

**SCHOOL OF PUBLIC HEALTH
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**EXPOSURE TO PESTICIDES AND SYMPTOMS OF ACUTE RESPIRATORY TRACT
INFECTION IN CHILDREN UNDER FIVE IN THE OFFINSO-NORTH DISTRICT**

BY

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DECLARATION

I hereby declare that apart from references to other people's work which have been duly acknowledged, this proposal is as a result of my own independent work. I further declare that this work has not been submitted for the award of any degree in this institution or other universities elsewhere.

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DEDICATION

This work is dedicated to my mother and father (Nathaniel and Georgina Akyeampong) and my siblings (Stephen, Portia, Dorcas and Lordina Akyeampong) whose inspiration and support has brought me this far.



LIST OF ABBREVIATIONS

ALRI	Acute lower respiratory infection
ARI	Acute respiratory infection
COPD	Chronic obstructive pulmonary disease
CI	Confidence Interval
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
GDP	Gross Domestic Product
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
OR	Odds Ratio
ONFAHS	Offinso-North District Farm Health Study
OP	Organophosphate
POPs	Persistent organic pollutants
PCBs	Polychlorinated biphenyls
FAO	Food and Agriculture Organization
URI	Upper respiratory infection
W.H.O	World Health Organization



ABSTRACT

Background: The suppression of the immune system by persistent exposure to organic pollutants can induce or exacerbate airway inflammation, which can be a predictor of respiratory infections.

Objective: The study examined the association between exposure to pesticides and symptoms of acute respiratory infections (ARIs) among children under five years in the Offinso North District in the Ashanti Region of Ghana.

Methodology: The study population was derived from a population-based cross-sectional design, the Offinso North Farm Health Study (ONFAHS). Information on self-reported indicators to pesticide exposure was gathered with an interview-administered questionnaire. The residues of five organochlorine pesticides and one pyrethroid pesticide was assayed in urine collected from 100 children under five years by gas chromatography equipped with an electron capture detector. A generalized linear model with binomial distribution and log link function was used to assess the association between exposure indicators to pesticides and symptoms of respiratory infection.

Results: The proportion of acute lower respiratory infection (ALRI), was 67.06% among all the children (0-4 yrs). ALRI was common among children ≤ 1 yr (37.14%). Border line significance was recorded between contact with contaminated surfaces (0.97-2.24), bad hygienic practices (0.98-2.33) and bad mouthing behaviour (0.92-4.14) and symptoms of ALRI in children. There was significance association between contact with contaminated surfaces (1.14-47.39) and bad mouthing (1.05-135.38) and symptoms of ALRI. No significant exposure-response association was observed between urine samples and ALRI. The mean residue of Lambda-cyhalothrin (3.25 $\mu\text{g/L}$; 0.66) was higher in children below the age of 1 yr and that of gamma-HCH was highest among children aged 2-4 yrs (3.16 $\mu\text{g/L}$; 0.95).

Conclusion: Exposure to pesticides is associated with symptoms of acute lower respiratory infections in children under five years.

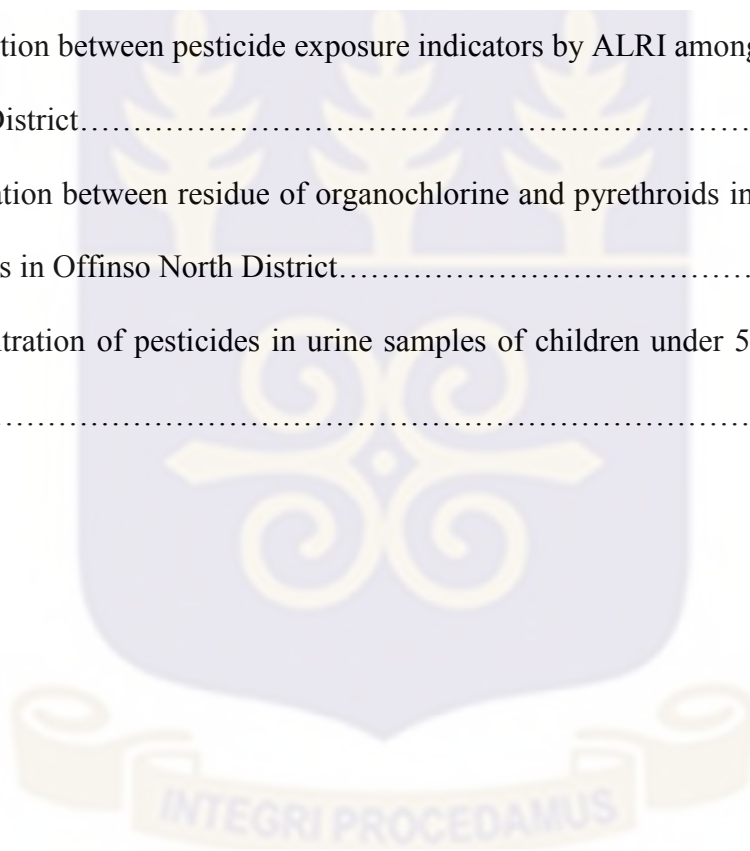
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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

One of the major headaches of the public health sector in developing countries is children below the age of five being affected with acute respiratory infection (ARI). It is the chief cause of illnesses and deaths among babies and young children below the age of five. Yearly, ARI claims about 3.9 million of young children's lives across the world (Goel, et al., 2012). On the average, a child below the age of five experience about five episodes of ARI yearly and this accounts to 238 million attacks. In addition to viruses and bacteria, environmental agents are accepted to cause or worsen airway inflammation, a possible determinant of chronic respiratory infections (Michielsen, et al., 2002).

According to studies, environmental pollutants, which include persistent organic pollutants (POPs), are key elements likely to cause infections and ARI through the early ages of existence (Winans et al., 2011). POPs are 'fat-loving' man-made compounds that stay in the surroundings and bio-accumulate in the food web in man and animal oily tissues. It comprise many different sets of compounds, including polychlorinated biphenyls (PCBs), dioxins, dichlorodiphenyldichloroethylene (DDE) and hexachlorobenzene (HCB) (Crinnion, 2012).

Pesticides are substances or mixtures meant for the prevention, destruction, repelling and mitigation of pests. According to USEPA (2011), any living organism that dwell at undesirable places or that harm crops, humans or animals is a pest. Pesticides – herbicides, insecticides, fungicides, bactericides and rodenticides—are extensively used to control pests and pest-induced diseases (Damalas & Eleftherohorinos, 2011). Over five billion pounds of pesticide are consumed yearly across the world, with organophosphate (OP) and carbamate insecticides

(34%), dithiocarbamate fungicides (18%) and phenoxy herbicides (12%) being used frequently (Ming et al., 2013).

Majority of POPs have the tendency to bridge the placental wall, thus prenatal human exposure begins in the uterus (Covaci et al., 2002; Sala et al., 2001). New-borns come into contact with POPs through breast feeding, food intake or by an undeviating contact with equipments contaminated with these compounds (Aliyu et al., 2010; Fischer et al., 2006; LaKind et al., 2004). The initial indication of possible harmful effects of exposure to high concentrations of PCBs on human respiratory and immune systems was poisoning incidents that happened in the 1970s (Aoki, 2001; Guo et al., 2004); these researches exposed increased levels of immune markers, as well as higher frequencies of respiratory infections among both children and adults. The developing and maturing of immune and respiratory systems during prenatal and postnatal early life, to a greater extent may be vulnerable to the effects of POPs. All major respiratory elements – the bronchioles and alveolar ducts – appear before birth with proliferation of alveoli continuing after birth. Full maturation of the respiratory system is then completed during late adolescence (Dietert et al., 2000; Pinkerton and Joad, 2000).

The body's ability to produce a normal immune response following antigen exposure (immunocompetence) begins to develop after birth and continuous during the first years of life" (Dietert et al., 2000). This involves the development of the innate system (natural killer cells (NK-cells), eosinophils, basophils, neutrophils, macrophages or dendritic cells) that provides immediate defense against infection, and the adaptive immune system (antibodies produced by B-cells and cell-mediate response regulated by cytokines released by T cells) that provides long-lasting or protective immunity through humoral response.

Exposure of these systems to POPs during development may result in disruption and reduction in capacity to fight infections, thereby increasing the risk to developing allergic manifestations

later in life (Bisgaard and Bonnelykke, 2010; Busse et al., 2010; Dietert et al., 2000; Puig et al., 2008).

The disease burden estimates from environmental risks highlight the vulnerability of children when facing environmental risks. For instance, while 24% of the global burden of disease is attributable to the environment, as much as 33% is attributable to the environment for children (WHO, 2006). Seriously affected are the poor, neglected, and malnourished children. These children mostly live in unhealthy housing, do not have access to clean water and sanitation services, and have lesser access to health care and education.

Consequently, respiratory symptoms, such as coughing, wheezing and airway inflammation, are commonly observed among children exposed to POPs such as pesticides (O'Malley, 1997; Sanborn et al., 2002).

Epidemiological research have endeavoured to examine the relationship between work-related exposures to pesticides and symptoms of acute respiratory tract diseases, including asthma, chronic obstructive pulmonary disease (COPD) and lung cancer (Hoppin, et al, 2009; Hoppin, et al., 2007 and Louis et al., 2008).

Majority of these studies carried out in developing countries with more controlled environmental settings, where children and adults are exposed to low levels of POPs, established an association between exposure to POPs and symptoms of ARIs. On the contrary, there are no known studies conducted in Africa where children and adults are exposed to high levels of POPs.

This study examined the association between the postnatal exposure to pesticides and acute respiratory tract infections among children under five years in the Offinso North District in Ghana.

1.2 Problem Statement

Acute respiratory infections, have been suggested to be responsible for about one third of all deaths occurring in children <5 years of age in developing countries (Nair et al., 2010). Epidemiological studies have established an association between occupational pesticide exposures and symptoms of acute respiratory tract diseases, even at low exposure levels (Hoppin, et al, 2009; Ming et al., 2013)

The prevalence of ARIs in the Offinso North district is higher than that reported in other farming communities in the Ashanti region (Health Officer at the Offinso North Health Directorate, personal communication, 2016). Several environmental pollutants such as indoor air particulate matter, arsenic and residential pesticides have been associated with the risk of ARI in children in the United States of America (Crinnion, 2012).

Offinso-North district, composed of Akomadan, Nkenkenso and Afencho, is a farming community in Ghana known for the cultivation and production of vegetables and the highest reported use of pesticides than any other community in Ghana (Ntow et al., 2009; Quansah et al., 2016). Body burden of organochlorine and pyrethroids pesticides identified in urine of the population in Offinso north is higher than reported elsewhere in African and in the developed world (Quansah et al., 2016).

