PESTICIDE EXPOSURE AMONG FARMERS IN TRANS-NZOIA COUNTY, KENYA

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DECLARATION

Student Declaration

This thesis is my original work and has not been presented for a degree in any other university or for any other award

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DEDICATION

To my beloved wife Imelda, parents Charles and Consolata, you are the best. My Siblings Ian, Rose, Brian and Faith, you guys are amazing support systems.

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ACRONYMS

CNS- Central Nervous System

DDT- Dichlorodiphenyltrichloroethane

FAO- Food and Agriculture Organization

FGDs- Focused Group Discussions

GDP – Gross Domestic Product

KFA- Kenya Farmers Association

NACOSTI- National Commission for Science and Technology Innovations

SPSS- Statistical Package for Social Sciences

USAF- The United States Armed Forces

MSDS – Material Safety Data Sheets

OPERATIONAL DEFINITIONS

Biomagnification - This is any concentration of a toxin such as pesticides in the tissues of tolerant organisms at successive higher levels in the food chain.

Exposure – The measurement of both the amount of, and the frequency with which, a substance comes into contact with a person or the environment.

Hawthorne effect – Modification of behavior by individuals as a reaction toward being observed.

Neurotoxicity - This is a kind of toxicity whereby a xenobiotic either chemical, physical or biological, causes an adverse effect on the structure and /or function of the nervous system.

Pesticides- Chemicals used to kill or repel pests and they can be classified as insecticides, fungicides, herbicides, nematicides, acaricides and molluscicides.

Threshold Dose- This is the maximum amount of dose for a particular substance

that can be accommodated by the body without causing any adverse health effects. Above this dose is where a response is witnessed.

Toxicity - This is the potential of a substance to cause an adverse effect.

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ABSTRACT

Kenya as a country relies on agriculture to sustain its economy. Agriculture contributes up to 33% GDP. The quality and quantity of agricultural produce is dependent on the use of different pest controlling mechanisms such as pesticides. The use of pesticides exposes farmers to health complications resulting from contact with chemicals through the application and handling. The main objective of this study was to determine pesticide exposure among farmers of Kwanza sub-county in Trans-Nzoia County. The specific objectives were; to determine the exposure rate of farmers to pesticides, to assess the level of knowledge, determine practice associated with handling pesticides, finding out the perceived health effects and determining the significant risk factors associated with pesticide exposure. To achieve its specific objectives, the study employed a cross-sectional study design. The study used purposive sampling to select participants from Kwanza subcounty and stratified random sampling was employed to pick the participants from within the four elective wards. The study involved 323 participants who filled semistructured questionnaires as a data collection tool. In addition to the use of semi-

structured questionnaires, FGDs and observation checklist was also used to collect data. Data was analyzed using SPSS version 22. Confidence interval used to prove exposure proportion, likert scale and a chi square test of independence to determine levels of knowledge and practice, Odds Ratio was used to show the association among variables (Sociodemographics and pesticide exposure). Qualitative data was analyzed and presented thematically according to the study objectives. The proportion of farmers exposed was 61% which was within range of CI calculated (51.6% and 70.4%). The socio-demographic factors income (1.66), gender (2.26), age (1.38) and education (4.02) were found to be strongly associated with pesticide exposure due to their OR values being above 1 and chi square test for independence being below $P<0.05$. Knowledge and practice were below the $P<0.05$ indicating significance and showing good knowledge and practice that is above average. The study established that farmers in Kwanza sub-county in Trans-Nzoia County employed standard practices when handling pesticides. The Gastro intestinal Tract was found to be the primary medium of acute exposure to pesticides among the farmers. The study found out that farmers' knowledge of pesticides increased with high education level and training. On practice, the study established that training offered and level of education of individuals is effective in reducing exposure. The study concluded that farmers of Kwanza sub-county in Trans-Nzoia County had basic knowledge on the best practices to handle pesticides but lacked the necessary finances to implement. Thus, it is recommended that farmers in Kwanza sub-county needed to explore financial platforms to help on financial constraints. Furthermore, emphasis on avoiding contamination to reduce the occurrences of acute toxicity while on the farm should be implemented via sanitation practices. Additionally, it's also recommended that regular monitoring and evaluation of practices when handling pesticides should be done to further increase on the practices of pesticide handling.

