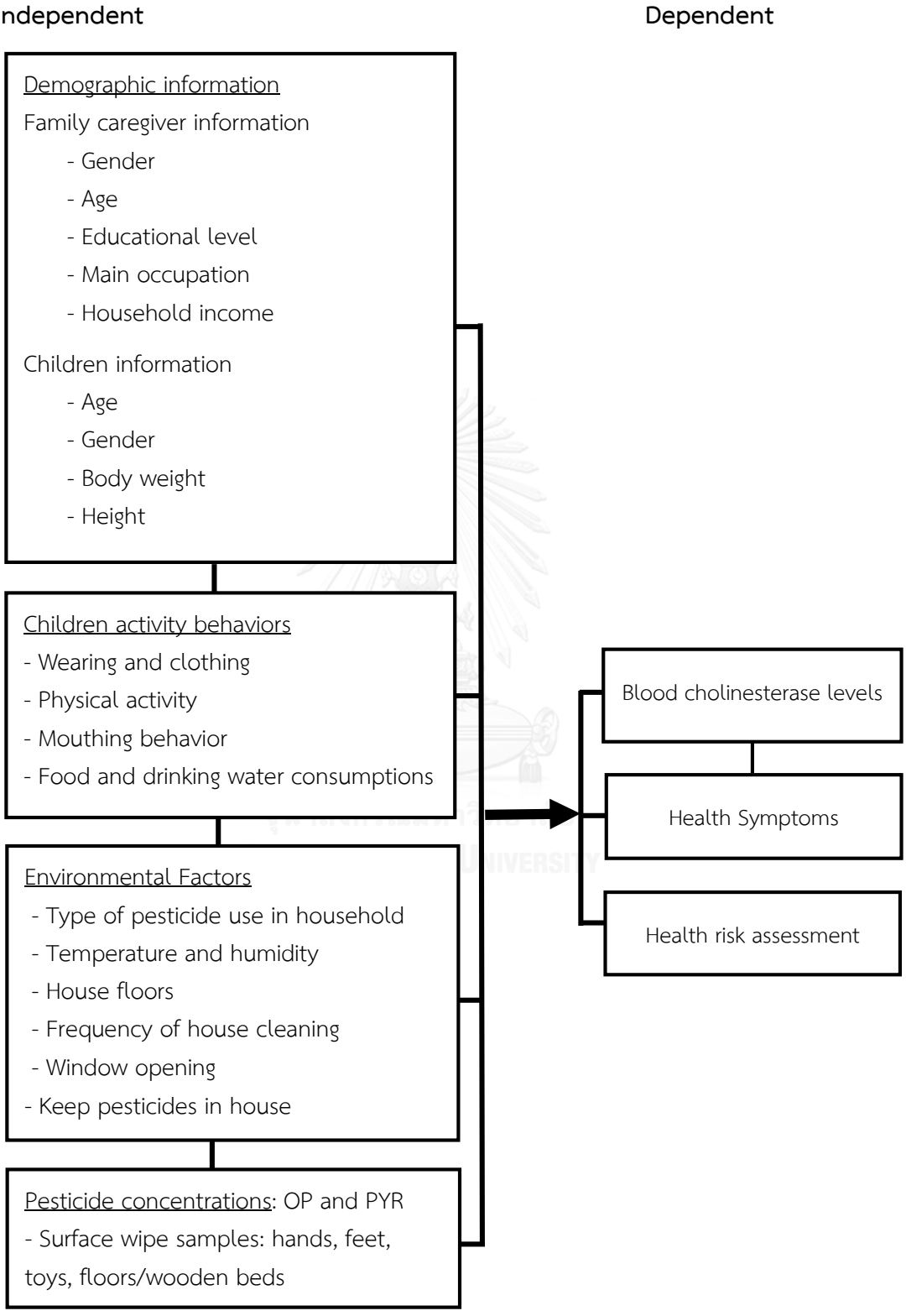
1.5 Conceptual Framework



1.6 Terms of Definitions

Family caregiver

Only one person include male or female who take care of child and close child in the same house. They are living in an agricultural community at Khamin sub-district and Changkrung sub-district, Muang Sakon Nakhon districts, Sakon Nakhon province, Thailand.

Young Children

Children with age between 12 and 36 months [14] who living in an agricultural community at Khamin sub-district and Chiangkrung sub-district, Muang Sakon Nakhon districts, Sakon Nakhon province, Thailand.

Pesticide exposures

This study focused on cholrpyrifos insecticide which was extensively used on farms. Cypermethrin and permethrin insecticide were widely used to control insects in households. Young children were exposed to pesticide residues (chlorpyrifos, cypermenthrin and permethrin) via dermal contact on children's hands and feet.

Children activity behavior

Children activity behavior which they interact with their environment may have a profound effect on the magnitude of exposures to contaminants and differences in exposure at different ages such as wearing and clothing, mouthing behavior, food and drinking water consumptions, and physical activity [14].

Pesticide concentrations

Pesticide concentrations were analyzed from surface wipe samples of children's hands and feet, floor or wooden bed in their house, and children's toy [35]. The pesticide concentrations were detected in this study consist of chlorpyrifos, cypermethrin, and permethrin.

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Toys

Toys of this study made from smooth materials such as plastic, wood and rubber. These are most favorite play items of young children.

Environmental Factors

Many things in the environment may affect to children health in agricultural community as follows:

- Type of pesticide use in household (aerosol, bait, electronic, chalk and coil).
- Temperature and humidity (during data collection).
- House floors (1st floor and 2nd floor).
- Frequency of house cleaning
- Window opening
- Keep pesticides in house
- Time spend inside/outside at home (indoor and outdoor) [36].

Blood cholinesterase level

Level of cholinesterase (U/ml) in red blood cell (AChE) and plasma (PChE) in blood sample of young children.

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Dry season

Starting from October to April. The main crops including rice, watermelons, cantaloupes, chilies, and flowers. Data collection was done from January - February 2016. During data collection, the temperature and humidity in this study area in dry season (January and February 2016) was 18.80 to 29.70 ºC and 19 to 43%.

Wet season

Time in May to September. The main crops consist of rice, watermelons, cantaloupes and cucumbers. Data collection was done from July - August 2016. During

data collection in wet season, the weather condition was 26.9 to 35.0 ºC of temperature and 55 to 90% of humidity.

Crop field

Crop field in this study consist of rice, watermelons, cantaloupes, chilies, cucumbers, and cannas flowers.

Inside area of home

Inside area of house is the area in the roof that has the walls and the door for close and open to inside at home such as bed room and living room.

Outside area of home

Outside area of home is outdoor area that without the walls.

Health risk

Health risk in this study is pesticide concentrations, blood cholinesterase levels, risk assessment and health symptoms. Pesticide exposures of children in agricultural community are showed that pesticide concentration residue on children's hands and feet and blood cholinesterase levels. Health risk assessment consists of hazard Identification, dose-response, exposure assessment and risk characterization.

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Health symptoms

Some of the most symptoms are related to OP and PYR exposures that include general symptoms (nausea, vomiting and anorexia), respiratory symptoms (cough, excessive wheezing and runny nose), skin symptoms (skin irritation and diaphoresis), gastrointestinal symptoms (diarrhea and salivation), central nervous symptoms (lethargy and seizures) and eye symptoms (irritation and lacrimation) [5]. Symptoms of children in this study were conducted by a doctor.

CHAPTER II
LITERATURE REVIEW

Pesticides are widely used in the world, which use in agricultural area to protect crops and the residential use of these chemicals to control vectors or insects. Pesticide can be exposed to human by multiple pathways. Especially, children may be exposed to some environmental contaminants. In addition, rapid changes in behavior and activity may lead to differences in exposure as a child grows up [21]. Health risk assessment is important for children who living in agricultural community.

2.1 Agricultural and pesticides in Thailand

Thailand is the largest agricultural community. One of the world exports food and agriculture products including rice, cassava, tropical fruit, rubber and corn [37]. Agriculture is the main of occupation in Thailand, 46.54 % with the area of agriculture and the most of agriculture area (63.85%) is the northeastern, Thailand [1]. The rapid growth in pesticide use is a significant problem [38]. The most commonly used of pesticide are herbicides, insecticides, and fungicides. In 2010-2015, Thailand imported pesticides more than 130,000 tons per year [3]. Thai farmers are exposed to a wide variety of pesticide. Although, the government have been promoted organic pesticides use.

Department of Agriculture, Ministry of Agriculture and cooperatives, (2016) [39] reported that the top ten imported insecticides into Thailand in 2015 are demonstrated in the Table 2.1. Chlorpyrifos was the most intensive used in agricultural community with over two million kilogram, flowed by cypermethrin, carbaryl, cartap hydrochloride, carbosulfan, imidacloprid, dichlorvos, profenofos, chlorpyrifos+cypermethrin, isoprocarb respectively.

Table 2.1 Top ten imported insecticide into Thailand in 2015

Rank	Insecticides	
	Name	Kilogram
1	chlorpyrifos	760,914
2	cypermethrin	305,993
3	carbaryl	220,031
4	carbosulfan	186,999
5	profenofos	124,948
6	imidacloprid	113,250
7	chlorpyrifos+cypermethrin	89,241
8	dichlorvos	88,440
9	fenobucarb	77,150
10	dinotefuran	75,272

2.2 Type of insecticides

Insecticides are widely used in agriculture to protect crops. The main groups of insecticides include organophosphates (OP), carbamates (CA), and pyrethroids (PYR). OP is a group of chemical compounds, several of which are highly toxic and used for the control and elimination of insects for crop in agriculture [5]. PYR concentrations may be used especially high in home or residence [6]. Although most people are not occupationally exposed to pesticides, nearly everyone has some level of exposure resulting from food, air, water, or dermal contact [40].

2.2.1 Organophosphate

Organophosphate (OP) insecticides are a group of chemical compounds used for the control and elimination of insects in agriculture area [9] including chlorpyrifos, malathion, diazinon, and parathion. In Thailand, chlorpyrifos are the most

widely used in crops and higher imported of OP group [3]. OP is included of a phosphate moiety and an organic moiety. This insecticide, after being enzymatically changed to their active oxon form, are potent cholinesterase inhibitors by binding to the serine residue in the active site of acetylcholinesterase (AChE), thus preventing its natural function in metabolism of acetylcholine. This action is not unique to insects, but can be produced the same effects in humans [41]. OP exposure has been related with a range of adverse health effects [42]. OP can be affected to human organs, the brain is the primary target organ, especially during prenatal and neonatal period, and seems to be much more vulnerable than the adult brain. Exposure to anticholinesterase (anti-ChE) pesticide appears to predispose humans to chronic ailments like diabetes or neurodegenerative disease like Alzheimer's or Parkinson's disease [43]. OP insecticides are generally found in the children's residential environments. Symptoms usually develop within 4 hours of exposure, but may be delayed up to 12 hours with dermal exposure [45]. Children are more likely than adults to have central nervous system (CNS) signs [12].

2.2.2 Carbamate

Carbamate (CA) insecticide act similarly to organophosphates in binding AChE, but the bonds are more readily reversible. The clinical symptoms produced are not easily differentiated from those of organophosphate poisoning [12]. CA insecticides have the same mechanism of toxicity as the OP, except their effects are more reversible and less severe [41].

2.2.3 Pyrethroid

Pyrethroids (PYR) are significant insecticide used in resident [46]. Pyrethrins are naturally-occurring chemicals that are produced by chrysanthemums. Natural pyrethrins are comprised of many isomeric forms and are usually classified as the pyrethrin I and II isomer sets with pyrethrum being a representative pyrethrin [47].

Synthetic pyrethroids are man-made chemicals. However, synthetic pyrethroid structures are more stable affording them a longer environmental half-life and their insecticide activity more effective. Their chemical structures are typically consisted of a chrysanthemic acid analogue that is esterified most often with a ringed structure [41]. However, PYR is exerted their neurotoxicity by slowing the opening and closing of voltage-gated sodium channels in insect and mammalian nerve cells and relations between in utero exposures and persistent changes in neurochemistry, motor activity, behavior, and learning [48].

Pyrethrum and synthetic pyrethroids are absorbed from the gastrointestinal and respiratory tracts but only very slightly though the skin. The active ingredient usually is formulated (mixed with carriers, solvents, or synergists) with inert ingredients that may be toxic. Absorption of extraordinarily high doses rarely may be caused incoordination, dizziness, headaches, nausea, and diarrhea (Table 2.2) [12]. Children are important higher concentrated to PYR than did adolescents and adults, they are likely exposed to PYR from multiple sources including food, dust, and on surfaces at residence [49, 50].

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2.2.4 Organochlorines

Organochlorine insecticides were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence (e.g. DDT and chlordane) [2].

2.3 Health effect of pesticide

The relationships between pesticide exposure to human and possible health outcomes can be described using an exposure-effect continuum. As presented in Figure 2.1, major components of this continuum include exposure, internal dose, biologically effective dose, early biological effects, and ultimate health effects [51].

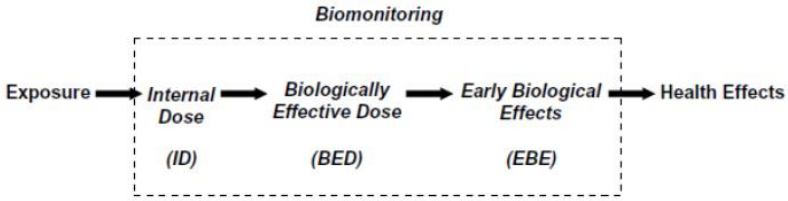

Figure 2.1 Generalized exposure effect continuum for pesticides.

Agricultural activities may be produced contaminants in multiple media in agricultural communities. Children residing in rural setting may encounter environmental hazards derived from agricultural production activities (Figure 2.2) [52].

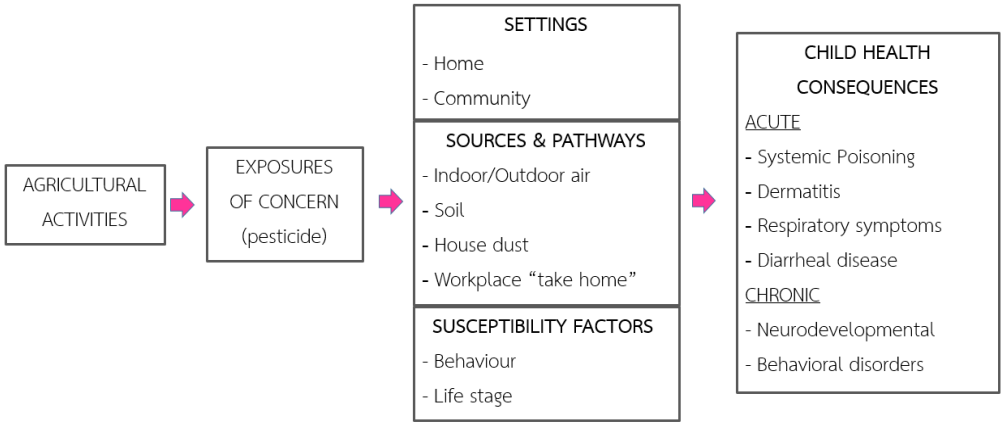

Figure 2.2 Factors influencing environmental health consequences of agricultural production on children

OP is rapidly distributed throughout the body. Consequently, acute poisoning by OP tends to be more severe and refractory than that of CA. PYR have adverse effects on the nervous system, gastrointestinal tract, and skin. [53]. The major of signs and symptoms for insecticide was shown in Table 2.2.[5, 54, 55]

Table 2.2 Summarizes features of signs and symptoms for insecticide.

Insecticide	Signs and symptom
Organophosphate and cabamate	- Nonspecific early symptoms: headache, nausea, vomiting, abdominal pain, and dizziness. - Sometimes hypersecretion: sweating, salivation, lacrimation, rhinorrhea, diarrhea, and bronchorrhea. - Progressive symptoms: muscle fasciculation, muscle weakness, and respiratory symptoms (bronchospasm, cough, wheezing, and respiratory depression). - Bradycardia is typical, although early in acute poisoning, tachycardia may be present. - Central nervous system: respiratory depression, lethargy, coma, and seizures.
Pyrethroid	- Central nervous system (respiratory depression, lethargy, coma, and seizures). - The hypersecretion, muscle fasciculation, respiratory symptoms, and seizures. - Headache, fatigue, vomiting, diarrhea, and irritability. - Dermal (skin irritation and paresthesia).
Organochlorine	- Mental status changes and seizures. - Paresthesia, tremor, ataxia, and hyperreflexia.

Farmers in Thailand and their families are exposed to pesticides in the spraying season [4]. Children can be exposed to pesticide among their family and agricultural community [54]. Reported case of pesticide poisoning in 2014 by age-group, young children under 4 year of age had highly incidence rate that is shown in the third of age group (Figure 2.3) [56].

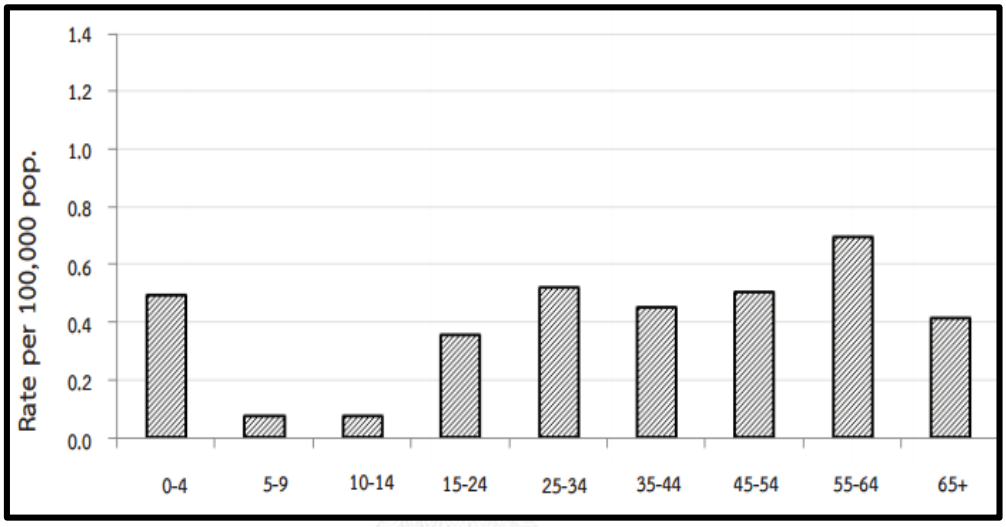

Figure 2.3 Reported Cases of Pesticide poisoning by Age-group, Thailand, 2014

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2.4 Biomarkers of pesticide exposure

Biological markers (Biomarkers) can be used to indicate that a person has been exposed and that the chemical has been absorbed into the body. They can be used to rank exposure among persons [14]. Biomarker measurements can also provide a reality check to verify the realism and reasonableness of scenario-based exposure assessments. The value of a particular biomarker for exposure assessment depends generally on the half-life of the maker in the body, the specificity of the marker for the pesticides of interest, the relative ease of sample collection, and the difficulty or cost of chemical analysis [20]. Human biomonitoring is provided an efficient and cost-effective way to identify exposure to chemical substances, including those having

deleterious effects on human organism [57]. Biomonitoring of exposure is a common tool for assessing human exposure to pesticides and involves the measurement of the parent pesticide, its metabolite or reaction product in biological media, to determine if an exposure has occurred and the extent of that exposure. Urine, blood and breast milk are common media collected for biomarker measurements [27, 41, 58].

Red blood cell AChE and plasma cholinesterase (PChE) or plasma butylcholinesterase (BuChE) activities are used as biomarkers in clinical and occupational setting [9]. OP and CA are a potent inhibitor of cholinesterases, including acetylcholinesterase (AChE) and plasma cholinesterase (PChE). Because of the importance of acetylcholine (ACh) as a neurotransmitter in the mammalian nervous system, chemicals that inhibit acetylcholinesterase (AChE) can exert profound effects on behaviors mediated by the cholinergic system. These effects may be either beneficial or detrimental, depending on the dose and degree of inhibition of the regulatory enzyme and the physiological condition of the treated individual. Nonetheless, the widespread use of cholinesterase-inhibiting compounds as pesticides has generated concerns regarding their effects on public health. These concerns center around the acute adverse effects of high doses of these agents, how these effects may change with repeated exposure, and the possibility of long-term consequences of chronic, low-level exposure to them [59].

Measurement of acetylcholinesterase (AChE) is recommended in the management of OP poisoning, which results in 200,000 deaths worldwide annually. The Test-mate ChE 400 is a portable field kit designed for detecting occupational organophosphorus exposure that measures red blood corpuscles AChE and PChE within 4 minutes. There was good agreement between the Test-mate ChE and the reference laboratory for RBC AChE and PChE [60]. Serum or plasma AChE is a better short-term indicator of cholinesterase inhibition than red blood corpuscles AChE due

to its more rapid response to expose; it is used as an indicator of recent, acute exposure to cholinesterase inhibiting pesticides. The primary pesticide being applied is chlorpyrifos, which has a preferentially inhibiting effect on serum AChE rather than red blood corpuscles AChE [61].

2.5 Surface wipes technique

Wipe sampling is an important technique for the estimation of contaminant deposition on a variety of surfaces, including those in buildings, homes, outdoor areas, and hands (dermal wipes). Wipe sampling techniques are used for environmental sampling, industrial hygiene monitoring, monitoring of remedial processes, security monitoring, compliance monitoring, and various other related applications [62]. Surface wipe sampling is a widely used and accepted method for collecting chemical residues to estimate human exposures and used technique for measuring persistent pollutants in residential environments. The surface wipe can be used to estimate dermal exposure, indirect ingestion exposure from hand-to-mouth contact, and dietary ingestion exposure for children, it have been routinely collected from floors and other types of surfaces in a home [63].

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2.6 Health risk assessment

Risk assessment is the process used by toxicologists to evaluate the potential for adverse health effects from exposure to the chemicals which can be found in media such as food, air, drinking water, soil, consumer products, general environment, or the workplace. It typically includes an evaluation of exposure and toxicological data from humans, animals, and other experimental systems to estimate the probability of harm or effect that a chemical may pose following exposure, using cause-effect and dose-response data, with an evaluation of the biological basis, and a description of the various assumptions and uncertainties that are applied. The results of risk assessment

are used to provide a scientific basis to support risk managers in risk management decision making relating to the use of chemicals or their presence in the environment in order to protect human health [64]. The four components of risk assessment as follow;

Hazard Identification	Defines and describes the hazard's anticipated effect on human health by systematically reviewing all relate data exhibiting an acute or chronic health effect.
Dose-response	Characterizes the relationship between the doses of a hazard received and the incidence of an adverse health effect in exposed populations.
Exposure Assessment	Determines the route of exposure, amount, and duration of exposure to an agent. Determines the size and nature of population exposed.
Risk characterization	The exposure assessment and dose response are integrated together to estimate the magnitude of the public health problem and evaluate variability and uncertainty [65].

One of the more useful of these derived equations is the Average Daily Dose (ADD). The ADD, which is used for many non-cancer effects, averages exposures or doses over the period of time exposure, occurred. The ADD can be calculated by averaging the potential dose over body weight and an averaging time [21].

The most vulnerable of all groups are children and infants, who are at a very high risk of organophosphate exposure. Children may not understand the risk of expose to pesticide and can be unexpectedly exposed in the home. Especially children of parents who are exposed to pesticides at work that increases the health risks for children [66].

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2.7 Children activity behaviors

Children are differed susceptibilities during different life stages owing to their dynamic growth and developmental processes as well as physiological, metabolic, and behavioral differences. They are consumed more food and beverages than adults by kilogram of body weight. Moreover, children have a higher body surface area to body weight ratio, which may be led to increased exposures. Children are influenced by a special set of pesticide sources and pathways as they experience rapid increases in mobility and important changes in behaviors and activities. Children's normal behaviors, for example crawling on the ground and putting their hands or something in their mouths, can result in exposures not confronted by parent [21].

Children's metabolic pathways may be differed from those of adults. They have more years of future life and thus more time to develop chronic diseases that take decades to appear and that may be triggered by early environmental exposures. They are often unaware of environmental risks and generally have no voice in decision-making [14]. In addition to providing more area for dermal absorption, a large surface area relative of children means that body heat loss will be more rapid, requiring a higher rate of metabolism. Children also need extra metabolic energy to fuel growth and development. The higher basal metabolic rate and energy requirements in children mean that both oxygen and food requirements are greater per kilogram of body weight. The higher breathing rate and food consumption rate required to meet these physiological needs can lead to a high risk of environmental contamination in the air and food relative to adults. Both physiological and behavioral characteristics affect children's exposure to environmental contaminants. Physiological characteristics influence exposure by affecting a child's rate of contact with exposure media or by altering the exposure-uptake relationship [14].

Mouthing behavior includes all activities in which objects, including fingers, are touched by the mouth or put into the mouth except for eating and drinking, and includes licking, sucking, chewing and biting. Children may be also ingested soil and dust through deliberate hand to mouth movements, or unintentionally by eating food that has dropped on the floor. Thus, understanding soil and dust ingestion patterns is an important part of estimating children's overall exposures to environmental chemicals [21].

Children may be exposed due to sources that contribute pollution to ambient air. Children may inhale chemicals from indoor use of various consumer products. Due to their size physiology and activity level, breathing rate of children different from adults. Children may be more highly exposed to environmental toxicants through dermal routes than adults. For example, children may crawl, roll or sit on the surface that has been treated with chemicals and play with objects such as toys where residues may settle. Children also tend to wear less clothing than adults. As a result, children may have a higher dermal contact with contaminated materials [21].

An activity or time spent in a given activity will vary among children on the basis of, for example, culture, ethnicity, hobbies, location (i.e. urban versus rural), gender, age, socioeconomic characteristics, season, and personal preferences. Other factors that mention above can also have an important impact on activities and exposure. However, limited information is available regarding ethnic, cultural and socioeconomic differences in children’s choice of activities or time spent in a given activity [21].

Children’s behavior and the way in which they interact with their environment may have a profound effect on the magnitude of exposures to contaminants and differences in exposure at different ages (Figure 2.4)[14]. Gender has been identified as a factor influencing activity level and type of activity. In many cultures, there are

important gender differences in activity patterns [14]. Although it is common to speak of children as a homogeneous group, there are important differences in exposure-related attributes by age. For example, dietary and non-dietary exposures are likely to be substantially different for a 2-year-old toddler, a 6-year-old elementary school student, and a 14-year-old adolescent, even if they live in the same household [20].

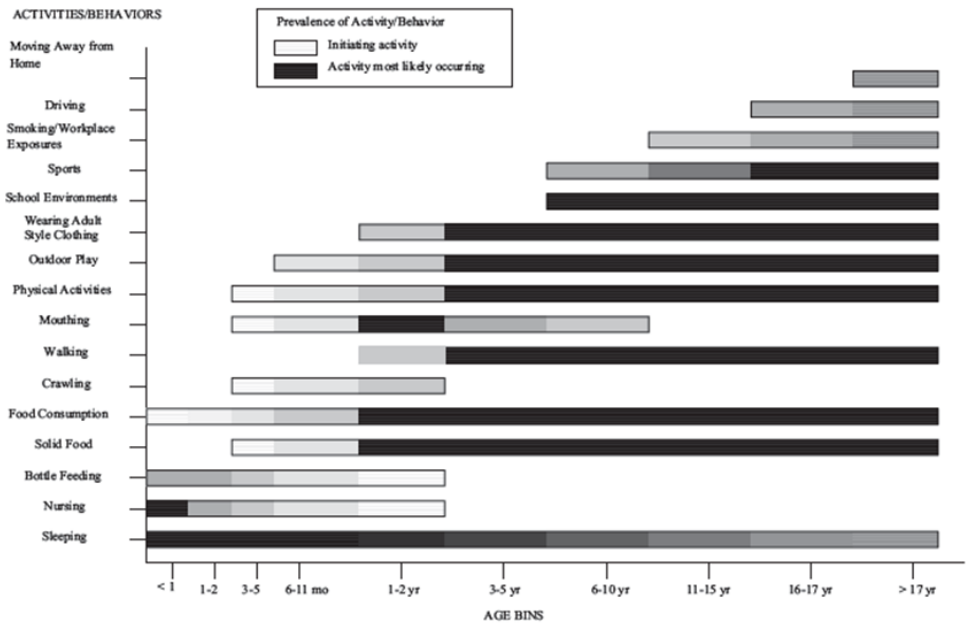

Figure 2.4 Children's activities that impact exposure as a function of developmental age.