There is the need to understand whether exposure to high levels of pesticides contribute to the risk of acute respiratory tract infection in children under the age of five living in the Offinso North District

1.3 Conceptual Framework

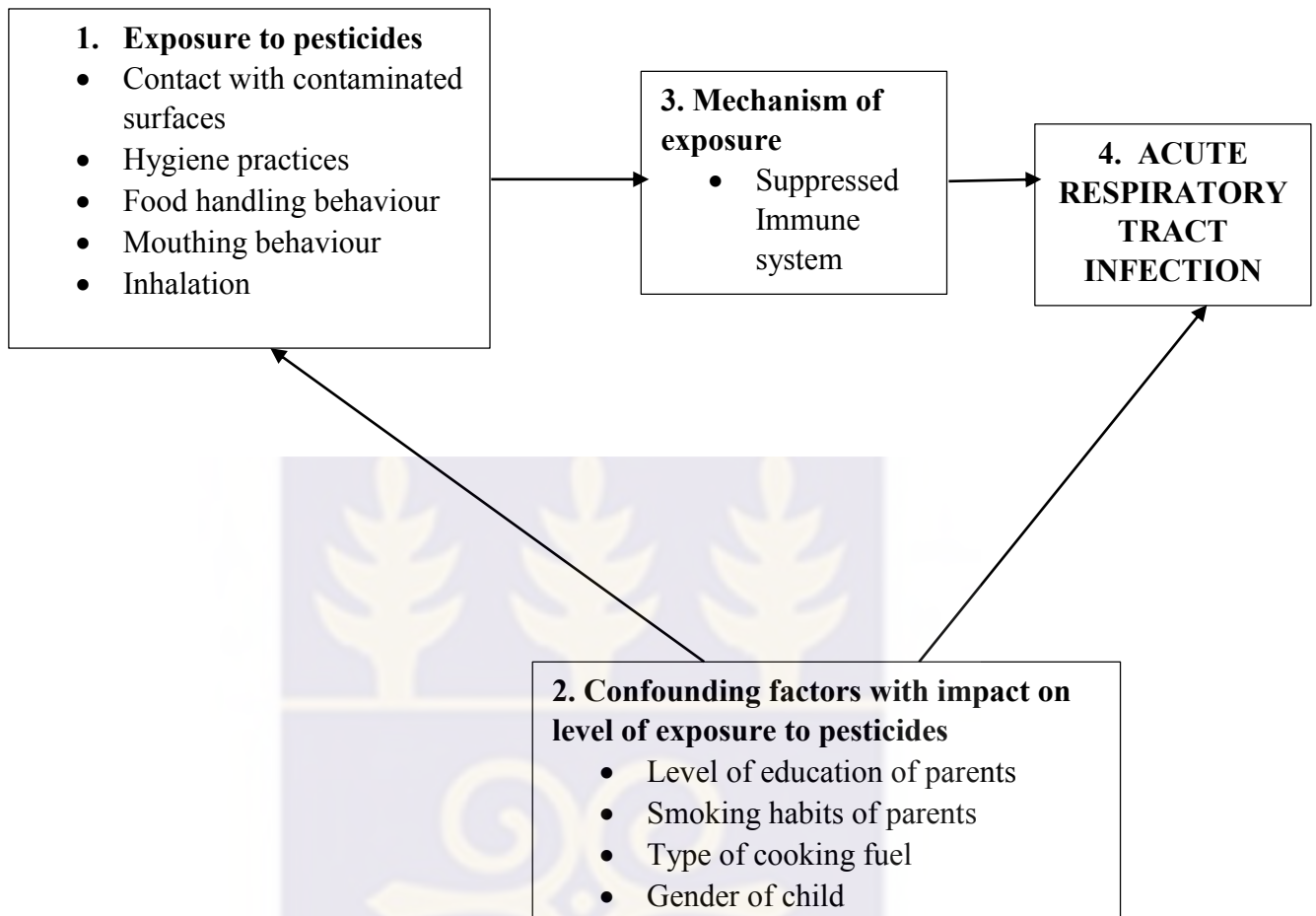


Fig. 1: Conceptual framework showing pesticide exposure pathway and acute respiratory tract infection in children < five years

Concept 1 describes postnatal exposure to pesticides. Contact with contaminated surfaces such as pesticides equipment like knapsack, protective clothing and pesticides containers by children under five years is an exposure route to pesticides residue and increases the likelihood of exposure of pesticide to the under five year old child. Taking children to the farm could expose them to pesticide contaminated air. Children are also exposed to particulate matter from home. These increase their likelihood exposure to pesticides.

Poor hygiene practices includes children under five years eating without properly washing hands especially after coming into contact with surfaces possibly contaminated with pesticides. Bad mouthing practices comprise the instances where children picked up non-food and food materials from possibly contaminated areas and placing them in their mouths.

Concept 2 describes the intermediary factors that contributes to reducing acute respiratory tract infection especially from parents. The level of education of parents to a large extent determines children exposure to pesticides. Thus, well-educated parents are likely to have a greater insight on children that could reduce their exposure to pesticides both at home and on the farm. Financially stable parents are more likely to have a well-balanced meal for their children. This could reduce children under five to pesticide exposure. Well informed parents who observes good safety practices such as wearing children protective gears, disinfecting contaminated surfaces, are more likely to protect children under five years from exposure to pesticides. Observing hygienic practices such as washing the hands of children under five years with soap, and before feeding could reduce exposure to ingestion. Washing and wiping the nipple before breast feeding could reduce exposure to pesticides residue in children under five years.

Concept 3 describes the mechanism of exposure that could result in respiratory infections. Early childhood exposure to pesticides could hamper immune development. This could result in respiratory tract infections. Exposures to pesticides involve immune suppression. Endocrine disrupting chemicals can have permanent and irreversible effects on health. This could result in respiratory diseases. High levels of pesticides exposure and poisoning can suppress metabolic activities. This could result in respiratory tract infections. Concept 5 describes the outcome variable of interest for the study. The outcome variable is acute respiratory tract infection.

1.4 Justification

Considering the semi-volatile nature of pesticides, these substances enter the body through the skin, the digestive system and respiratory tracts. The importance of these different pathways may differ regarding the type of exposure, the formulation used (sprays, wettable powders, diffusive devices or solid forms), the location of use (indoor or outdoor), and many other factors. Occupational exposure in agriculture occurs mainly via dermal route, whereas the dietary oral route is considered to be the most important route of exposure for the general population (Baldi, et al. 2014; Bouvier, et al. 2006).

However, non-dietary and respiratory routes is also an important way of exposure, especially for children. Children also come into contact with pesticides by trans-placental passage and via breast milk contamination, notably with persistent bio accumulative pesticides. In addition, levels of exposure of workers handling pesticides or working with treated crops or in treated environments are usually considered to be higher than levels of exposure for the general population.

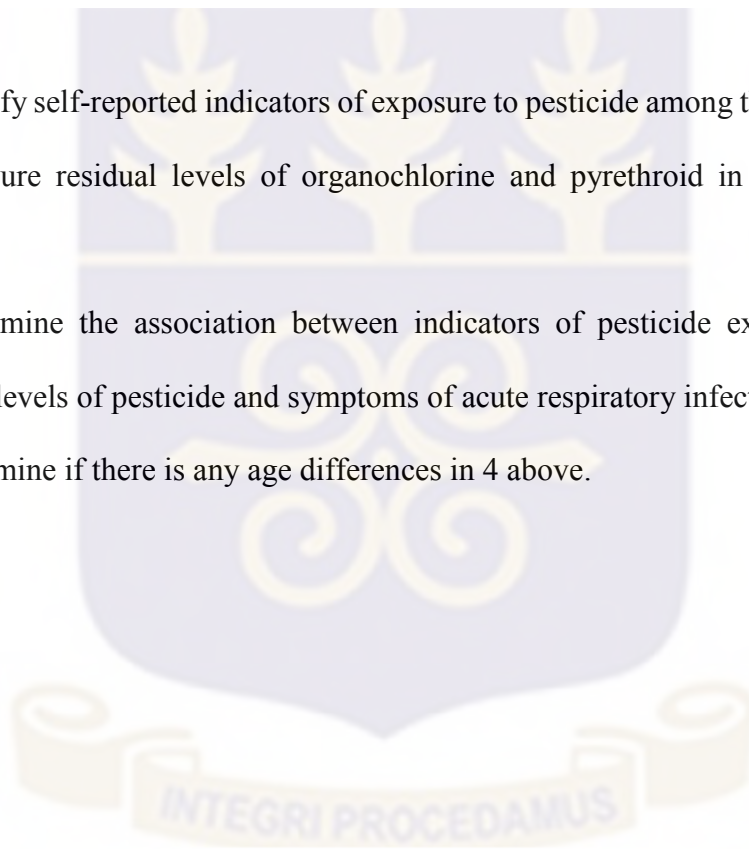
Nonetheless, in Ghana as in many other African countries, the data required to elucidate the full, or even partial, extent of the health effects of pesticides exposure on children under five years is difficult to obtain. This could be due to the lack of effective monitoring systems for the activities farmers engage in, especially at the regional and local level and the absence of epidemiologic evidence. This lack of evidence on the presence of acute respiratory tract infection among children under five due to exposure to pesticide provided the basis for this study.

1.5 General Objective

The general objective was to understand pesticide exposure experience in relation to the burden of self-reported symptoms of acute respiratory infection in children under-five years old living in the Offinso- North District.

1.6 Specific Objectives

1. To determine the proportion of children with symptoms of acute respiratory tract infection
2. To identify self-reported indicators of exposure to pesticide among these children
3. To measure residual levels of organochlorine and pyrethroid in urine of the children.
4. To determine the association between indicators of pesticide exposure/urine residual levels of pesticide and symptoms of acute respiratory infection
5. To determine if there is any age differences in 4 above.



CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

A generic overview of pesticides and pesticides use in Ghana is discussed. Classification of pesticides, its composition and uses was reviewed. Pesticides exposure, its route of exposure would as well was reviewed. A systematic search of PubMed with the following keywords: (acute respiratory infection OR ARI OR ALRI OR URI OR asthma) AND pesticide did not come up with any studies on pesticide exposure and acute respiratory infections. This review thus, focuses on studies on pesticide exposure and respiratory symptoms/ pneumonia in children.

2.1 Definition of Pesticides

According to the United Nations Organization for food and Agriculture (FAO), pesticides are combined substances which are intentionally assigned to prevent, destroy or control pests, such as vectors of human disease or animal species unwanted plants or animals that cause damage or otherwise interfere in the production, processing, storage, transport or marketing of food, agricultural products, wood and wood products or animal feeds or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (FAO, 2006). Pesticides, according to Garcia et al., (2012), are chemicals man applies to control agricultural pests and the most acceptable and effective way to ensure maximum production and quality of crops lies in its correct application. High application and wrong handling of pesticides have increase the worry on the risks and damage that could be imposed on the economy, the environment and public health (Villanueva-Jiménez & Hoy, 1998). Pesticides are however meant to

destroy particular living organisms having peculiar group of biocides that can be greatly deadly. In addition, they are used to control the physiological functions in plants such as regulating flowering, thinning fruit, preventing fruit drop, defoliating crops before harvest to mention a few. Pesticides are employed in a lot of situations constituting in crops, forestry, homes, gardens, hospitals, drains, waterways, on animals, and even on people to control for pests such as scabies and head lice. They are dispersed in exposed spaces and city streets for disease vector control. They can be appended to products such as paints, textile, clothing and bed nets.