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter encapsulates what pesticides are, their uses and the different types according to function and chemical structure. Additionally, the importance of the use of pesticides in agriculture has also been covered in this section. The health effects resulting from exposure to pesticides have been covered with key focus on humans and also why the matter of exposure to pesticides needs global, regional and local attention. Consequently, the problem statement, justification, research questions and objectives have been shown in plain sight to direct this study. The significance of this study, its limitations and delimitations have also been discussed with keen emphasis laid on the conceptual framework as it is the model guiding this study.

1.1 Background of the Study

Pesticides are a large spectrum of substances ranging from herbicides, insecticides, and fungicides all with the aim of preventing destroying or repelling pests from animals or cultivated crops (Barrón et al., 2020). The largest group of pesticides used all over the globe are mostly organophosphate pesticides which includes the classes of fungicides, herbicides, nematicides, acaricides and molluscicides. This class of pesticides has been in use since the early 1940s to control pests with impact on agricultural production and public health (ButlerDawson et al., 2018). Benefits reaped from the use of pesticides are protecting the crops from pests that are otherwise a nuisance to the farmer, increasing the yield of the crop and fighting potential disease-causing vectors to both plants and humans (Barrón et al., 2020). Despite the benefits of pesticides, they also have the potential to cause adverse health effects upon exposure to humans (Kim, Kabir & Jahan, 2017). Due of their high levels of toxicity and widespread use, pesticides present a serious threat to the populations in agricultural communities. Other than children, farmers in low-income countries are largely affected by exposure to pesticides due to poor practices in pesticide handling (Roberts et al., 2018). People

in agricultural communities are deemed to experience higher doses of exposure to pesticides (Chen et al., 2018).

Pesticides have different mechanisms of toxicity. Acute toxicity causes respiratory, Gastrointestinal, skin, eye and nonspecific symptoms like headaches. Neurotoxicity is most of the times a chronic effect except in cases like acute and high dose organophosphate poisoning which cause paralysis and peripheral neuropathy (Kim et al., 2017) Neurotoxicity happens by disrupting the ion channel function or blocking the normal acetylcholine breakdown (Kim et al., 2017). Herbicides have a tendency of affecting both target and non-target organisms. Herbicides have the ability to affect humans both acutely or chronically. Most of herbicides toxicity focuses on the nervous system by blocking normal acetylcholine breakdown (Damalas & Koutroubas, 2017).Neurotoxicity is mostly as a result of chronic effects except in the cases of acute poisoning that could cause symptoms like paralysis, slurry speech diarrhea and even death (Kim, Kabir & Jahan, 2017). Consequently, the dose and duration of exposure determines the degree of toxicity (Damalas et al., 2019). Other factors like the site of exposure usually determine the effects experienced after an exposure has occurred (Lombardi et al., 2021). Other factors that affect toxicity are the type of toxicant, dose, and route of exposure like ingestion, dermal absorption and inhalation (Brooks, 2017). Duration of exposure and age of individuals also affect toxicity (Brooks, 2017). The effects might be acute or chronic in nature (Brooks, 2017). Majority of pesticides have been noted to have the ability to inhibit acetylcholinesterase from breaking down acetylcholine. Sub chronic exposure could result in muscle weakness, muscle twitching, motor function impairment, and sensory disturbances as a result of overstimulation of the nerves and muscles (Kim et al., 2017).

These effects are acute and occur as a result of exposure to high doses of pesticides and within 24 hours (Kim et al., 2017). Long term exposure leads to chronic effects and which may lack symptoms from the onset. Such effects could be mental activity deterioration and learning disability (Kim et al., 2017). Some pesticides have the potency to bio-accumulate in the body of

an organism and cause severe health effects once the threshold dose has been passed (Emanuela et al., 2017). Metabolic syndrome and certain types of cancers have been associated with long term exposure to certain types of defoliant pesticides like Agent Orange which was used in the American Vietnamese war (Stellman & Stellman, 2018). Dichlorodiphenyltrichloroethane (DDT) which has been banned in many developed countries also has a high capability to bio-accumulate and impact negatively on the health of humans. When comparing the acute and chronic exposure to pesticides, chronic exposure has a higher level of occurrence than acute exposure. This is because acute exposure requires huge doses of exposure to the pesticide which is only possible during voluntary or accidental poisoning (Emanuela et al., 2017). However, chronic exposure to pesticides occurs over time. Chronic exposure also occurs when pesticides contaminate ground water and washed into rivers and water reservoirs like lakes which are sources of food and water (Chaza et al., 2018). When an individual is within the environment where pesticides are being applied, it counts as exposure regardless of the amount of dose exposed to an individual (Chen et al., 2018). Exposure is also determined by an individual's knowledge, practice, and perception towards the use of pesticides (Emanuela et al., 2017). Globally, 5.5 billion pounds of pesticides are produced each year and exposes over 1.8 billion workers in farming to pesticide poisoning each year (Mew et al., 2017). Additionally, Africa uses 20% of the 5.5 billion pounds of pesticides produced annually, yet it costs Africa’s health bill excess of $90 billion dollars each year as a result of pesticide use (Mew et al., 2017).