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There are numerous intrinsic and extrinsic factors in which differences between adults and children have been found and which also differ depending in the age, and some case gender, of the child. Intrinsic factors include physical characteristics such as respiration rate or surface-to-volume ratio and metabolic processes such as liver and kidney function or clearance rate of chemicals from the bloodstream. Extrinsic factors include behaviors and dietary habits that can modify both the potential opportunities for exposure to environmental contaminants and routes of exposure to environmental contaminants. A variety of physical characteristics may influence both exposure to and dose of environmental contaminants. The blood volume of young children is less than

in older children or adults, its circulation through the body may be repeated more frequently due to the higher heart rate. Children may metabolize the chemical differently from the way adults do or at a different rate. A child's sensitivity to one chemical does not mean that they will have a similar response to other chemicals [67].

Young children (1-3 years old) who spent time in house because they are before school-age children. The activities and behaviors of young children are different than older children such as pica, play in farms, soil contact, and spent time in house. Young children who living in house are surround that agricultural community may increase pesticides exposure.

2.8 Pathway of children's exposures

An exposure pathway is the course that a contaminant is taken from its source to the individual. When contaminants are released from a source into the environment, they are moved through multiple environmental media to humans by many pathways (Figure 2.5). House dust, water, soil, air and food are valuable environmental media for human exposure. For children, several other media, such as breast milk, amniotic fluids, and cord blood, are also important. The remainder of this section discusses significant pathways for children's exposure [14].

2.8.1 Ambient air exposure pathway

Contaminants in ambient air result in inhalation exposure either when the child is outdoors and breathe contaminated air or when contaminants in the air are transported indoors where the child spends time. Ambient air pollution has been declared an important health problem for developing countries. The applications of insecticides in and around the home are a more likely source for children's exposures (WHO, 2006). Ambient and indoor air is potential sources of children's exposure to toxic substances. Children can be exposed to contaminated air during a variety of

activities in different environments. They may be also inhaled chemicals from the indoor use of various consumer products. Due to their size, physiology, and activity level, the inhalation rates of children differ from those of adults [21].

2.8.2 Water exposure pathway

Ingestion of contaminant is the primary exposure pathway for drinking-water. Dermal absorption and inhalation of contaminants during bathing are other common pathways. When contaminated surface water serve as recreational areas for children, accidental ingestion (water or sediment) and dermal contact become additional pathways for exposure. Finally, aquatic organisms can be bio-accumulated contaminants in surface waters, which can be led to dietary exposure through the food- chain [14].

2.8.3 Soil exposure pathway

Ingestion of contaminated surface soil is a primary exposure route. Inhalation of contaminated dusts and direct dermal contact with contaminated soils can be also led to elevate exposure [14].

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2.8.4 Food-chain exposure pathway

Many contaminants in the environment are concentrated up the food-chain and result in dietary exposure. This pathway includes the exposure to chemicals by means of drinking animal milk or eating animal milk–based products. People are then exposed, for example, by eating contaminated fish. Children can be exposed to biological as well as chemical contaminants through the food-chain [14].

2.8.5 Human to human exposure pathway

In some occupations, both mothers and fathers can be transported chemical contaminants into the home environment on their skin and clothing. The

child can be exposed through contact with the parent or through contact with surfaces that the parent has been contaminated [21]. For example, farm children may be had a greater potential to be exposure to pesticide through multiple pathways, including agricultural take-home exposure pathway contributes to residential pesticide contamination in agricultural homes and drift as well as residential applications (Figure 2.5) [24, 44, 68, 69].

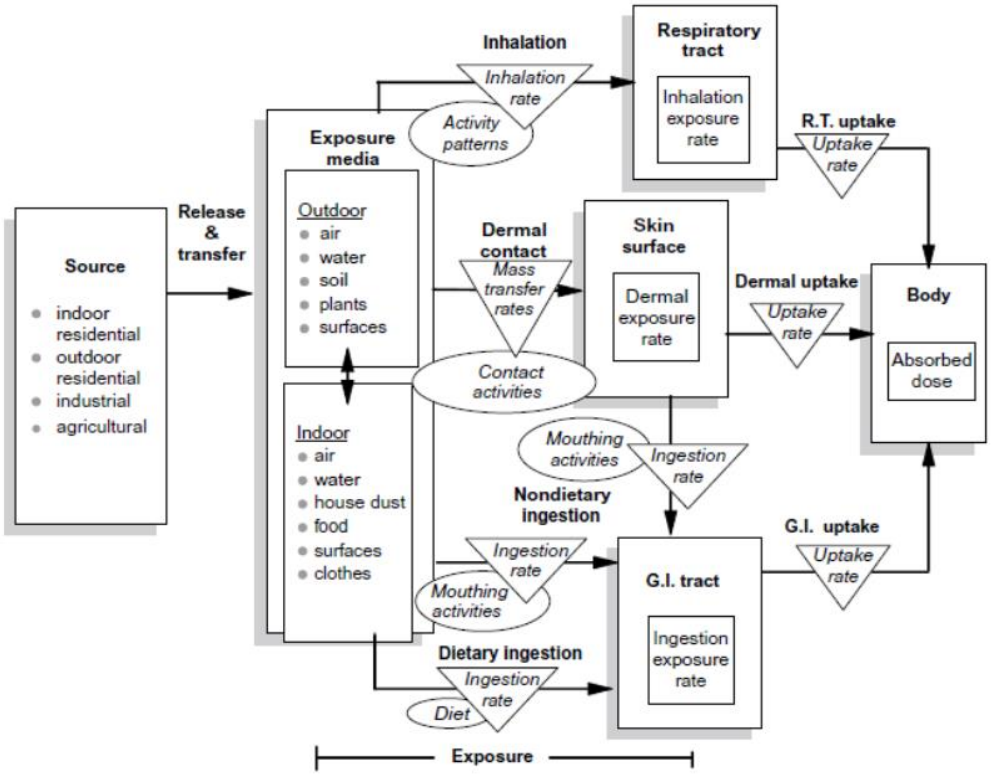

Figure 2.5 Children's pesticide exposure

Potential pathways of exposure to consumer products or chemicals were released from consumer products during use occur via ingestion, inhalation, and dermal contact [23].

Children, like adults, may be exposed to chemicals through the air they breathe, the water they drink, the foods they eat, and the surfaces and materials they

contact. In other words, a child's exposure is greatly affected by where the child is, what the child is being done, and what the child ingests. Children crawl, roll, and climb are over contaminated surfaces, resulting in higher dermal contact than would be experienced by adults in the same environment [14].

2.9 Environmental factors

Children may enter the work force, and occupational exposures may be become important. Most children are spent their time in a few specific setting, including the home, school, and recreational areas (playgrounds). However, these settings are also modified by external factors, such as those related to geographical areas or to environmental equity factors. Home is the most important setting for infants and young children. They are often eaten, played, and slept in the same area. Playground environments are provided opportunities for children's exposure to pollutants. Like any other setting, children will be exposed to contaminants that are presented at the site [14].

2.9.1 Residential

Residential is the most significant setting for children. They have more activities in house area. Examples of sources of exposure to pollutants include building materials (e.g. wood treated with arsenic-based pesticides), lead-based paints, insecticides that are sprayed indoors, fuel (e.g. coal and wood) for indoor cooking, disposal practices for domestic waste (e.g. incineration), household chemicals (e.g. solvents), and small-scale enterprises at the family residence [21].

2.9.2 Recreational area

Recreational area is provided for children's exposure to pesticides. Thus, playgrounds built near hazardous waste sites, mining waste sites, or agricultural fields may be contaminated and provided a pathway for exposure. Children will have

more direct contact with the contaminated environment through their play activities, making exposures in recreational areas greater. In addition to exposures to contaminants present in the natural environment, there are two other risks associated with playgrounds such as playground hazards, and materials used in playground equipment or in playground cover. Significantly more hazards per play area were identified in playgrounds near low income areas compared with those near high-income areas [21].

2.10 Pesticide exposure in children

There are many prior researches available for summary of children's exposure of organophosphates insecticides [15, 19, 31, 44, 61, 68-74] presented in Table 2.3.

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Table 2.3 Summary of children's exposure for organophosphates insecticides

Reference	Location	Specific age	Collection method	Exposure assessment	Result
Bradman et al., 2007	California	5-27 months	House dust, indoor and outdoor air, surfaces wipe: toy ,residues on clothing, food, urine samples	Organophosphate Pyrethroid Organochlorine	Pesticides were detected more frequently in house dust, surfaces wipe and clothing than other media, with chlorpyrifos, diazinon, chlorthaldimethyl, and cis- and trans-permethrin were detected in 90% to 100% of samples.
Kim et al., 2013	Korea	6 months-9 years old	Indoor air, indoor dust, surface wipe of indoor object and hand wash water of children	Organophosphate	Children ages 3 to 4 in daycare centers had a Hazard Quotient (HQ) of 0.5 for dichlorvos, which was 50% lower than the risk criterion level of 1 but was higher than the 95% percentile with a HQ of 1.9. This study postulates that children in childcare facilities may be exposed to specific OPs.

Table 2.3 Summary of children's exposure for organophosphates insecticides (continued)

Reference	Location	Specific age	Collection method	Exposure assessment	Result
Rohitrattana et al., 2013	Thailand	6-8 years old	Urine samples Blood cholinesterase	Organophosphate Pyrethriod	Children who live in rice farming communities were strongly influenced by farming activity, household environments, and child behaviors, suggesting that these are the primary pathways in which children living in these agricultural communities in Thailand were exposed to pesticides.
Lu et al., 2004	USA	3-4 years old	Indoor air, drinking water, soil, house dust, and hand and toy wipes and 24-h duplicate diets.	Organophosphate	Detectable levels of diazinon and azinphosmethyl in house dust were found in most of the agricultural homes. Quantifiable chlorpyrifos and azinphos-methyl were found on either agricultural children's hands or their toys.
Lu et al., 2000	USA	9 months- 6 years of age	Surface wipe samples	Organophosphate	Children had detectable OP pesticide on their hands. Children living with parents who live in proximity to pesticide treated farmland, have higher exposures than other children in the same community.

Table 2.3 Summary of children's exposure for organophosphates insecticides (continued)

Reference	Location	Specific age	Collection method	Exposure assessment	Result
Quandt et al., 2004	USA	12 and 84 months of age	floor surfaces, toys, and children's hands	Organophosphate Carbamate Pyrethroid	The most commonly detected residential pesticide was pyrethroid which on the floor was positively associated with detection on toys or hands.
Wason et al., 2013	USA	1-5 years old	Floor surfaces wipe samples	Organophosphate Pyrethroid	Concentration measurements were then connected with activity pattern data, short-term dermal and ingestion exposures and absorbed doses were simulated for children.
Curwin et al., 2007	USA	Less than 16 years of age	Urine	Organophosphate	The doses from farm children were higher than doses from the non-farm children. Doses were similar for male and female children. A trend of decreasing dose with increasing age was observed for chlorpyrifos.
Curwin et al., 2005	USA	Less than 8 years of age	Surfaces wipe samples	Organophosphate	Farm homes have more pesticide residue inside than non-farm homes. Chlorpyrifos was the most commonly detected pesticide in house.

Table 2.3 Summary of children's exposure for organophosphates insecticides (continued)

Reference	Location	Specific age	Collection method	Exposure assessment	Result
Abdel Rasoul et al., 2008	Egypt	9-15 years old	Blood cholinesterase	Organophosphate	Acetylcholinesterase was measured in both the applicator and control groups. A significant lower activity level of AChE was found in the applicator group compared to the control group.
Suarez- Lopez et al., 2012	Ecuador	4-9 years old	Blood cholinesterase	Organophosphate and carbamate	Mean acetylcholinesterase activity was 3.14 U/ml, standard deviation (SD) of 0.49. Cohabitation with a flower worker was related to lower acetylcholinesterase activity in children.
McConnell et al., 1999	Nicaragua	7-8 years old	Blood cholinesterase	Organophosphate	Six (35%) of the 17 exposed children had abnormally low cholinesterase levels. A possible explanation for this physiological effect of exposure to pesticides is the dermal absorption which may have occurred among children playing barefoot in puddles grossly contaminated by runoff from the airport.

CHAPTER III
METHODOLOGY

3.1 Study design

This study was cross - sectional in design that collects information on study exposure and outcome during the wet and dry seasons. Data collection for wet season was collected between July and August. For dry season was collected between January and February.

3.2 Study Areas

This study area is located in Khamin and Chiangkhruea sub-district, Muang Sakon Nakhon district, Sakon Nakhon province in the northeastern, Thailand (Figure 3.1) [75]. Khamin and Chiangkhruea sub-district consist of 29 villages (Khamin; 12 and Chiangkhruea; 17 villages) and 12 villages from 29 villages were selected to represent a range of geographic locations and demographic conditions (Table 3.1) [76]. This region is the most of agriculturally intense area that have been supported by irrigation that can cultivate crops all year. Household in this areas are surrounded by active agricultural activities that include intensive use of chlorpyrifos. In dry season (October - April), the major crops in this area are: rice, watermelons, cantaloupes, chilies, and flowers. In wet season (May - September), the main crops including rice, watermelons, cantaloupes and cucumbers [77]. Data of this areas were reported with 46.37 % of farmers to high risk of pesticide exposure, there farmers were detected by blood cholinesterase enzyme activity method [78].

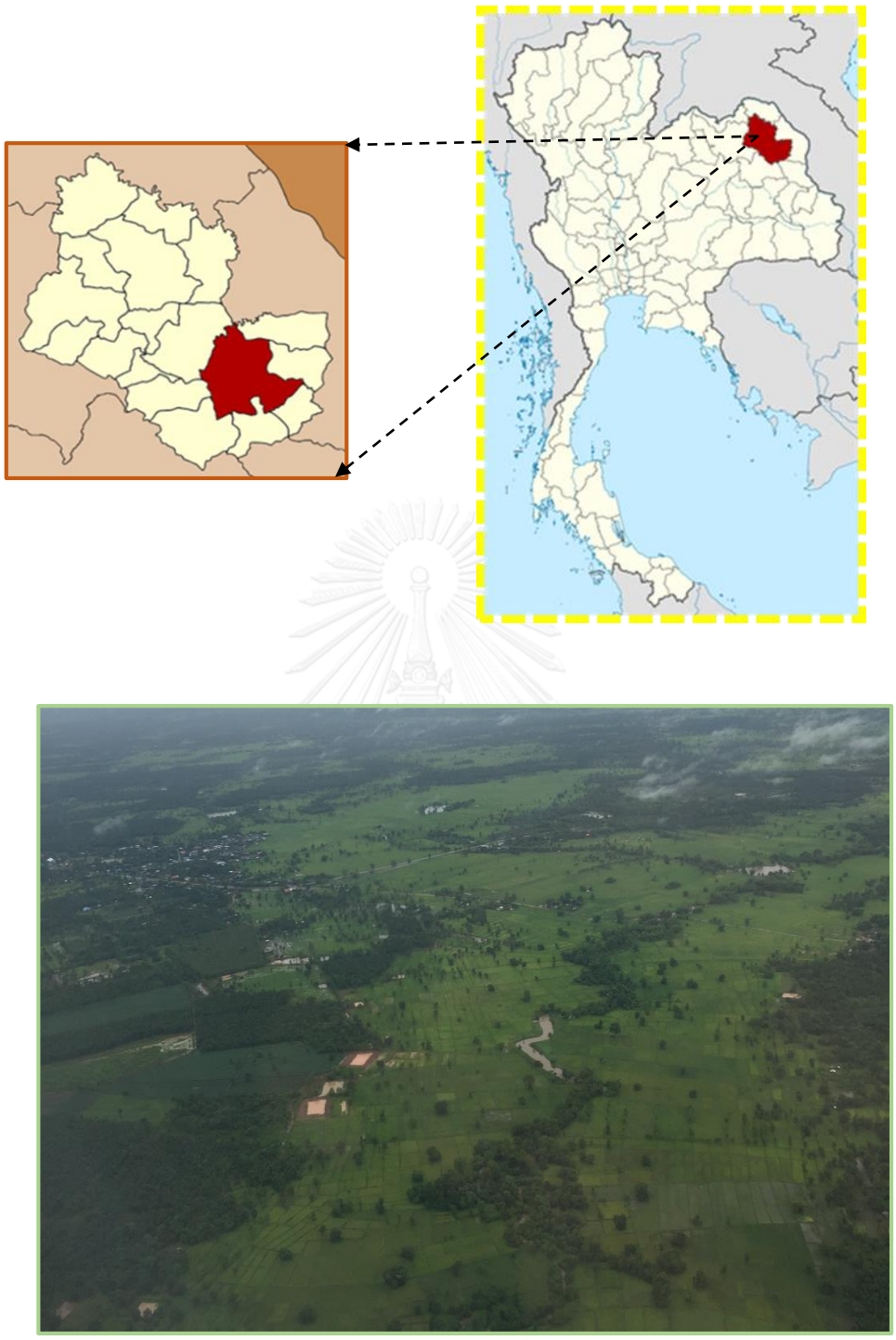

Figure 3.1 The Map of study area; Khamin sub-district and Chiangkrung sub-district, Muang Sakon Nakhon district, Sakon Nakhon province in northeastern, Thailand

3.3 Study population

- Thai children who have healthy boy and girl, reported by sub district health promoting hospital.

- Children participant were selected age between 1 and 3 years (one child per household).

3.4 Inclusion and exclusion criteria

Inclusion criteria

- Children participating were born and live in an agricultural community in Khamin sub-district and Chiangkrung sub-district, Muang Sakon Nakhon districts, Sakon Nakhon province.
- Children age between 12 and 30 months.
- Family caregivers were consent to children's participation in this study.
- Children live with family caregiver in the same home.
- Distance of crop field to home less than 50 meters from the agricultural activity (home in farm)[18].
- Healthy children reported by sub-district health promoting hospital.

Exclusion criteria

- Children who are disabled.

3.5 Sampling Technique

- The purposive sampling technique was used to select study area.

- The number of participants in sub-districts were randomized from the family caregiver who willing the participants and return consent forms.

- If children participants from a family that were selected only one of the youngest child because they were assumed stayed in house rather than going outdoor.

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- This research was allowed to study in Khamin sub-district and Chiangkrung sub-district from sub-district health promoting hospital and sub-district administrative organization. Public health officers were gave data about participants in this study and the village health volunteers supported when meeting with participants in this study areas.

3.6 Sample size

Approximately 200 children ages between 1 and 3 years old who live in the study area. Data from previous research was calculated the sample size. This research found that 2.89± 0.43 U/ml of blood cholinesterase level among 53 children (6-8 years old) in rice farm, Thailand [74]. The sample size was calculated by this formula [79] :

$$n = \frac{(Z_{1-\alpha/2})^2 \sigma^2}{E^2}$$

n = sample size

$Z_{1-\alpha/2}$ = 95 percent confidence interval (1.96)

σ^2 = variance (0.43^2)

E = the maximum difference between the observed sample mean $\overline{x}$ and the true value of the population mean μ; $|\overline{x} - \mu|$

$\overline{x}$ = population mean (2.89)

μ = 3.00; estimated by blood cholinesterase level among farmers (2.63± 0.55 U/ml) [80] and children in rice farm (2.89± 0.43 U/ml) in Thailand [74].

$$n = \frac{(1.96)^2 (0.43)^2}{|2.89-3.00|^2}$$

$$= 58.70$$

As a result, a sample of 59 children should be randomly select from population. However, in this study, up to 10% of the calculate sample size was added into the study sample in order to avoid the problem of subject dropout. Therefore, the sample size is 65 children.

For children selection was chosen from age 12 - 30 months in the first season (Figure 3.2). The total of participants in this study is 65 children.

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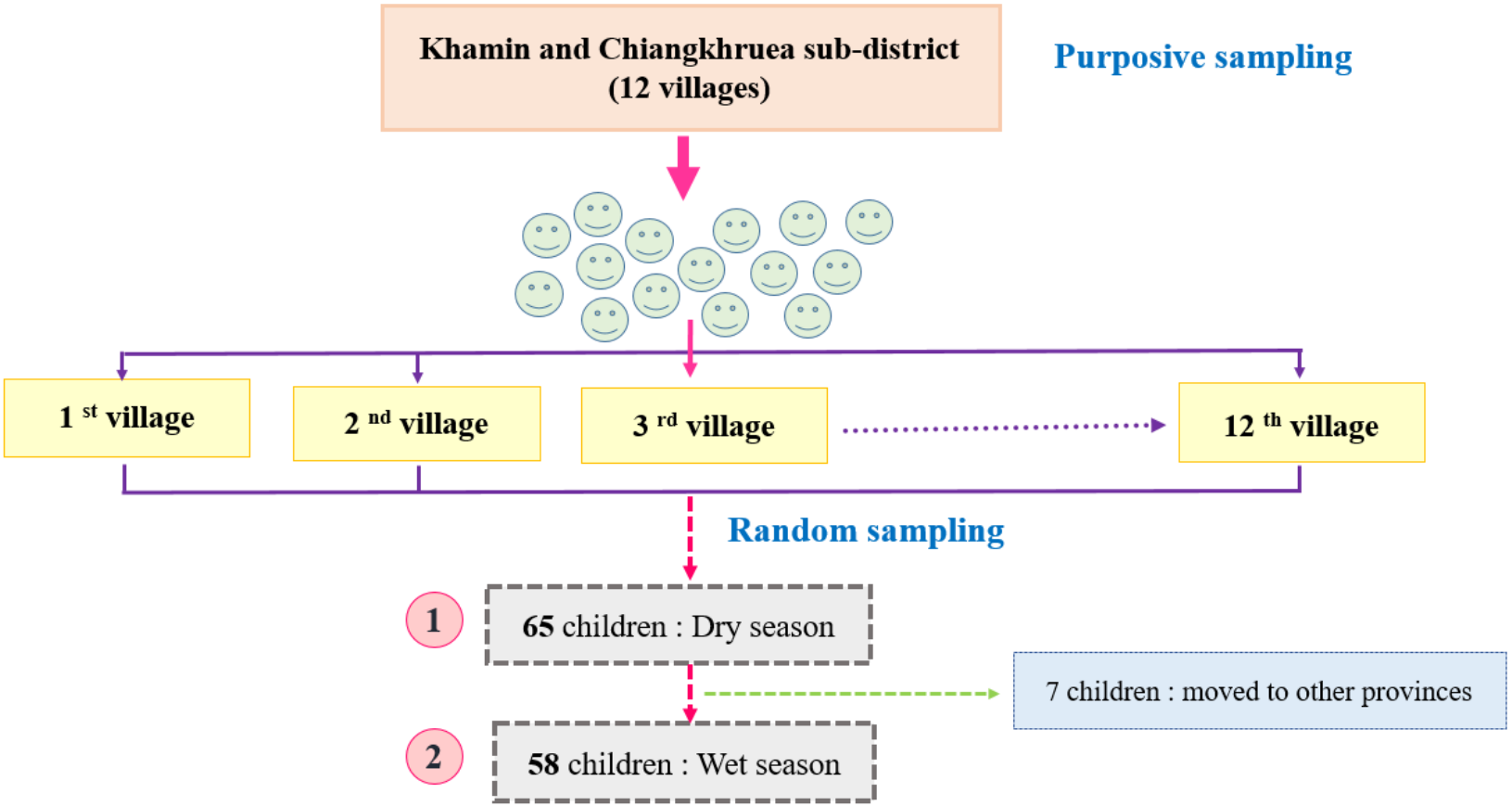

Figure 3.2 Diagram of sampling

Twelve villages from Khamin and Chiangkrung sub-districts, where the farmers are mostly intensive used of pesticides and their house are surrounded that agricultural areas. Young children including 88 children were randomized to participants 65 children (Table 3.1)

Table 3.1 Number of children in each village

Name of villages	Moo	Sub districts	Amount of children	Amount of participants
1. Panpattana	10	Khamin	9	7
2. Dongmafi	1	Khamin	7	5
3. Poonbok	6	Khamin	8	6
4. Dongmafipatana	12	Khamin	4	3
5. Khamin	5	Khamin	4	3
6. Khoklo	6	Khamin	6	4
7. Pakkaya	3	Khamin	7	5
8. Khoklonoi	5	Khamin	7	5
9. Dontonmoung	10	Khamin	8	6
10. Pawan	7	Chiangkrung	8	6
11. Nonghoi	17	Chiangkrung	8	6
12. Nakumhi	10	Chiangkrung	12	9
Total			**88**	**65**

3.7 Measurement Tool

Methods in this study were used by questionnaires and personal and environmental sample analysis. The details of method were used list as follow:

1. Questionnaire: Part 1 Demographic information

Part 2 Children activities

Part 3 Environmental factors

Part 4 Health effects

2. Personal and environment samples:

- Surface wipes samples

- Blood samples

3.7.1 Questionnaire

The questionnaire consist of four parts as following; demographic information, children activities, environmental factors and health effects. The validity was examined by 3 experts.

Part1 Demographic information

Parent information

- Gender
- Age
- Educational level
- Main occupation
- Household income

Children information

- Gender
- Age
- Height
- Body weight

Part 2 Children activities

- Wearing and clothing
- Physical activity
- Mouthing behavior (put something to mouth)

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- Food and drinking water consumption

Part 3 Environmental factors

- Type of pesticide use in household
- Temperature and humidity (during data collection).
- House floors (1st floor and 2nd floor).
- Frequency of house cleaning
- Window opening
- Keep pesticides in house

Part 4 Health Effects

- General symptoms
- Respiratory symptoms
- Skin symptoms
- Gastrointestinal symptoms
- Central nervous symptoms
- Eye symptoms

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3.7.2 Personal and environment sample analysis

3.7.2.1 Surface wipe samples

Surface wipe samples collection

In each young child was collected surface wipe sample on their hands, feet, house floors or wooden beds and toys. Hands and feet wipe sampling were performed in order to measure pesticides on the skin from participating child. One 4”×4” cotton gauze wet with 3 ml of 40 % isopropanol was wiped the area, which was used for the palm and the back of each hands that same to feet wipe samples. Floors or wooden beds were wiped with 30x30 cm (Figure 3.4) in the main living area in each home. For surface area of toys were wiped in 10x10 cm. The area for wipes sampling were based

on answer from questionnaire [44, 63, 70, 72]. Each surface wipe sample was covered in aluminium foil and kept in a zip-lock bag per sample. Samples were transported from the field in a cooler and transferred to a refrigerator in the laboratory, store at -20 ºC and extracted to find chlorpyrifos, cypermethrin and permethrin concentrations by researcher in laboratory.

Sample extraction

All surface wipe samples were extracted with modified technique from Anastassiades and Lehotay (2003) [81]. The gauze pads were added in Erlenmeyer flask with 25 ml acetonitrile (HPLC grade). Then, the sample was shaken for 10 minutes, and suppurated gauze pads from the solvent. Next, nitrogen gas 99.95% was used for solvent vaporization at 40±2 ºC to nearly dry off sample and added 1 ml of 0.1% acetic acid with acetonitrile. And then, the sample was removed to an eppendrof tube and added 25 mg, primary secondary amine (PSA) and 150 mg of $MgSO_4$. The tube was mixed by vortex tool at 1 minute and 2 minutes at 6,000 rpm centrifugation for clean-up. Finally, the sample was sucked (liquid) to 1.5 ml vial for analysis of chlorpyrifos, cypermethrin and permethrin by gas chromatograph (GC).

Gas chromatography analysis

All samples were analyzed chlorpyrifos insecticide using an Agilent 7890 gas chromatography with a flame photometric detector (GC-FPD). Cypermethrin and permethrin insecticide were analyzed by gas chromatography with microelectron capture detector (GC-μECD) in laboratory [50]. A chromatography column HP-5 (30 m length, 0.250 mm diameter, 0.25 μm film thickness) was used to analyze the pesticide. For chlorpyrifos, the column temperature was raised from 80 ºC at 12 min to 195 ºC, at 2 ºC/min to 210 ºC (held for 3 min), at 15 ºC/min to 225 ºC (held for 2 min), and at 40 ºC/min to 275 ºC (held for 7 min), respectively. Average recovery of chlorpyrifos by analyzing 10 replicates at 2 spiked levels (0.1 and 1.0 μg) were 108.1% and 4.0% with

a relative standard deviation (RSD). Correlation coefficients (R^2) from the calibration curves was shown 0.99906 chlorpyrifos concentrations with analysis of 3 replicates, 0.01 (µg/sample) for the limit of detection (LOD) and 0.02 (µg/sample) for the limit of quantitation (LOQ). For analyzing of cypermethrin and permethrin were set from 100 ºC at 20 ºC/min to 220 ºC (held for 3 min), at 10 ºC/min to 280 ºC (held for 5 min), respectively. Average recovery of cypermethrin and permethrin by analyzing 10 replicates at 2 spiked levels (0.1 and 1.0 µg) were between 84.29% and 124.73%% with a relative standard deviation (RSD), 10.37% and 9.45%. Correlation coefficients (R^2) from the calibration curves was shown 0.99950 to 0.99989 with analysis of 3 replicates, 0.01 (µg/sample) for the limit of detection (LOD) and 0.02 (µg/sample) for the limit of quantitation (LOQ). For analysis of pesticide concentrations were used one-half of the LOD when concentrations were below the LOD [82].