According to the 2008 World Bank report, 355,000 people die globally every year as a result of accidental pesticide poisoning. An older but convincing study by Jeyaratnam (1990) reckons that there are one million cases of colossal pesticide poisonings annually. Jeyaratnam (1990) suggested that this figure could be a mirage of the real problem and estimated that over 25 million farm workers in developing countries could be suffering from some kind of occupational pesticide poisoning annually, though majority of these infections are not documented and most of these sufferers did not seek medical cure.

Per the definitions above and for the purpose of this study, pesticides are defined as chemicals employed to kill or control unwanted insects, diseases on plants, weeds, slugs and vertebrate mammals regarded as pests such as rodents in the right quantities and proportions and handled appropriately and administered in the right protective gears to avoid being poisoned and/or exposed.

2.1.1 Agriculture and Pesticide Use in Ghana

About 60% Gross Domestic Product (GDP) is added to the Ghanaian economy by the agricultural sector, hence the importance of accelerated growth of the agricultural sector

to boost the country's overall economic growth. According to MoFA (1998) and Nyanteng (1997), policies on Ghana's agriculture are based on five main objectives.

These are:

- i. To ensure food security and adequate nutrition for all the people in the country,
- ii. To promote the supply of raw materials and inputs to other sectors of the economy,
- iii. To contribute to export earnings.
- iv. Increasing employment opportunities and income for the rural population and
- v. Generating resources for general economic development.

In connection with the intensification and structural changes in agricultural production, there is a high possibility of pesticide usage. The high usage of inputs such as fertilizers and chemical pesticides often times seems to be one of the best ways to increase production and food supply, since a good part of produce is lost through diseases, pests and weeds in the field and in storage.

However, it takes more than increase in input usage to attain a sustainable development of the agricultural sector. In the context of efforts to intensify agricultural production on a sustainable basis, crop protection policies play a crucial role. Nonetheless, Ghana has no comprehensive crop protection policy, especially for pesticide usage.

In addition, implementations of legal instruments are at the moment not enough to control and reduce the negative side effects of pesticides. Government decisions have partly taken into consideration the specific effects of pesticides, such as; the risks to human health and the environment, and are receiving in general the necessary attention.

Furthermore, farmers have inadequate knowledge and practice in crop protection to come up with a policy and extension planning. Farmers' and retailers' levels of pesticide handling and usage are not good enough in respect to effectiveness, safety, the health of farmers, the prevention of side-effects on consumers and the environment (EPA, 2009). Despite its overuse in some crops, EPA reports that pesticide usage in Ghana at the moment is largely low (EPA, 2009). Pesticide usage in Ghana is anticipated to rise in the near future as a result of government's strategy of intensified agricultural production.

2.1.1.1 Common Pesticides Banned in Ghana

In Ghana, a ban has been placed on the use of Dichlorodiphenyltrichloroethane (DDT), whiles, Lindane and Endosulfan are limited for the control of capsids on cocoa, stem-borers in maize and pests on coffee.

This tally with a study done by Ntow et al. (2008) who evaluated the accumulation of persistent organochlorine contaminants in breast milk and serum of farmers in Ghana. From the study, concentrations of persistent organochlorines such as DDT and its metabolites, HCH isomers, HCB and Dieldrin were found in samples of human breast milk and serum collected from vegetable farmers in Ghana.

Another study on analysis of pesticide and pathogen contamination of vegetables in Ghana's urban markets, revealed that, of a total of 180 vegetable samples randomly purchased from Accra, Kumasi and Tamale, chlorpyrifos (Dursban) was detected on 78% of the lettuce, lindane on 31%, endosulfan on 36%, lambda-cyhalothrin (Karate) on 11%, and DDT on 36% (Amoah, et al. 2006). The report showed that most of the residues measured exceeded the maximum residue limit.

Table 2.1: Provisional List of Banned Pesticides in Ghana

Name	Active ingredient	Reason for ban
Aldrex T	Aldrin and Parathion	Persistent, highly toxic
Aldrin	Aldrin	Persistent
Dieldrin	Dieldrin	Persistent
E-605 Combi	Parathion	Highly toxic
Parathion Methyl	Parathion Methyl	Highly toxic
DDT	DichloroDiphenylTrichloroEthane	Safer alternatives
EDIB	Ethylene Dibromide	Highly toxic
D-D	Dichloropropane	Banned internationally
Bidrin	Dicrotophos	Banned internationally

(Source: Environmental protection agency, 2010)

At the moment, a ban has been placed on ten pesticides in Ghana (Table 2.1). The persistence of the pesticides or their high toxicity could be the reasons for the ban imposed on these pesticides. This list is in line with international conventions. Eight more pesticides have restricted use (Table 2.2) in Ghana. Among this group are Uden and Lindane insecticides registered for capsid control in cocoa. However, six of the eight restricted pesticides can be found on the market in considerable quantities (Lydia, 2011)

Table 2.2: Provisional List of Severely Restricted Pesticides in Ghana

Product Name	Active Ingredient
Azodrin	Monocrotophos
Uden	Propoxur
Lindane	Gamma BHC
Elocron	Dioxacarb
Gramaxone	Paraquat
Furadan	Carbofuran
Thiodan	Endosulfan
Atrazine	Atrazine

(Source: EPA, 2010)

2.1.2 Classification of Pesticides

Depending on their chemical make-up, pesticides are grouped differently, spanning from organochlorine and organophosphorus compounds to inorganic compounds. For the purpose of this study, only some groups of pesticides relevant for the damage they cause to human health and high demand for its use will be classified. As such, pesticide is classified into four main groups as:

2.1.2.1 Organochlorines

According to Waliszewski et al. (2004) these are stable compounds that are extremely persistent in our surroundings and has the tendency to accumulate in fatty tissue. Because of this they are chiefly employed in the eradication of disease vectors such as mosquitoes that cause malaria. Cultivation of fruits, vegetables, cereals, grains, cotton and wood and for preservation are other uses of organochlorine. Ferrer (2003) asserts that contact or by ingestion are the leading exposure route of organochlorine. These substances or their metabolites in humans act primarily on the central nervous system by altering the electrophysiological properties and enzymatic neuronal membranes, which in turn alters the flow of the kinetics of Na^+ and K^+ through the membrane of the nerve cell. The outcome is the spread of numerous action possibilities for every stimulus (Ferrer, 2003), which brings about symptoms like seizures and acute poisoning death as a result of respiratory arrest.

2.1.2.2 Organophosphates

These are esters derived from phosphoric acid, and usually act by attacking the central nervous system by constraining acetyl cholinesterase [an enzyme that regulates the

quantity and stages of the neurotransmitter acetylcholine], unsettling the nerve impulse by serine phosphorylation of the hydroxyl group in the active site of the enzyme (Lu, 2009). These compounds are generally used in agriculture, typically in the form of insecticides and miticides. Thus, they are used in vegetable crops, fruit trees, grains, and sugarcane, among others. The loss of reflexes, headache, dizziness, nausea, convulsions, coma and even death according to Lu (2009) are plausible symptoms. Ingestion and contact are the exposure route of organophosphates.

2.1.2.3 Carbamates

These are esters derived from acids and used as insecticides, herbicides, fungicides and nematicides. Carbamates are not as persistent as organochlorines and organophosphates. Organophosphates impede acetyl cholinesterase, however, in the case of carbamates, action is fast and the kinetics of hindering acetyl cholinesterase is via the carbamylation of the enzyme through covalent attachment of electrophilic groups' to the steric carbamoyl sites of the enzyme (Moutchen-Dahmen et al., 1984).

2.1.2.4 Pyrethroids

They are obtained from natural insecticide derived from pyrethrum extract derived from chrysanthemum flowers, known as pyrethrins. Accordingly, pyrethrins were synthetically obtained and at the moment it is manufactured around 100 different commercial products (Sorgob and Vilanova 2002). Contact or ingestion are the exposure route. They act on the central nervous system to induce changes in the dynamics of the Na⁺ channels in the membrane of the nerve cell. These events can lead to neuronal hyperexcitation (Neghab et al, 2014).

Based on the type of toxicity, these chemicals have effect on the growth and survival of reproductive factors, and in the event of acute toxicity, exposed individuals may die. In addition, they have been linked with long-term carcinogenicity, mutagenicity, reproductive and hormonal effects, among others (Campbell 1987). The present study evaluated the type of pesticides that were likely to contribute to the symptoms of acute respiratory tract infection among children under five years in the Offinso North District.

2.2 Pesticides Exposure and Health

The World Health Organization (WHO) estimates that 500,000 to 1 million people are poisoned by pesticides every year and 5,000 - 20,000 die as a result. At least half of the intoxicated and 75% of those who die are farm workers, the remaining 25% are mainly poisoned by consuming contaminated food. Between the two groups, total mortality rates was peaked at 220,000 deaths per year (WHO 1990, Eddleston et al., 2002).

Individuals exposed to pesticides may experience acute and delayed health issues (US EPA, 2007). Exposure to pesticide can lead to a variety of adverse health effects. These effects can range from simple irritation of the skin and eyes to more severe effects such as affecting the nervous system, mimicking hormones causing reproductive problems, and also causing cancer. A systematic review in 2007 found that most studies on non-Hodgkin lymphoma and leukaemia showed positive associations with pesticide exposure and accordingly established that increasing use of pesticides should be lessened (Bassil et al., 2007). Substantial evidence are also available for other negative outcomes from pesticide exposure comprising neurological, birth defects, foetal death and neuro-developmental disorder (Sabon et al., 2007; Jurewicz and Hanke, 2008). The American Medical Association urges individuals to limit their exposure to pesticides and employ

safer alternatives (Council on Scientific Affairs, American Medical Association, 1997). With respect to low-dose pesticide exposures, there is a particular doubt cast about its long-term effects. At the moment there are few surveillance systems to identify possible exposure problems related either to pesticide usage or pesticide-related illnesses.

Exposure to pesticides, through whatever means, have serious health implications on humans. These implications are not always immediate. Sometimes it takes a long time – even years – for these implications to appear. Though everybody in the country (Ghana) is exposed to pesticides, farmers are highly at risk and as such require biomonitoring studies to evaluate acute and chronic diseases caused by exposure to pesticides.