In Kenya, 60% of the 15,600 metric tons imported is classified as bad actor pesticides and harmful to human health (Ali et al., 2021). With the increasing rate of agriculture, pesticide exposure is expected to increase overtime. Therefore, there is need for a study to give insight of the significance between the indices of pesticide exposure and the perceived health effects that might arise from pesticide exposure without forgetting the knowledge and practice of the farmers. Kwanza Sub County, which solely depends on agriculture as a source of economic

sustenance raises the question of finding out if pesticides are of great use in this region. The Kenya Farmers Association of Kwanza sub county are objective in improving lives by growing agriculture in the region by increasing production of the crops. This gives the calculated assumption that pesticides are being employed in large quantities in order to achieve maximum production of food crops since pesticides are important in protecting crops from damage and boosting production (Clutterbuck, 2017). This study targeted farmers since they are in direct contact with pesticides as part of their economic activity.

1.2 Problem Statement

Kenya is highly dependent on agriculture which makes upto 33% of her Gross Domestic Product with an import of pesticides reaching 15,600 metric tons annually (Sun et al., 2020). The tons of pesticides being imported are done in a bid to match the high demand of pesticide use throughout the country's agricultural areas (Kim, Kabir & Jahan, 2017). Bad actor pesticides that have been banned in the western countries have been noted to be exported to African countries that practice agriculture (Jawale et al., 2017). Kenya specifically gets a 44% import of bad actor pesticides from the European Union. The sales data in Kenya also show that 76% of pesticides sales made by Kenya contain more than one active ingredient that has been classified as highly hazardous (Afata et al., 2021). In Kenya, Kwanza sub county the increase in pesticide use has risen from a 55% use of pesticides in 2013 to 70% use in 2020 as recorded in the farmer's registry that also indicates 75% of households are dependent on agriculture for economic sustenance. (KFA, 2020). Transnzoia county alone produces at least 27% of the country's food with kwanza sub county being the leading sub-county in terms of large scale production of maize and vegetables (KFA, 2020). Additionally, the financial reports from the county agricultural committee indicates that as of 2021 Trans-Nzoia county purchases at least 4,200 of pesticides with kwanza sub county using up 45% of the total pesticides purchased by the county (KFA, 2020). This increase in pesticide use increases the susceptibility

of the farmers to pesticide exposure and thus puts them at a higher risk of health effects. This study intended to establish the significant risk factors associated with pesticide exposure and how that exposure impacts on the health of the farmers in Kwanza Sub County. This study also assessed the level of knowledge and practice of use of pesticides. The need to assess knowledge and practice is to establish a guiding tool for putting forth recommendations that focus on filling knowledge gaps and identifying behavioral patterns that may highlight problems for planning and implementation of interventions. Therefore, there was need to carry out a study in Kwanza to determine the significant risk factors. This focus is expected to have a meaningful reduction in the outcome of interest which is reducing pesticide exposure.

1.3 Justification

Pesticides have the potential for bioaccumulation and Biomagnification in humans (Cimino *et al.,* 2016). Exposure could either cause nausea, vomiting, skin rashes and even death or paralysis at high doses. Additionally, chronic exposure could cause cancers, endocrine disruption and even aplastic anemia to the victim (Mostafalou & Abdollahi, 2017).Exposure to pesticides and its effects is dependent on the risk factors such as the type of the pesticide, age of the individual and other socio demographic factors, behavior and the environment (Bernhardt et al., 2017). Knowledge and practice of pesticides have also been identified as some of the risk factors that influence exposure to pesticides (Chaza et al., 2018). Socio demographic factors, knowledge and practice have been identified as risk factors to pesticide exposure but do not show their significance (Mostafalou & Abdollahi, 2017). Additionally, use of different pesticides is common in Kwanza, which could cause additive reactions that might have undocumented health effects due to the different crops being cultivated like: maize, wheat, vegetables, potatoes (Afata et al., 2021). Consequently, Kwanza sub-county hospital records approximately 100 cases of either deliberate or accidental poisoning from pesticides annually. Therefore, results of the study aimed at: identifying the significant risk factors in a bid to come up with programs an intervention to reduce exposure among the farmers. Additionally,