Table 3.2 The total of surface wipe samples of this study in each season

Samples	Wet season	Dry season
Hand wipes	65	65
Feet wipes	65	65
Toy wipes	35	38
Wooden bed or floor wipes	65	65
Total	463 samples	

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3.7.2.2 Blood samples

AChE, HAChE, and PChE level were measured from finger-stick blood samples using the EQM Test-mate ChE Cholinesterase Test System (model 400) [19, 60]. The Test-mate ChE is intended for use in the assessment and diagnosis of

asymptomatic pesticide poisoning. Most organophosphate or carbamate pesticides inhibit the blood enzymes erythrocyte acetylcholinesterase (AChE) and/or plasma cholinesterase (PChE). The Test-mate ChE system is only intended for monitoring exposure to pesticides. The Test-mate ChE is a complete, self-contained and portable cholinesterase testing system. The system requires only 10 µl for each blood test, which may be conveniently obtained from a finger-stick sample. The entire assay may be completed in under 4 minutes, facilitating the rapid evaluation of poisoning status [83]. In pervious study, EQM Test-mate ChE Cholinesterase Test System (model 400) was used to analysis blood cholinesterase level in agricultural areas [19, 74, 80, 84, 85].

3.8 Data collection

This study during data was collected in wet and dry seasons. The first time period was occurred from January to February (dry season) and the second time in wet season was collected in July to August. The collection time line for child in each season presented in Tables 3.3, 3.4 and summary of data collection in two seasons showed in Table 3.5. Children were participated in two seasons and the same person all of study (Figure 3.3). This study is performed a total of visits on 3 days in each season per child as follow:

- The first visit: giving information about this research and obtain sign inform write consent from participant, overview of the sampling procedures.

- The second visit: health symptoms of children participant (part 4 of questionnaires) were observed by a doctor. Blood sample was collected from each child by a nurse. The samples were sent to analyze by Test-mate 400. Blood samples were collected one time per child in each season.

- The third visit: questionnaires (part 1-3) were collected from their family caregiver and wipe surface samples were collected in their house by researcher.

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Table 3.3 Time of collection in each season

Season	Time for data collection	Types of plant in area
Wet season (May - September)	July - August	Rice Curcambers Watermelons Cantaloups
Dry season (October - April)	January- February	Rice Chilies Flowers Cantaloups Watermelons

Table 3.4 Period of sample collection in each child

Data collection	Day 1	Day 2	Day 3
Giving information	◄------►		
Health effects Blood samples		◄------►	
Questionnaires collection Surface wipe samples			◄------►

Remark: ◄-► Period of time for data collection.

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Table 3.5 Summary of data collection in each season

Data collection	Activities	Time for collection
Dry season (January-February)	Surface wipe samples - Dermal: Hands and feet - Toys, wooden beds or floors Blood Samples Questionnaires collection	- For blood samples were collected one sample per child. - The area collection for wipe sample base on answer from questionnaire.
Wet season (July - August)	Surface wipe sample - Dermal: Hands and feet - Toys, wooden beds or floors Blood Samples Questionnaires collection	

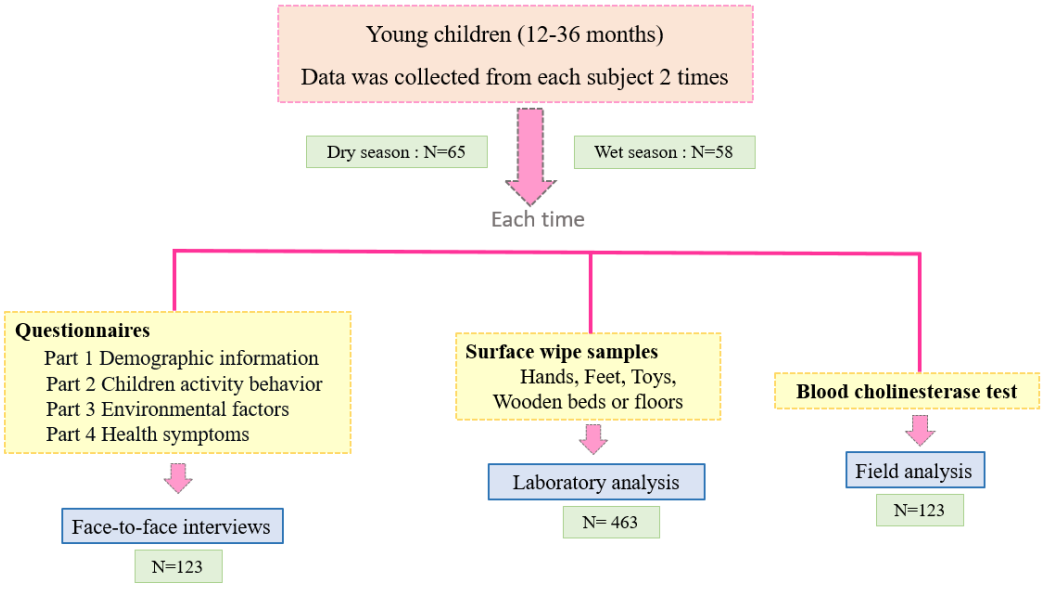


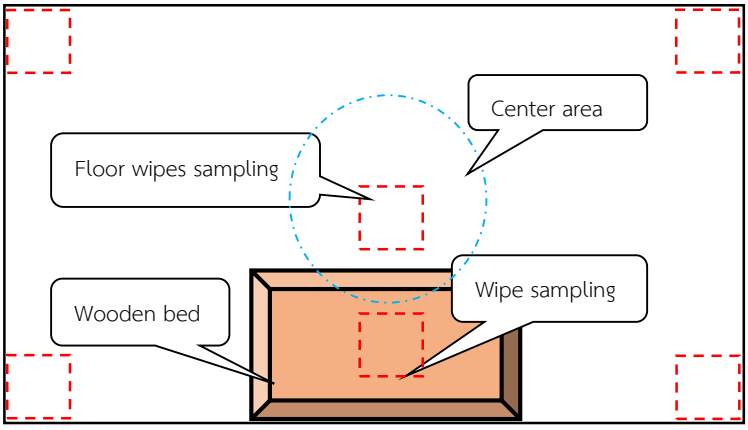
Figure 3.3 Data collection flow chart

3.8.1 Questionnaires collection

Questionnaires were translated from English to Thai version. The interviewer talked around 10-15 minutes with their family care giver by face to face interview. Family care givers talked about demographic information, children activity behavior, environmental factors. Data were collected after children and family caregivers obtain the information about this study and they were enrolled into the biomonitoring study.

3.8.2 Surface wipes sampling

Surface wipe samples were collected, using a procedure adapted from Clifton et al (2013) [63]. Children were wiped on their hands (all of hand areas), feet (all of feet areas), toy (one point of surface wipe sampling), wooden bed or floor (five points of surface wipes sampling) at their home before washing or cleaning. Location of sampling at home showed in Figure 3.4. Each surface wipe sample was covered in aluminum foil and kept in a zip-lock bag per sample. Multiple gauze pads were combined and analyzed together in each type of surface sample. All samples were transported back to the laboratory inside coolers containing ice. All surface wipe samples were extracted to find pesticide concentration by researcher in laboratory.



Remark: Area of wipe sampling (30x30 cm)

Figure 3.4 Areas of surface wipe sampling

3.8.3 Blood cholinesterase level test

Blood samples were collected at 20 µl (2 drops) per child. Children cleaned and washed their hand with soap. A nurse will clean the finger by cotton with alcohol moisture. Next, a nurse used a needle to puncture their finger and take the drop out of blood. And then a nurse collected sample from finger blood by capillary tube. Blood cholinesterase level was analyzed with EQM Test-mate Cholinesterase Test System (model 400). The result reported to participants immediately. If the result of blood cholinesterase level is showed abnormal, the researcher will suggest that the participant have to meet a doctor.

3.9 Data Analysis

3.9.1 Statistical analysis

- Description demographic of this study was presented by detection frequencies, percentage, mean, standard deviation, percentile and median.

- Kolmogorov-Smirnov Test was used to check the normality distribution.

- Pair t-test was used to present difference continuous data in wet and dry seasons (the same children in seasons). If non-parametric was used Wilcoxon test.

- McNemar test was used to present difference categorical data between health symptoms and seasons.

- Chi-square test was used to find the association between pesticide concentrations and demographic information, children activity behavior, environment factors (categorical).

- Spearman's correlation was used to find the association between pesticide concentrations and blood cholinesterase activities.

- Binary logistic regression and multiple linear regression were used to estimate and describe the relationship between demographic information, children

activity behavior factors, environment factors, pesticide concentrations (independent) and dependent variable (blood cholinesterase level and health symptoms).

- Statistical analysis used Statistical Package for the Social Sciences Program (SPSS), version 22.

3.9.2 Health risk assessment

Pesticide concentrations (chlorpyrifos, cypermethrin, and permethrin) from surface wipe samples on children's hands and feet were calculated absorbed daily dose (ADD), hazard quotient and hazard index [35]. This study area was detected chlorpyrifos, cypermethrin, and permethrin which are widely used in farms and households. Chlorpyrifos, cypermethrin, and permethrin are non-carcinogenic chemicals and related to human health effects. Chlorpyrifos is moderately toxic [86]. This mode of action, in which cholinesterase inhibition leads to neurotoxicity [43]. AChE inhibition, particularly in blood, still provides the most sensitive dose-response data for the chlorpyrifos human health risk assessment [87]. Permethrin and cypermethrin are a pyrethroid. This structural group targets sodium channels and affects neuromuscular signal conduction [88, 89]. Health risk assessment consists of 4 steps as follows:

Step 1 Hazard identification; chlorpyrifos, cypermethrin and permethrin

Step 2 Dose-response assessments; Reference dose (RfD)

Table 3.6 Reference dose (RfD) for children

Pesticdes	Reference dose for children (mg/kg/day)	References
OP: Chlorpyrifos	0.00003	U.S.EPA, 2002 [90]
PYR: Cypermethrin	0.023	U.S.EPA, 2006 [89]
PYR: Permethrin	0.25	U.S.EPA, 2009 [88]

Step 3 Exposure assessment for dermal contact; non-carcinogenic effects [35].

The average daily dose (ADD) from pesticide exposures (chlorpyrifos, cypermethrin, and permethrin) via dermal exposure was calculated by a formula as follows:

$$\text{ADD dermal (mg/kg-day)} = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

Where; ADD = Exposure duration (mg/kg-day)

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

(Concentration of pesticide (mg-event) / SA (cm^2) × dermal absorption)

SA = Skin surface area (cm^2)

EF = Exposure frequency (day/year)

ED = Exposure duration (year)

BW = Body weight (kg)

AT = Average time (ED x 365 days) (days)

EV = Event frequency (event/day)

* for non-carcinogenic effects, AT = ED in days

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Table 3.7 Variables for calculating average daily dose (ADD)

Variable	Values	References
EV	1 event/day	US. EPA, 2004 [91]
ED	1 year	US. EPA, 2008 [21]
EF	365 days/year	US. EPA, 2004 [91]
BW	10.70 kg ; Dry season 11.56 kg ; Wet season	Questionnaire
AT	ED×365 days	US. EPA, 1997 [35]
Dermal absorptions for children	Chlorpyrifos : 3% Cypermethrin : 2.5% Permethrin : 5.7%	US. EPA, 2002 [90] US. EPA, 2006 [89] US. EPA, 2009 [88]
SA: Hands and Feet	630 cm^2; Dry season 750 cm^2 ; Wet season	US. EPA, 2008 [21]
Pesticide concentrations	At 95th percentile level	US. EPA, 1992 [92]

Step 4 Risk characterization

Hazard Quotient (HQ) = ADD / RfD

If HQ > 1, there may be concern for potential adverse systemic health effects in exposed individuals.

HQ ≤ 1, there may be no concern [67].

For multiple pesticides;

HI (Hazard index) = ∑ HQ

If HI > 1, there is concern for potential health effects for non-carcinogenic.

HI ≤ 1, no concern for potential non-carcinogenic effect.

3.10 Ethical Consideration

- This study was approved by the ethics review committee for research involving human research subjects, health science group, Chulalongkorn University, Thailand (COA No.221/2015).

- Samples were collected after parents fully inform and give their written consent for children's participation in the study.

- Participants can say no all the time, when they are unsatisfactory feeling in this research.

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CHAPTER IV
RESULTS

This study was a cross - sectional design that collected information on study exposure. This study area is located in Khamin and Chiangkhruea sub-district, Muang Sakon Nakhon district, Sakon Nakhon province in the northeastern, Thailand. The areas were selected to represent a range of geographic locations and demographic conditions. There are the most of agricultural activity and the areas have been supported by irrigation that can cultivate crops all year. Households in the area are surrounded by agricultural community with intensive use of chlorpyrifos insecticide. The major crops consist of rice, watermelons, cantaloupes, chilies, cucumbers, and canna flowers [93]. Young children were selected by inclusions criteria which were 1) born and lived in an agricultural community, 2) age between 1 and 3 years old, 3) spent most of their time at home in farm area, 4) stay with family caregiver in the same home and 5) their house located from farm less 50 meters (home in/nearby farm) [18]. The purposive sampling technique was used to select study area. The number of participants in sub-districts were randomized by proportional to size from the family caregiver who willing to participate. The youngest child from each household was selected. A total of 65 young children in dry season and 58 children in wet season. Seven children (10% of 65 children) lost from this study because they moved to other provinces with their parents. Data was collected after children and family caregiver obtained the information about this study. They were enrolled into the biomonitoring study. During data collection, the temperature and humidity at Sakon Nakhon province, in dry season (January and February 2016) were 18.80 to 29.70 ºC and 19 to 43%. For wet season (July and August 2016) was 26.90 to 35 ºC of temperature and 55 to 90% of humidity.

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4.1 Questionnaire information

4.1.1 Demographics of parents and young children

Table 4.1 presents descriptive analysis of parents and young children characteristics. The majority of parents were female (93.8%), average of age (±SD) was 39.26 ± 11.84 years old. Parents graduated from primary school (61.5%) and secondary school (33.9%). The main of occupation was farmers (87.7%) and 41.5% of household income was 5001-10,000 baht/month.

In dry season, thirty nine of children (60%) were boys and 26 (40%) were girls. The average age (±SD) of the participants was 19.92 ± 5.99 months. Average of height, and weight of young children were 78.91±6.60 cm and 10.70±1.93 kg. In wet season, the average of age (±SD) was 25.45±5.95 months. Average height, weight of young children were 82.78±5.70 cm and 11.56±2.14 kg. There were significant differences of age, height, weight, and body surface area between dry and wet season (p-value <0.001).

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Table 4.1 Characteristics of parents and young children, activities behavior and environment condition of participants

	Factors	Dry season (N=65)		Wet season (N=58)		P-value
		N	%	N	%	
Parents	**Gender**					
	Male	4	6.2%	-	-	-
	Female	61	93.8%			
	Age (years) (mean±SD)	39.26 ± 11.84 (Min.=18.0 Max.=64.0)		-	-	-
	Education level					
	Primary school	40	61.5%	-	-	-
	Secondary school	22	33.9%			
	College and University	3	4.6%			
	Occupational					
	Farmer	57	87.7%	-	-	-
	Non farmer	8	12.3%			
	Household income (per month)					
	less than 5000	16	24.6%	-	-	-
	5001-10000	27	41.5%			
	10001-15000	16	24.6%			
	15001-20000	4	6.2%			
	20001-30000	2	3.1%			
Children	**Gender**					
	Boy	39	60%	36	55.4%	1.000[b]
	Girl	26	40%	22	33.8%	
	Drop out	-		7	10.8%	
	Age (month) (mean±SD)	19.92 ± 5.99 (Min.=12.0 Max.=30.0)		25.45±5.95 (Min.=18.0 Max.=36.0)		0.000[a]
	Height (Centimeter) (mean±SD)	78.91 ± 6.60 (Min.=7.0 Max.=17.3)		82.78±5.70 (Min.=7.6 Max.=18.8)		0.000[a]
	Weight (Kilogram) (mean±SD)	10.70 ± 1.93 (Min.=67.0 Max.=99.0)		11.56±2.14 (Min.=71.0 Max.=101.0)		0.000[a]
	Body surface area (m^2) (mean± SD)	133.47±7.60 (Min.=119.0 Max.=159.60)		136.85±8.43 (Min.=121.32 Max.=165.57)		0.000[a]

[a] Wilcoxon Signed rank test

[b] Mcnemar test

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4.1.2 Activities, behaviors, and household environments of participants

Young children's behaviors, activities, and household environments were presented in Table 4.2. The average of frequency of children's hands/feet washing and frequency of shower were 3.86 ±1.41 and 1.98 ±0.54 times/day respectively. Most of the participants reported that they wore cloths in house area and outside area. The majority of young children 46.2% reported as non-usual wearing shoes. The presents of 55.4 % of young children, sometime touched their face, 44.6% sometime taking hands to mouth and 76.9% sometime taking non-food to mouth. Most young children (67.7%) were found to have taking food by bare hands and 81.5% of them were taking food by their parents. The majority of normal food of young children were rice, milk, vegetables, and fruits. Twenty percent of young children was breast feeding from their mothers. Source of drinking water was 56.9% of bottle/tank water.

The average of playing duration (hours/day) was 7.26 (±1.73) hour/day. 43.1% of them always played in farm, spent time on wooden beds (47.7%) and spent on floors (52.3%). Sixty percent of young children were outdoor playing and 76.9% of them soil contacted to their body. The majority of young children (81.5%) were spent at terrace/space under a Thai house and 33.8% of them were exposed during spaying in farm.

Household environments presented that 27.7% of kept pesticide for agriculture in their houses. 27.7% of parents washed their children cloths with others family members, and 64.6% of them dried their cloths near farm area. 61.5% clothes were kept in storage and 60 % of the parents cleaned floor everyday and they used wet mop and broom (41.5%). 41.5% of parents used insecticide in house. 20% of them reposted using spray, 15.4% of them used pesticide chalk while only 9.2% of them used coil. For housing characteristic, 83.1% of them had one story house and 63.1% of them opened windows daily.

For young children's behaviors, activities, and household environments between dry and wet season were different in many factors. Frequency of shower (times) and playing duration (hour/day) in wet season were found to have higher than dry season (p-value <0.001). Taking food by yourself in wet season were higher than dry season (p-value<0.001). Young children's activities presented that exposing during spraying and playing in farm were difference between dry and wet seasons (p-value <0.001 and p-value<0.05). Window opening between dry and wet season were difference base on the weather (p-value< 0.01).

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Table 4.2 Characteristics of young children, behavior, activities and household environment of participants

	Factors	Dry season (N=65)		Wet season (N=58)		P-value
		N	%	N	%	
Behaviors	Frequency of hands/feet washing (times) (mean±SD)	3.86 ±1.41 (Min.=1.0 Max.=7.0)		3.84±1.79 (Min.=2.0 Max.=10.0)		0.849[a]
	Frequency of shower (times) (mean±SD)	1.98 ±0.54 (Min.=1.0 Max.=3.0)		2.46±0.70 (Min.=1.0 Max.=5.0)		0.000[a]
	Wearing clothing in house area					
	Always	62	95.4%	58	100%	-
	Sometime	3	4.6%			
	Wearing clothing when going outside home					
	Always	65	100%	58	100%	-
	Sometime	-	-	-		
	Shoes wearing					
	Always	20	30.8%	23	39.7%	
	Often	8	12.3%	6	10.3%	0.587[b]
	Sometime	30	46.2%	25	43.1%	
	None	7	10.8%	4	6.9%	
	Face touching					
	Always	5	7.7%	-		
	Often	22	33.8%	20	34.5%	-
	Sometime	36	55.4%	38	65.5%	
	None	2	3.1%	-		
	Taking hand to mouth					
	Always	4	6.2%	3	5.2%	
	Often	15	23.1%	11	19%	0.464[b]
	Sometime	29	44.6%	29	50%	
	None	17	26.2%	15	25.8%	
	Taking non-food to mouth					
	Often	15	23.1%	10	17.2%	0.454[b]
	Sometime	50	76.9%	48	82.8%	

[a] Wilcoxon Signed rank test [b] Mcnemar test

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Table 4.2 Characteristics of young children, behavior, activities and household environment of participants (continued)

	Factors	Dry season (N=65)		Wet season (N=58)		P-value
		N	%	N	%	
Behaviors	Taking food to mouth					
	Bare hand	44	67.7%	42	72.4%	0.541[b]
	Spoon or fork	21	32.3%	16	27.6%	
	Taking food by					
	Themself	12	18.5%	32	55.2%	0.000[b]
	Their parents	53	81.5%	26	44.8%	
	Normally food					
	Milk	58	89.2%	55	94.8%	0.219[b]
	Rice	65	100%	58	100%	-
	Vegetables	59	90.8%	43	74.1%	0.035[b]
	Fruit	64	98.5%	54	93.1%	0.375[b]
	Breast milk	13	20%	9	15.5%	0.219[b]
	Source of drinking water					
	Tap water	8	12.3%	8	13.8%	
	Rain water	5	7.7%	4	6.9%	
	Bottle / tank water	37	56.9%	37	63.8%	0.344[b]
	Ground water	3	4.6%	1	1.7%	
	Jar	12	18.5%	8	13.8%	
Activities	Playing duration (hour/day) (mean± SD)	7.26 ± 1.73 (Min.=5.0 Max.=10.0)		9.10 ±2.07 (Min.=5.0 Max.=11.0)		0.000[a]
	Playing on farm					
	Always	28	43.1%	35	60.3%	0.011[b]
	Sometime	37	56.9%	23	39.7%	
	Spent time on					
	Wooden bed	31	47.7%	26	44.8%	0.774[b]
	Floor	34	52.3%	32	55.2%	

[a] Wilcoxon Signed rank test

[b] Mcnemar test

Table 4.2 Characteristics of young children, behavior, activities and environment households of participants (continued)

	Factors	Dry season (N=65)		Wet season (N=58)		P-value
		N	%	N	%	
Activities	Sleeping and playing duration (the most activity during daytime)					
	Sleeping	3	4.6%	-	-	-
	Outdoor playing	39	60%	20	34.5%	
	Indoor playing	23	35.4%	38	65.5%	
	Soil exposures activity					
	Always	50	76.9%	41	70.7%	0.302[b]
	Sometime	15	23.1%	17	29.3%	
	Area for spent during daytime					
	In room	3	4.7%	6	10.3%	
	Terrace/space under the house	53	81.5%	35	60.4%	0.152[b]
	Farm	9	13.8%	17	29.3%	
	Exposed during spraying					
	Yes	22	33.8%	1	1.7%	0.000[b]
	No	43	66.2%	57	98.3%	
Household environments	Keeping pesticides in house					
	Yes	18	27.7%	23	39.7%	0.286[b]
	No	47	72.3%	35	60.3%	
	Clean clothes combined with family					
	Yes	18	27.7%	23	39.7%	0.332[b]
	No	47	72.3%	35	60.3%	
	Dry clothes near farm					
	Yes	42	64.6%	42	72.4%	0.016[b]
	No	23	35.4%	16	27.6%	
	Clothes kept in storage					
	Yes	40	61.5%	29	50%	0.210[b]
	No	25	38.5%	29	50%	

[a] Wilcoxon Signed rank test

[b] Mcnemar test

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Table 4.2 Characteristics of young children, behavior, activities and environment condition of participants (continued)

	Factors	Dry season (N=65)		Wet season (N=58)		P-value
		N	%	N	%	
Household environments	Tool for house cleaning					
	Wet mop	-	-	-	-	
	Broom	38	58.5%	28	48.3%	0.557
	Both	27	41.5%	29	50%	0.541
	Frequency of house cleaning					
	Everyday	39	60%	36	62.1%	0.678
	Sometimes	26	40%	22	37.9%	
	Insecticide used in house					
	Yes	27	41.5%	22	37.9%	0.804
	No	38	58.5%	36	62.1%	
	Type of insecticide in house					
	Spray					
	Yes	13	20%	10	17.2%	0.508
	No	52	80%	48	92.8%	
	Electronic					
	Yes	2	3.1%	1	1.7%	1.000
	No	63	96.9%	57	98.3%	
	Pesticide powder					
	Yes	5	7.7%	2	3.4%	0.375
	No	60	92.3%	56	96.6%	
	Pesticide chalk					
	Yes	10	15.4%	11	19.0%	0.791
	No	55	84.6%	47	81.0%	
	Coil					
	Yes	6	9.2%	5	8.6%	1.000
	No	59	90.8%	53	91.4%	
	House floors					
	Up	11	16.9%	9	15.5%	1.000
	Down	54	83.1%	49	84.5%	
	Window opening					
	Every day open	41	63.1%	51	87.9%	0.001
	Sometimes open	24	36.9%	7	12.1%	

[a] Wilcoxon Signed rank test

[b] Mcnemar test

4.2 Detections and concentrations of pesticides

Pesticide concentrations (chlorpyrifos, cypermethrin and permethrin) were measured on children's hands and feet, floors/wooden beds in their house and children's toys. The exposure to pesticides of young children in dry and wet seasons are shown in Table 4.3. The most of chlorpyrifos concentrations were detected in dry season. From surface wipe samples were highly detected on children's hands (61.5%) follow by children's toys (57.14%), floors/wooden beds (53.8%) and children's feet (30.8%), respectively. All of surface wipe samples were detected concentrations of cypermethrin (100%) in dry and wet seasons. For permethrin concentrations were low frequently detected in this study, the highest detection was 26.1% on floors or wooden beds in dry season and 12.30% on children's feet in wet season.

Table 4.3 Pesticide detected in surface wipe samples in dry and wet season

Pesticide	Detected samples							
	Hands (%)		Feet (%)		Floors/wooden beds (%)		Toys (%)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry*	Wet**
OP: Chlorpyrifos	40 (61.5%)	nd	20 (30.8%)	1 (1.53%)	35 (53.8%)	2 (3.08%)	20 (57.14%)	2 (5.26%)
PYR: Cypermethrin	65 (100%)	58 (100%)	65 (100%)	58 (100%)	65 (100%)	58 (100%)	35 (100%)	38 (100%)
PYR: Permethrin	9 (13%)	6 (9.23%)	11 (16.9%)	8 (12.30%)	17 (26.1%)	5 (7.7%)	3 (8.6%)	1 (2.6%)

Dry season: N=65

Wet season: N=58

* 35 samples, ** 38 samples, nd = no detectable

The exposure to pesticides are shown in Table 4.4. The most of chlorpyrifos concentrations were detected in dry season because of in wet season, about 90% of agricultural areas were filed crops that chlorpyrifos insecticide was used low frequency in farms. Chlorpyrifos concentrations from surface wipe samples were highly concentrations on children's toys (1.287 ± 0.757μg/cm^2), follow by floors/wooden

beds (0.030 ± 0.022μg/m^2), children's hands (0.015 ± 0.026 μg/on hands) and children's feet (0.009 ± 0.006μg/on feet), respectively.

Table 4.4 Concentrations of chlorpyrifos insecticide in surface wipe samples from children's hands, feet, floors or wooden bed and toys in dry season

Surface wipe samples	Detected frequency (N=65)	Mean± SD	Min	Max	Percentile			
					25th	50th	75th	95th
Hands (μg/hands)[a]	40(61.5%)	0.015± 0.026	<LOD	0.212	<LOD	0.014	0.016	0.026
Toys* (μg/m^2)[d]	20(57.14%)	1.287±0.757	<LOD	3.022	<LOD	1.518	1.812	2.653
Floors/wooden beds (μg/m^2)[c]	35(53.8%)	0.030±0.022	<LOD	0.096	<LOD	0.033	0.041	0.081
- Floors	15(23.0%)	0.024±0.019	<LOD	0.087	<LOD	<LOD	0.036	0.079
- Wooden beds	20(30.8%)	0.036±0.024	<LOD	0.095	<LOD	0.035	0.047	0.088
Feet (μg/feet)[b]	20(30.8%)	0.009±0.006	<LOD	0.032	<LOD	<LOD	0.015	0.019

Dry season: N=65

[a] LOD = 0.01 μg/ hands, [b] LOD =0.01 μg/feet, [c] LOD = 0.02μg/m^2, [d] LOD =1 μg/m^2

* 35 samples

Table 4.5 shows cypermethrin concentrations in dry season. Cypermethrin concentrations from surface wipe samples were detected all of samples (100%). Cypermethrin insecticide were highest concentrations on toys (16.682±14.543 μg/cm^2) follow by floors/wooden beds (0.8066±1.111μg/m^2), feet (0.1308±0.111μg/on feet) and hands (0.0988± 0.076 μg/on hands), respectively.