In the Offinso North District, farm workers may have been affected with genotoxic damage type of infection as a result of continuous and systematic use of pesticides. The level of damage can be signal for the need for continuous biomonitoring of farmers who are occupationally exposed (Ntow, 2001; 2008). Nonetheless, few studies have been done on the health effect of pesticides exposure of farmers and their associated respiratory tract infection in their children below five years of age. This study sought to fill this void by assessing the association between exposure of children under five years to pesticides and symptoms of respiratory tract infection.

2.2.1 Pesticides Exposure Route

Exposure is any condition which provides an opportunity for an external environmental agent (any chemical, biological, or physical material capable of eliciting a biological response) to enter the body (Link, 2006).

Pesticides exposure pose harms for users, regulators or those who work with these products. Individuals are exposed to pesticides through direct contact (skin, inhalation,

ingestion) when using them, direct skin contact after someone else has used them, spray drift from neighbouring applications, in food, water and drinks, and applications on pets (Link, 2006).

Unborn children are exposed while in their mothers' womb, as pesticides absorbed by their mothers cross the placenta and are taken up by the foetus. The first faeces of new born infants have been found to contain traces of pesticides. A wide range of pesticides are commonly found in breast milk and as such infants are exposed again as they are breast fed (Link, 2006).

According to the World Health Organization (WHO) (2007) there are one million people around the world experiencing acute poisoning caused by pesticide exposure every year, with a fatality rate of 0.4% and 1.9%. 70% of these fatalities are estimated to be as a result of occupational exposure. In addition, continual exposure to low-doses of pesticides has been linked to a variety of disorders in the medium and long term, including various cancers, reproductive disorders and nervous system disorders, among other problems. The use of agrochemicals is an extensively prevalent practice globally (Benitez et al., 2009).

2.2.2 Sources and Exposure Patterns of Pesticides

Through farming, the environment serves as a major source of pesticide exposure. About 47% of the applied product is deposited at or adjacent soil and water is dispersed in the atmosphere. This situation is influenced by weather conditions such as rain and wind direction and intensity of geological and soil type, as well as the presence of water currents (Damalas, 2007).

The drift of pesticides are mostly influenced by strong winds, high temperatures and unstable terrain. Other occurrences that support environmental distribution are photo degradation, volatilization, leaching and washing soil surface. Just like a source of pesticide exposure, work activity is important in agricultural workers and their families, in chemical industry workers manufacturer of these products, fumigants, and in general, all those who formulated, manufactured, mixed, transported, loaded, stored or apply pesticides (Garcia-Garcia et al., 2015).

As a result of continuous close contact with the chemicals, these groups have significantly higher level of exposure and higher possibility of acute poisoning. Though relatively, the period of contact with the agents is short, they are still serious and repeated during the working day, causing toxic effects that vary with the type and amount of pesticide exposure, being relatively infrequent episodes of such accidental or intentional.

The exposure distressing the general population tend to be common. There are numerous categories of pesticides for protracted phases, from multiple sources and how low doses penetrate the body using different routes. Plant or animal foods, and to a lesser extent water, air, soil, fauna and flora contaminated are the main sources of exposure in the population (Dey, 2010).

The history of contact with pesticides is important but not sufficient to characterize exposure. Exposure should be supplemented with information obtained by other techniques such as environmental and/or biological monitoring, to more accurately determine the level of exposure of the study subjects.

2.3 Symptoms of Acute Respiratory Tract Infection

According to Hart and Cuevas (2007), the number one cause of deaths among children below the age of five around the world is acute respiratory tract infections (ARI). ARI – upper respiratory infection (URI) and acute lower respiratory infection (ALRI) – takes into account all infections of the respiratory tract. ALRI is any infection affecting the airways below the epiglottis and includes acute laryngitis, tracheitis, bronchitis and bronchiolitis and lung infections such as pneumonia, tuberculosis and empyema (Hart and Cuevas, 2007). From the year 2000 to 2003, the number of deaths among children below the age of five is estimated to be 10.6 million. Fifty four percent of these deaths were as a result of four communicable diseases – malaria, pneumonia, diarrhoeal disease and measles – while 2 million (19%) of these deaths were the result of ARI. Majority of the deaths are due to bronchiolitis and pneumonia (Bryce, et al. 2005). Viruses are responsible for many of the cases. Nonetheless, the introduction of genome detection system such as polymerase chain reaction or micro-array technology, has given the public a better insight on the impact of ARI.

Though majority of respiratory viruses infect the respiratory tract, they do not necessarily show forth clinical manifestation of ALRI always. Clinical manifestation of ALRI is influenced by factors such as environmental (air-pollution from indoor fires or cigarettes, humidity), family circumstances (poverty, access to medical care, birth order, overcrowding) and medical circumstances (malnutrition, prematurity, measles, chronic lung disease, diarrhoeal disease, malaria, micronutrient deficiency, e.g. vitamin A).

By estimation, every child in their first two years of life experiences 8–9 episodes of URI each year. However, URI advances to ALRI often for children in the developing countries (Williams, et al. 2002). Current median global estimation of the incidence of pneumonia among children below the age of five is 0.28 episodes per child year (e/cy)

with a 25% to 75% interquartile range of 0.21-0.71 e/cy (Rudan, et al. 2004). This equates to around 150.7 million new cases of pneumonia each year. Definition of pneumonia in this studies cover those with signs of pneumonia which also included those with bronchiolitis (Rudan et al., 2004).

Per the above literature review, it is very clear that acute respiratory tract infections are a result of viral and bacterial agents. Nevertheless, little studies in Ghana (Quansah et al., 2016, Ntow et al., 2001; 2008) have assessed acute respiratory tract infection as a result of pesticides exposure. However, no known studies have established an association between symptoms of ARI and postnatal exposure to pesticides. As such, this study sought to assess the association between postnatal exposure to pesticides and symptoms of acute respiratory tract infection.

2.4 Exposures to Pesticides and Respiratory Symptoms/Asthma in Children

In Southern California, a case–control study on early life environmental risk factors for asthma was performed on a sample of 691 subjects selected from the Children’s Health Study cohort recruited from public schools (fourth, seventh and tenth grades). Pesticide exposure was assessed by a phone questionnaire with the children’s mothers about agricultural and domestic use of pesticides. An analysis of 279 children with asthma and 412 children without asthma showed that asthma diagnosed before 5 years of age was associated with exposure to herbicides (OR 4.58, 95% CI 1.36–15.43) and to other pesticides (OR 2.39, 95% CI 1.17–4.89) both at home and outdoors in the first year of life” (Salam et al. 2004). Furthermore, an Ontario Farm Family Health Study explored respiratory health effects among 3405 children (from 1 to >12 years-old) of farmers having used pesticides on the six largest crops of this state. The study revealed no

meaningful link between exposure to fungicides, herbicides and insecticides during pregnancy and persistent cough or bronchitis (OR 1.21, 95% CI 0.77–1.90, n=104), or asthma (OR 1.00, 95% CI 0.71–1.40, n=174) in children” (Gascon et al., 2012).

A cross-sectional study was carried out in Hamburg among 343 children, aged 7–10 years, to analyse the link between postnatal exposure to organochlorine insecticides, particularly DDE, and the existence of asthma. However, exposure to DDE (DDE blood levels $\geq 0.3 \text{ mg}\cdot\text{L}^{-1}$) was highly connected with asthma (OR 3.71, 95% CI 1.10–12.56, n=170) (Karmaus et al. 2001). Lastly, a cross-sectional study carried out in Lebanon among 3291 Lebanese schoolchildren between the ages of five and sixteen revealed the different types of pesticide exposure among the parents (residential, domestic and para-occupational) were linked to a risk of respiratory diseases (OR 1.82, 95% CI 1.40–2.37) in children. The highest risks were observed for asthma and para-occupational exposure (OR 2.98, 95% CI 1.58–5.56), and for wheezing and residential exposure (OR 2.53, 95% CI 1.93–3.33). A questionnaire on family conditions of exposure was used to examine exposure (Salameh et al., 2003).

In Menorca, a study was conducted by Sunyer et al., (2005) among 482 mothers during antenatal care over a period of 12 months in 1997–1998, with a follow-up of 405 children after birth until the age of 6 years. Wheezing exposure was assessed by an interviewer led questionnaire. The study revealed that the concentration of dichlorodiphenyldichloroethylene (DDE), a metabolite of dichlorodiphenyltrichloroethane (DDT), in the cord blood at birth had a link with an increased risk of wheezing at 4 years of age (relative risk 2.36, 95% CI 1.19–4.69) for the highest quartile ($>1.90 \text{ ng}\cdot\text{mL}^{-1}$). Similarly, Sunyer et al., (2006) conducted a new study in 2006 by performing assays on cord blood at birth on 402 children. Asthma exposure was assessed by an interviewer led questionnaire. The study corroborated the relationship DDE concentrations in cord blood had with the risk contracting asthma at age 6

(OR 1.18, 95% CI 1.01–1.39); and a moderate, but not significant, increase in wheezing (OR 1.13, 95% CI 0.98–1.30) at age 4 after adjusting on duration of breastfeeding. Birth cohort in Sweden had 190 pregnant women and their babies up to the age of 3 months from 1996 to 1999. Estimation of prenatal and post-natal exposures were done based on maternal serum concentrations of PCBs and DDE during the first trimester of pregnancy and concentrations in mother's milk 3 weeks after birth respectively.

From the studies reviewed in section 2.4, almost all the studies showed a link between postnatal exposure to pesticides and symptoms of acute respiratory tract infection at low exposure levels. This could be that children under five years in farming communities in these developed countries could not 'engaged' directly in farming activities. In Ghana, for instance, children under five years (normally between 1-4 years) are taken to the farm by parents and thus, are more likely to be exposed to high levels of pesticides. However, no research work has reported on the relationship between postnatal exposure to pesticides and symptoms of acute respiratory tract infection among children below the age of five in Africa. The present study, therefore sought to fill this void by investigating the association between postnatal exposure to pesticides and symptoms of acute respiratory tract infection in children under five years in the Offinso North district.

2.5 Chapter Summary and Conclusion

Most of the documented studies on pesticides have been carried out in the United States of America and a number of Asian countries like India and Japan. However, substantial research work on pesticides have been conducted in Ghana. Similarly, exposure route of pesticides have been conducted in Ghana. Similar studies have also been conducted using other biological media such as breast milk and urine to analyse pesticides residues in

farmers in Ghana. However, there are no known findings on the association between exposure to pesticides in children under five years and symptoms of acute lower respiratory tract diseases in Ghana.



CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was derived from the Offinso North District Farm Health Study (ONFAHS). ONFAHS is a population-based cross sectional design among households including children and their parents in the Offinso-North District of the Ashanti Region of Ghana. Offinso-North District is about 95km North-West of Kumasi, the capital of the Ashanti Region. The district is divided into three geographical zones and each zone comprise a major farming community. The major farming communities are Akumadan (the biggest), Nkenkenso and Afrancho. According to Quansah et al., (2016), Offinso-North District is a hetero-ethnic inhabitation with a population of thirty thousand (30,000) of which 85% are directly involved in farming. The major vegetables cultivated in the town are pepper, garden eggs, okro and tomatoes (Ntow, 2001). Other crops cultivated are maize, cassava, plantain and cocoa .There is no statistics on the amount of pesticide farmers in the district consumes annually, but evidence has it that vegetable farmers in Offinso North District utilize pesticides more than any other farming communities in Ghana (Ntow et al., 2009; Quansah et al., 2016).