knowledge and practice were interrogated with a goal of identifying gaps and putting forth recommendations from the same to ensure safe practices are maintained. Exploring the perceived health effects was done to identify areas where more research is needed and can guide the development of public health policies within the county and Kenya at large. This study gets its uniqueness from identifying gaps where policies that guide pesticide safety in relation to food safety can be adopted to ensure sustainable human and agricultural productivity. This is done by the policymakers and farmers to make more informed decisions about how to protect crops without putting human health at risk

1.4 Research Questions

1. What is the proportion of farmers exposed to pesticides in kwanza Sub County?
2. What is the level of knowledge on pesticides among farmers of Kwanza Sub County?
3. What are the practices associated with handling pesticides among the farmers of kwanza Sub County?
4. What are the perceived health effects of pesticide exposure among the farmers of Kwanza Sub County?
5. What are the significant risk factors associated with pesticide exposure among farmers of Kwanza Sub County?

1.5 Objectives

1.5.1 Broad objective

To determine pesticide exposure among the farmers of Trans-Nzoia County in Kenya.

1.5.2 Specific Objectives

1. To determine proportion of farmers exposed to pesticides in Kwanza Sub County
2. To assess the level of knowledge on pesticides among farmers of Kwanza Sub County
3. To determine practices associated with handling pesticides among farmers of Kwanza Sub County

4. To establish the perceived health effects of exposure to pesticides among farmers of Kwanza Sub County.
5. To determine the significant risk factors associated with pesticide exposure among farmers of Kwanza sub county

1.6 Significance and Anticipated Output

The findings of this study will help in bridging the gaps that will be discovered among the farmers of Kwanza Sub County. Advising and ensuring that farmers have access to financial options when it comes to farming activities is key in Kwanza sub county. This is important because income plays a huge role in deterring the efforts put forth by good knowledge and safe practices on pesticides. Therefore, providing alternate sources of financial aid for farmers is important. Additionally, advising the farmers to maintain a good credit score is important to help them in getting access to good agricultural loans at good rates.

1.7 Delimitation and Limitation

The scope to which this particular study was carried out, focused mainly on farmers of Kwanza Sub County in Trans-Nzoia County. Farmers were focused on because most of them are at risk of exposure to pesticides. This was attributed to the fact that pesticide use is an occupational hazard for farmers. Carrying out this study had a limitation. The local dialect being spoken among the many farmers of kwanza Sub County is mainly Kalenjin and Luhya. The researcher minimized this limitation by finding locals who willingly acted as translators to those who do not understand English or Swahili.

1.8 Conceptual Framework

This study was guided by the conceptual framework in the figure 1. Socio demographic factors, knowledge and practice were identified to be predictors of pesticide exposure among farmers.

In this model the socio demographic factors comprise of age, gender, education, income. Knowledge includes the health information one has on pesticide exposure and the signs and symptoms of exposure to pesticides. Practices involve the use of PPEs, cleaning after using pesticides, storage and application of pesticides either indoor or outdoor. According to the studies by (Bernhardt et al., 2017) and Ochieng *et al.*, 2016, all the above factors can either act in unison or individually to influence the exposure of a farmer to pesticides.