Cypermethrin concentrations in wet season from surface wipe samples were detected all of samples (100%). Cypermethrin insecticide were high concentrations on toys (37.931±23.229 μg/cm^2) follow by floors/wooden beds (4.1247±9.461μg/m^2), feet (0.8626±2.620μg/on feet) and hands (0.5029± 0.661 μg/on hands), respectively. Concentration of cypermethrin on floors were detected higher concentrations than wooden beds (Table 4.6).

Table 4.5 Concentrations of cypermethrin insecticide in surface wipe samples from children's hands, feet, floors or wooden bed and toys in dry season

Surface wipe samples	Detected frequency (N=65)	Mean± SD	Min	Max	Percentile			
					25th	50th	75th	95th
Hands (μg/hands)[a]	65(100%)	0.0988± 0.076	0.047	0.559	0.066	0.075	0.106	0.246
Feet (μg/feet)[b]	65(100%)	0.1308±0.111	0.040	0.531	0.062	0.085	0.159	0.423
Floors/wooden beds (μg/m^2)[c]	65(100%)	0.8066±1.111	0.029	6.082	0.191	0.436	1.023	3.473
- Floors	34(52.31%)	0.8948±1.111	0.02870	5.2768	0.2147	0.5092	1.1428	4.2383
- Wooden beds	31(47.69%)	0.7098±1.120	0.1087	6.082	0.1838	0.3410	0.7323	3.7383
Toys* (μg/m^2)[d]	35(100%)	16.682±14.543	<LOD	68.811	7.534	11.484	18.726	56.069

Dry season: N=65

[a] LOD = 0.01 μg/ hands, [b] LOD =0.01 μg/feet, [c] LOD = 0.02μg/m^2, [d] LOD =1 μg/m^2

* 35 samples

Table 4.6 Concentrations of cypermethrin insecticide in surface wipe samples from children's hands, feet, floors or wooden bed and toys in wet season

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Surface wipe samples	Detected frequency (N=65)	Mean± SD	Min	Max	Percentile			
					25th	50th	75th	95th
Hands (μg/hands)[a]	65(100%)	0.5029± 0.661	0.063	2.917	0.151	0.258	0.500	2.510
Feet (μg/feet)[b]	65(100%)	0.8626±2.620	0.061	19.306	0.155	0.304	0.715	1.892
Floors/wooden beds (μg/m^2)[c]	65(100%)	4.1247±9.461	0.149	44.070	0.413	1.045	3.243	39.939
- Floors	32(55.17%)	4.7072±10.688	0.1490	44.070	0.4866	1.0891	2.8272	42.4811
- Wooden beds	26(44.83%)	3.4077±7.840	0.2251	39.851	0.4041	0.5552	3.4195	29.1379
Toys** (μg/m^2)[d]	38(100%)	37.931±23.229	9.668	131.886	13.534	23.229	40.144	130.357

Wet season: N=58; [a] LOD = 0.01 μg/ hands, [b] LOD =0.01 μg/feet, [c] LOD = 0.02μg/m^2, [d] LOD =1 μg/m^2

** 38 samples

Concentrations of permethrin insecticide from surface wipe samples of children's hands, feet, floors or wooden beds and children's toys in dry and wet season as in Table 4.7. In dry season, permethrin insecticide was high frequently detected on floors/ wooden beds (26.1%) follow by children's feet, hands, and toys, respectively. The highest permethrin concentration, of 2.275±2.908 μg/m^2 was collected from surface wipe samples on children's toy. Permethrin detection in wet season was detected highest on children's feet (12.30%) and only one sample of permethrin concentration on children's toy (205.730 μg/m^2) was the highest of permethrin concentration.

Table 4.7 Concentrations of permethrin insecticide in surface wipe samples from children's hands, feet, floors or wooden beds and toys in dry and wet seasons

Seasons	Surface wipe samples	Detected frequency (N=65)	Mean± SD	Min	Max
Dry	Hands (μg/hands)[a]	9 (13%)	0.064±0.099	<LOD	0.298
	Feet (μg/feet)[b]	11 (16.9%)	0.084±0.156	<LOD	0.545
	Floors/wooden beds (μg/m^2)[c]	17 (26.1%)	1.104±3.354	<LOD	14.048
	Toys* (μg/m2)[d]	3 (8.6%)	2.275±2.908	<LOD	5.595
Wet	Hands (μg/hands)[a]	6(9.23%)	1.428± 1.197	<LOD	3.542
	Feet (μg/feet)[b]	8 (12.30%)	3.113±1.573	<LOD	4.939
	Floors/wooden beds (μg/m^2)[c]	5 (7.7%)	15.481±9.623	<LOD	27.485
	Toys** (μg/m2)[d]	1 (2.6%)	205.730	<LOD	205.730

Dry season: N=65, Wet season: N=58

[a] LOD = 0.01 μg/ hands, [b] LOD =0.01 μg/feet, [c] LOD = 0.02μg/m^2, [d] LOD =1 μg/m^2

* 35 samples, ** 38 samples

4.3 Blood cholinesterase activities

Blood cholinesterase activities of young children in dry and wet season were presented in Table 4.8. Average of AChE, hemoglobin-adjusted AChE (HAChE), and PChE in dry season were 2.388±0.442 U/ml, 23.794±4.764 U/g Hgb, and 2.808±0.815 U/ml, respectively. For wet season were 2.357±0.495 U/ml of AChE, 22.988±5.025 U/g Hgb of HAChE, and 2.822±0.919 U/ml of PChE.

Table 4.8 Blood cholinesterase activities of young children in dry and wet seasons

Seasons	Detected frequency	Mean± SD	Median	Min	Max
Dry	AChE (U/ml)	2.388± 0.442	2.420	0.930	3.520
	HAChE (U/g Hgb)	23.794±4.764	23.900	9.900	40.200
	PChE (U/ml)	2.808±0.815	2.710	1.150	4.810
Wet	AChE (U/ml)	2.357±0.495	2.370	0.630	3.650
	HAChE (U/g Hgb)	22.988±5.025	23.000	8.200	39.500
	PChE (U/ml)	2.822±0.919	2.555	1.150	4.880

Dry season: N=65, Wet season: N=58

4.4 Pesticide concentrations, blood cholinesterase activities and health effects between dry and wet seasons.

From general objective to compare pesticide concentration (cypermethrin) between dry and wet seasons. Table 4.9 are presented comparison of cypermethrin concentrations from surface wipe samples between dry and wet seasons. Cypermethrin insecticide in all samples (children's hands, feet, toys and floors/ wooden bed) were different concentrations in dry and wet seasons (p-value<0.001).

Cypermethrin concentrations in wet season was found to have higher concentrations than dry season, except surface wipe samples on children's hands.

Table 4.9 Cypermethrin concentrations from surface wipe samples between dry and wet seasons

Surface wipe samples	Dry Season (N=65)		Wet Season (N=58)		Mean differences	p-value
	Conc. (mean±SD)	Detected (%)	Conc. (mean±SD)	Detected (%)		
Hands (μg/hands)[a]	0.988±0.076	100%	0.503±0.661	100%	0.407	<0.001
Feet (μg/feet)[b]	0.131±0.111	100%	0.863±2.620	100%	-0.733	<0.001
Floors /wooden beds (μg/m^2)[c]	0.807±1.111	100%	4.125±9.461	100%	-3.293	<0.001
Toys* (μg/m^2)[d]	16.68±14.543	100%	37.931±38.489	100%	-14.553	<0.001

Wilcoxon Signed rank test, p-value < 0.001

Dry season: N=65, Wet season: N=58

* thirty five samples for dry season and thirty eight samples for wet season

In Table 4.10 shows a comparison of blood cholinesterase levels between dry and wet season. AChE and PChE of young children were not significant differences between dry and wet season. However, HAChE was significant difference (p-value < 0.001) and found a higher level in wet season than dry season.

Table 4.10 Blood cholinesterase activities between dry and wet season

Blood cholinesterase	Dry Season (N=65)		Wet Season (N=58)		Mean differences	p-value
	Mean±SD	Min-Max	Mean±SD	Min-Max		
AChE (U/ml)	2.380±0.440	0.930-3.520	2.360±0.490	1.150-4.880	0.037	0.400[a]
HAChE(U/g Hgb)	23.790 ± 4.760	9.900-40.200	22.990±5.030	8.200-39.500	0.739	<0.001[b]
PChE (U/ml)	2.810 ± 0.810	1.150-4.810	2.820±0.920	0.630-3.650	-0.020	0.530[b]

[a] Pair t-test, [b] Wilcoxon Signed rank test, p-value < 0.001

The comparisons of health symptoms between dry and wet seasons were presented in Table 4.11. From the questionnaire in part 4; health effects that consist of 5 health effects; general (nausea, vomiting and anorexia), respiratory (cough, excessive wheezing and runny nose), gastrointestinal (diarrhea and salivation), nervous (lethargy and salivation), eyes (irritation and lacrimation), and skin (skin irritation and diaphoresis). Nervous symptom was not presented from participants in this study. In dry season, this study found a higher frequencies of all health effects than wet season. General symptom was significant differences between dry and wet seasons (p-value < 0.05). Similarly, differences in respiratory symptom between dry and wet season were observed (p-value <0.01). There were no significant differences for gastrointestinal, nervous, eyes, and skin symptom.

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Table 4.11 Health effects between dry and wet seasons

Health Effects	Dry season (N=65)		Wet season (N=58)		p-value
	Had in the last month	%	Had in the last month	%	
General	22	33.8	10	17.2	0.035*
Respiratory	39	60	21	36.2	0.004**
Gastrointestinal	20	30.8	13	22.4	0.230
Nervous	0	0	0	0	-
Eyes	6	9.2	2	3.4	0.453
Skin	21	32.3	16	27.6	0.648

McNemar's test

* Significance at the 0.05 level (2-tailed)

** Significance at the 0.01 level (2-tailed)

4.5 The associations with pesticide concentrations, blood cholinesterase activities and health effects among young children

Spearman's correlations presented moderately and strongly significant association between chlorpyrifos concentrations on children's hands, feet, toys and floors/wooden beds (r= 0.452-0.643, p-value <0.001). In dry season, cypermethrin concentrations on children's hands presented moderately significant relation to cypermethrin concentrations on children's feet (r=0.519, p-value <0.001). There are presented moderately significant association between cypermethrin concentrations on floors or wooden beds and children's toys (r= 0.572, p-value<0.001). In wet season, the correlations showed moderately and strongly significant association between cypermethrin concentrations on children's hands, feet, and floors/wooden beds (r= 0.498-0.69, p-value<0.001). The correlations showed weakly significant association

between cypermethrin concentrations on children's hands and toys (r= 0.323, p-value <0.05) in Table 4.12.

Table 4.12 The association of pesticide concentration in surface wipe samples

Surface wipe samples	Spearman's rho			
	Hands	feet	Floors/wooden beds	toys
Chlorpyrifos : Dry season				
Hands	1.000			
Feet	0.643**	1.000		
Floors/ wooden beds	0.533**	0.521**	1.000	
Toys	0.603**	0.506**	0.452**	1.000
Cypermethrin : Dry season				
Hands	1.000			
Feet	0.519**	1.000		
Floors/ wooden beds	0.027	0.108	1.000	
Toys	0.021	0.275	0.572**	1.000
Cypermethrin: Wet season				
Hands	1.000			
Feet	0.501**	1.000		
Floors/ wooden beds	0.595**	0.691**	1.000	
Toys	0.323*	0.519**	0.498**	1.000

*Correlation coefficient significant at p < 0.05

**Correlation coefficient significant at p < 0.001

Blood cholinesterase activities of young children in dry and wet seasons were presented in Table 4.13. AChE was strongly significant association with HAChE in dry season (r=0.723, p-value<0.001). The correlations in wet season were strongly significant association between AChE and HAChE (r=0.868, p-value<0.001). The relations were weakly significant association between PChE and HAChE (r= 0.253, p-value= 0.055), and PChE and AChE (r=0.228, p-value=0.086).

Table 4.13 the associations of blood cholinesterase activities in dry and wet seasons

Blood cholinesterase activities	Spearman's rho					
	HAChE		AChE		PChE	
	Correlation Coefficient	p-value	Correlation Coefficient	p-value	Correlation Coefficient	p-value
Dry season						
HAChE (U/g Hgb)	1.000					
AChE (U/ml)	0.723**	<0.001	1.000			
PChE (U/ml)	-0.008	0.950	-0.042	0.742	1.000	
Wet season						
HAChE (U/g Hgb)	1.000					
AChE (U/ml)	0.868**	<0.001	1.000			
PChE (U/ml)	0.253	0.055	0.228	0.086	1.000	

*Correlation coefficient significant at $p < 0.05$

**Correlation coefficient significant at $p < 0.001$

Spearman's correlations presented that chlorpyrifos concentrations on children's hands and feet were not significantly associated with blood cholinesterase activities (AChE, HAChE and PChE) in Table 4.14.

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Table 4.14 The associations between chlorpyrifos concentrations (hands and feet) and blood cholinesterase activities (HAChE, AChE and PChE) in dry season

Blood cholinesterase activities	Spearman's rho Chlorpyrifos concentrations					
	Hands		Feet		Hands and feet	
	Correlation Coefficient	p-value	Correlation Coefficient	p-value	Correlation Coefficient	p-value
HAChE (U/g Hgb)	-0.060	0.637	-0.126	0.317	-0.073	0.563
AChE (U/ml)	0.017	0.894	-0.088	0.486	-0.020	0.876
PChE (U/ml)	0.005	0.967	0.018	0.885	0.006	0.961

N=65: dry season

Chlorpyrifos concentrations on children's feet were found to correlated with skin symptom (p-value<0.05) and likely related to eyes symptom (p-value=0.077). There were no significant association with general, respiration, gastrointestinal symptoms in dry season (Table 4.15).

Table 4.15 The association between chlorpyrifos concentrations (hands and feet) and health effects in dry season

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Health effects	Pesticide exposures Cholrpyrifos concentrations p-value		
	Hands	Feet	Hand and feet
General	0.542 [b]	0.896 [b]	0.663 [b]
Respiration	0.753 [b]	0.583 [b]	0.919 [b]
Gastrointestinal	0.830 [b]	0.622 [b]	0.535 [b]
Eyes	0.077 [a]	0.166 [a]	0.105 [a]
Skin	0.130 [b]	0.047* [b]	0.066 [b]

[a] Fisher's Exact Test, [b] Pearson Chi-square test, * Significant level at p-value < 0.05, Cut off is median of chlorpyrifos concentrations on hands and feet (µg/sample)

In dry and wet seasons, cypermethrin concentrations on children's hands and feet were no associated with health effects (general, respiration, gastrointestinal, eyes, and skin symptoms) in Table 4.16.

Table 4.16 The association between cypermethrin concentrations (hands and feet) and health effects in dry and wet season

Health effects	Pesticide exposures Cypermethrin concentrations			
	Dry season p-value		Wet season p-value	
	Hands	Feet	Hands	Feet
General	0.138 [b]	0.540 [b]	0.487 [b]	0.487[b]
Respiration	0.265 [b]	0.685 [b]	0.412 [b]	0.412[b]
Gastrointestinal	0.535 [b]	0.535 [b]	0.753 [b]	0.115[b]
Eyes	0.414 [b]	0.166[a]	0.491[a]	0.491[a]
Skin	0.726 [b]	0.726 [b]	0.240 [b]	0.557[b]

[a] Fisher's Exact Test, [b] Pearson Chi-square test,

* Significant level at p-value < 0.05

Cut off is median of cypermethrin concentrations on hands and feet (µg/samples)

The association between blood cholinesterase activities and health effects in dry and wet seasons were presented in Table 4.17. General symptom was related to PChE (p-value < 0.05) and likely associated with AChE (p-value=0.188) in dry season. Gastrointestinal symptom was probable associated with AChE and PChE (p-value=0.185) and (p-value=0.156). Respiration symptom was possible correlated with HAChE (p-value=0.156). There were no correlation between blood cholinesterase activities and health effects in wet season.

Table 4.17 The associations between blood cholinesterase activities and health effects in dry and wet seasons

Health effects	Blood cholinesterase activities					
	Dry season p-value			Wet season p-value		
	HAChE	AChE	PChE	HAChE	AChE	PChE
General	0.663[b]	0.188[b]	0.018*[b]	0.481[a]	0.302[a]	0.499[a]
Respiration	0.156[b]	0.839[b]	0.683[b]	0.529[b]	0.977[b]	0.702[b]
Gastrointestinal	0.934[b]	0.185[b]	0.156[b]	0.242[b]	0.375[b]	0.692[b]
Eyes	0.321[b]	0.618[b]	0.224[a]	1.000[a]	1.000[a]	1.000[a]
Skin	0.857[b]	0.993[b]	0.273[b]	0.587[b]	0.513[b]	0.821[b]

[a] Fisher's Exact Test, [b] Pearson Chi-square test,

* Significant level at p-value < 0.05

Cut off is median of blood cholinesterase levels; HAChE (U/g Hgb), AChE (U/ml), and PChE (U/ml)

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4.6 Factors associated with pesticide concentrations, blood cholinesterase activities, and health effects between dry and wet seasons

4.6.1 Factors and chlorpyrifos concentrations

The factors (activities, behaviors and household environments from questionnaire were used to analyze for factor associations with pesticide concentrations (chlorpyrifos and cypermethrin). A linear regression that controlled surface area of children's hands, age, and gender. The associations between factors (activities, behaviors and household environments) and chlorpyrifos concentrations on children's hands were presented in Table 4.18. The results found that frequency of hands/feet wash (times) were possible related to chlorpyrifos concentration on hands

(p-value = 0.067) and frequency of shower (times) were associated with chlorpyrifos concentration on hands (p-value = 0.057).

Table 4.18 Factors associated with cholrpyrifos concentrations on hands

Independent factors	Chlorpyrifos concentrations						
	Hands						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.084	0.000	0.002	0.009	0.944	-0.004	0.004
Sitting/Laying on wooden bed	0.105	-0.008	0.006	-0.149	0.234	-0.020	0.005
Exposing during spraying	0.089	-0.004	0.007	-0.080	0.541	-0.018	0.010
Sleeping and playing duration	0.085	0.001	0.006	0.033	0.794	-0.010	0.013
Contract soil	0.085	0.002	0.008	0.038	0.764	-0.013	0.018
Behaviors:							
Frequency of hands/feet wash (times)	0.134	-0.004	0.002	-0.236	0.067	-0.009	0.000
Frequency of shower (times)	0.138	-0.011	0.006	-0.024	0.056	-0.023	0.000
Face touching	0.091	-0.005	0.007	-0.092	0.477	-0.018	0.008
Taking non-food to mouth	0.084	-0.002	0.008	-0.031	0.819	-0.018	0.014
Taking food to mouth	0.089	0.004	0.007	0.007	0.558	-0.010	0.018
Environments:							
Frequency of house cleaning	0.100	-0.007	0.007	-0.133	0.299	-0.020	0.006
Window opening	0.087	0.003	0.007	0.057	0.649	-0.010	0.016
Keeping pesticide in house	0.120	0.011	0.007	0.196	0.120	-0.003	0.025

Adjust: Surface area (SA), age and gender

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Factors associated with chlorpyrifos concentrations on feet were showed in table 4.19. The results showed that sitting/laying on wooden bed was significantly associated with chlorpyrifos concentrations on feet (p-value < 0.01). Chlorpyrifos concentration on feet were significantly related to frequency of hands/feet wash (times) (p<0.05). Shoes wearing and frequency of shower (times) were likely correlated with chlorpyrifos concentration on children's feet (p-value=0.061) and (p-value= 0.068). Playing duration was significant negative association with chlorpyrifos concentrations on feet (p-value < 0.01).

Table 4.19 Factors associated with cholrpyrifos concentrations on feet

Independent factors	Chlorpyrifos concentrations						
	Feet						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.135	-0.001	0.000	-0.357	0.008**	-0.002	0.000
Sitting/Lying on wooden bed	0.162	-0.005	0.001	-0.372	0.003**	-0.007	-0.002
Exposing during spraying	0.029	0.001	0.002	0.044	0.743	-0.003	0.004
Sleeping and playing duration	0.028	0.000	0.001	0.028	0.830	-0.002	0.003
Contract soil	0.046	0.002	0.002	0.142	0.275	-0.002	0.006
Behaviors:							
Frequency of hands/feet wash	0.109	-0.001	0.001	-0.302	0.022*	-0.002	0.000
Frequency of shower	0.080	-0.003	0.001	-0.236	0.068	-0.005	0.000
Shoes Wearing	0.083	0.005	0.003	0.246	0.061	0.000	0.010
Environments:							
Frequency of house cleaning	0.029	-0.001	0.002	-0.042	0.753	-0.004	0.003
Window opening	0.060	-0.002	0.002	-0.183	0.151	-0.005	0.001
Keeping pesticide in house	0.029	-0.001	0.002	-0.046	0.727	-0.004	0.003

Adjust: Surface area (SA), age and gender

* Significant level at p-value < 0.05; ** Significant level at p-value < 0.01

Table 4.20 was showed association between factors and cholrpyrifos concentrations on floors or wooden beds and children's toys. The results found that cholrpyrifos concentrations on children's toys were related to window opening (p-value = 0.027) and frequency of house cleaning (p-value=0.05). For cholrpyrifos concentrations on floors or wooden beds were no significantly associated with factors.

Table 4.20 Factors associated with cholrpyrifos concentrations on floor or wooden beds and children's toys

Cholrpyrifos concentrations	Factors	Chi-square p-value
Floors or wooden beds	Keeping pesticide in house	0.633
	Wet mop and broom	0.248
	Frequency of house cleaning	0.919
	Window opening	0.924
Toys	Keeping pesticide in house	0.460
	Wet mop and broom	0.640
	Frequency of house cleaning	0.050*
	Window opening	0.027*

Pearson Chi-square test

* Significant level at p-value < 0.05

Cut off is median of chlorpyrifos concentration on floors/wooden beds and toys (μg/m^2)

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4.6.2 Factors and cypermethrin concentrations

Factor associations with cypermethrin concentrations on hands in dry season were presented in Table 4.20. Cypermethrin concentrations on children's hands were not presented significant association with many factors.

Table 4.21 Factors associated with cypermethrin concentrations on children's hands in dry season

Independent factors	Cypermethrin concentrations						
	Hands						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.037	0.002	0.006	0.046	0.732	-0.804	1.152
Sitting/Laying on floor/wooden bed	0.037	0.006	0.019	0.041	0.752	-0.033	0.045
Exposing during spraying	0.046	-0.018	0.021	-0.111	0.407	-0.060	0.025
Sleeping and playing duration	0.035	-0.002	0.017	-0.012	0.924	-0.035	0.032
Contract soil	0.052	0.023	0.023	0.131	0.314	-0.023	0.070
Behaviors:							
Frequency of hands/feet wash	0.072	-0.011	0.007	-0.202	0.127	-0.025	0.003
Frequency of shower	0.050	-0.017	0.018	-0.123	0.343	-0.053	0.019
Face touching	0.042	-0.013	0.020	-0.088	0.509	-0.054	0.027
Taking non-food to mouth	0.043	-0.015	0.021	-0.092	0.481	-0.058	0.028
Taking food to mouth	0.067	-0.030	0.021	-0.187	0.162	-0.073	0.012
Environments:							
Frequency of house cleaning	0.063	-0.027	0.020	-0.173	0.187	-0.067	0.013
Window opening	0.059	0.024	0.020	0.159	0.228	-0.015	0.063
Using pesticide in house	0.043	0.014	0.020	0.093	0.485	-0.026	0.055
Keeping pesticide in house	0.061	-0.028	0.022	-0.164	0.204	-0.071	0.015

Adjust: Surface area (SA), age and gender

Table 4.22 showed the association of factors and cypermethrin concentrations on feet in dry season. Cypermethrin concentrations on feet were not significantly related to factors (activities, behaviors, and environments). Sleeping and playing

duration was possible related to cypermethrin concentrations on feet (p-value =0.060), young children who have to higher concentrations of cypermethrin on feet when they playing than sleeping. Sitting/laying on wooden bed was likely associated with cypermethrin concentrations on children's feet (p-value=0.105).

Table 4.22 Factors associated with Cypermethrin concentrations on feet in dry season

Independent factors	Cypermethrin concentrations						
	Feet						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
playing duration	0.095	0.007	0.009	0.107	0.424	-0.010	0.024
Sitting/Laying on floor/wooden bed	0.125	-0.044	0.027	-0.201	0.105	-0.098	0.010
Exposing during spraying	0.086	-0.005	0.030	-0.023	0.863	-0.065	0.055
Sleeping and playing duration	0.138	0.044	0.023	0.235	0.060	-0.002	0.091
Contract soil	0.101	0.033	0.033	0.128	0.312	-0.032	0.099
Behaviors:							
Frequency of hands/feet wash	0.085	-0.001	0.010	-0.012	0.927	-0.021	0.019
Frequency of shower	0.091	0.015	0.026	0.075	0.555	-0.036	0.066
Shoes wearing	0.111	0.059	0.045	0.166	0.195	-0.031	0.149
Environments:							
Frequency of house cleaning	0.088	-0.012	0.029	-0.055	0.667	-0.070	0.045
Window opening	0.090	0.015	0.028	0.065	0.600	-0.042	0.071
Using pesticide in house	0.085	0.002	0.029	0.009	0.943	-0.056	0.060
Keeping pesticide in house	0.113	-0.042	0.030	-0.170	0.176	-0.103	0.019

Adjust: Surface area (SA), age and gender

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Factor associations with cypermethrin concentrations on floor or wooden beds and children's toys in dry season are presented in Table 4.23. This study found that cypermenthrin concentrations on floors or wooden beds were related to window opening (p-value=0.05). For cypermethrin concentrations from children's toys were not associated with any factors.

Table 4.23 Factors associated with cypermethrin concentrations on floor or wooden beds and toys in dry season

Cypermethrin concentrations	Factors	Chi-square p-value
Floors or wooden beds	Using pesticide in house	0.173
	Wet mop and broom	0.515
	Frequency of house cleaning	0.685
	Window opening	0.050*
Toys	Using pesticide in house	0.214
	Wet mop and broom	0.229
	Frequency of house cleaning	0.625
	Window opening	0.632

Pearson Chi-square test

* Significant level at p-value < 0.05

Cut off is median of cypermethrin concentration on floors/wooden beds and toys (μg/m^2)

Factor associations with cypermethrin concentrations on hands in wet season were presented in table 4.24. Cypermethrin concentrations on hands were significantly related to using pesticide in house (p-value<0.01).

Table 4.24 Factors associated with cypermethrin concentrations on hands in wet season

Independent factors	Cypermethrin concentrations						
	Hands						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
playing duration	0.024	-0.005	0.045	-0.017	0.906	-0.096	0.085
Sitting/Laying on floor/wooden bed	0.037	0.155	0.183	0.118	0.400	-0.211	0.521
Exposing during spraying	0.030	0.389	0.694	0.077	0.577	-1.003	1.782
Sleeping and playing duration	0.033	-0.128	0.187	-0.093	0.498	-0.503	0.247
Contract soil	0.025	-0.059	0.213	-0.041	0.783	-0.486	0.368
Behaviors:							
Frequency of hands/feet wash	0.129	0.445	0.176	0.336	0.014*	-0.009	0.000
Frequency of shower	0.051	0.173	0.140	0.185	0.221	-0.107	0.149
Face touching	0.042	-0.187	0.187	-0.135	0.323	-0.562	0.188
Taking non-food to mouth	0.025	0.061	0.240	0.035	0.802	-0.420	0.541
Taking food to mouth	0.031	-0.125	0.209	-0.085	0.553	-0.544	0.295
Environments:							
Frequency of house cleaning	0.057	-0.246	0.181	-0.182	0.180	-0.609	0.117
Window opening	0.024	-0.023	0.277	-0.012	0.933	-0.580	0.533
Using pesticide in house	0.145	0.474	0.173	0.351	0.009**	0.126	0.822
Keeping pesticide in house	0.088	-0.349	0.182	-0.260	0.060	-0.713	0.015

Adjust: Surface area (SA), age and gender

* Significant level at p-value < 0.05

** Significant level at p-value < 0.01

Table 4.25 presented factor associations with cypermethrin concentrations on feet in wet season. The result found that using pesticide in house was significantly related to cypermethrin concentrations on feet (p-value<0.05).