3.2 Study Population

The source population included all children under the age of five years in the Offinso North District of the Ashanti Region of Ghana. One hundred and seventy (170) of these children were identified from ONFAHS for the present study.

3.3 Study Design

The study employed a population based cross-sectional study design using quantitative methods to determine the exposure to pesticides and symptoms of acute respiratory tract infection among children under five years in households in Offinso-North District.

3.3.1 Inclusion Criteria

The eligibility criteria of households selected into the study included the household should have a man and/or woman who was above 18 years, at least the man or the woman or both is/are a farmer(s), the man or woman or both is/are permanent resident(s) in the study area, both the man and/or the woman has a biological child who is below the age of five years, and lastly, the man and/or the woman was willing to follow the study protocol to the completion of the study.

3.3.2 Exclusion Criteria

The exclusion criteria of households included the household should have a no man and/or woman who was above 18 years, either the man or the woman or both is/are a farmer(s), man or woman or both is/are not permanent resident(s) in the study area, both the man and/or the woman has no biological child who is below the age of five years.

3.4 Sampling Size Calculation

The Yamane's formula was used in calculating the sample size (Hazell et al., 2013). The emphasis of the study was the households with under-five (5) years' children, hence the sampling size was calculated based on the estimated portion of children in Offinso-North District. Data was not available on the population of under five years' old children of farmers in the district, hence, an estimation based on the census report in the Ashanti Region was employed.

Estimated farming population= 2295 (Ntow et al., 2009)

Estimated percentage of under five years olds = 11.6%;~12% (Kumasi District Population Report, 2010)

The estimated population of children under five born to farmers was therefore about 276. (12% of 2295)

Using the Yamane equation

$$n = \frac{N}{1 + Ne^2}$$
$$= \frac{276}{1 + 276(0.05)^2}$$
$$= 163.31$$

Where n is the sample size, N is the population, e is the error margin of 0.05. Taking into consideration 5% non-responsiveness, an estimated population of 170 under five years children was selected from the Offinso North Farm Health Study (ONFAHS)

3.5 Study Variables

3.5.1 Exposure Variables

Self-reported indicators of exposure to pesticides included (i) four (4) pesticide exposure indicators on the farm, (ii) four (4) pesticide exposure indicators at home, (iii) organochlorine, and pyrethroids residues present in hexane extracts of 24 h urine samples collected in the early h of the morning. Exposure indicators on the farm and at home were defined as mouthing behaviour, food handling practices, hygiene practices, contact with pesticide containers, contact with pesticide equipment and contact with contaminated surfaces (Appendix E)

3.5.2 Outcome Variables

The main outcome of interest was self-reported symptoms of acute lower respiratory infection (ALRI). Acute lower respiratory tract infection here was defined as cough

accompanied by short and rapid breathing and feverish condition at any time in the 2-week period preceding the survey interview (Misra, 2003; Bautista et al., 2009).

3.5.3 Confounding Variables

The following variables were considered as potential confounders; type of cooking fuel used; level of parental education; smoking habit of parents, gender of child (Smith et al. 2000).

3.6 Sampling Procedure

The ONFAHS used convenience sampling technique to select 300 households including 300 children under-five years, and their parents (i.e 600) from the study site (Offinso North District). The ONFAHS was in two phases. Phase one involved the administration of questionnaire to household and phase two involved collection of soil, vegetables, plants and urine samples. For this study, all 100 of 300 children who provided urine samples were selected from ONFAHS dataset. Using the Proc surveyselction without replacement command in SAS 9.3, seventy (70) individuals were selected from the remaining children. .

One hundred (100) children from the sample population was randomly selected to provide urine samples (Sarstedt, S-monovette, Germany). The parents of the children were provided with 50ml sterile, metal-free plastic urine containers. They (parents) were advised to use clean water and soap to wash their hands before handling the sterile metal-free plastic urine containers. They were also instructed to void out the first portion of the urine stream before the collection of 50ml mid-stream urine in the plastic urine container. Ten (10) ml of the urine was then drawn into each of four sterile sample tubes (Sarstedt, S-monovette, Germany) and stored in refrigerated boxes containing ice packs (at 4–8 °C)

and transported to the Ghana Standards Authority. Residue concentrations in urine were determined using a gas chromatograph (CP-3800, Varian, Inc., Walnut Creek, CA) equipped with an electron capture detector (CP-3800, Varian, Inc.) (GC-ECD) and a capillary column (VF – 5mS, 40 mx0.25mmx0.25 μ m, also from Varian, Inc.). The GC-ECD operation conditions were: temperature program, 70 °C (for 2 min) to 180 °C (for 1 min) increasing at 25 °C/min, to 300 °C increasing at 5 °C/min; injector temperature, 270 °C; detector temperature, 300 °C; carrier gas, nitrogen at 1.0 ml/min, and make up gas, nitrogen at 29 ml/min. Liquid-liquid extraction was used for the extraction of the pesticides from the urine samples. Urine (5 ml sample) was measured into a well labelled 25 ml separating funnel and 20 ml of hexane was added. The separating funnel and its contents was shaken for about 10 min and the hexane extract (organic layer) was separated from the aqueous layer. Extraction of the aqueous layer was repeated three times, the organic layers combined and dried over 2.0 g anhydrous sodium sulfate. The hexane extract was then concentrated on a rotary evaporator to about 5 ml. Each hexane extract was passed through a glass column prepared by packing 4 g pre-activated silica adsorbent into the column, and then adding 0.5 g anhydrous sodium sulfate on top of the silica adsorbent. The packed column was conditioned with 10 ml of hexane prior to addition of the entire hexane extract to the column. Hexane (10 ml) was then added to the column and the eluate collected into a 50 ml conical flask. The eluate was concentrated to near dryness on a vacuum rotary evaporator and the residue dissolved in 1.5 ml ethyl acetate. The extract was transferred into a 2 ml glass vial using a Pasteur pipette and an aliquot subjected to GC analysis. Organochlorine, organophosphate, pyrethroid, carbamate residues was identified based on identical retention times to those of authentic standards.

3.7 Data Analysis

Proportions were computed for categorical variables. A generalized linear model with binomial distribution and log link function was used to assess the association between self-reported exposure indicators to pesticides and symptoms of respiratory infection; where model failed to converge, a Poisson distribution log link function was used to assess the association between self-reported exposure indicators to pesticides and symptoms of respiratory infection. The effect measure is prevalence ratio (PR). The following confounders were adjusted for in the analysis: type of cooking fuel used; level of parental education; smoking habit of parents, gender of child. The analysis was done with SAS 9.3 version.

3.8 Ethical Consideration

Approval letter from the Ghana Health Service Ethical Review Board and the school of Public Health was made available to chiefs, agriculture officers, agriculture extension officers, the agriculture extension department and district assembly at Offinso-North District. The details of the study was explained in depth for easy comprehension to merit the needed assistance. Consent was sought from all probable participating households during which the purpose of the study and the merits of its outcome was communicated to them (participating households).

Informed consent was developed based on the World Health Organization (WHO) guidelines and it contained information detailing the researcher's background and contact information, purpose of the study, procedure, confidentiality, risk, voluntary participation and benefits of participating in the study and a certificate of consent which was signed and/or thumb printed by participants to indicate their willingness of

participation. They were informed about the purpose, procedures, risks and benefits of participating in the study.

There was no risk involved in participating in the study and there was no conflict of interest. Informed consent was obtained from participants in the language they understand and confidentiality of information shared and results obtained was guaranteed before their engagement in the study. Assent was also be obtained from the under five children. Participants were assured that there was no consequences, like loss of benefit, if they choose to withdraw from the study. Only the researcher and the project supervisor had access to the data.

3.9 Quality Assurance

To ensure quality control, research assistants were trained before assisting with the administration of the questionnaire and collection of the urine samples. The training was done to ensure that they understood the research topic, objective and the sensitivity of the topic and the need for confidentiality of data collected. The training also ensured that they were adequately equipped to undertake the data collection. Supervision was carried out by the principal investigator during the entire period of the field work.

CHAPTER FOUR

RESULTS

4.1 Socio-demographic characteristics

Characteristics of the study population (children and their parents) is shown in Table 4.1. Most of children were 3 years 40.59% (69/170), were males 72.35% (123/170), have mothers 71.34% (117/170) or fathers 72.19% (122/170) with no formal education. They lived in homes where biomass fuel 92.94% (158/170) was used, have mothers 97.04% (164/170) or fathers 88.02% (147/170) who never smoked and mothers 90.59% (154/170) or fathers 84.71% (144/170) who never drank alcoholic beverages.

Table 4.1: Characteristics of study population of children under 5 years (n=170). The Offinso-North District Farm Health Study (ONFAHS)

Characteristics of study population	N (Frequency)	Percentage (%)
Age of child		
>1 year	21	12.35
2 years	25	14.71
3 years	69	40.59
4 or 5 years	55	32.35
Gender of child		
Male	123	72.35
Female	47	27.65
Highest level of mother's education		
Have not been to school before	117	71.34
JSS/middle school/primary school	39	23.78
secondary school/vocational or technical training	8	4.88
Highest level of father's education		
Have not been to school before	122	72.19
JSS/middle school/primary school	40	23.67
secondary school/vocational or technical training	7	4.14
Types of cooking fuel		
*Cleaner fuel	5	2.94
Biomass fuel	158	92.94
* ¹ Combination of fuels	7	4.12
Father's cigarette smoking habit		
Current smoker	6	3.59
Past smoker	14	8.38
Never smoked	147	88.02
Mother's cigarette smoking habit		
Current smoker	1	0.59
Past smoker	4	2.37
Never smoked	164	97.04

* refers to for example liquid petroleum gas, biogas, etc. *¹refers to the use of biomass fuel and cleaner fuel

Table 4.1 continued

Father's alcoholic drinking habit		
Current drinker	6	3.53
Past drinker	20	11.76
Never drank	144	84.71
Mother's alcoholic drinking habit		
Current drinker	12	7.06
Past drinker	4	2.35
Never drank	154	90.59

* refers to for example liquid petroleum gas, biogas, etc. *¹refers to the use of biomass fuel and cleaner fuel



4.2 Proportion of symptoms of Acute Lower Respiratory Infection

The proportion of children reporting symptoms of acute lower respiratory infection was 67.06% and was higher among children below the age of 1 yr (37.14%) and least common among children who were three (3) years old (22.86%) (Figure 4.1)