Independent Variables **Dependent Variable**

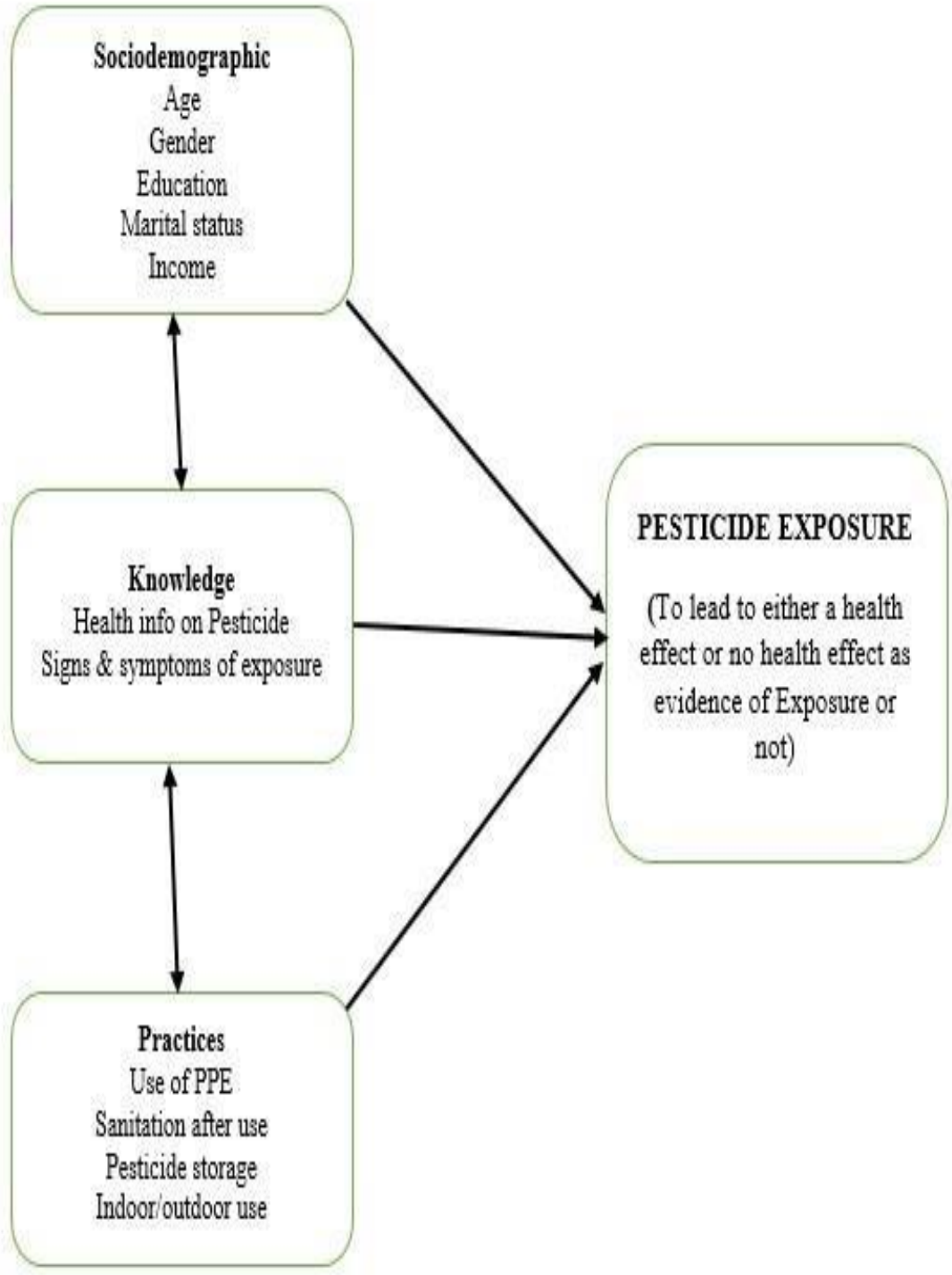

Figure 1: Conceptual Framework

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

In this chapter, a review of literature relating to pesticide exposure and it effects to humans are explored. Furthermore, the history of pesticides, factors that have linked to pesticide exposure have also been discussed to shed more light on how they relate to pesticides using literature review from several studies. The use of pesticides from the early days in Mesopotamia have also been discussed to indicate evolution of pesticide.

2.1 The History of Pesticide Use

Ever since 2000 BC, humans have used pesticides to protect their plants and food from destruction (Tudi et al., 2021). The first ever known pesticide was elemental sulfur that was used about 4500 years ago in Mesopotamia (Tudi et al., 2021). A 4000-year-old Rig Veda tells of how poisonous plants were used to control pest during that ancient time (Brown, 2021). By the time humans were approaching the 15th century the use of toxic chemicals like arsenic, lead and mercury were being largely applied to crops as pesticides. Towards the 17th century, tobacco juice was extracted from tobacco leaves and was used as a pesticide (Tudi et al., 2021). The 19th century also introduced two natural organic pesticides which are rotenone and pyrethrum (Shahrajabian et al., 2021). In the 1950s, arsenic-based pesticides had widely dominated the market. However, towards the 1970s most of the arsenic-based pesticides were replaced by the organophosphate and carbamate pesticides (Meinke et al., 2021). Organophosphate and carbamate pesticides remain the most used pesticides all over the world up to date. Scientific studies are phasing out various types of pesticides because they are being classified as hazardous to human health. An example is the Dichlorodiphenyltrichloroethane (DDT) which was a very effective insecticide used during the second world war as a control measure against mosquitos. (Clarke & Brown, 2022).