Table 4.25 Factors associated with cypermethrin concentrations on feet in wet season

Independent factors	Cypermethrin concentrations						
	Feet						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
playing duration	0.087	-0.120	0.173	-0.095	0.490	-0.467	0.227
Sitting/Laying on floor/wooden bed	0.084	-0.381	0.706	-0.073	0.592	-1.797	1.035
Exposing during spraying	0.081	-0.921	2.679	-0.046	0.732	-6.293	4.452
Sleeping and playing duration	0.093	0.647	0.718	0.118	0.372	-0.793	2.087
Contract soil	0.083	0.411	0.819	0.072	0.618	-1.231	2.053
Behaviors:							
Frequency of hand/foot wash	0.096	-0.197	0.197	-0.135	0.323	-0.592	0.199
Frequency of shower	0.106	0.680	0.538	0.183	0.212	-0.400	1.760
Shoes wearing	0.097	-1.484	1.440	-0.145	0.307	-4.372	1.404
Environments:							
Frequency of house cleaning	0.099	-0.760	0.701	-0.142	0.283	-2.167	0.646
Window opening	0.082	0.458	1.067	0.057	0.669	-1.681	2.598
Using pesticide in house	0.151	1.449	0.685	0.271	0.039*	0.075	2.823
Keeping pesticide in house	0.081	0.255	0.722	0.048	0.726	-1.193	1.703

Adjust: Surface area (SA), age and gender

* Significant level at p-value < 0.05

Factor associations with cypermethrin concentrations on floor or wooden beds and children's toys in wet season are presented in Table 4.26. This study found that cypermenthrin concentrations on floors or wooden beds were likely correlated with using pesticide in houses (p-value=0.104). For cypermethrin concentrations from children's toys were not associated with factors.

Table 4.26 Factors associated with cypermethrin concentrations on floor or wooden beds and toys in wet season

Cypermethrin concentrations	Factors	Chi-square p-value
Floors or wooden beds	Using pesticide in house	0.104
	Wet mop and broom	0.793
	Frequency of house cleaning	0.588
	Window opening	1.000
Toys	Using pesticide in house	0.319
	Wet mop and broom	0.189
	Frequency of house cleaning	0.305
	Window opening	1.000

Pearson Chi-square test

* Significant level at p-value < 0.05

Cut off is median of cypermethrin concentration on floors/wooden beds and toys (μg/m^2)

4.6.3 Factors and blood cholinesterase activities

Factor associations with blood cholinesterase activities (acetyl cholinesterase adjust hemoglobin: HAChE) in dry season were showed in Table 4.27. The frequency of house cleaning was significantly associated with an increase in HAChE (p-value<0.05).

Table 4.27 Factors associated with blood cholinesterase levels (acetyl cholinesterase adjust hemoglobin: HAChE) in dry season

Independent factors	Blood cholinesterase activity						
	HAChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
playing duration	0.020	-0.184	0.367	-0.067	0.618	-0.917	0.550
Sitting/Laying on floor/wooden bed	0.024	0.865	1.200	0.091	0.474	-1.535	3.266
Exposing during spraying	0.016	-0.223	1.297	-0.022	0.864	-2.817	2.371
Sleeping and playing duration	0.020	-0.490	1.037	-0.060	0.473	-2.563	1.583
Contract soil	0.024	-1.032	1.443	-0.092	0.477	-3.918	1.853
Shoes wearing	0.016	-0.186	1.984	-0.012	0.926	-4.152	3.781
Behaviors:							
Frequency of hands/feet wash	0.053	0.679	0.438	0.201	0.126	-0.196	1.554
Frequency of shower	0.017	-0.250	1.137	-0.029	0.826	-2.524	2.023
Face touching	0.022	0.747	1.255	0.078	0.554	-1.763	3.256
Taking non-food to mouth	0.040	1.858	1.512	0.166	0.224	-1.166	4.881
Taking food to mouth	0.020	0.665	1.357	0.066	0.626	-2.048	3.379
Environments:							
Frequency of house cleaning	0.077	2.419	1.204	0.251	0.049*	0.012	4.826
Window opening	0.016	0.170	1.254	0.017	0.892	-2.336	2.677
Keeping pesticide in house	0.016	0.005	1.372	0.000	0.997	-2.739	2.749

Adjust: age and gender

* Significant level at p-value < 0.05

Factor associations with blood cholinesterase activities (AChE) in dry season were showed in Table 4.28. From the result found that likely significant association between an increase in AChE and frequency of house cleaning (p-value=0.084).

Table 4.28 Factors associated with blood cholinesterase activities (Acetyl cholinesterase: AChE) in dry season

Independent factors	Blood cholinesterase activity						
	AChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.021	-0.037	0.034	-0.144	0.283	-0.105	0.031
Sitting/Laying on floor/wooden bed	0.016	0.102	0.112	0.116	0.366	-0.122	0.326
Exposing during spraying	0.005	0.045	0.121	0.049	0.711	-0.197	0.287
Sleeping and playing duration	0.003	-0.012	0.097	-0.015	0.906	-0.206	0.183
Contract soil	0.015	0.116	0.135	0.111	0.394	-0.154	0.385
Shoes wearing	0.004	0.005	0.185	0.039	0.770	-0.316	0.425
Behaviors:							
Frequency of hands/feet wash	0.005	0.015	0.042	0.049	0.715	-0.068	0.099
Frequency of shower	0.019	-0.105	0.105	-0.129	0.324	-0.316	0.106
Face touching	0.005	0.048	0.117	0.054	0.684	-0.187	0.283
Taking non-food to mouth	0.003	0.032	0.143	0.031	0.825	-0.254	0.318
Taking food to mouth	0.012	0.094	0.127	0.100	0.459	-0.159	0.347
Environments:							
Frequency of house cleaning	0.051	0.199	0.113	0.222	0.084	-0.028	0.426
Window opening	0.003	0.024	0.117	0.026	0.842	-0.211	0.258
Keeping pesticide in house	0.018	0.124	0.127	0.127	0.332	-0.130	0.379

Adjust: age and gender

Table 4.29 presented factor associations with blood cholinesterase activities (Plasma cholinesterase: PChE) in dry season. The result not showed factors related to PChE.

Table 4.29 Factors associated with blood cholinesterase activities (Plasma cholinesterase: PChE) in dry season

Independent factors	Blood cholinesterase activity						
	PChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
playing duration	0.040	0.073	0.062	0.156	0.243	-0.051	0.197
Sitting/Laying on floor/wooden bed	0.035	-0.211	0.204	-0.130	0.305	-0.619	0.197
Exposing during spraying	0.019	-0.031	0.222	-0.018	0.889	-0.474	0.412
Sleeping and playing duration	0.019	-0.006	0.177	-0.004	0.973	-0.361	0.349
Contract soil	0.024	-0.142	0.247	-0.074	0.567	-0.636	0.351
Shoes wearing	0.041	-0.404	0.335	-0.155	0.232	-1.073	0.266
Behaviors:							
Frequency of hands/feet wash	0.025	0.049	0.076	0.086	0.518	-0.102	0.201
Frequency of shower	0.020	0.049	0.194	0.033	0.803	-0.340	0.437
Face touching	0.049	0.297	0.212	0.181	0.166	-0.126	0.720
Taking non-food to mouth	0.043	-.0325	0.258	-0.169	0.213	-0.841	0.191
Taking food to mouth	0.019	0.056	0.232	0.032	0.811	-0.408	0.520
Environments:							
Frequency of house cleaning	0.021	0.090	0.212	0.054	0.674	-0.334	0.513
Window opening	0.020	-0.069	0.214	-0.041	0.747	-0.497	0.359
Keeping pesticide in house	0.024	-0.135	0.234	-0.075	0.565	-0.603	0.332

Adjust: age and gender

Factor associations with blood cholinesterase activities (acetyl cholinesterase adjust hemoglobin: HAChE) in wet season were presented in Table 4.30. Sitting/Laying on wooden beds were likely related to lower HAChE (p-value= 0.061).

Table 4.30 Factors associated with blood cholinesterase activities (acetyl cholinesterase adjust hemoglobin: HAChE) in wet season

Independent factors	Blood cholinesterase activity						
	HAChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.017	0.229	0.331	0.094	0.492	-0.434	0.892
Sitting/Laying on floor/wooden bed	0.071	-2.544	1.329	-0.254	0.061	-5.209	0.121
Exposing during spraying	0.008	0.268	5.286	0.007	0.960	-10.331	10.867
Sleeping and playing duration	0.009	0.349	1.422	0.033	0.807	-2.502	3.200
Contract soil	0.021	1.335	1.592	0.122	0.405	-0.857	4.528
Shoes wearing	0.038	3.577	2.782	0.182	0.204	-2.001	9.156
Behaviors:							
Frequency of hands/feet wash	0.009	-0.089	0.392	-0.032	0.821	-0.875	0.697
Frequency of shower	0.019	-0.785	1.034	-0.110	0.451	-2.857	1.288
Face touching	0.020	1.122	1.414	0.107	0.431	-1.712	3.957
Taking non-food to mouth	0.019	1.378	1.806	0.104	0.449	-2.243	4.999
Taking food to mouth	0.046	-2.258	1.535	-0.203	0.147	-5.336	0.819
Environments:							
Frequency of house cleaning	0.009	0.280	1.397	0.027	0.842	-2.521	3.080
Window opening	0.024	1.933	2.090	0.126	0.359	-2.257	6.122
Keeping pesticide in house	0.032	1.586	1.369	0.156	0.252	-1.159	4.331

Adjust: age and gender

Table 4.31 are presented factors association with blood cholinesterase activities (Acetyl cholinesterase: AChE) in wet season. The result found that taking food to mouth by bare hands were possible associated with lower AChE (p-value= 0.077).

Table 4.31 Factors associated with blood cholinesterase activities (acetylcholine-esterase: AChE) in wet season

Independent factors	Blood cholinesterase activity						
	AChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.015	0.023	0.033	0.096	0.487	-0.043	0.088
Sitting/Laying on floor/wooden bed	0.040	-0.184	0.133	-0.186	0.173	-0.451	0.083
Exposing during spraying	0.006	0.039	0.522	0.010	0.941	-1.007	1.085
Sleeping and playing duration	0.008	0.037	0.140	0.035	0.795	-0.245	0.318
Contract soil	0.017	0.121	0.157	0.112	0.447	-0.195	0.436
Shoes wearing	0.037	0.360	0.274	0.186	0.195	-0.190	0.910
Behaviors:							
Frequency of hands/feet wash	0.006	-0.001	0.039	-0.003	0.983	-0.078	0.077
Frequency of shower	0.012	-0.055	0.102	-0.078	0.595	-0.260	0.150
Face touching	0.008	-0.037	0.140	-0.036	0.792	-0.318	0.244
Taking non-food to mouth	0.006	0.003	0.179	0.003	0.985	-0.356	0.363
Taking food to mouth	0.063	-0.270	0.150	-0.246	0.077	-0.571	0.031
Environments:							
Frequency of house cleaning	0.014	0.090	0.137	0.089	0.515	-0.185	0.365
Window opening	0.024	0.206	0.206	0.137	0.321	-0.207	0.619
Keeping pesticide in house	0.013	0.080	0.136	0.080	0.559	-0.193	0.354

Adjust: age and gender

Factor associations with blood cholinesterase activities (plasma cholinesterase: PChE) in wet season showed in Table 4.32. PChE was not presented significant association with factors.

Table 4.32 Factors associated with blood cholinesterase activities (plasma cholinesterase: PChE) in wet season

Independent factors	Blood cholinesterase activities						
	PChE						
						95% CI	
	R^2	B	S.E.	Beta	p-value	Lower bound	Upper bound
Activities:							
Playing duration	0.015	0.043	0.061	0.097	0.482	-0.078	0.164
Sitting/Laying on floor/wooden bed	0.030	-0.286	0.248	-0.156	0.254	-0.784	0.212
Exposing during spraying	0.026	-0.993	0.958	-0.142	0.305	-2.914	0.928
Sleeping and playing duration	0.007	0.035	0.260	0.019	0.892	-0.487	0.558
Contract soil	0.050	-0.452	0.287	-0.226	0.121	-1.027	0.124
Shoes wearing	0.014	-0.345	0.515	-0.096	0.505	-1.378	0.687
Behaviors:							
Frequency of hands/feet wash	0.033	-0.086	0.071	-0.169	0.229	-0.228	0.056
Frequency of shower	0.016	0.141	0.189	0.108	0.460	-0.239	0.520
Face touching	0.011	0.130	0.260	0.068	0.618	-0.390	0.651
Taking non-food to mouth	0.008	0.109	0.332	0.045	0.744	-0.557	0.775
Taking food to mouth	0.040	-0.385	0.282	-0.189	0.177	-0.950	0.179
Environments:							
Frequency of house cleaning	0.051	0.400	0.250	0.213	0.116	-0.102	0.901
Window opening	0.014	-0.254	0.384	-0.091	0.512	-1.023	0.516
Keeping pesticide in house	0.010	0.116	0.253	0.062	0.648	-0.391	0.624

Adjust: age and gender

4.6.4 Factors and health Effects

From questionnaire in part 4 health effects in dry season were analyzed to found that association between factors and health effect in Table 4.33-4.37. Multiple logistic regression was used to analysis in each health effects consist of general, respiratory, gastrointestinal, eyes, and skin symptoms. The result presented that factors associated with general symptom in dry season in Table 4.33. Sleeping and playing duration and contract soil were possible related to general symptom, p-value= 0.080

and 0.057, respectively. PChE was significantly associated with general symptom (p-value< 0.05).

Factors associated with respiratory symptom in dry season are presented in Table 4.34. Respiratory symptom was significantly associated with sitting/Laying on wooden bed (p-value<0.05). Keeping pesticide in houses were related to respiratory symptom (p-value< 0.05). House story was likely related to respiratory symptom (p-value=0.101). Gastrointestinal symptom was probable related to playing duration (p-value= 0.097), taking non-food to mouth (p-value= 0.094 in Table 4.35. The result showed factors associated with eyes symptom in Table 4.36, that house story was related to eyes symptom (p-value<0.05). Table 4.37 presented association between factors and skin symptom. The result showed that skin symptom was significantly correlated with exposing during spraying (p-value <0.01), frequency of play in farms (p-value<0.05). Keeping pesticide in house was likely related to skin symptom, p-value = 0.109.

Table 4.38-4.42 presented the association between factors and health effects in wet season that analyzed by multiple logistic regression. The results showed that general symptom was possible correlated with taking non-food to mouth (p-value= 0.075) in Table 4.38.

Respiratory symptom was probable associated with frequency of hands/feet wash (p-value= 0.108) in Table 4.39. Gastrointestinal symptom was no significantly related to many factors in Table 4.40. Eyes symptom were no significantly association with many factors (Table 4.41). Skin symptom was likely related to shoes wearing (p-value=0.080), and house story (p-value=0.053) that showed in Table 4.42.

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Table 4.33 Factors associated with general effects in dry season

Independent factors	Health Effect						
	General						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	0.087	0.168	0.268	0.605	1.091	0.785	1.515
Sitting/Laying on floor/wooden bed	-0.115	0.528	0.048	0.827	0.891	0.317	2.507
Exposing during spraying	0.159	0.565	0.079	0.778	1.172	0.388	3.547
Sleeping and playing duration	0.934	0.534	3.066	0.080	2.546	0.894	7.246
Contract soil	1.589	0.836	3.614	0.057	4.898	0.952	25.202
Shoes wearing	-1.439	1.147	1.572	0.210	0.237	0.025	2.249
Behaviors:							
Frequency of hands/feet wash	0.325	0.205	2.512	0.113	1.384	0.926	2.070
Frequency of shower	0.825	0.533	2.395	0.122	2.282	0.803	6.489
Face touching	0.762	0.551	1.913	0.167	2.143	0.728	6.313
Taking non-food to mouth	0.648	0.649	0.995	0.318	1.911	0.535	6.822
Taking food to mouth	0.162	0.597	0.073	0.787	1.175	0.364	3.791
Environments:							
Frequency of house cleaning	-0.278	0.550	0.256	0.613	0.757	0.258	2.224
Window opening	-0.011	0.550	0.000	0.984	0.989	0.336	2.909
Keeping pesticide in house	-0.315	0.622	0.256	0.613	0.730	0.216	2.469
Blood cholinesterase activities:							
HAChE	-0.163	0.539	0.091	0.762	0.850	0.296	2.443
AChE	0.703	0.535	1.725	0.189	2.021	0.707	5.771
PChE	1.354	0.598	5.124	0.024	3.875	1.199	12.520
Chlorpyrifos concentrations:							
Hands	-0.333	0.563	0.350	0.554	0.717	0.238	2.162
Feet	0.106	0.570	0.035	0.852	1.112	0.364	3.397
Floors and wooden beds	-0.059	0.542	0.012	0.913	0.942	0.326	2.728
Toys	-0.798	0.766	1.085	0.298	0.450	0.100	2.021
Cypermethrin concentrations:							
Hands	0.882	0.565	2.439	0.118	2.416	0.798	7.313
Feet	-0.247	0.547	0.203	0.652	0.781	0.267	2.285
Floors and wooden beds	0.606	0.534	1.291	0.256	1.834	0.644	5.218
Toys	-0.044	0.761	0.003	0.954	0.957	0.215	4.254

Adjusts: age and gender

Table 4.34 Factors associated with respiratory effects in dry season

Independent factors	Health Effect						
	Respiratory						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	0.044	0.603	0.005	0.942	1.045	0.320	3.410
Sitting/Laying on floor/wooden bed	-1.271	0.553	5.271	0.022*	0.281	0.095	0.830
Exposing during spraying	-0.159	0.555	0.082	0.775	0.853	0.287	2.532
Sleeping and playing duration	0.396	0.441	0.807	0.369	1.485	0.626	3.523
Contract soil	0.977	0.617	2.513	0.113	2.657	0.794	8.897
Shoes wearing	-0.059	0.846	0.005	0.944	0.943	0.179	4.953
Behaviors:							
Frequency of hands/feet wash	0.398	0.531	0.561	0.454	1.489	0.525	4.219
Frequency of shower	1.023	0.847	1.458	0.227	2.781	0.528	14.640
Face touching	-0.212	0.534	0.158	0.691	0.809	0.284	2.305
Taking non-food to mouth	0.682	0.670	1.035	0.309	1.977	0.532	7.353
Taking food to mouth	-0.038	0.575	0.004	0.947	0.963	0.312	2.969
Source of water	-0.766	0.538	2.029	0.154	0.465	0.162	1.334
Environments:							
Frequency of house cleaning	-0.335	0.526	0.406	0.524	0.715	0.255	2.004
Window opening	0.442	0.535	0.681	0.409	1.555	0.545	4.443
Keeping pesticide in house	1.563	0.714	4.793	0.029*	4.773	1.178	19.340
House story	1.141	0.696	2.688	0.101	3.131	0.800	12.251
Blood cholinesterase activities:							
HAChE	0.660	0.530	1.554	0.212	1.935	0.685	5.464
AChE	0.128	0.514	0.062	0.803	1.137	0.415	3.115
PChE	0.307	0.524	0.344	0.558	1.360	0.487	3.799
Chlorpyrifos concentrations:							
Hands	0.069	0.541	0.016	0.899	1.071	0.371	3.091
Feet	-0.325	0.554	0.345	0.557	0.722	0.244	2.139
Floors and wooden beds	-0.067	0.529	0.016	0.899	0.935	0.331	2.639
Toys	-0.011	0.724	0.000	0.988	0.989	0.239	4.090
Cypermethrin concentrations:							
Hands	0.459	0.529	0.751	0.386	1.582	0.561	4.463
Feet	-0.289	0.536	0.289	0.591	0.749	0.262	2.144
Floors and wooden beds	-0.046	0.513	0.008	0.928	0.955	0.349	2.608
Toys	0.819	0.745	1.210	0.271	2.268	0.527	9.763

Adjusts: age and gender * Significant level at p-value < 0.05

Table 4.35 Factors associated with gastrointestinal effects in dry season

Independent factors	Health Effect						
	Gastrointestinal						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	0.361	0.217	2.753	0.097	1.434	0.937	2.196
Sitting/Laying on floor/wooden bed	-0.143	0.541	0.070	0.792	0.867	0.300	2.504
Exposing during spraying	-0.349	0.594	0.345	0.557	0.705	0.220	2.259
Sleeping and playing duration	0.665	0.520	1.634	0.201	1.945	0.702	5.390
Contract soil	0.673	0.722	0.870	0.351	1.960	0.477	8.063
Shoes wearing	-0.169	0.904	0.035	0.852	0.845	0.143	4.973
Behaviors:							
Frequency of hands/feet wash	0.179	0.204	0.767	0.381	1.195	0.802	1.783
Frequency of shower	2.800	0.862	10.540	0.001**	16.446	3.033	89.168
Face touching	0.240	0.564	0.182	0.670	1.271	0.421	3.839
Taking non-food to mouth	1.149	0.686	2.808	0.094	3.154	0.823	12.092
Taking food to mouth	-0.286	0.610	0.220	0.639	0.751	0.227	2.483
Environments:							
Frequency of house cleaning	0.052	0.559	0.009	0.926	1.053	0.352	3.151
Window opening	-0.202	0.559	0.130	0.718	0.817	0.273	2.445
Keeping pesticide in house	0.171	0.610	0.078	0.780	1.186	0.359	3.920
Blood cholinesterase activities:							
HAChE	0.023	0.551	0.002	0.966	1.023	0.348	3.014
AChE	0.748	0.552	1.839	0.175	2.113	0.717	6.232
PChE	0.856	0.580	2.177	0.140	2.354	0.755	7.341
Chlorpyrifos concentrations:							
Hands	-0.189	0.571	0.110	0.740	0.828	0.270	2.535
Feet	0.297	0.577	0.264	0.607	1.346	0.434	4.171
Floors and wooden beds	0.797	0.571	1.946	0.163	2.218	0.724	6.791
Toys	-0.012	0.744	0.000	0.987	0.988	0.230	4.250
Cypermethrin concentrations:							
Hands	-0.442	0.558	0.628	0.428	0.643	0.215	1.918
Feet	-0.320	0.563	0.324	0.569	0.726	0.241	2.188
Floors and wooden beds	-0.241	0.541	0.198	0.656	0.786	0.272	2.271
Toys	-0.420	0.753	0.311	0.577	0.657	0.150	2.876

Adjusts: age and gender

** Significant level at p-value < 0.01

Table 4.36 Factors associated with eyes effects in dry season

Independent factors	Health Effect						
	Eyes						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	-0.283	0.284	0.998	0.318	0.753	0.432	1.313
Sitting/Laying on floor/wooden bed	0.816	0.947	0.742	0.389	2.261	0.353	14.458
Exposing during spraying	0.436	0.993	0.193	0.661	1.547	0.221	10.841
Sleeping and playing duration	0.576	0.867	0.442	0.506	1.780	0.325	9.736
Contract soil	0.807	1.185	0.463	0.496	2.240	0.220	22.864
Shoes wearing	-19.016	14560.329	0.000	0.999	0.000	0.000	-
Behaviors:							
Frequency of hands/feet wash	0.225	0.351	0.412	0.512	1.253	0.629	2.493
Frequency of shower	-0.225	0.840	0.072	0.789	0.799	0.154	4.140
Face touching	1.173	0.965	1.479	0.224	3.233	0.488	21.420
Taking non-food to mouth	0.379	1.017	0.139	0.709	1.461	0.199	10.712
Taking food to mouth	0.280	0.968	0.084	0.772	1.323	0.199	8.813
Environments:							
Frequency of house cleaning	-1.682	1.180	2.030	0.154	0.186	0.018	1.881
Window opening	1.248	1.164	1.148	0.284	3.482	0.356	34.101
Keeping pesticide in house	0.341	0.976	0.122	0.727	1.406	0.208	9.512
House story	-2.342	1.087	4.639	0.031*	0.096	0.011	0.810
Blood cholinesterase activities:							
HAChE	1.047	0.981	1.139	0.286	2.849	0.416	19.499
AChE	0.057	0.890	0.004	0.949	1.059	0.185	6.063
PChE	1.283	1.156	1.232	0.267	3.607	0.374	34.758
Chlorpyrifos concentrations:							
Hands	-19.166	7899.098	0.000	0.998	0.000	0.000	-
Feet	-19.423	8465.557	0.000	0.998	0.000	0.000	-
Floors and wooden beds	-0.355	0.973	0.133	0.715	0.701	0.104	4.718
Toys	-20.097	7988.896	0.000	0.998	0.000	0.000	-
Cypermethrin concentrations:							
Hands	1.592	1.061	2.250	0.134	4.914	0.614	39.340
Feet	0.836	0.987	0.718	0.397	2.307	0.334	15.952
Floors and wooden beds	0.819	0.935	0.767	0.381	2.267	0.363	14.173
Toys	19.855	8927.351	0.000	0.998	419805 700.5	0.000	-

Adjusts: age and gender

* Significant level at p-value < 0.05

Table 4.37 Factors associated with skin effects in dry season

Independent factors	Health Effect						
	Skin						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	0.319	0.204	2.441	0.118	1.376	0.922	2.055
Sitting/Laying on floor/wooden bed	-0.251	0.540	0.216	0.642	0.778	0.270	2.244
Exposing during spraying	1.847	0.607	9.254	0.002**	6.340	1.929	20.839
Sleeping and playing duration	0.574	0.507	1.283	0.257	1.776	0.657	4.797
Contract soil	0.375	0.682	0.303	0.582	1.456	0.382	5.543
Shoes wearing	-0.487	0.918	0.282	0.596	0.614	0.102	3.714
Frequency of play in farm	1.133	0.576	3.863	0.049	3.104	1.003	9.602
Behaviors:							
Frequency of hands/feet wash	-0.225	0.203	1.223	0.269	0.799	0.537	1.189
Frequency of shower	0.086	0.508	0.028	0.866	1.089	0.402	2.949
Face touching	-0.068	0.564	0.014	0.905	0.935	0.310	2.821
Taking non-food to mouth	-0.663	0.706	0.880	0.348	0.515	0.129	2.058
Taking food to mouth	0.055	0.610	0.008	0.928	1.057	0.320	3.494
Environments:							
Frequency of house cleaning	0.169	0.554	0.093	0.760	1.184	0.400	3.507
Window opening	0.478	0.582	0.674	0.411	1.613	0.516	5.044
Keeping pesticide in house	0.998	0.622	2.575	0.109	2.714	0.802	9.186
House story	-0.642	0.690	0.860	0.354	0.526	0.136	2.043
Blood cholinesterase activities:							
HAChE	0.013	0.553	0.001	0.981	1.013	0.343	2.995
AChE	0.014	0.540	0.001	0.979	1.014	0.352	2.921
PChE	0.604	0.565	1.143	0.285	1.829	0.605	5.534
Chlorpyrifos concentrations:							
Hands	-0.985	0.616	2.560	0.110	0.373	0.112	1.248
Feet	-1.298	0.703	3.413	0.065	0.273	0.069	1.082
Floors and wooden beds	0.291	0.555	0.275	0.600	1.338	0.450	3.974
Toys	-0.512	0.790	0.421	0.516	0.599	0.127	2.816
Cypermethrin concentrations:							
Hands	-0.257	0.554	0.214	0.643	0.774	0.261	2.293
Feet	0.015	0.558	0.001	0.978	1.016	0.340	3.032
Floors and wooden beds	-0.093	0.539	0.030	0.864	0.912	0.317	2.622
Toys	-0.359	0.801	0.202	0.653	0.698	0.145	3.352