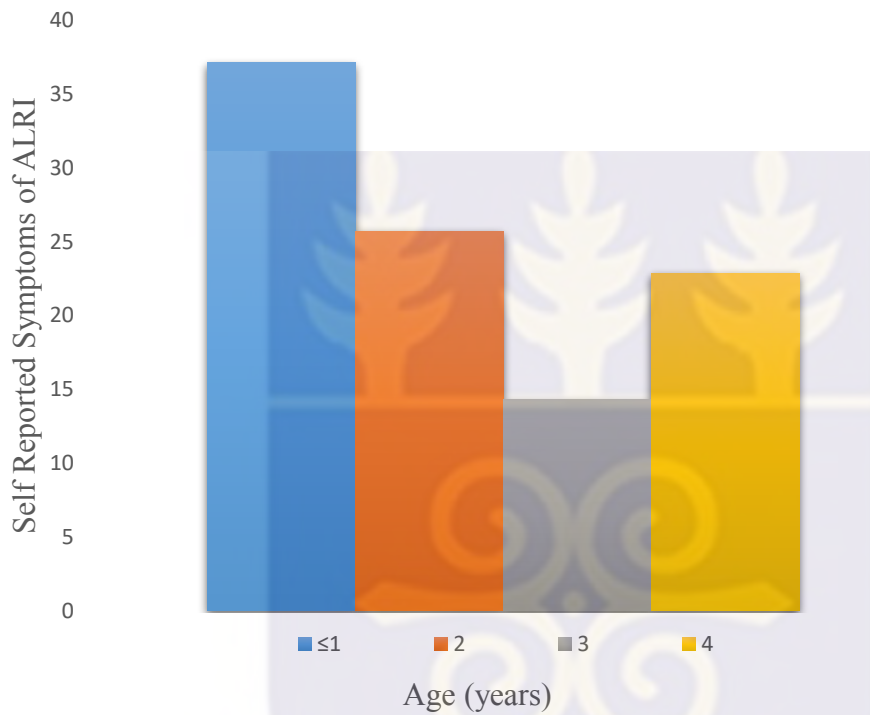


Fig. 4.1: Proportion of children with symptoms of ALRI among children under the age of 5 in Offinso North District (n=170)

4.3 Self-reported exposure indicators to pesticides among children below 5 years

Self-reported exposure to pesticides on the farm or at home by age is presented in Table 4.2. Contact with contaminated surfaces was common on the farm compared to at home (51.18% vs. 46.46%). Unhygienic practices on the farm was least compared to that at home (57.65% vs. 77.06%). Bad mouthing behaviour was least common on the farm compared to at home (58.24% vs. 84.12%) and bad food handling behaviour was very common on the farm compared to at home (82.35% vs. 77.06%). Stratifying by age, contact with contaminated surfaces was common on the farm among children who were 2-4 yrs compared to those below the age of 1 yr at home (57.69% vs. 65.38%). Unhygienic practices was common among ≤ 1 years at home compared to 2-4 yrs on the farm (75.69% vs. 69.23%); bad mouthing behaviour was common among ≤ 1 yr at home compared to 2-4 yrs on the farm (82.64% vs. 73.08%) and food handling behaviour was poor and common among 2-4 yrs at home compared to ≤ 1 yr on the farm (88.46% vs. 81.94%).

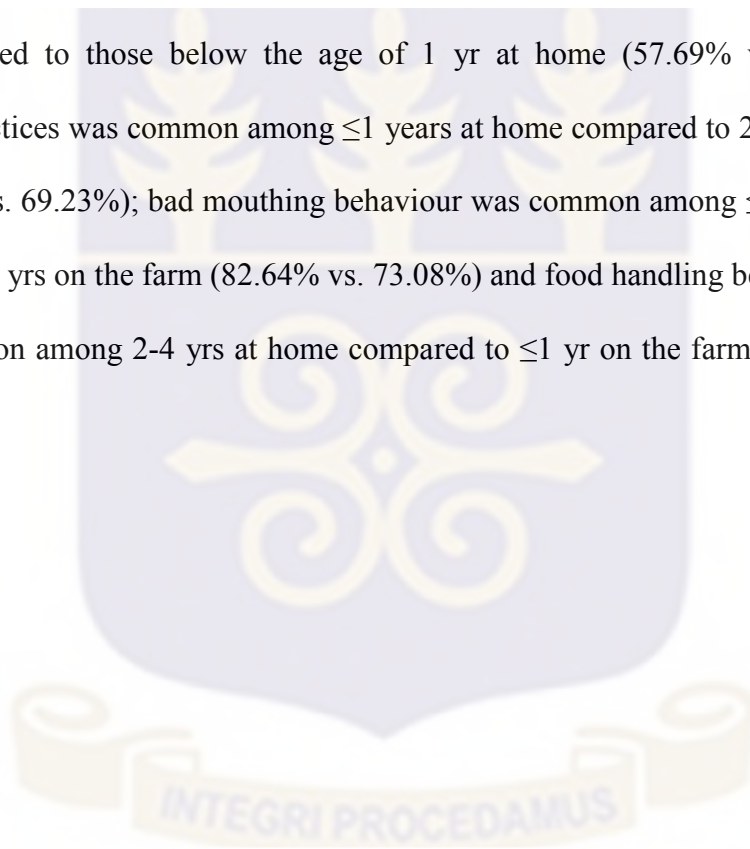


Table 4.2: Prevalence of exposure symptoms by age of a child (0-4 years) in the Offinso North District

Exposure indicator	All children N (%)	≤ 1 year	2-4 years
On the farm			
*Contact with contaminated surfaces?			
Yes	87 (51.18)	70 (48.61)	17 (65.38)
No	83 (48.82)	74 (51.39)	9 (34.62)
*Good hygiene practices?			
Yes	72 (42.35)	64 (44.44)	8 (30.77)
No	98 (57.65)	80 (55.56)	18 (69.23)
*Good mouthing behaviour?			
Yes	71 (41.76)	64 (44.44)	7 (26.92)
No	99 (58.24)	80 (55.56)	19 (73.08)
*Good food handling behaviour?			
Yes	30 (17.65)	26 (18.06)	4 (15.38)
No	140 (82.35)	118 (81.94)	22 (84.62)
At home			
*Contact with contaminated surfaces?			
Yes	79 (46.46)	64 (44.44)	15 (57.69)
No	91 (53.53)	80 (55.64)	11 (42.31)
*Good hygiene practices?			
Yes	39 (22.94)	35 (24.31)	4 (15.38)
No	131 (77.06)	109 (75.69)	22 (84.62)
*Good mouthing behaviour?			
Yes	27 (15.88)	25 (17.36)	2 (7.69)
No	143 (84.12)	119 (82.64)	24 (92.31)
*Good food handling behaviour?			
Yes	39 (22.94)	36 (25.00)	3 (11.54)
No	131 (77.06)	108 (75.00)	23 (88.46)

* Contact with contaminated surfaces=contact with empty pesticides, contaminated equipment (nose mask), parent hold or carry baby with farm/unclean clothes etc * Hygiene practices=child crawling on the ground, wash hands before eating, etc * Mouthing behaviour=child placing thumb/fingers in the mouth, putting non-food items in their mouth, eating soil on the floor etc

4.4 Concentrations ($\mu\text{g/L}$) of organochlorine and pyrethroids pesticides residues in urine of children

Five organochlorine pesticides and one pyrethroid were detected in the hexane extract of urine samples of the children (Table 4.3). The concentrations of all the residue in the urine were above the level of detection. The mean residue and standard deviation of Lambda-cyhalothrin ($3.25 \mu\text{g/L}$; 0.66) was higher in children below the age of 1 yr compared to those aged 2-4 yrs ($3.15 \mu\text{g/L}$; 0.92). On the contrary, the mean residue concentration and standard deviation of gamma-HCH recorded was highest among children aged 2-4 yrs ($3.16 \mu\text{g/L}$; 0.95) compared with children under 1 yr ($3.13 \mu\text{g/L}$; 0.72).

Table 4.3: Concentration of pesticides in urine samples of children under 5 in the Offinso North District

All children									
Pesticide	N	LOD	Mean	SD	Median	LQ	UQ	Min	Max
Organochlorine									
<i>gamma-HCH</i>	92	0.01	3.13	0.75	3.10	2.55	3.35	2.00	5.60
<i>beta-HCH</i>	95	0.01	2.84	0.64	2.60	2.40	3.20	1.60	4.80
<i>delta-HCH</i>	86	0.01	2.38	0.38	2.20	2.10	2.50	2.00	3.50
<i>Heptachlor</i>	92	0.01	3.55	0.90	3.30	3.10	4.10	2.00	5.60
<i>Aldrin</i>	98	0.01	0.02	0.01	0.02	0.02	0.03	0.00	0.04
Pyrethroid									
Lambda-cyhalothrin	99	0.01	3.24	0.70	3.20	2.70	3.70	2.00	4.90
≤ 1 year									
Organochlorine									
<i>gamma-HCH</i>	79	0.01	3.13	0.72	3.10	2.50	3.60	2.00	5.20
<i>beta-HCH</i>	81	0.01	2.83	0.64	2.60	2.40	3.10	1.60	4.80
<i>delta-HCH</i>	72	0.01	2.40	0.40	2.25	2.10	2.50	2.00	3.50
<i>Heptachlor</i>	80	0.01	3.56	0.88	3.30	3.10	4.10	2.00	5.60
<i>Aldrin</i>	84	0.01	0.02	0.01	0.02	0.14	0.03	0.01	0.04
Pyrethroid									
Lambda-cyhalothrin	85	0.01	3.25	0.66	3.20	2.80	3.40	2.00	4.90
2-4 years									
Organochlorine									
<i>gamma-HCH</i>	13	0.01	3.16	0.95	2.80	2.60	3.50	2.00	5.60
<i>beta-HCH</i>	14	0.01	2.89	0.66	2.65	2.50	3.20	2.10	4.50
<i>delta-HCH</i>	14	0.01	2.29	0.27	2.20	2.10	2.40	2.10	3.10
<i>Heptachlor</i>	12	0.01	3.51	1.10	3.25	2.80	3.85	2.10	5.60
<i>Aldrin</i>	14	0.01	0.02	0.01	0.02	0.02	0.03	<0.01	0.03
Pyrethroid									
Lambda-cyhalothrin	14	0.01	3.15	0.92	3.25	2.20	4.00	2.10	4.60

*LOD=level of detection LQ=Lower quartile UQ=Upper quartile SD=Standard deviation N=frequency

4.5 Association between pesticides exposure indicators/pesticide residues in urine and symptoms of acute lower respiratory infections

The association between pesticide exposure and symptoms of acute lower respiratory infection is shown in Table 4.3 and the association between residue of organochlorine and pyrethroids in urine with ALRI is shown in Table 4.4.