However, Dichlorodiphenyltrichloroethane has been banned in many countries due to its

ability to biomagnifying in the food chain. Its bioaccumulation and biomagnification have been found to cause endocrine disruption and development disorders in birds. DDT has also shown ability to cause cancer, damage liver and cause aplastic anemia (Hiyoshi et al., 2023). Other pesticides like 2.4-D, 2.5-T and agent orange are defoliant herbicides that were banned due to their carcinogenic and teratogenic nature (Clarke & Brown, 2022). The herbicides affected many of those who were in contact with the chemicals either directly or indirectly.

2.2 Risk Factors Associated with Pesticides

Pesticides are widely used in agriculture and can have significant effects on human health and the environment. Exposure to pesticides can occur through various routes, including inhalation, ingestion, and skin contact (Afata et al., 2021). Several risk factors have been identified that can affect the likelihood and severity of exposure to pesticides. The severity shall depend on the durations of exposure and how many risk factors as identified are present in an individual (Lombardi et al., 2021). According to a study that which has depicted age, gender income, marital status and level of education as risk factors associated with pesticide exposure among farmers (Afata et al., 2021).

2.2.1 Age: Studies have shown that age can be a risk factor for pesticide exposure among farmers. Studies have shown that older farmers are more likely to be affected by pesticide exposure than younger farmers (Chetty-Mhlanga et al., 2021). This vulnerability is due to several factors, including decreased immune function, reduced metabolism, longer exposure time, and pre-existing health conditions (Afata et al., 2021). As farmers age, their immune function decreases, making them more susceptible to the adverse effects of pesticides. Pesticides can weaken the immune system, leading to increased susceptibility to infections and other illnesses (Ali et al., 2020). Furthermore, older farmers may have pre-existing health conditions that make them more vulnerable to the adverse effects of pesticides. Metabolism also plays a crucial role in the vulnerability of older farmers to pesticide exposure (Hofmann

et al., 2021). As individuals age, their metabolism slows down, which means that pesticides may remain in their bodies for longer periods, leading to increased exposure and potential adverse health effects (Shammi et al., 2020). Additionally, older farmers may have been exposed to pesticides for longer periods than younger farmers. This extended exposure can increase the likelihood of chronic health effects associated with pesticide exposure, such as neurological disorders and cancer. Furthermore, older farmers may be more reluctant to adopt new farming practices that can reduce pesticide exposure (Ali et al., 2020). This reluctance may be due to a lack of knowledge, resources, or resistance to change. As a result, older farmers may continue to use outdated and potentially harmful farming practices, leading to increased exposure to pesticides (Chetty-Mhlanga et al., 2021).

2.2.2 Income Level: Low-income individuals may be at increased risk for pesticide exposure due to their greater likelihood of working in agriculture or other industries where exposure to pesticides is common (Barrón et al., 2020). For example, a study of Latino farmworkers in North Carolina found that those with lower incomes had higher levels of pesticide metabolites in their urine compared to those with higher incomes (Mueller et al., 2022). Low-income individuals may also be less able to afford protective equipment or to seek medical treatment if they experience symptoms of pesticide exposure (Mueller et al., 2022).

2.2.3 Gender: Women may be at increased risk for pesticide exposure due to their greater likelihood of working in agriculture or other industries where exposure to pesticides is common. For example, a study of farmworkers in California found that women had higher levels of pesticide metabolites in their urine compared to men, and that women who were pregnant had even higher levels of metabolites (Pinto et al., 2020). In addition, women may be more vulnerable to the effects of pesticides due to their hormonal differences, which can affect the way their bodies metabolize and eliminate toxins (Pinto et al., 2020).

2.2.4 Marital Status: Marital status may also be a risk factor for pesticide exposure. Single individuals may be more likely to work in agriculture or other industries where pesticide exposure is common, and may not have the same level of social support as married individuals, which can affect their ability to take protective measures (Manley et al., 2022). For example, a study of rural farmers in China found that unmarried farmers were more likely to use pesticides without protective equipment compared to married farmers (Yuan et al., 2022).