Adjusts: age and gender

** Significant level at p-value < 0.01

Table 4.38 Factors associated with general effects in wet season

Independent factors	Health Effect						
	General						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	-0.182	0.151	1.462	0.227	0.833	0.620	1.120
Sitting/Laying on floor/wooden bed	0.256	0.729	0.123	0.726	1.291	0.309	5.319
Exposing during spraying	-20.476	40192.970	0.000	1.000	0.000	0.000	-
Sleeping and playing duration	0.368	0.736	0.250	0.617	1.445	0.341	6.122
Contract soil	0.664	0.930	0.510	0.475	1.944	0.314	12.031
Shoes wearing	1.212	1.164	1.085	0.298	3.362	0.343	32.920
Frequency of play in farm							
Behaviors:							
Frequency of hands/feet wash	0.346	0.194	3.191	0.074	1.414	0.967	2.068
Frequency of shower	-0.174	0.522	0.111	0.739	0.840	0.302	2.338
Face touching	0.815	0.727	1.256	0.262	2.259	0.543	9.395
Taking non-food to mouth	1.416	0.796	3.162	0.075	4.121	0.865	19.634
Taking food to mouth	-0.652	0.772	0.714	0.398	0.521	0.115	2.365
Environments:							
Frequency of house cleaning	-0.444	0.770	0.332	0.565	0.642	0.142	2.905
Window opening	19.732	14912.826	0.000	0.999	371181170.3	0.000	-
Keeping pesticide in house	0.068	0.734	0.009	0.926	1.070	0.254	4.515
Blood cholinesterase activities:							
HAChE	-0.408	0.723	0.318	0.573	0.665	0.161	2.745
AChE	-1.088	0.750	2.101	0.147	0.337	0.077	1.467
PChE	0.807	0.774	1.087	0.297	2.240	0.492	10.210
Cypermethrin concentrations:							
Hands	0.329	0.728	0.204	0.652	1.389	0.333	5.790
Feet	0.580	0.731	0.629	0.428	1.786	0.426	7.489
Floors and wooden beds	-0.725	0.742	0.957	0.328	0.484	0.113	2.071
Toys	0.787	0.952	0.684	0.408	2.198	0.340	14.205

Adjusts: age and gender

Blood cholinesterase activities; 1= low, 0= high; median = cut of point

Pesticide concentrations; 1= high, 0= low; median = cut of point

Table 4.39 Factors associated with respiratory effects in wet season

Independent factors	Health Effect						
	Respiratory						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	0.022	0.140	0.025	0.875	0.875	0.777	1.345
Sitting/Laying on floor/wooden bed	-0.713	0.568	1.575	0.209	0.490	0.161	1.492
Exposing during spraying	22.027	40192.969	0.000	1.000	3682925567.3	0.000	-
Sleeping and playing duration	0.590	0.582	1.027	0.311	1.803	0.577	5.639
Contract soil	0.588	0.699	0.708	0.400	1.800	0.458	7.078
Shoes wearing	0.707	1.126	0.394	0.530	2.028	0.223	18.438
Behaviors:							
Frequency of hands/feet wash	-0.349	0.217	2.590	0.108	0.705	0.461	1.079
Frequency of shower	0.312	0.432	0.522	0.470	1.366	0.586	3.185
Face touching	-0.123	0.589	0.044	0.835	0.884	0.279	2.803
Taking non-food to mouth	-2.116	1.123	3.549	0.060	0.120	0.013	1.089
Taking food to mouth	-1.136	0.664	2.932	0.087	0.321	0.087	1.179
Environments:							
Frequency of house cleaning	0.083	0.576	0.021	0.886	1.086	0.351	3.360
Window opening	-0.134	0.849	0.025	0.875	0.875	0.166	4.619
Keeping pesticide in house	-0.051	0.573	0.008	0.930	0.930	0.309	2.925
Cooking	0.675	0.522	1.668	0.197	1.964	0.705	5.467
Blood cholinesterase activities:							
HAChE	0.402	0.594	0.457	0.499	1.494	0.466	4.788
AChE	-0.092	0.572	0.026	0.872	0.912	0.297	2.799
PChE	0.183	0.581	0.099	0.753	1.201	0.384	3.754
Cypermethrin concentrations:							
Hands	-0.529	0.572	0.856	0.355	0.589	0.192	1.807
Feet	-0.406	0.560	0.526	0.468	0.666	0.222	1.998
Floors and wooden beds	-1.215	0.601	4.091	0.043	0.297	0.091	0.963
Toys	0.270	0.667	0.164	0.686	1.310	0.355	4.839

Adjusts: age and gender

Blood cholinesterase activities; 1= low, 0= high; median = cut of point

Pesticide concentrations; 1= high, 0= low; median = cut of point

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Table 4.40 Factors associated with gastrointestinal effects in wet season

Independent factors	Health Effect						
	Gastrointestinal						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	-0.032	0.153	0.045	0.832	0.968	0.718	1.306
Sitting/Laying on floor/wooden bed	0.432	0.662	0.425	0.514	1.540	0.421	5.634
Exposing during spraying	-20.198	40192.970	0.000	1.000	0.000	0.000	-
Sleeping and playing duration	-0.771	0.737	0.931	0.335	0.491	0.116	2.082
Contract soil	0.118	0.797	0.022	0.882	1.125	0.236	5.365
Shoes wearing	-0.057	1.268	0.002	0.964	0.944	0.079	11.326
Frequency of play in farm	0.488	0.694	0.495	0.481	1.630	0.418	6.347
Behaviors:							
Frequency of hands/feet wash	0.105	0.180	0.341	0.559	1.111	0.780	1.582
Frequency of shower	0.200	0.475	0.177	0.674	1.221	0.481	3.096
Face touching	0.187	0.662	0.080	0.777	1.206	0.329	4.415
Taking non-food to mouth	-0.360	0.883	0.166	0.683	0.698	0.124	3.937
Taking food to mouth	-1.388	0.727	3.644	0.056	0.250	0.060	1.038
Environments:							
Frequency of house cleaning	0.084	0.660	0.016	0.898	1.088	0.299	3.966
Window opening	-0.250	0.936	0.071	0.790	0.779	0.124	4.875
Keeping pesticide in house	-0.436	0.683	0.407	0.523	0.647	0.170	2.465
Cooking	0.148	0.576	0.066	0.798	1.159	0.375	3.584
Blood cholinesterase activities:							
HAChE	-0.339	0.656	0.267	0.605	0.713	0.197	2.576
AChE	-0.757	0.663	1.303	0.254	0.469	0.128	1.721
PChE	-0.237	0.656	0.130	0.718	0.789	0.218	2.856
Cypermethrin concentrations:							
Hands	-0.310	0.651	0.227	0.634	0.733	0.205	2.625
Feet	-1.002	0.680	2.173	0.140	0.367	0.097	1.391
Floors and wooden beds	-1.206	0.698	2.983	0.084	0.299	0.076	1.176
Toys	0.261	0.789	0.109	0.741	1.298	0.277	6.088

Adjusts: age and gender

Blood cholinesterase activities; 1= low, 0= high; median = cut of point

Pesticide concentrations; 1= high, 0= low; median = cut of point

Table 4.41 Factors associated with eyes effects in wet season

Independent factors	Health Effect						
	Eyes						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	17.639	2543.329	0.000	0.994	457530 62.71	0.000	-
Sitting/Laying on floor/wooden bed	-0.282	1.460	0.037	0.847	0.754	0.043	13.179
Exposing during spraying	-17.810	40192.970	0.000	1.000	0.000	0.000	-
Sleeping and playing duration	0.662	1.446	0.209	0.647	1.938	0.114	32.970
Contract soil	-0.848	1.582	0.287	0.592	0.428	0.019	9.517
Shoes wearing	-17.946	20056.625	0.000	0.999	0.000	0.000	-
Behaviors:							
Frequency of hands/feet wash	0.187	0.340	0.30.	0.528	1.206	0.619	2.349
Frequency of shower	0.086	1.133	0.006	0.940	1.090	0.118	10.037
Face touching	0.694	1.446	0.230	0.631	2.002	0.118	34.076
Taking non-food to mouth	-18.007	12658.067	0.000	0.999	0.000	0.000	-
Taking food to mouth	18.425	9932.205	0.000	0.999	100457 675.8	0.000	-
Environments:							
Frequency of house cleaning	-18.425	8503.571	0.000	0.998	0.000	0.000	-
Window opening	17.932	15142.422	0.000	0.999	613133 42.08	0.000	-
Keeping pesticide in house	18.823	6782.064	0.000	0.998	149552 586.1	0.000	-
Cooking	-1.444	1.347	1.148	0.284	0.236	0.017	3.310
Blood cholinesterase activities:							
HAChE	-0.614	1.481	0.172	0.679	0.541	0.030	9.860
AChE	-0.208	1.466	0.020	0.887	0.812	0.046	14.362
PChE	-0.385	1.490	0.067	0.796	0.680	0.037	12.628
Cypermethrin concentrations:							
Hands	-18.548	7582.908	0.000	0.998	0.000	0.000	-
Feet	18.657	7548.560	0.000	0.998	12669 1135.9	0.000	-
Floors and wooden beds	-0.011	1.443	0.000	0.994	0.989	0.058	16.751
Toys	-17.258	9016.047	0.000	0.998	0.000	0.000	-

Adjusts: age and gender

Blood cholinesterase activities; 1= low, 0= high; median = cut of point

Pesticide concentrations; 1= high, 0= low; median = cut of point

Table 4.42 Factors associated with skin effects in wet season

Independent factors	Health Effect						
	Skin						
					OR (95% CI)		
	B	S.E.	Wald	p-value		Lower	Upper
Activities:							
Playing duration	-0.030	0.143	0.043	0.835	0.971	0.734	1.284
Sitting/Laying on floor/wooden bed	0.114	0.606	0.035	0.851	1.120	0.342	3.671
Exposing during spraying	-20.586	40192.970	0.000	1.000	0.000	0.000	-
Sleeping and playing duration	0.594	0.617	0.929	0.335	1.812	0.541	6.066
Contract soil	0.630	0.772	0.667	0.414	1.878	0.414	8.524
Shoes wearing	2.260	1.289	3.073	0.080	9.587	0.766	120.002
Behaviors:							
Frequency of hands/feet wash	-0.024	0.178	0.019	0.891	0.976	0.689	1.382
Frequency of shower	-0.152	0.452	0.113	0.736	0.859	0.354	2.083
Face touching	0.532	0.613	0.752	0.386	1.702	0.512	5.658
Taking non-food to mouth	-0.018	0.780	0.001	0.982	0.982	0.213	4.530
Taking food to mouth	1.280	0.851	2.266	0.132	3.598	0.679	19.059
Environments:							
Frequency of house cleaning	0.389	0.610	0.406	0.524	1.475	0.446	4.880
Window opening	-0.745	0.856	0.758	0.384	0.475	0.089	2.541
Keeping pesticide in house	0.688	0.611	1.266	0.260	1.989	0.600	6.593
House story	-1.494	0.771	3.757	0.053	0.224	0.050	1.017
Blood cholinesterase activities:							
HAChE	-0.597	0.612	0.950	0.330	0.551	0.166	1.828
AChE	-0.557	0.615	0.821	0.365	0.573	0.171	1.913
PChE	-0.084	0.613	0.019	0.891	0.920	0.277	3.056
Cypermethrin concentrations:							
Hands	0.627	0.614	1.042	0.307	1.872	0.562	6.240
Feet	0.414	0.603	0.472	0.492	1.513	0.464	4.928
Floors and wooden beds	-0.108	0.604	0.032	0.857	0.897	0.275	2.929
Toys	0.765	0.747	1.048	0.306	2.149	0.497	9.301

Adjusts: age and gender

Blood cholinesterase activities; 1= low, 0= high; median = cut of point

Pesticide concentrations; 1= high, 0= low; median = cut of point

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4.7 Health risk assessment

As the research objective in this study to assess health risk from pesticide exposures among young children (1-3 years old) in agricultural community, Sakon Nakhon province, Thailand. Health risk assessment was find by dermal exposure assessment (children's hands and feet). Surface wipe samples on hands and feet were analyzed to detect frequency and concentration of pesticides. In dry season, young children in this study were detected chlorpyrifos, cypermethrin and permethrin concentrations but in wet season, surface wipe samples were low detected chlorpyrifos concentration. The result from the average daily dose (ADD) were used to fine the hazard quotient (HQ) and hazard index (HI), respectively. The concentrations of pesticide were used to calculate for ADD. Using the maximum concentration for permethrin and 95 th percentile for chlorpyrifos and cypermethrin concentrations to calculate risk assessment [94]. The risk assessment was estimated using the Hazard Quotients (HQ). The HQ was calculated based on the decision process of defining the RfD to access non-carcinogenic substances [71]. The cumulative exposures for detected chlorpyrifos (OP), cypermethrin (PYR) and permethrin (PYR) pesticides, were estimated using the Hazard Index (HI) method for pesticides with considering mode of action and without considering mode of action. The method for calculation of health risk assessment was mentioned in Chapter III.

Health risk assessment is presented in Table 4.43. The results showed that ADD from permethrin exposures was the highest for ADD in dry and wet seasons (ADD_{DRY}= 4.500×10^{-6} mg/kg/day and ADD_{WET}= 4.835×10^{-4} mg/kg/day). ADD from dermal exposure to OP in dry season was 1.298×10^{-7} mg/kg/day (with considering mode of action). ADD from dermal exposure to PYR with considering mode of action in wet season was higher than in dry season (ADD_{DRY}= 4.934×10^{-4} mg/kg/day and ADD_{WET}= 5.848×10^{-6} mg/kg/day). Without considering mode of action; ADD in wet season was higher than in dry season (ADD_{WET} = 4.934×10^{-4}mg/kg/day) and ADD_{DRY} =5.978×10^{-6}mg/kg/day). The hazard

quotient (HQ) in dry season found that cholrpyrifos exposures was the highest potential risk (HQ=4.326×10^{-3}) followed by cypermethrin (HQ=5.862×10^{-5}) and permethrin (HQ=1.798×10^{-5}). In wet season, permethrin exposures was higher than cypermethrin; HQ= 1.934×10^{-3} and HQ= 4.301×10^{-4}, respectively. The health risk assessment from pesticide exposures (chlorpyrifos, cypermethrin and permethrin) without considering mode of action in dry season was higher than in wet season (HI_{DRY} = 4.403×10^{-3} and HI_{WET} = 2.364×10^{-3}).

Table 4.43 Health risk assessment of chlorpyfos, cypermethrin and permethrin in young children

Pesticides	ADD (mg/kg/day)		HQ (Hazard Quotient)	
	Dry season	Wet season	Dry season	Wet season
OP: Cholrpyrifos	1.298×10^{-7}	-	4.326×10^{-3}	-
PYR: Cypermetrin	1.348×10^{-6}	9.893×10^{-6}	5.862×10^{-5}	4.301×10^{-4}
PYR: Permethrin	4.500×10^{-6}	4.835×10^{-4}	1.798×10^{-5}	1.934×10^{-3}
Total PYR	5.848×10^{-6}	4.934×10^{-4}	7.660×10^{-5}	2.364×10^{-3}
Total OP and PYR	5.978×10^{-6}	4.934×10^{-4}		
HI(Hazard Index)			4.403×10^{-3}	2.364×10^{-3}

Health risk assessment of young children in this study area may be not concerned for potential non-carcinogenic effect from dermal exposure via their hands and feet from exposure to chlorpyrifos, cypermethrin and permethrin that without considering mode of action. When the Hazard index (HI) is less than 1 (HI_{DRY} = 4.403×10^{-3} and HI_{WET} = 2.364×10^{-3}), the cumulative risk from exposure to the compounds is considered to be acceptable (HI ≤ 1, there may be no concern for potential non-carcinogenic effect).

CHAPTER V
DISCUSSIONS

5.1 The differences of pesticide concentration, blood cholinesterase level, and health symptoms between wet and dry seasons

5.1.1 Detection and pesticide concentrations

The study focused on young children (1-3 years old) who living in agricultural community. The results found that chlorpyrifos and cypermethrin were mainly detected in this study area, similar to a previous study related to insecticide imported into Thailand [39, 95]. Chlorpyrifos concentrations were detected in dry season because it is widely used for main crops e.g. chilies, cantaloupes, cucumbers and flowers. From the observations, children may be frequently exposed to chlorpyrifos in dry season due to weekly pesticides application on chili farms around their houses. In wet season, about 90% of agricultural areas were paddy farms that required less use of chlorpyrifos. In addition, chlorpyrifos residues are likely leached by rain and humidity during the wet season.

Cholropyrifos was mostly detected on children's hands, followed by toys, floors/wooden beds and children's feet. Chlorpyrifos concentrations on hands were higher than chlorpyrifos concentrations on feet. This might be due to shoes wearing which reduce exposure to pesticides. The results presented that concentrations of chlorpyrifos on floors were slightly lower than on wooden beds. This finding agrees with Qaundt et al. [69] that the floor may accumulate pesticide residues in the household. The result can imply that the way Thai people build their houses in rural areas is not structurally complete. Some houses do not have windows and doors; some houses have the kitchen outside of the house, and some have terraces and spaces. Thai houses are designed for daily activities. There are open spaces and

ventilation; which may increase pesticide exposures and dermal contract. Cleaning the surfaces that children live on such as the floor or wooden bed could remove the pesticide residue; therefore, children who stay on the floor or wooden bed had less contact with the pesticide residue. In this study, both wet mop and broom were used for house cleaning. It is not enough to use a broom to remove dust of pesticides from the floor/wooden bed. Pesticide accumulation in houses were increased by spraying pesticides on farms [4]. Young children played with or crawled into soil and contract with contaminated pesticide at home surrounded by agricultural fields [96]. In addition, activity behaviours of young children such as low frequency of hands/feet washing and showering, no shoes wearing, and playing in fields may exposed to pesticide on their hands and feet. Children's hand to mouth contact was more frequent; and eating by bare hands may expose them to chlorpyrifos through ingestion. However, the concentration of chlorpyrifos in this study was less than other countries' research, based on activities and behaviors [18, 69, 70].

All surface wipe samples detected presence of cypermethrin (100%) in dry and wet seasons. For permethrin, low amounts detected in this study in both seasons. Cypermethrin and permethrin are used to eliminate insects in the household such as ants, cockroaches, and mosquitos. These pesticides are easy to buy at the supermarket in different forms, such as insecticide spray, coil, electronic, powder, and chalk. Cypermethrin concentrations were higher in wet season than dry season because of the high frequency of insects in the house in wet season compare to dry season. In addition, body surface areas of young children were larger in wet season than dry season that may increate skin surface areas to cypermethrin exposures on children's hands and feet. Cypermrthrin concentration in dry season from surface wipe samples were highest in children's toys followed by floors or wooden beds, children's feet,

and hands, respectively. There are consistent concentrations of cypermethrin between dry and wet season.

Although, permethrin was low detected in this study but there is highest concentration of pesticides. All surface wipe samples detected pesticides residues and found highest pesticide concentrations on children's toys; this was because children bring their toys everywhere with them (houses and farms). There was a chance of children's toys to contact soil and be exposed to pesticides on farms. Pesticides were detected on children's toys from the favorite item, which may not be cleaned frequently. However, pesticide concentrations on hands were positively related to pesticide concentrations on feet, floors/wooden beds and children's toys, which is similar to a previous report of Qaundt et al. [69]. The findings of this study confirm that children's hands, feet, floors or wooden beds and children's toys may accumulate pesticides. Unlike previous studies that have reported surface wipe samples of children's toys and hands below the LOD (0.05µg/samples), that approximately 70% of all samples [44].

5.1.2 Blood cholinesterase activities of young children

Young children are often exposed to chlorpyrifos on farms, which reduces blood cholinesterase activities [43]. However, no AChE standards exist for children [19]. Blood cholinesterase activities (AChE and PChE) of young children showed no significant difference between dry and wet season. Although, cholrpyrifos was detected only dry season that may affect to blood cholinesterase activities. HAChE of young children in wet season was significantly lower than dry season. This may be due to additional exposure pathways by ingestion and inhalation.

Although, young children in agricultural communities had more chances to be exposed to chlorpyrifos compare to other areas. This study found no significant

relationship between blood cholinesterase activities (HAChE, AChE, and PChE) and concentrations of chlorpyrifos. Nevertheless, blood cholinesterase activities (HAChE and AChE) among young children (1-3 years old) living in agricultural area in this study were lower than those in other studies (4-9 years old). Rohitrattana and colleagues [74] found that AChE of children aged 6-8 years living in rice farms in Thailand was 2.89±0.34 U/ml for high pesticide use period. According to the study in Ecuador, Suarez- Lopez et al. [19] found AChE of 3.08±0.51 U/ml among children (4-9 years old) living with flower plantation workers. Furthermore, AChE in our study was lower than the study among Indonesia children age of 7-8 years (3.3±0.5 U/ml) living in agricultural villages [97]. This may be explained by AChE level increasing linearly with age of children [19]. Also, young children may be exposed to pesticides because of their behaviors and activities such as playing close to ground, hand-to-mouth behaviors, and dietary patterns [98]. Moreover, they may be more highly exposed to environmental toxicants than adults because young children have a higher body surface area (per body weight) and higher metabolite rate (per body mass) [21, 99].

5.1.3 Health effects

Health symptoms, consist of 6 symptoms; general, respiratory, gastrointestinal, nervous, eyes, and skin symptoms. In dry season, there were higher frequencies of all health effects than in wet season. This could be due to dry season having lower temperatures and humidity than wet season. In addition, pesticide concentrations were higher in dry season than wet season that may have affected the health of young children. Nervous symptoms (lethargy and salivation) were not presented in this study because this was a cross-sectional study with a short period for study. The results found that general symptoms (nausea, vomiting, and anorexia) and respiratory symptoms (cough, excessive wheezing, and runny nose) were significant differences

between dry and wet seasons (p-value< 0.05 and p-value<0.01). There were no significant differences for gastrointestinal, nervous, eyes, and skin symptoms.

5.2 Factors associated with pesticide concentrations, blood cholinesterase activities and health effects

5.2.1 Factors associated with pesticide concentrations

In dry season, the multiple linear association between pesticide exposure and daily activities of participants could be explained by more frequency of showing and hands/feet washing which decreased chlorpyrifos and cypermethrin concentrations on hands and feet. The results show a significant negative association between chlorpiryfos concentration on feet and playing duration, which could be due to children wearing shoes or showering. This finding confirms that chlorpyrifos concentrations on feet were lower than chlorpyrifos concentrations on hand, floors/wooden beds and children's toys. Chlorpyrifos concentrations on feet were related to chlorpyrifos concentration on children's hands, floors/wooden beds and children's toys. Pesticide concentrations on skin were reduced by hands/feet washing and showering [31]. The association of keeping pesticides in their houses was likely related to the concentration of chlorpyrifos on children's hands. This may increase exposure to pesticides due to young children's playing close to houses and farms. Using pesticide in the houses was related to cypermethrin concentrations on children's hands and feet because young children spent more time inside than outside. On other hand, pesticide concentrations on children's feet were possibly correlated with shoes wearing. The linear regression models were adjusted for age and gender as factor associated to children activities and behaviors [19]. Concentration of chlorpyrifos on children's toys were related to frequency of house cleaning and window opening which may increase pesticide exposure by ventilation from outside the house. Similar

to concentration of cypermethrin on floors/wooden beds is also linked with window opening.

In wet season, cypermethrin concentrations on children's hands and feet were associated with using pesticide in house. Furthermore, cypermethin insecticide is mainly used inside household, and is easy to buy in a Thailand supermarket.

5.2.2 Factors associated with blood cholinesterase activities

Spearman's correlations presented that chlorpyrifos concentrations on hands and feet were not significantly associated with blood cholinesterase activities, suggesting that exposure to chlorpyrifos in this study was not sufficiently severe enough to cause overt toxicity that could be detected by AChE. This is similar to a study by Sekiyama (2015) [97].

In this study, it was found that taking food to mouth by bare hands was probably related to lower blood cholinesterase activities (HAChE, AChE, and PChE) in young children. Children generally consume sticky rice, fresh vegetables and fruits from fresh market, which can expose them to pesticides by the ingestion pathway.

In dry season, health effects in this study found that general symptoms (nausea, vomiting and anorexia) were related to PChE and acute exposure, referring to an intense exposure over a short time period [21]. This finding agreed with El-Naggar et al (2009) that the most frequent clinical signs in children were vomiting, diarrhea, miosis, salivation, sweating, and change in mental status. The diagnosis was confirmed by measuring plasma cholinesterase levels. Low plasma cholinesterase levels support the diagnosis of insecticide poisoning [100]. However, this study presented a possible association between gastrointestinal symptom and lower level of AChE and PChE, which is different from a study by Jones et al (2014), which found that common signs such as diarrhea and salivation may not be obvious in young children, and

gastrointestinal symptoms were not associated with pesticide residue exposures (as measured by urinary metabolites) in young children (1-4 years old) in the UK [101]. In wet season, no association between blood cholinesterase activities and health effects may be due to pesticide exposure and weather were different than in dry season.

5.2.3 Factors associated with health effects

In dry season, young children behaviors including sleeping and playing duration and soil contact were possibly related to general symptoms, because pesticides could be exposed to young children through dermal exposure. Respiratory symptoms (cough, excessive wheezing and runny nose) were associated with sitting/laying on wooden beds and keeping pesticide in house. Because of pesticide detections on wooden beds and keeping near living area of young children, this could cause children to be exposed to contamination during a variety of activities in different environments [21]. Gastrointestinal symptoms (diarrhea and salivation) were probably correlated with playing duration and taking non-food to mouth which could cause exposure by ingestion. Skin symptoms (skin irritation and diaphoresis) were associated with exposure during spraying and frequency of play on farm, increasing dermal contract. Moreover, skin symptoms were possibly related to playing duration and keeping pesticide in house, which could increase pesticide exposure via skin. Pesticide concentrations on hands were likely related to eye symptoms (irritation and lacrimation). This may be because young children make frequent hand contact to their eyes and face, and pesticides exposure occurs through children rubbing their eyes. These observations were similar to other study findings in young children (<6 years old) who were exposed to pesticides at home from toxic category I and II pesticides [102].

In wet season, general symptoms were possibly related to taking non-food to mouth that which causes exposure via ingestion. Frequency of hands/feet washing was correlated with respiratory symptom. Skin symptoms were probably associated with

shoes wearing that may have contacted soil or dust. House floors were significantly related to decreased eye and skin symptoms because young children who mostly spent time on 2 nd floor might be exposed to pesticide less than those on 1 st floor.

Children are not small adults and life stage from birth to adulthood influences both exposure variability and toxicological sensitivity to the health effects of exposure to pesticide in agricultural areas [5, 14, 96]. Because bodies of young children are growing, they have fewer natural defenses and can change serious health effects if overexposed to pesticides [103]. However, health effects could be caused by many factors including weather, temperature, and humidity in different seasons.

5.3 Health risk assessment from pesticide exposure among young children

The average daily dose (ADD= 4.934×10^{-4} mg/kg/day) from dermal exposure to pesticides (chlorpyrifos, cypermethrin, and permethrin) in wet seasons was higher than the average daily dose (ADD=5.978×10^{-6}) in dry seasons. Dermal exposure to permethrin was the highest average daily dose in dry and wet seasons (ADD= 4.50×10^{-6} mg/kg/day and 4.835×10^{-4} mg/kg/day). The hazard quotient in dry season found that cholrpyrifos exposures were highest potential risk (HQ=4.326×10^{-3}) followed by cypermethrin (HQ=5.862×10^{-5}) and permethrin (HQ=1.798×10^{-5}). In wet season, permethrin exposures were higher than cypermethrin, HQ= 1.934×10^{-3} and HQ= 4.301×10^{-4}. The health risk assessment from pesticide exposures (chlorpyrifos, cypermethrin and permethrin) found hazard index (HI) in dry season (HI_{DRY} = 4.403×10^{-3}) higher than in wet season (HI_{WET} = 2.364×10^{-3}). The HI was considered for chlorpyrifos cypermethrin, and permethrin as non-carcinogenic ingredients. Health risk assessment of young children (ages 1 to 3 years old) in this study presented that HI_{DRY} for dermal exposure of chlorpyrifos, cypermethrin, and permethrin were around 2 times higher than HI_{WET}. It is implied that risk of pesticide exposure in dry season is higher than wet season.

Health risk assessment of young children in this study area was not concerned for potential non-carcinogenic effect from dermal exposure via children's hands and feet from exposure to chlorpyrifos, cypermethrin and permethrin which without considering mode of action. When the Hazard index (HI) is less than 1, (HI_{DRY} = 4.403 $\times 10^{-3}$ and HI_{WET} = 2.364×10^{-3}), cumulative risk from exposure to the compounds is considered to be acceptable (HI ≤ 1, there may be no concern for potential non-carcinogenic effect). However, this study did not cover all of pesticide exposure in the farm. This study focused only on intensive use in an agricultural area. Dermal exposure assessment was estimated from children's hands and feet which was not the whole body. Pesticides exposure residues via multiple-exposure pathways need to be considered (inhalation, and ingestion, are other routes of exposure).

Finally, young children could not protect themselves from pesticides on farms because they are not aware of the health risks and toxic effects of pesticides. Therefore, parents must realize and protect their children in agricultural areas that could be at higher exposure to pesticide than non-agricultural communities.

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CHAPTER VI

CONCLUSIONS

6.1 Conclusion

The study participants were focused on young children 12-36 mouths of age. A total of 65 young children in dry season and 58 children in wet season. This study area is located in Khamin and Chiangkhruea sub-district, Muang Sakon Nakhon district, Sakon Nakhon province in the northeastern, Thailand. Household in the areas are surrounded by agricultural community with intensive use of chlorpyrifos insecticide. The major crops consist of rice, watermelons, cantaloupes, chilies, cucumbers, canna flowers and vegetables [93].