There was no significant association between indicators of pesticide exposures and symptoms of acute respiratory tract infection in all the children. By stratifying analysis by age, contact with contaminated surfaces (Prevalence Ratio (PR)=1.45 (95% CI 0.97-2.24), bad hygiene practices (1.51, 0.98-2.33) and bad mouthing behaviour (1.40, 0.92-4.14) on the farm had a border line significance association with symptoms of acute lower respiratory infection among children under 1 yr but not among children between 2 to 4 yrs.

Good hygiene practices (7.36, 1.14-47.39) and good food handling behaviour at home (11.95, 1.05-135.38) increased the risk of symptoms of acute lower respiratory infection in children between 2-4 yrs; however, the point estimates were imprecise.

There was no significant association between residual levels of organochlorines and pyrethroids pesticides in urine and symptoms of ALRI in the analysis considering all the children and the children by age (Table 4.4)

Table 4.4: Association between pesticide exposure indicators by ALRI among children (0-4years) in Offinso North District

Exposure indicators	Acute Lower Respiratory Infection (ALRI)					
	All children		≤ 1year		2-4 years	
	Crude PR	Adjusted PR	Crude PR	Adjusted PR	Crude PR	Adjusted PR
On the farm						
Contact with contaminated surfaces?						
Yes	1.04 (0.80-1.34)	1.03 (0.62-1.73)	1.45 (0.96-2.20)	1.45 (0.97-2.24)	0.95 (0.37-2.41)	0.93(0.36-2.34)
No	1.00	1.00	1.00	1.00	1.00	1.00
Good hygiene practices?						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.02 (0.78-1.32)	1.01 (0.60-1.73)	1.50 (0.97-2.31)	1.51 (0.98-2.33)	0.99 (0.40-2.44)	0.95 (0.38-2.39)
Good mouthing behaviour?						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.04 (0.75-1.45)	1.04 (0.55-1.80)	1.40 (0.92-2.15)	1.40 (0.92-4.14)	1.29 (0.51-3.27)	1.33 (0.52-3.42)
Good food handling behaviour?						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.02 (0.78-1.32)	1.01 (0.60-1.73)	0.85 (0.48-1.49)	0.86 (0.48-1.52)	0.99 (0.40-2.44)	0.95 (0.38-2.39)
At home						
Contact with contaminated surfaces?						
Yes	1.97 (0.62-6.24)	2.53 (0.66-9.69)	1.04 (0.81-1.32)	1.04 (0.63-1.69)	5.92(1.45-24.16)	7.36 (1.14-47.39)
No	1.00	1.00	1.00	1.00	1.00	1.00
Good hygiene practices?						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.68 (0.54-5.29)	2.28 (0.58-8.94)	0.96 (0.72-1.30)	0.96 (0.50-1.84)	6.05(0.85-42.92)	8.66 (0.89-84.11)
Good mouthing behaviour?						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.50 (0.34-5.84)	1.67 (0.34-7.39)	0.99 (0.74-1.33)	0.99 (0.54-1.82)	6.99(0.98-49.28)	11.95 (1.05-135.38)
Good food handling behaviour						
Yes	1.00	1.00	1.00	1.00	1.00	1.00
No	1.18 (0.43-3.23)	1.49 (0.45-4.98)	0.96 (0.72-1.30)	0.96 (0.51-1.82)	6.05(0.85-42.92)	7.47 (0.78-71.21)

Table 4.5: Association between residue of organochlorine and pyrethroids insecticides with ALRI among <5yrs in Offinso North District

Pesticides residue	Acute Lower Respiratory Infection (ALRI)					
	All children		≤ 1year		2-4 years	
	Crude PR (95% CI)	Adjusted PR (95% CI)	Crude PR (95% CI)	Adjusted PR (95% CI)	Crude PR (95% CI)	Adjusted PR (95% CI)
Organochlorine						
Gamma-HCH	1.10 (0.92-1.31)	1.20 (0.61-2.34)	1.07 (0.88-1.30)	1.13 (0.53-2.41)	1.30 (0.79-2.13)	1.63 (0.25-10.42)
Beta-HCH	1.00 (0.82-1.21)	1.00 (0.48-2.07)	0.92 (0.74-1.14)	0.85 (0.36-2.02)	1.32 (0.81-2.14)	1.69 (0.28-10.19)
Delta-HCH	1.23 (1.01-1.49)	1.61 (0.71-3.63)	1.18 (0.97-1.44)	1.02 (0.70-1.49)	1.50 (0.28-8.13)	2.04 (0.51-8.23)
Heptachlodrin	1.04 (0.86-1.25)	1.05 (0.53-2.07)	1.05 (0.83-1.33)	1.02 (0.70-1.49)	1.03 (0.72-1.48)	1.06 (0.45-2.51)
Aldrin	0.94 (0.82-1.08)	0.87 (0.48-1.57)	0.88 (0.76-1.01)	0.86 (0.62-1.19)	1.44 (0.46-4.56)	1.35 (0.67-2.71)
Pyrethroids						
Lambda-cyhalothrin	1.03 (0.89-1.20)	1.07 (0.56-2.04)	1.00 (0.85-1.18)	1.00 (0.70-1.43)	1.25 (0.80-1.94)	1.52 (0.53-4.32)

CHAPTER FIVE

DISCUSSION

5.0 Main findings

In this cross sectional study, the proportion of acute lower respiratory infection (ALRI) was high among the children under five years. This could be attributable to parents sharing the same rooms with children. Also, carrying children while in farm cloths could be assigned to the high proportion of ALRI. Again, burning mosquito coils in children's room minutes prior to sleeping could account for the high proportion of ALRI. Going to the farm with children could be a reason for the high proportion of ALRI.

Contact with contaminated surfaces, unhygienic practices; bad mouthing behaviour and bad food handling behaviour on the farm was common among all children. However, contact with contaminated surfaces; unhygienic practices; bad mouthing behaviour and bad food handling behaviour on the farm was associated with self-reported symptoms of ALRI among children below 1 yr compared to those between 3-4 yrs. There was suggestive evidence of an association between contact with contaminated surfaces, bad mouthing behaviour and symptoms of ALRI. This could be attributable to parents' nonchalant attitude towards the wellbeing of their children. Thus, not paying attention to what they put in their mouths, whether they wash fruits before eating them.

Except for *aldrin*, urine residual levels of organochlorine and pyrethroid pesticides were high. But urine residual levels of organochlorine and pyrethroids pesticides were not related to symptoms of ALRI. Though organochlorines have been banned and pyrethroids are cleared from the body in days, the residual levels recorded could be as a result of persistence from historical application.

5.1 Validity of methodology

The Offinso North Farm Health Study (ONFAHS), from which samples were selected for this study, had a high participation rate therefore, minimizing selection bias. The population for this study comprised children under 5 years who were randomly selected from ONFAHS dataset. Data on pesticide exposure was collected objectively and subjectively and findings on the pesticide body burden and prevalence of exposure experience were the same. Thus, the effect of information bias in this study is minimal. The study population was quite homogeneous with regard to culture and by socio-economic status, reducing the potential effect of unmeasured confounding. Again this is the first study in Ghana to look at this association.

Study Limitations

Irrespective of the strength of this study, the study had some limitations. The ONFAHS study used convenience sampling techniques to select study participants; it was possible that some children may have been missed. However, the effect of this on the study estimates need to be verified. Irrespective of the fact pyrethroid insecticides are metabolized easily in humans, it was measured and traces of pyrethroids were detected. To still detect pyrethroid insecticide residues in the urine samples of children despite the fact that pyrethroids are cleared from the body in just a few days suggested that exposure to pyrethroids was common in the study population and that a single measurement as applied in this present study reflects average exposure over a longer period. Again, the cross-sectional design restricted the ability to discern any temporality. The present findings may be complicated by domestic use of pesticides to control insects, such as mosquitoes, which was not the focus of this study. Future studies that follow farm children prospectively and collect data on occupational and non-occupational use of pesticides will help to clarify this possibility.

5.3 Comparison of present findings with previous studies

Exposure to pesticides and respiratory infection in children under five (5) yrs is a dire public health concern. However, a systematic search of this literature did not identify any study on this in children in Africa as compared to developed countries (Gascon et al. 2012; Dallaire et al. 2006; Koch et al. 2003; Stolevik et al. 2011; Amato et al. 2010; Nigatu et al. 2015). In addition, the finding on direct contact with pesticide and respiratory symptoms confirmed those in an earlier study (Wilkins et al. 1999). The findings are also consistent with recent studies among children living on a farmland (Tagiyeva et al. 2010; Xu et al. 2012).

The finding was confirmed by results obtained in studies among 82 Ethiopian male farmers (Ejigu et al. 2005) and in 108 India farmers (Pathak et al. 2011). On the contrary, studies among Tanzanian coffee plantation workers (Ngowi et al. 2001) and Palestinian male fruit and vegetable workers (Abu et al. 2010) did not observe any significant association of organophosphate or organochlorine pesticide use, respectively with respiratory symptoms. This is in agreement with this study which found no association between ALRI and organochlorine and pyrethroids.

This study was conducted among children under the age of five yrs in a predominately farming community where precautionary and safety measures are problematic. To the best of my knowledge, this study is the first to have investigated the association between pesticides with symptoms of acute lower respiratory infection among children under 5 years. The results suggest that exposure to pesticides through indicators such as contact with contaminated surfaces, unhygienic practices, bad mouthing and food handling behaviour in children under five yrs increases the risk of symptoms of acute lower respiratory infection.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From the results gathered, it could be concluded that there is higher proportion of symptoms of acute lower respiratory infection among children aged below 1 yr compared to children aged 3 yrs.

Also, the study could be concluded that self-reported indicators of exposure to pesticides (contact with contaminated surfaces, hygiene practices, food handling and mouthing behaviour) associated with symptoms of acute lower respiratory infections increased with age among the children both at home and on the farm.

It was finally concluded that except for *aldrin*, urine residual levels of organochlorine and pyrethroid pesticides were high. But urine residual levels of organochlorine and pyrethroids pesticides were not related to symptoms of ALRI.

6.2 Recommendations

From the findings, it is recommended that awareness is created in health facilities for parents on antenatal care on the safety practices to protect their children from being exposed to contaminated equipments. Also, agencies such as agricultural extension officers and the ministry of agriculture must be resourced monetary to educate and train farmers on the 'right' ways of storing and/or keeping their farm equipments. Also, policies should be instituted on use of banned pesticides which persist in the environment for a long while after spraying.

6.2.1 Recommendation for further studies

Longitudinal studies are encouraged to ascertain the findings of this study.

Further research is encouraged to find out the safety practices farmers adopt and association between acute respiratory infections.



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APPENDIX A: INFORMED CONSENT

School of Public Health

University of Ghana

Title of study	Exposure to pesticides and symptoms of acute respiratory infection among children under five years in Offinso North District	
Researcher	Department	Phone
Enoch Akyeampong	Biological, Environmental and Occupational Health	0244818696

Background

Dear participant, Enoch Akyeampong is my name, a student of the School of Public Health, University of Ghana, Legon. I am undertaking a study in pesticide exposure among children under five years. The study hopes to assess the exposure indicators of pesticides and symptoms of acute respiratory infection in Offinso-North District.