Mainly, chlorpyrifos and cypermethrin were detected in this study area. Permethrin was lower detected in both seasons but highest concentration of pesticides. Chlorpyrifos was detected only dry season and cypermethrin was detected in dry and wet seasons. Pesticide detection on children's hands were higher than floors/wooden beds, children's toys and feet, respectively. Pesticide concentrations were highest on children's toys. Blood cholinesterase activities of young children were measured including HAChE, AChE and PChE which were lower than those in previous studies among children living in an agricultural area.

Young children are exposed to pesticides by living in an agricultural communities. Behavioral factors among young children affect the pesticide concentrations on children's hands and feet. Children are exposed to pesticides from floors and children's toys in their living areas. Children may be at risk from residential exposure to pesticide. Moreover, young children have additional exposure to pesticide with their farmer parents in an agricultural area. Frequencies of all health effects including general, respiratory, gastrointestinal, eyes, and skin symptoms were higher in

dry season than wet season. These may be due to pesticide exposure and many factors including characteristic weather in dry and wet seasons.

Health risk assessment of young children in this study area were not concerned for potential non-carcinogenic effect from dermal exposure via their hands and feet from exposure to chlorpyrifos, cypermethrin and permethrin which without considering mode of action. The cumulative risk from exposure to the compounds is considered to be acceptable (HI ≤ 1, there may be no concern for potential non-carcinogenic effect). Health risk assessment in this study was assess from young children who living in agricultural community in Sakon Nakhon province, northeastern, Thailand.

As the result, young children may not be at risk to pesticide exposure but behaviors and activities of young children are correlated with pesticide residue on children's hands, feet, toys and household environments (floors/ wooden beds). Finding suggest that insecticide was found on children's skin and household surfaces, therefore, risk communication must be informed to families of young children in this study area for reducing and protecting against pesticide exposure in an agricultural community.

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The current study evaluated only pesticide exposure via dermal routes, mainly hands and feet. For further study, inhalation and ingestion routes should be investigated together with a more specific biomarker, for example, urinary pesticide metabolite. In addition, properly organized environment and good personal hygiene practices, especially showering and hands/feet washing reduce exposure to pesticide. Frequency of using household pesticides should be collected data on next study because this data may relate to pesticide concentration on children's hands, feet, floors/wooden beds and toys. This study provides the first biological monitoring data on pesticide exposure in agricultural community of young children (1-3 years old) in

Thailand. A longitudinal design and frequency of personal and environmental data should be collected for next study.

6.2 Limitation

This study design is a cross- sectional study, and focuses on children age 1-3 years old, so it might be not appropriate to find a causal relationship, and cannot be generalized to other populations. Farmers in this study area did not know what kind of pesticide was used on the farm. Most of crops in dry season were supplied by agricultural agency. They supplied seed, pesticide and chemical fertilizer to the farmers. Several pesticides in farms did not have a label of the chemical products, that can't identify kind of pesticides. Some crops in this study area did not allow surveying of their farm because they sprayed pesticide on farm and they did not wish to be interviewed.

6.3 Recommendations

1. Parents should wash their children's hand and feet at least 4 time per day and bathe their children at least 2 times/day.

2. Shoes wearing may reduce pesticide exposure on children's feet.

3. Children's toys should be cleaned to reduce pesticide exposure by soap and water.

4. Keep children's toys and clothes away when pesticide are applied on farms.

5. Frequency of house cleaning where children are living such as floor, wooden bed could remove the pesticide residue by broom and wet mop.

6. Close the windows and doors when pesticide spraying on farm near houses, if possible.

7. Using household pesticide may lead to health effects therefore, it should be of concern.

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8. Store food in closed containers to protect from pesticide on farm and insecticide in households.

9. Fresh vegetables and fruits should be cleaned by running under water before eating.

10. Water from natural sources should be boiled before drinking to decrease pesticide contaminations.

11. Before using pesticide on farm, need to communicate with people to avoid exposure to pesticides.

12. Store agricultural pesticides in specific area outside home to prevent pesticide exposure in children.

13. Farmers, using pesticide commonly on farm, should be carefully considered by using natural chemicals (organic pesticides) because pesticide used on farm detected in house such as floors, wooden beds, and toys.

6.4 Expected benefits of this study

1. This study will be useful for understanding of pesticide exposure among young children who living in agricultural community (wet and dry seasons).

2. The findings of this study will inform about health risk among young children who expose to pesticide in agricultural community.

3. The result of this study will be send to participants on the prevention of young children's exposure to pesticide in an agricultural community.

4. The study will be provided information to public health professionals about training reduction of health risks of children relate to pesticide exposure in agricultural community.

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REFERENCES

1. Ministry of Agricultural and Cooperatives. Area of agriculture in Thailand: 2015; 2012 [Febuary 20]. Available from: http://www.moac.go.th/home.php.

2. U.S. Environmental Protection Agency (U.S. EPA). About pesticides Washington, DC, USA.2015 [cited 2015 15 March]. Available from: http://www2.epa.gov/science-and-technology/pesticides-science.

3. The Office of Agricultural Economics and The Department of Agriculture. Data of Agricultural Economics at Sakon Nakhon province, Thailand. In: The Office of Agricultural Economics and The Department of Agriculture, editor. 2015.

4. Hanchenlaksh C, Povey A, O'Brien S, de Vocht F. Urinary DAP metabolite levels in Thai farmers and their families and exposure to pesticides from agricultural pesticide spraying. Occup Environ Med. 2011;68(8):625-7.

5. U.S. Environmental Protection Agency (U.S. EPA). Recognition and management of pesticide poisonings. 6 ed. Washington, DC, USA.: United States Environmental Protection Agency Office of Pesticide Program; 2013.

6. Trunnelle K, Bennett D, Tancredi D, Gee S, Stoecklin-Marois M, Hennessy-Burt T, et al. Pyrethroids in house dust from the homes of farm worker families in the MICASA study. Environment international. 2013;61:57-63.

7. Bureau of Occupational and Environmental Diseases. Environmental Diseases Department of Disease Control, Ministry of Public Health, Thailand.2014. Available from: www. Envocc.ddc.moph.go.th.

8. Babina K, Dollard M, Pilotto L, Edwards J. Environmental exposure to organophosphorus and pyrethroid pesticides in South Australian preschool children: a cross sectional study. Environment international. 2012;48:109-20.

9. Munoz-Quezada M, Lucero B, Barr D, Steenland K, Levy K, Ryan P, et al. Neurodevelopmental effects in children associated with exposure to organophosphate pesticides: a systematic review. Neurotoxicology. 2013;39:158-68.

10. Wielgomas B, Nahorski W, Czarnowski W. Urinary concentrations of pyrethroid metabolites in the convenience sample of an urban population of Northern Poland. Int J Hyg Environ Health. 2013;216(3):295-300.

11. Snelder D, Masipiqueña M, de Snoo G. Risk assessment of pesticide usage by smallholder farmers in the Cagayan Valley (Philippines). Crop Protection. 2008;27(3-5):747-62.

12. Etzel R, Balk S. Pediatric Environmental Health. 2, editor. United State of America: American Academy of Pediatrics; 2003.

13. Curwin B. Bringing Work Home Canada: Moncton; 2006.

14. World Health Organization (WHO). Principles for evaluating health risks in children associated with exposure to chemicals: WHO Library Cataloguing in Publication Data; 2006.

15. Lu C, Fenske R, Simcox N, Kalman D. Pesticide exposure of children in an agricultural community: evidence of household proximity to farmland and take home exposure pathways. Environmental research. 2000;84(3):290-302.

16. Panuwet P, Prapamontol T, Chantara S, Thavornyuthikarn P, Montesano M, Whitehead R, et al. Concentrations of urinary pesticide metabolites in small-scale farmers in Chiang Mai Province, Thailand. Sci Total Environ. 2008;407(1):655-68.

17. Petchuay C, Visuthismajarn P, Vitayavirasak B, Hore P, Robson M. Biological monitiring of organophosphate pesticide in preschool children in an agricutural community in Thailand. INT J OCCUP ENVIRON HEALTH. 2006;12:133-44.

18. Norkaew S. Pesticide Exposure of Family in Chili Farm Community, Hua-Rua sub-district, Muang district, Ubonratchathani province, Thailand: Chulalongkorn University; 2012.

19. Suarez-Lopez J, Jacobs D, Himes J, Alexander B, Lazovich D, Gunnar M. Lower acetylcholinesterase activity among children living with flower plantation workers. Environmental research. 2012;114:53-9.

20. Adgate J, Sexton K. Emerging Issues :Children's Exposure to Pesticides in Residential Settings. Handbook of Pesticide Toxicology. 1: Academic press; 2001. p. 887-904.

21. U.S. Environmental Protection Agency (U.S. EPA). Child-Specific Exposure Factors Handbook. Washington, DC, USA.: National Center for Environmental Assessment

Office of Research and Development, Washington, USA; 2008.

22. Baker S, Driver J, McCallum. Residential Exposure Assessment. Sourcebook A, editor. New York: Plenum; 2001.

23. Fortmann R, Tulve N, Clifon. Hayes' Handbook of Pesticide Toxicology2010.

24. Curl C, Fenske R, Elgethun K. Organophosphorus Pesticide Exposure of Urban and Suburban Preschool Children with Organic and Conventional Diets. Environmental Health Perspectives. 2002;111(3):377-82.

25. Griffith W, Curl CL, Fenske RA, Lu CA, Vigoren EM, Faustman EM. Organophosphate pesticide metabolite levels in pre-school children in an agricultural community: within- and between-child variability in a longitudinal study. Environmental research. 2011;111(6):751-6.

26. Munoz-Quezada M, Lglesias V, Lucero B, Steenland K, Barr D, Levy K, et al. Predictors of exposure to organophosphate pesticides in schoolchildren in the Province of Talca, Chile. Environment international. 2012;47:28-36.

27. Naeher L, Tulve N, Egeghy P, Barr D, Adetona O, Fortmann R, et al. Organophosphorus and pyrethroid insecticide urinary metabolite concentrations in young children living in a southeastern United States city. Sci Total Environ. 2010;408(5):1145-53.

28. Panuwet P, Prapamontol T, Chantara S, Barr DB. Urinary pesticide metabolites in school students from northern Thailand. Int J Hyg Environ Health. 2009;212(3):288-97.

29. Roca M, Miralles-Marco A, Ferre J, Perez R, Yusa V. Biomonitoring exposure assessment to contemporary pesticides in a school children population of Spain. Environmental research. 2014;131:77-85.

30. Valcke M, Samuel O, Bouchard M, Dumas P, Belleville D, Tremblay C. Biological monitoring of exposure to organophosphate pesticides in children living in peri-urban

areas of the Province of Quebec, Canada. International archives of occupational and environmental health. 2006;79(7):568-77.

31. Wason S, Julien R, Perry M, Smith T, Levy J. Modeling exposures to organophosphates and pyrethroids for children living in an urban low-income environment. Environmental research. 2013;124:13-22.

32. Rohitrattana J, Siriwong W, Tunsaringkarn T, Panuwet P, Ryan PB, Barr DB, et al. Organophosphate pesticide exposure in school-aged children living in rice and aquacultural farming regions of Thailand. Journal of agromedicine. 2014;19(4):406-16.

33. Fiedler N, Rohitrattana J, Siriwong W, Suttiwan P, Ohman Strickland P, Ryan P, et al. Neurobehavioral effects of exposure to organophosphates and pyrethroid pesticides among Thai children. Neurotoxicology. 2015;48:90-9.

34. Panuwet P, Siriwong W, Prapamontol T, Ryan P, Fiedler N, Robson M, et al. Agricultural Pesticide Management in Thailand: Situation and Population Health Risk. Environ Sci Policy. 2012;17:72-81.

35. U.S. Environmental Protection Agency (U.S. EPA). Exposure Factors Handbook. Washington, DC, USA.: United State Environmental Protection Agency Office of pesticide programs; 1997.

36. Stone M, Faulkner G. Outdoor play in children: associations with objectively-measured physical activity, sedentary behavior and weight status. Prev Med. 2014;65:122-7.

37. Ministry of Agriculture and Cooperatives. Agriculture products, 2015 [cited 2015 March 27]. Available from: http://www.moac.go.th/home.php

38. Grovermann C, Schreinemachers P, Berger T. Quantifying pesticide overuse from farmer and societal points of view: An application to Thailand. Crop Protection. 2013;53:161-8.

39. Office of Agricultural Economics, [Internet]. 2015 [cited June 5]. Available from: http://www.oae.go.th/main.php?filename=journal_all.

40. Nollet L, Rathore H. Handbook of pesticide2010.

41. Barr D. Biomonitoring of exposure to pesticides. Journal of Chemical Health and Safety. 2008;15(6):20-9.

Chulalongkorn University

42. Berman T, Goldsmith R, Goen T, Spungen J, Novack L, Levine H, et al. Urinary concentrations of organophosphate pesticide metabolites in adults in Israel: demographic and dietary predictors. Environment international. 2013;60:183-9.

43. Gupta R, C.,, Malik J, K.,, Milatovic D. Organophosphate and carbamate pesticide. Reproductive and Developmental Toxicology: Elsevier Inc; 2011. p. 471 - 83.

44. Lu C, Kedan G, Fisker-Andersen J, Kissel J, Fenske R. Multipathway organophosphorus pesticide exposures of preschool children living in agricultural and nonagricultural communities. Environmental research. 2004;96(3):283-9.

45. Gupta R, Milatovic D. Insecticides. 2014:389-407.

46. Heudorf U, Angerer J. Metabolites of Pyrethorid Insecticide in Urine Speciment: Current Exposure in an Urban Population in Germany. Environmental Health Perspectives. 2001;109:213-7.

47. Starr J, Graham S, Ross D, Tornero-Velez R, Scollon E, Devito M, et al. Environmentally relevant mixing ratios in cumulative assessments: a study of the kinetics of pyrethroids and their ester cleavage metabolites in blood and brain; and the effect of a pyrethroid mixture on the motor activity of rats. Toxicology. 2014;320:15-24.

48. Xue J, Zartarian V, Tornero-Velez R, Tulve N. EPA's SHEDS-multimedia model: children's cumulative pyrethroid exposure estimates and evaluation against NHANES biomarker data. Environment international. 2014;73:304-11.

49. Barr D, Olsson A, Wong L, Udunka S, Baker S, Whitehead R, et al. Urinary concentration of metabolites of pyrethroid insecticides in the general U.S. population: national health and Nutrition Examination Survey 1999-2002. Environmental Health Perspectives. 2010;118:742-8.

50. Morgan M. Children's exposures to pyrethroid insecticides at home: a review of data collected in published exposure measurement studies conducted in the United States. Int J Environ Res Public Health. 2012;9(8):2964-85.

51. Sobus J, Morgan M, Pleil J, Barr D. Biomonitoring: Uses and Considerations for Assessing Nonoccupational Human Exposure to Pesticides. Hayes' Handbook of Pesticide Toxicology2010.

52. Karr C. Children's environmental health in agricultural settings. Journal of agromedicine. 2012;17(2):127-39.

53. Roberts J, Karr C, Council On Environmental H. Pesticide exposure in children. Pediatrics. 2012;130(6):e1765-88.

54. American Academy of Pediatrics. Pesticide exposure in children. Pediatrics. 2012;130(6):e1757-63.

55. Satoh T. Global Epidemiology of Organophosphate and Poisonings. Toxicology of Organophosphate and Carbamate Compounds: Elsevier Inc; 2006. p. 89-100.

56. Siripanich S. Annual Epidemiological Surveillance Report : Pesticide poisoning. In: Ministry of Public Health ; Bureau Of Epidemiology, editor. 2014. p. 179-82.

57. Kapka-Skrzypczak L, Cyranka M, Skrzypczak M, Kruszewski M. Biomonitoring and biomarkers of organophosphate pesticides exposure state of the art. Annals of Agricultural and Environmental Medicine. 2011;18:294-303.

58. Huen K, Bradman A, Harley K, Yousefi P, Boyd Barr D, Eskenazi B, et al. Organophosphate pesticide levels in blood and urine of women and newborns living in an agricultural community. Environmental research. 2012;117:8-16.

59. Bushnell P, Moser C. Behavioral Toxicity Toxicology of Organophosphate and Carbamate Compounds. Organ Toxicity: Elsevier, Inc; 2006. p. 347-60.

60. Rajapakse BN, Thiermann H, Eyer P, Worek F, Bowe SJ, Dawson AH, et al. Evaluation of the Test-mate ChE (cholinesterase) field kit in acute organophosphorus poisoning. Ann Emerg Med. 2011;58(6):559-64 e6.

61. Abdel Rasoul G, Abou Salem M, Mechael A, Hendy O, Rohlman D, Ismail A. Effects of occupational pesticide exposure on children applying pesticides. Neurotoxicology. 2008;29(5):833-8.

62. U.S. Environmental Protection Agency (U.S. EPA). A Literature Review of Wipe Sampling Methods for Chemical Warfare Agents and Toxic Industrial Chemicals. Washington, DC, USA.: Environmental Protection Agency policy and approved for publication; 2007.

63. Clifton M, Wargo J, Weathers W, Colon M, Bennett D, Tulve N. Quantitative analysis of organophosphate and pyrethroid insecticides, pyrethroid transformation

products, polybrominated diphenyl ethers and bisphenol A in residential surface wipe samples. J Chromatogr A. 2013;1273:1-11.

64. Fan A. Biomarkers in toxicology, risk assessment, and environmental chemical regulations. 2014:1057-80.

65. Friis R. The Praeger Handbook of Environmental Health. The United States of America2012.

66. Jaga K., Dharmani C. Sources of exposure to and public health implications of organophosphate pesticides. Pan Am J Public Health 2003;14(3):171-85.

67. Robson M, Toscano W. Risk assessment for environmental health. The United States Of America: JOSSEY-BASS; 2007.

68. Curwin B, Hein M, Sanderson W, Striley C, Heederik D, Kromhout H, et al. Pesticide dose estimates for children of Iowa farmers and non-farmers. Environmental research. 2007;105(3):307-15.

69. Quandt S, Arcury T, Rao P, Snively B, Camann D, Doran A, et al. Agricultural and Residential Pesticides in Wipe Samples from Farmworker Family Residences in North Carolina and Virginia. Environmental Health Perspectives. 2004;112(3):382-7.

70. Bradman A, Whitaker D, Quiros L, Castorina R, Claus Henn B, Nishioka M, et al. Pesticides and their metabolites in the homes and urine of farmworker children living in the Salinas Valley, CA. J Expo Sci Environ Epidemiol. 2007;17(4):331-49.

71. Kim H, Lim Y, Yang J, Shin D, Ham H, Choi B, et al. Health risk assessment of exposure to chlorpyrifos and dichlorvos in children at childcare facilities. Sci Total Environ. 2013;444:441-50.

72. Curwin B, Hein M, Sanderson W, Nishioka M, Reynolds S, Ward E, et al. Pesticide contamination inside farm and nonfarm homes. J Occup Environ Hyg. 2005;2(7):357-67.

73. McConnell R, Pacheco F, Wahlberg K, Klein W, Malespin O, Magnotti R, et al. Subclinical Health Eįects of Environmental Pesticide Contamination in a Developing Country: Cholinesterase Depression in Children. Environmental Research Section. 1999:81(2):7-91.

74. Rohitrattana J. Behavioral Health Effects of Pesticide Exposure Among Children Living in Pathumthani Province Thailand: Chulalongkorn University; 2013.

75. Wikipedia. Sakon Nakhon Province Map. 2017 [updated 9 Febuary 2017]. Available from: th.wikipedia.org/w/index.php?

76. Khamin Sub-district Administrative Organization. Information of Khamin Sub district, . In: Khamin Sub district Administrative Organization, editor. 2015.

77. Sakon Nakhon provincial Agriculture Extention office. Agriculture in Sakon Nakhon province,. In: Sakon Nakhon provincial Agriculture Extention office, editor. 2015.

78. Department of public health Sakon Nakhon province. Health risk of farmer at Sakon Nakhon province, Thailand. In: Department of public health Sakon Nakhon province T, editor. 2014.

79. Lemeshow S, Hosmer D, Klar J, Lwanga S. Adequacy of sample size in health studies: Chichester : Wiley; 1990. Published on behalf of the World Health Organization, 239 p.]. Available from: http://www.who.int/iris/handle/10665/41607.

80. Wiliawan W, Siriwong W. Assessment of health effects related to organophosphate pesticides exposure using blood cholinesterase activity as a biomarker in agricultural area at Nakhon Nayok province, Thailand. J Health Res. 2014;28:23-30.

81. Anastassiades M, Lehotay S. Fast and Easy Multiresidue Method Employing Acetonitrile Extraction/Partitioning and “Dispersive Solid-Phase Extraction” for the Determination of Pesticide Residues in Produce. JOURNAL OF AOAC INTERNATIONAL. 2003;VOL. 86, NO. 2:412-30.

82. Berman T, Hochner-Celnikier D, Barr DB, Needham LL, Amitai Y, Wormser U, et al. Pesticide exposure among pregnant women in Jerusalem, Israel: results of a pilot study. Environment international. 2011;37(1):198-203.

83. EQM Research I. Test-mate ChE Cholinesterase Test System (Model 400)2003.

84. Reiner E, Rudolf V. Method for measuring Cholinesterase Activitys in Human Blood. Toxicology of Organophosphate and Carbamate Compounds. 2006
199-208.

85. Dasgupta S, Meisner C, Wheeler D, Xuyen K, Thi Lam N. Pesticide poisoning of farm workers-implications of blood test results from Vietnam. Int J Hyg Environ Health. 2007;210(2):121-32.

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University

86. U.S. Environmental Protection Agency (U.S. EPA). Interim Reregistration Eligibility Decision for Chlorpyrifos. Washington, DC, USA.: US Environmental Protection Agency Office of Pesticide Programs
2002.

87. U.S. Environmental Protection Agency (U.S. EPA). Chlorpyrifos: Preliminary Human Health Ris Assessment for Registration Review. Washington, DC, USA.2011.

88. U.S. Environmental Protection Agency (U.S. EPA). Permethrin : Sixth Revision of the HED Chapter of the Reregistration Eligibility Decision Document(RED). Washington, DC, USA.2009.

89. U.S. Environmental Protection Agency (U.S. EPA). Zata-cypermethrin: Revised Human Health Risk assessment Washington, DC, USA.2006.

90. U.S. Environmental Protection Agency (U.S. EPA). Interim Reregistration Eligibility Decision for Chlorpyrifos. Washington, DC, USA.: US Environmental Protection Agency Office of Pesticide Programs; 2002.

91. U.S. Environmental Protection Agency (U.S. EPA). Example exposure scenarios: Washington, DC, USA.; 2004.

92. U.S. Environmental Protection Agency (U.S. EPA). Guidelines for Exposure Assessment. Washington, DC, USA.1992.

93. Sakon Nakhon provincial Agriculture Extention office. Agricultural community at Sakon Nakhon province, 2015. Available from: http://www.sakonnakhon.doae.go.th/home.html/.

94. Yusà V, Coscollà C, Millet M. New screening approach for risk assessment of pesticides in ambient air. Atmospheric Environment. 2014;96:322-30.

95. Norkaew S, Taneepanichskul N, Siriwong W, Siripattanakul S, Robson M. Indirect exposure of farm and non-farm families in an agricultural community, ubonratchathani province, thailand. J Health Res. 2013;27 no.2:79-84.

96. Ding G, Bao Y. Revisiting pesticide exposure and children's health: Focus on China. Science of the Total Environment. 2014;472:289-95.

97. Sekiyama M, Shimmura T, Nakazaki M, Akbar Ieva B, Gunawan B, Abdoellah O, et al. Organophosphorus Pesticide Exposure of School Children in Agricultural Villages in Indonesia. Journal of Pregnancy and Child Health. 2015.

98. Landrigan P, Claudio L, Markowitz S. Pesticides and inner-city children: exposures, risks, and prevention. Environmental health perspectives. 1999;107:431.

99. Landrigan P J GLR. Children's vulnerability to toxic chemicals: a challenge and opportunity to strengthen health and environmental policy. Health Affairs. 2011;30 (5):842-50.

100. El-Naggar A. Clinical findings and cholinesterase levels in children of organophosphates and carbamates poisoning. Eur J Pediatr. 2009.

101. Jones K, Everard M, Harding A. Investigation of gastrointestinal effects of organophosphate andcarbamate pesticide residues on young children. International Journal of Hygiene and Environmental Health Perspectives. 2014;217 392– 8.

102. Spann M, Blondell J, Hunting K. Acute hazards to young children from residential pesticide exposures. American journal of public health. 2000;90(6):971.

103. U.S. Environmental Protection Agency (U.S. EPA). Pesticides and Their Impact on Children Key Facts and Talking Points Washington, DC, USA.2007. Available from: www.epa.gov/pesticdes.

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APPENDIX

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APPENDIX A

The ethical approval document

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AF 02-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University
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Tel/Fax: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 221/2015

Certificate of Approval

Study Title No. 204.1/58 : **HEALTH RISK ASSESSMENT RELATED TO PESTICIDE EXPOSURES AMONG YOUNG CHILDREN: A CASE STUDY IN AGRICULTURAL COMMUNITY, SAKON NAKORN PROVINCE, THAILAND**

Principal Investigator : MISS SATINEE SIRIWAT

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

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University, Thailand, has approved constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP) and/or Code of Conduct in Animal Use of NRCT version 2000.

Signature: Prida Tasanapradit ..... Signature: Nuntaree Chaichanawongsaroj .....

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

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

Date of Approval : 28 November 2015 Approval Expire date : 27 November 2016

The approval documents including

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

Protocol No. 204.1/58
Date of Approval 28 NOV 2015
Approval Expire Date 27 NOV 2016

The approved investigator must comply with the following conditions:

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

APPENDIX B

Questionnaire (Thai version)

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University

แบบสอบถาม

การประเมินความเสี่ยงจากการสัมผัสสารกำจัดศัตรูพืชของเด็กเล็ก การศึกษาในสังคมเกษตรกรรม จังหวัดสกลนคร ประเทศไทย

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1. แบบสอบถามประกอบด้วย 4 ส่วน

ส่วนที่ 1 ข้อมูลทั่วไป จำนวน 16 ข้อ

ส่วนที่ 2 พฤติกรรม/กิจวัตรประจำวัน จำนวน 26 ข้อ

ส่วนที่ 3 ปัจจัยทางสิ่งแวดล้อม จำนวน 12 ข้อ

ส่วนที่ 4 อาการทางสุขภาพ จำนวน 14 ข้อ

2. กรุณาตอบคำถามที่เป็นจริงที่สุด

3. แบบประเมินสำหรับสัมภาษณ์ผู้ปกครองที่ดูแลเด็กอย่างใกล้ชิดเท่านั้น

4. การประเมินมีดังนี้

ทุกครั้ง หมายถึง ปฏิบัติกิจกรรมนั้น 9-10 ครั้งจาก 10 ครั้ง

บ่อยครั้ง หมายถึง ปฏิบัติกิจกรรมนั้น 5-8 ครั้งจาก 10 ครั้ง

บางครั้ง หมายถึง ปฏิบัติกิจกรรมนั้น 1-4 ครั้งจาก 10 ครั้ง

ไม่เคย หมายถึง ไม่เคยปฏิบัติกิจกรรมนั้น

5. การตอบแบบสอบถาม

ส่วนที่ 1-3 ผู้วิจัยเป็นผู้ถามคำถามโดยมีผู้ปกครอง/ผู้ดูแลเด็กเป็นผู้ตอบคำถาม

ส่วนที่ 4 แพทย์ถามคำถามโดยมีผู้ปกครอง/ผู้ดูแลเด็กเป็นผู้ตอบคำถาม และแพทย์สังเกตอาการเด็กเล็กว่ามีอาการทางสุขภาพหรือไม่

รหัสแบบสอบถาม_____ครัวเรือนที่_____ชื่อหมู่บ้าน_____หมู่ที่_____

วันที่_____ ฤดูกาล ☐ แล้ง ☐ ฝน

ส่วนที่ 1 ข้อมูลทั่วไป

สำหรับ ผู้ปกครอง/ผู้ดูแลเด็กเล็ก

1. เพศ ☐ ชาย ☐ หญิง

2. อายุ.....ปี

3. ระดับการศึกษา

- ☐ ไม่ได้ศึกษา
- ☐ ประถมศึกษา
- ☐ มัธยมศึกษา
- ☐ วิทยาลัย
- ☐ มหาวิทยาลัย

4. อาชีพหลักของท่าน

- ☐ เกษตรกร
- ☐ ไม่ใช้เกษตรกร (ข้ามไปข้อ 9)
  - ☐ พ่อค้า แม่ค้า
  - ☐ รับราชการ/ พนักงานเอกชน
  - ☐ รับจ้างทั่วไป
  - ☐ แม่บ้าน
  - ☐ อื่นๆ.....

5. ชนิดของพืชที่เพาะปลูกในระยะเวลา 1 ปี (ตอบได้มากกว่า 1 ข้อ)

☐ ข้าว ☐ มะเขือเทศ ☐ พริก ☐ ผัก

☐ ข้าวโพด ☐ แตงกวา ☐ แคนตาลูป ☐ แตงโม

☐ ดอกไม้ ☐ อื่นๆ.....

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6. พื้นที่ทำการเกษตร (ไร่)

☐ < 5 ☐ 16-20 ☐ 6-10

☐ 21-30 ☐ 11-15 ☐ > 30

7. ในช่วง 6 เดือนที่ผ่านมาท่านหรือครอบครัวของท่านทำงานเกี่ยวข้องกับการใช้สารกำจัดศัตรูพืชหรือไม่

☐ ไม่ใช่ (ข้ามไปข้อ 9) ☐ ใช่

8. ในระยะเวลา 6 เดือนที่ผ่านมา ท่านใช้สารกำจัดศัตรูพืชชนิดใดบ่อยที่สุด 3 อันดับแรก (โปรดระบุ)

....

....

9. ท่านมีรายได้เฉลี่ยต่อครัวเรือนเท่าไหร่

☐ ≤ 5,000 บาท/เดือน

☐ 5,001- 10,000 บาท/เดือน

☐ 10,001- 15,000 บาท/เดือน

☐ 15,001- 20,000 บาท/เดือน

☐ 20,001- 30,000 บาท/เดือน

☐ ≥ 30,001 บาท/เดือน

10. ท่านอาศัยอยู่ในพื้นที่ ต.ขมิ้น มาแล้วเป็นเวลา.....เดือน/ปี

11. ท่านได้ดูแลบุตรหลานมาแล้วเป็นเวลา.....เดือน/ปี

12. ความสัมพันธ์/ เกี่ยวข้องกับเด็ก.....

ข้อมูลสำหรับเด็กเล็ก

13. เพศ ☐ ชาย ☐ หญิง

14. อายุ.....เดือน

15. น้ำหนัก.....กิโลกรัม

16. ส่วนสูง.....เซนติเมตร

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ส่วนที่ 2 พฤติกรรม/กิจวัตรประจำวัน

เสื้อผ้าและการสวมใส่

1. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านสวมใส่เสื้อผ้า เมื่ออาศัยอยู่บริเวณภายในบ้านบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่สวมใส่

2. ชนิดของเสื้อผ้าที่บุตรหลานของท่านสวมใส่เป็นประจำเมื่ออาศัยอยู่บริเวณภายในบ้าน (ตอบได้มากกว่า 1 ข้อ)

☐ เสื้อแขนสั้น ☐ เสื้อแขนยาว ☐ กางเกงขาสั้น ☐ กางเกงขายาว

☐ อื่นๆ.....

3. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านสวมใส่เสื้อผ้า เมื่ออยู่บริเวณนอกบ้านบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่สวมใส่

4. ชนิดของเสื้อผ้าที่บุตรหลานของท่านสวมใส่เป็นประจำ เมื่ออยู่บริเวณนอกบ้าน (ตอบได้มากกว่า 1 ข้อ)

☐ เสื้อแขนสั้น ☐ เสื้อแขนยาว ☐ กางเกงขาสั้น ☐ กางเกงขายาว

☐ อื่นๆ.....

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5. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านสวมใส่รองเท้า เมื่ออยู่บริเวณนอกบ้านบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่สวมใส่

6. ชนิดของรองเท้าที่บุตรหลานของท่านสวมใส่เป็นประจำ (ตอบได้มากกว่า 1 ข้อ)

☐ รองเท้าชนิดที่ห่อหุ้มเท้าไว้ทั้งหมด ☐ ร้องเท้าแตะชนิดหูคีบ

☐ รองเท้าแบบสวมเปิดส้นเท้า ☐ อื่นๆ.....

พฤติกรรม/กิจวัตรประจำวัน

7. บุตรหลานของท่านใช้เวลาทำกิจกรรมใดนานที่สุดในเวลากลางวัน

☐ นอนกลางวัน ☐ เล่นในบ้าน ☐ เล่นนอกบ้าน ☐ อื่นๆ.....

8. บุตรหลานของท่านใช้เวลาอยู่นอกบ้านนานเท่าไหร่

.....นาที/ชั่วโมง

9. บุตรหลานของท่านล้างมือ/เท้า กี่ครั้งต่อวัน

..... ครั้ง/วัน

10. บุตรหลานของท่านอาบน้ำ กี่ครั้งต่อวัน

..... ครั้ง/วัน

11. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านไปที่สวน/ ไร่/ นา บ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่เคย

12. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านเล่นหรืออาศัยอยู่บริเวณ สวน/ ไร่/ นา ขณะที่มีการพ่นสารกำจัดศัตรูพืชบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่เคย

13. ในแต่ละวันบุตรหลานของท่านสัมผัสฝุ่นหรือดิน ติดบริเวณผิวหนัง บ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่สัมผัส

14. บุตรหลานของท่านใช้เวลาอยู่ที่ใดมากที่สุดในเวลากลางวัน

☐ บริเวณภายในบ้าน ได้แก่ ห้องนอน ห้องนั่งเล่น

☐ ชานบ้าน ใต้ถุนบ้าน

☐ บริเวณนอกบ้าน ได้แก่ พื้นที่นอกรั้วบ้าน พื้นที่ทำการเกษตร

☐ อื่นๆ.....

15. โดยปกติบุตรหลานของท่านเมื่ออยู่ที่บ้านมักใช้เวลาอยู่บริเวณใดมากที่สุด

☐ แคร่ไม้ ☐ พื้นบ้านที่ไม่ใช่ดิน ☐ พื้นบ้านที่เป็นดิน ☐ อื่นๆ.....

16. ในสัปดาห์ที่ผ่านมาบุตรหลานของท่านเล่นของเล่นหรือไม่

☐ ไม่เล่น

☐ เล่น โปรดระบุ ชนิดของของเล่น.....

17. ระยะเวลาในการเล่น.....นาที/ชั่วโมงต่อวัน

18. ในแต่ละวันบุตรหลานของท่านใช้มือสัมผัสบริเวณใบหน้าบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่สัมผัส

พฤติกรรมนำสิ่งของเข้าปาก

19. ในแต่ละวันบุตรหลานของท่านใช้มือหรือนิ้วมือเข้าปากบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่เคย

20. ในแต่ละวันบุตรหลานของท่านเอาของเล่นหรือสิ่งของที่ไม่ใช่อาหารเข้าปากบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่เคย

21. ถ้าท่านพบเห็นบุตรหลานของท่านเก็บขนมหรือสิ่งสกปรกจากพื้นเข้าปาก ท่านจะปฏิบัติต่อบุตรหลานของท่านอย่างไร

☐ ล้างมือ ☐ ล้างปาก ☐ ล้างมือและปาก ☐ อื่นๆ .....

การบริโภคอาหารและน้ำดื่ม

22. โดยปกติบุตรหลานของท่านรับประทานอาหารอย่างไร

☐ รับประทานด้วยตัวเอง ☐ มีคนป้อน ☐ รับประทานเองและมีคนป้อน

23. โดยปกติบุตรหลานของท่านรับประทานอาหารด้วยวิธีใด (ตอบได้มากกว่า 1 ข้อ)

☐ มือเปล่า ☐ ช้อน/ ส้อม ☐ อื่นๆ.....

24. โดยปกติบุตรหลานของท่านดื่มน้ำอย่างไร

☐ แก้วน้ำ ☐ ขวดน้ำ ☐ มือเปล่า ☐ อื่นๆ.....

25. บุตรหลานของท่านรับประทานอาหารชนิดใดเป็นประจำ (ตอบได้มากกว่า 1 ข้อ)

☐ นมผง/ นมกล่อง ☐ ข้าวและกับข้าว ☐ ผักสด เช่น แตงกวา ถั่วฝักยาว

☐ ผลไม้สด เช่น กล้วย ส้ม ผลไม้ตามฤดูกาล ☐ อื่นๆ.....

26. ครอบครัวของท่านบริโภคน้ำชนิดใดเป็นประจำ (ตอบได้มากกว่า 1 ข้อ)

☐ น้ำประปา ☐ น้ำฝน ☐ น้ำดื่มบรรจุขวด ☐ น้ำใต้ดิน

☐ อื่นๆ.....

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ส่วนที่ 3 ปัจจัยทางสิ่งแวดล้อม

1. ที่บ้านของท่านมีการจัดเก็บสารกำจัดศัตรูพืชหรือสารเคมีสำหรับการเกษตรไว้ใกล้บริเวณบ้านหรือไม่

☐ ใช่ ☐ ไม่ใช่

2. ที่บ้านของท่านซักหรือทำความสะอาดเสื้อผ้าที่ใส่ในการเกษตรรวมกับเสื้อผ้าของบุตรหลานของท่านหรือไม่

☐ ใช่ ☐ ไม่ใช่

3. ที่บ้านของท่านตากเสื้อผ้าใกล้กับบริเวณ สวน/ ไร่/ นา หรือไม่

☐ ใช่ ☐ ไม่ใช่

4. ที่บ้านของท่านเก็บเสื้อผ้าที่ผ่านการซักแล้วไว้ในบ้านหรือบริเวณที่มิดชิดหรือไม่

☐ ใช่ ☐ ไม่ใช่

5. ที่บ้านของท่านทำความสะอาดบ้านกี่ครั้งต่อสัปดาห์

☐ ทุกวัน ☐ อาทิตย์ละครั้ง ☐ 2-3 วันต่อสัปดาห์ ☐ 4-5 วันต่อสัปดาห์

☐ ไม่เคย

6. ที่บ้านของท่านใช้อุปกรณ์ใดในการทำความสะอาดบ้าน (ตอบได้มากกว่า 1 ข้อ)

☐ ผ้าเปียก ☐ ไม้กวาด ☐ ผ้าเปียกและไม้กวาด ☐ อื่นๆ.....

7. ที่บ้านของท่านใช้ยาฆ่าแมลงหรือไม่

☐ ใช้

☐ ไม่ใช้ (ข้ามไปข้อ 10)

8. ประเภทของยาฆ่าแมลงที่ท่านใช้ภายในบ้าน

☐ สเปรย์ ☐ กับดัก ☐ อิเลคทรอนิคส์

☐ ช็อก ☐ ขด ☐ อื่นๆ.....

9. ยี่ห้อของยาฆ่าแมลงที่ท่านใช่บ่อยที่สุด 3 อันดับแรก

....., ..., ...

10. บุตรหลานของท่านอาศัยอยู่บริเวณชั้นใดของบ้านมากที่สุด

☐ ชั้นล่าง ☐ ชั้นบน

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11. โดยปกติที่บ้านของท่านเปิดหน้าต่างเพื่อระบายอากาศบ่อยแค่ไหน

☐ ทุกครั้ง ☐ บ่อยครั้ง ☐ บางครั้ง ☐ ไม่เคย

12. บ้านของท่านใช้ฟืนหรือถ่านในการประกอบอาหารหรือไม่

☐ ใช้ ☐ ไม่ใช้

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ส่วนที่ 4 อาการทางสุขภาพ

สำหรับอาการที่แสดง 1 เดือนที่ผ่านมา

วันที่_____ฤดูกาล ☐ แล้ง ☐ ฝน

ครัวเรือนที่_____ หมู่ที่_____

อาการ	ไม่มีอาการ	มีอาการ	
		บางครั้ง	บ่อยครั้ง
อาการทั่วไป			
1. คลื่นไส้			
2. อาเจียน			
3. เบื่ออาหาร			
อาการทางระบบทางเดินหายใจ			
4. ไอ			
5. หายใจมีเสียงวี้ด			
6. น้ำมูกไหล			
อาการทางระบบทางเดินอาหาร			
7. ท้องเสีย			
8. น้ำลายไหล			
อาการทางระบบประสาท			
9. ซึม อิดโรย			
10. ลมชัก			
อาการทางตา			
11. ระคายเคืองตา			
12. น้ำตาไหล			
อาการทางผิวหนัง			
13. ระคายเคืองผิว			
14. เหงื่อออกมากกว่าปกติ			

หมายเหตุ บางครั้ง หมายถึง 1-3 ครั้ง ต่อเดือน

บ่อยครั้ง หมายถึง มากกว่า 3 ต่อเดือน

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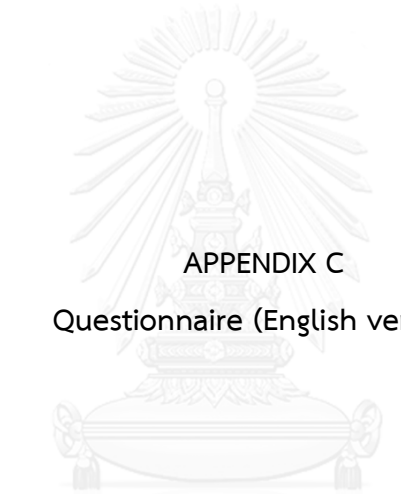

APPENDIX C

Questionnaire (English version)

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HEALTH RISK ASSESSMENT RELADED TO PESTICIDE EXPOSURES AMONG YOUNG CHILDREN: A CASE STUDY IN AGRICULTURAL COMMUNITY, SAKON NAKHON PROVINCE, THAILAND

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1. The questionnaires consist of 4 parts as following;

   Part1 Demographic information (16 items)

   Part 2 Children activity behaviors (26 items)

   Part 3 Environmental factors (12 items)

   Part 4 Health symptoms (14 items)

2. Please choose only one answer in each item (✕) and add short information in the gap.

3. The questionnaire for family giver of child.

4. Frequently for answer as follows:

   Always, between 9-10 from 10 times

   Often, between 5-8 from 10 times

   Sometime, between 1-4 from 10 times

   Never, no practice

5. Answers of questionnaire

   Part 1-3: interview by researcher and answer by family care giver

   Part 4: identify by doctor

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Code: _____

Date: _____season:_____

Part 1 Demographic information

Family caregiver

1. Gender ☐ male ☐ Female

2. Age ..... years

3. Educational level

- ☐ Uneducated
- ☐ Primary School
- ☐ Secondary School
- ☐ College Graduate
- ☐ Bachelor or higher

4. Main occupation

- ☐ Agricultural occupation
- ☐ Non-agricultural occupation (cross to item 8)
  - ☐ Merchant and trader
  - ☐ Government and company employee
  - ☐ Laborer
  - ☐ Housewife
  - ☐ Other.....

5. Main corps in farm (You can select more than one choice)

☐ Rice ☐ Tomatoes ☐ Chili ☐ Vegetables

☐ Corns ☐ Cucumber ☐ Cantaloupe ☐ Watermelon

☐ Flower ☐ Other.....

6. Area agricultural (Rai)

☐ < 5 ☐ 16-20

☐ 6-10 ☐ 21-30

☐ 11-15 ☐ > 30

7. Do you use pesticide in your farm within 6 month?

☐ No ☐ Yes

8. Pleases identify type of pesticide that you used in farm within 6 months

....

....

9. Household income

☐ ≤ 5,000 baht/month

☐ 5,001- 10,000 baht/month

☐ 10,001- 15,000 baht/month

☐ 15,001- 20,000 baht/month

☐ 20,001- 30,000 baht/month

☐ ≥ 30,001 baht/month

10. How long lived in this area? .....years

11. How long for take care your child? .....years

12. Your relationship with child.....

Children information

13. Gender ☐ boy ☐ girl

14. Age child.....months

15. Body weight.....kg.

16. Height.....cm.

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Part 2 Children activity behavior

Wearing and clothing:

1. How often your child wearing the cloth when stay at home in the last week?

☐ Always ☐ Often ☐ Sometimes ☐ Never

2. What kind of your child wearing the cloth when stay at home in the last week? (You can select more than one choice)

☐ Short Sleeve ☐ long sleeve shirt ☐ shorts ☐ long trousers

☐ Other.....

3. How often your child wearing the cloth when stay outside home in the last week?

☐ Always ☐ Often ☐ Sometimes ☐ Never

4. What kind of your child wearing the cloth when stay at home in the last week? (You can select more than one choice)

☐ Short Sleeve ☐ long sleeve shirt ☐ shorts ☐ long trousers

☐ Other.....

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5. How often of your child ware shoes when outdoor play activities in the last week?

☐ Always ☐ Often ☐ Sometimes ☐ Never

6. What kind of child's shoes? (You can select more than one choice)

☐ High sneakers/Oxfords ☐ Thongs ☐ Sandal ☐ Other.....

Physical activities:

7. What are the activities of your child spent time during in daytime?

☐ Sleeping ☐ playing in house ☐ playing outside ☐ Other.....

8. How long your child does spent time in outside the home per day?

.....minutes/hours

9. How many time does your child wash her/his hand/feet per day?

.....times

10. How many time does your child take a bath per day?

.....times

11. How often your child playing in farms in the last week?

☐ Always ☐ Often ☐ Sometimes ☐ Never

12. How your child play in farm during pesticide spraying in the last week?

☐ Always ☐ Often ☐ Sometimes ☐ Never

13. How often of your child contact with dirt/soil in outdoor play activity per day?

☐ Always ☐ Often ☐ Sometimes ☐ Never

14. Where does your child spend time in the home per day?

☐ Inside home such as bed room, common room

☐ Common area in home

☐ Outside area

☐ Other.....

15. Where your child spent time at home area?

☐ Wooden bed ☐ Floor ☐ Soil ☐ Other.....

16. Does your child playing toy?

☐ No

☐ Yes, what kind of toy.....

17. How long for playing .....minute/hours/day

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18. How often of your child use their hands to contract around her/his face regularly per day?

☐ Always ☐ Often ☐ Sometimes ☐ Never

Mouthing behavior:

19. How often of your child put hands or fingers in his/her mouth?

☐ Always ☐ Often ☐ Sometimes ☐ Never

20. How often of your child put toy or non-food in his/her mouth per day?

☐ Always ☐ Often ☐ Sometimes ☐ Never

21. If you see your child keep snack or non-food from floor put in mouth, you will dissuade them?

☐ Hand washing ☐ mouth washing ☐ Hand and mouth washing

☐ Other.....

Food and drinking water consumptions:

22. How about eating of your child's food?

☐ By child ☐ By parent ☐ By child and parent

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23. What about taking food to mouth of child?

☐ Bare hand ☐ Spoon/ fork ☐ other.....

24. How about drinking water?

☐ Water glass ☐ Bottle ☐ Bare hand ☐ Other.....

25. Does your child like consumption? (You can select more than one choice)

☐ Powdered milk / UHT milk ☐ Rice and dishes

☐ Fresh vegetable ☐ Fresh fruit ☐ Other.....

26. What type drinking water for your drink in family? (You can select more than one choice)

☐ Tap water ☐ Rain water ☐ Bottled water ☐ Ground water

☐ other.....

Part 3 Environmental Factor

1. Does you keep pesticide or chemical for agriculture in house?

☐ Yes ☐ No

2. Does your work clothes mix with family laundry?

☐ Yes ☐ No

3. Does dry your clothes by outdoor in farm?

☐ Yes ☐ No

4. Does store your clothes in house (wardrobe)?

☐ Yes ☐ No

5. How many times for floor cleaning in your house per week?

☐ Everyday ☐ 2-3 days/time ☐ 4-5 days/time

☐ Week/time ☐ Never

6. How is the house cleaned? (You can select more than one choice)

☐ Wet mop ☐ broom ☐ other.....

7. Do you use household insecticide?

☐ Yes ☐ No (skip to 10.)

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8. What type of household insecticide? (You can select more than one choice)

☐ Aerosol ☐ Bait ☐ Electronic

☐ Chalk ☐ Coil ☐ Other.....

9. What is the commercial brand of insecticide in your home use?

....., ..., ...

10. How many your house story?

☐ 1 ☐ 2

11. Do you open the window for air flow in your resident?

☐ Always ☐ Often ☐ Sometimes ☐ Never

12. Do you use coal stove for cooking?

☐ Yes ☐ No

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Part 4 Health symptoms

For 1 month ago

Symptoms	No	Yes	
		Sometime	Often
General symptoms			
Nausea			
Vomiting			
Anorexia			
Respiratory symptoms			
Cough			
Excessive wheezing			
Runny nose			
Skin symptoms			
Skin irritation			
Diaphoresis			
Gastrointestinal symptoms			
Diarrhea			
Salivation			
Central nervous systems			
Lethargy			
Seizures			
Eye symptoms			
Irritation			
Lacrimation			

Remark: Sometime = 1-3 time/ month

Often = more than 3 time/ month

APPENDIX D

Standard calibration curves of organophosphate and pyrethroid pesticides

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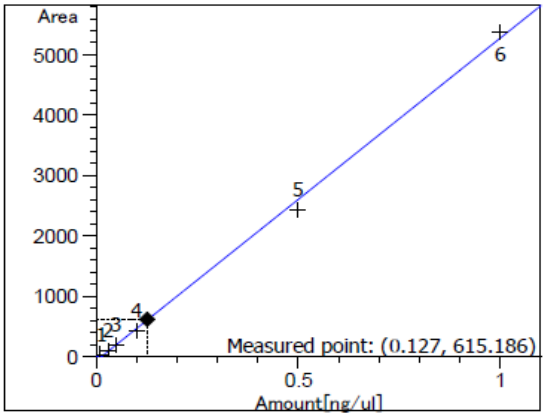
1. Organophosphate

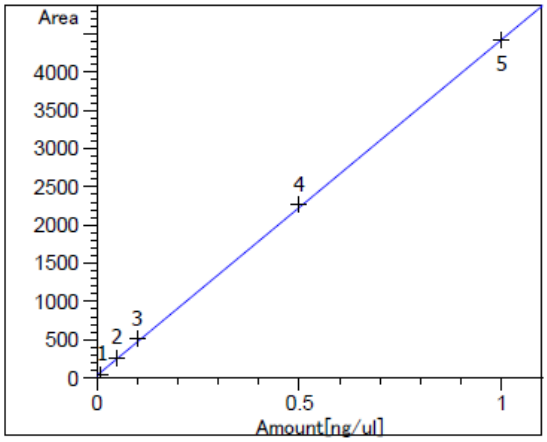
Chlorpyrifos



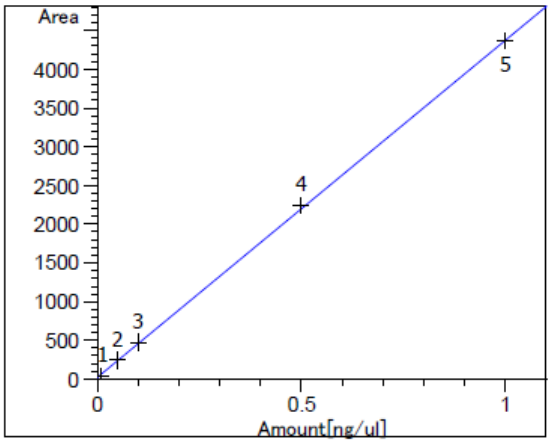

```
Chlorpyrifos at exp. RT: 14.358
DFPD1 B, Back Signal 2
Correlation:          0.99906
Residual Std. Dev.:  96.00915
Formula: y = mx + b
      m:   5356.83916
      b:    -67.46242
      x: Amount
      y: Area
```

2. Pyrethroid

Permethrin

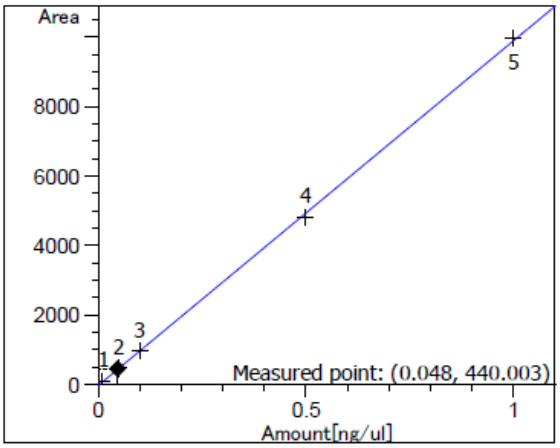



```
Permethrin-I at exp. RT: 14.530
ECD1 A, Front Signal
Correlation:          0.99986
Residual Std. Dev.:  32.73726
Formula: y = mx + b
      m:   4403.85251
      b:     30.07676
      x: Amount
      y: Area
```

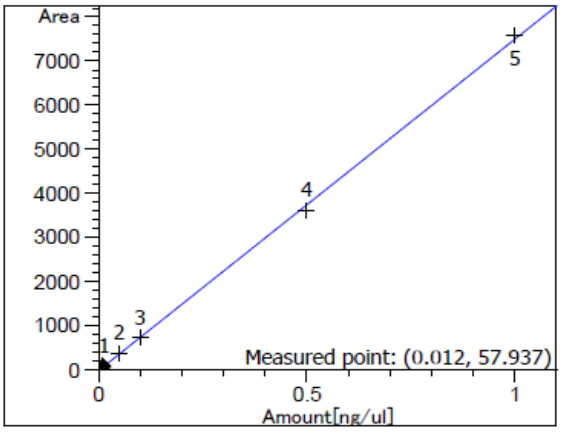



```
Permethrin-II at exp. RT: 14.660
ECD1 A, Front Signal
Correlation:          0.99989
Residual Std. Dev.:  28.64086
Formula: y = mx + b
      m:   4363.14902
      b:     22.02360
      x: Amount
      y: Area
```

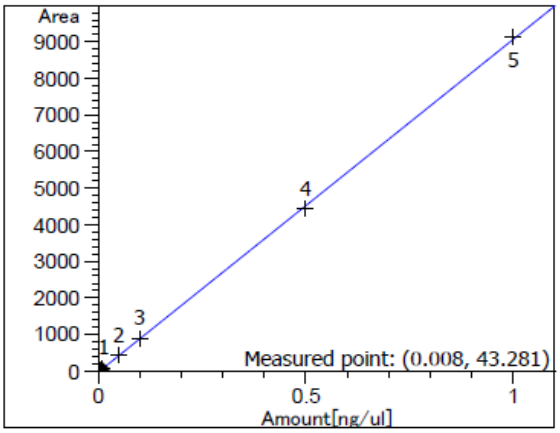
Cypermethrin



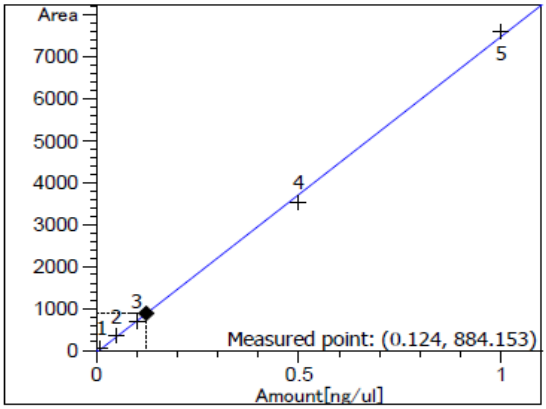
Cypermethrin-I at exp. RT: 15.530
ECD1 A, Front Signal
Correlation: 0.99985
Residual Std. Dev.: 78.20498
Formula: y = mx + b
m: 9959.39114
b: -38.13451
x: Amount
y: Area



Cypermethrin-II at exp. RT: 15.650
ECD1 A, Front Signal
Correlation: 0.99974
Residual Std. Dev.: 77.16433
Formula: y = mx + b
m: 7541.18189
b: -32.06462
x: Amount
y: Area



Cypermethrin-III at exp. RT: 15.740
ECD1 A, Front Signal
Correlation: 0.99988
Residual Std. Dev.: 63.54573
Formula: y = mx + b
m: 9120.96877
b: -33.10109
x: Amount
y: Area



Cypermethrin- IV at exp. RT: 15.780
ECD1 A, Front Signal
Correlation: 0.99950
Residual Std. Dev.: 106.58272
Formula: y = mx + b
m: 7540.39827
b: -47.75106
x: Amount
y: Area

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VITA

Miss Satinee Siriwat was born in Mukdahan province, Thailand. Her research interest is now focused on health risk assessment related to pesticide exposures among young children. She finished a master of science (Environmental Science), Chulalongkorn University, Thailand and she also did a bachelor of science (Environmental Science), Khon Kaen University, Thailand.