Procedures

The study will involve urine samples. Urine sample will be taken from farmers for laboratory analysis. This is purely an academic research which forms part of my work for the award of a master of public health degree. I would be very grateful to have you as part of this study. The farmers will be provided with sterile, metal-free plastic urine containers (50ml). They will be advised to use clean water and soap to wash their hands before handling the sterile metal-free plastic urine containers. They will also be instructed to void out the first portion of the urine stream before the collection of 50 ml midstream urine in the plastic urine container. 10 ml of the urine will then be drawn into each of four sterile sample tubes and stored in refrigerated boxes containing ice packs at (4-8 °C) and transported to the Ghana Atomic Energy Commission for analysis.

Risks and Benefits

The study will not cause any discomfort to participants. It is hoped that results obtained for this study will be used by policy makers and the community in particular to either improve upon existing safety measures or to enforce existing ones with the objective of better protecting farmers from pesticides.

Right to refuse

Participation in this study is voluntary and participants can choose not to answer any particular question or all questions. You are at liberty to withdraw from the study at any time. However, it is encouraged that you participate since your opinion is important in determining the outcome of the study.

Anonymity and Confidentiality

I would like to assure you that whatever information provided will be handled with strict confidentiality and will be used purely for the research purposes. Your data will not be shared with anybody who is not part of the research team. Data analysis will be done at the aggregate level to ensure anonymity. Urine samples will be discarded a week after analysis. Your identity will not be disclosed in the material that is published.

Dissemination of results

The result of this study will be mailed to you if you provide your address below. Before taking the consent, do you have any question you wish to ask about the study?

Yes

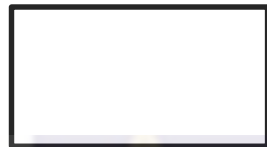
No

Consent

I....., declare that the purpose of the study has been thoroughly explained to me in English language and twi and I have understood. I hereby agree to answer the questions

Signature..... Date.....

Thumb print



Interviewer's Statement

I, the undersigned, have explained this consent form to the subject in the English language that he/she understands the purpose of the study, procedures to be followed as well as risks and benefits involved. The subject has freely agreed to participate in the study.

Interviewer's signature.....

Date..... Address.....

If you have questions later, you may contact me on 0244818696 or Administrator, Ghana Health Service Ethical Review Committee,

Miss Hannah Frimpong – (0507041223/0243235225) OR Miss Nana Abena Kwaa Addai-Donkor – (0244712919)

APPENDIX B: QUESTIONNAIRE

<p>I am student of the School of Public Health, University of Ghana, Legon, conducting a study on postnatal exposure to pesticide and symptoms of acute lower and upper respiratory infections in under five year old children. The questionnaire seeks to collect information on the demographics, pesticide use and hopes to assess the relationship between prenatal and postnatal exposure to pesticides and symptoms of acute respiratory infections among the under five year old children in the Offinso North District. All information will be treated with maximum confidentiality.</p>				
No.	QUESTIONS	Codes	Coding categories	answers
SECTION 1: CHILD DEMOGRAPHICS:				
1	Age at last birthday?	Age		
2	Gender?	Sex	1. Male	
3	Level of education?	Edu	1. crèche 2. kindergarten 3. Lower Primary 4. No education	
4	On the average how many hours does the child spend per week on the farm?	ahof		
5	What type of crop is cultivated?	toce	1. Vegetables 2. Maize 3. Cassava 4. Others Specify.....	
SECTION 2: GUARDIAN'S DEMOGRAPHIC INFORMATION				
6.	Age of Guardian?		
7.	Gender of guardian?		1. Male 2. Female	
8.	Relationship to the child?		
9.	Level of education of the Guardian?		1. Lower primary leaver 2. Junior high school leaver	
10.	Average income of the Household?			
11.	Specific role on the farm			
SECTION 3 PESTICIDES EXPOSURE				
12.	Do you use pesticides in your farms?	upif	1. Yes 2. No	
13.	If yes how long have you been using pesticides (in years)	lopu		
14.	How often does the child come in to contact with pesticides?	ccp	1. Everyday 2. Once a week 3. Once a month	

15.	What activity makes you come into contact with pesticides?	amup	<ol style="list-style-type: none"> 1. transportation of the pesticides 2. mixing 	
16	Where are the pesticides stored before and after use?	psba	<ol style="list-style-type: none"> 1. Home 2. farm 	
17.	Do children have contact with stored pesticides?	chcp	<ol style="list-style-type: none"> 1. Yes 2. No 	
18.	If yes, how often do they come into contact with these stored pesticides?	hosp	<ol style="list-style-type: none"> 1. Everyday 2. Once a week 3. Once a month 	
19.	Where are pesticides mixed before application?	pmba	<ol style="list-style-type: none"> 1. Home 2. Farm 3. both 	
20.	Are there spillages during the mixing process?	spill	<ol style="list-style-type: none"> 1. yes 2. no 	
21	If yes, how often do these spillages occur?	hosso	<ol style="list-style-type: none"> 1. Not often 2. Often 3. Very often 	
22.	Do children have contact with such spillages?	chss	<ol style="list-style-type: none"> 1. Yes 2. No 	
23.	If yes, how often do the children come into contact with spillages?	hocs	<ol style="list-style-type: none"> 1. Not often 2. Often 3. Very often 	
24.	Do pesticides come with specific instructions on how to use?	pcsi	<ol style="list-style-type: none"> 1. Yes 2. No 	
25.	If yes, in what form?	iwf	<ol style="list-style-type: none"> 1. MSDS 2. Label on container 3. Others Specify.....	
26.	Are you aware of any adverse health effects of pesticide?	awep	<ol style="list-style-type: none"> 0. No 1. Yes 	
27	If yes to the above what are preventive measure put in place?	wpmi	<ol style="list-style-type: none"> 1. Utility gloves 2. Goggles 3. safety boot 4. others specify.....	
28.	How often do you use personal protection when coming in to contact with pesticides?	uppc	<ol style="list-style-type: none"> 1. Regularly 2. Sometimes 3. never 	

29.	If no to question 28 any reason for not using any preventive measure?	ntqr	1. discomfort 2. I don't have them 3. Others specify.....	
Proximity of child to contaminated /exposure surfaces				
30	Does the child come into contact with the used protective attire/equipment?	ccue	0. No 1. Yes	
31	Does the child come into contact with contaminated surfaces such as used containers or dresses	cccs	0. No 1. Yes	
32	Does the child play on the ground in the home?	cpgh	0. No 1. Yes	
33	Does the child ingest soil materials at home or farm?	Cish/f	0. No 1. Yes	
3.RESPIRTORY SYMPTOM				
COUGH				
34	Does the child usually have a cough?	Cuhc	0. No 1. Yes	
35	Does he usually cough as much as 4 to 6 times a day, 4 or more days out of the week?	cm4w	0. No 1. Yes	
36	Does the child usually cough at all on getting up, or first thing in the morning?	Ucgu	0. No 1. Yes	
37	Does the child usually cough at all during the rest of the day or at night?	Ucdr	0. No 1. Yes	
38	Does the child cough like this on most days for 3 consecutive months or more during the year?	clom3	0. No 1. Yes	
39	For how many months has this cough been present?	Hmmc	
4.PHLEGM				
40	Does the child usually bring out phlegm from the chest?	Cbpc	0. No 1. Yes	
41	Does he usually bring up phlegm like this as much as twice a day, 4 or more days out of the week?	Bplm	0. No 1. Yes	
42	Does the child bring out phlegm first thing in the morning or on getting up?	Bpfm	0. No 1. Yes	
43	Does the child usually bring up phlegm at all during the rest of the day or at night?	Bpad	0. No 1. Yes	

APPENDIX C: WORK SCHEDULE

Activity	Time interval	Persons in charge	Duration
Proposal submission for ethical clearance	November, 2016	Researcher	
Training of research assistance	January, 2017	Researcher	4 days
Sample and data collection	February, 2017	Researcher and field assistance	4 weeks
Laboratory analysis on urine samples and data sorting and analysis	March, 2017	Researcher and laboratory assistants	7 weeks
Final thesis compilation	May, 2017	Researcher	3 weeks
Submission of thesis	June, 2017	Researcher	



APPENDIX D: BUDGET

Item	Purpose	Expenditure
Research personnel	Allowance for assistance with sample and data collection	800
Ethical review	For clearance to commence data collection	50
Data collection equipment	Ice chest for urine storage, empty plastic containers for urine collection, research questionnaires, stationary	500
Motivation package	To make up for the lost time of participants and to hasten the process of data collection	400
Laboratory analysis cost	170 Urine sample analysis	2000
Communication	Interactions with field assistants, laboratory assistants and project supervisor	100
Transportation and accommodation	Travelling to Offinso-North District from Accra and stopovers at Ghana Atomic Energy laboratory	700
Printing and final binding	Final compilation of research work for submission	80
Miscellaneous	Expenditure not budgeted for	100
Total		4730

APPENDIX E – VARIABLES FOR ANALYSIS

Mouthing behaviour on the farm

When the child accompanies the parent to the farm, how often does the child place thumb/fingers in the mouth?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child accompanies the parent to the farm, how often does the child put nonfood items in the mouth?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how often does the child eats soil on the floor at home?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always at home

When the child is at home, how often does the child eats soil on the floor at home?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how often does the child places thumb/fingers in the mouth?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how often does the child pick nonfood items from the floor into the mouth?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

Food handling practices

On the farm

When the child accompanies the parent to the farm, how often does your child eat food dropped on floor in the farm?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child accompanies the parent to the farm, how often does the child eat food with fingers?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always at home

When the child is at home, how often does the child eat food dropped on floor?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how often does the child eat food with fingers at home?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

Hygiene practices

On the farm

When the child accompanies the parent to the farm, how often does the child crawl on the ground?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child accompanies the parent to the farm, how often does the child wash hands before eating?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

At home

When the child is at home, how often does the child wash hands before eating?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how often does the child crawls on the floor?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

Contact with contaminated pesticides containers/equipment

On the farm

When the child accompanies the parent to the farm, how often does the child come into contact with empty pesticide containers/pesticide containers?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child accompanies the parent to the farm, how often does the child come into contact with pesticide contaminated equipment (e.g. nose mask, goggles, etc)?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child accompanies the parent to the farm, how often does the parent hold or carry the baby when he has not changed into clean clothes?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

At home

When the child is at home, how often does the child come into contact with pesticide contaminated equipment (e.g. nose mask, goggles, etc)?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how does the father hold or carry the baby when he has not changed into clean clothes?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

When the child is at home, how does the mother hold or carry the baby when she has not changed into clean clothes?

- a. Never b. Rarely c. Sometimes d. Most of the time e. Always