2.2.5 Education Level: Individuals with lower levels of education may be at increased risk for pesticide exposure due to their lack of knowledge about the risks associated with pesticides and how to properly handle and dispose of pesticides (Afshari et al., 2021). For example, a study of smallholder farmers in Ethiopia found that those with lower levels of education were less likely to use protective equipment when applying pesticides compared to those with higher levels of education (Tessema et al., 2021). In addition, individuals with lower levels of education may be more likely to work in agriculture or other industries where pesticide exposure is common. Understanding these risk factors can help policymakers and individuals take steps to reduce exposure to pesticides and protect human health and the environment (Afshari et al., 2021). Targeted interventions may be needed for vulnerable populations, such as low-income individuals, women, and those with lower levels of education.

2.3 Knowledge Associated with Pesticides

Knowledge is an important factor that can influence pesticide exposure. Individuals who are knowledgeable about the risks associated with pesticides and how to properly handle and dispose of them may be less likely to experience adverse health effects from exposure (Afshari et al., 2021). On the other hand, individuals who lack knowledge about pesticides may be more likely to handle them improperly or to be exposed to them accidentally (Tessema et al., 2021). Several studies have examined the relationship between knowledge and pesticide exposure, with varying results. For example, a study of farmers in India found that those who had more

knowledge about pesticides were more likely to use protective equipment when applying them (Afshari et al., 2021). Another study of smallholder farmers in Ethiopia found that those who had received training on pesticide use and safety were more likely to use protective equipment and to dispose of pesticides properly (Afshari et al., 2021).

However, other study (Sharifzadeh & Abdollahzadeh, 2021) have found that knowledge alone may not be sufficient to prevent pesticide exposure. For example, a study of Latino farmworkers in North Carolina found that although many of the workers had received training on pesticide safety, they still experienced high levels of exposure due to a lack of access to protective equipment and inadequate training on how to use it (Walton et al., 2021). Similarly, the study of farmworkers in North Carolina found that although many of the workers were aware of the risks associated with pesticides, they still experienced high levels of exposure due to a lack of access to protective equipment and inadequate training on how to use it (Walton et al., 2021).

Several factors may influence the effectiveness of knowledge in reducing pesticide exposure. One important factor is access to protective equipment (Sharifzadeh & Abdollahzadeh, 2021). Even if individuals are knowledgeable about the risks associated with pesticides, they may not be able to protect themselves if they do not have access to gloves, respirators, and other protective equipment. In addition, the cost of protective equipment may be prohibitive for some individuals, particularly those with lower incomes. Another important factor is the language in which training is provided (Walton et al., 2021). Many farmworkers in the United States speak Spanish or indigenous languages, and may not be proficient in English. Training that is provided in a language that workers do not understand may be less effective in preventing pesticide exposure.

2.4 Pesticide handling Practices and its Association with Pesticide Exposure

Pesticides are widely used in agriculture and other industries, and improper handling and

application can lead to exposure and adverse health effects. Proper handling practices can help to reduce the risk of exposure and protect the health of individuals who work with pesticides (Kosamu et al., 2020). Several studies have examined the relationship between handling practices and pesticide exposure, with varying results. For example, a study of farmers in Sri Lanka found that those who used backpack sprayers to apply pesticides had higher levels of exposure than those who used hand pumps (Sumudumali et al., 2021). Another study of farmers in China found that those who applied pesticides using high-pressure sprayers had higher levels of exposure than those who used low-pressure sprayers (ZHANG et al., 2022).

In addition to the type of equipment used, other handling practices can also impact pesticide exposure. For example, a study of grape growers in Italy found that those who wore gloves and other protective equipment when handling pesticides had lower levels of exposure than those who did not (Garrigou et al., 2020). Additionally, those farmworkers in Italy found that those who used a wash station to clean their hands and equipment after working with pesticides had lower levels of exposure than those who did not (Garrigou et al., 2020). Several factors may influence the handling practices used by individuals who work with pesticides. One important factor is access to protective equipment (Walton et al., 2021). Individuals who do not have access to gloves, respirators, and other protective equipment may be more likely to experience exposure when handling pesticides. Another important factor is training. Individuals who have received training on how to properly handle and apply pesticides may be more likely to use protective equipment and to follow other best practices (Sharifzadeh & Abdollahzadeh, 2021). In addition, individuals who have received training may be more likely to understand the risks associated with pesticides and to take steps to protect themselves from exposure (Tessema et al., 2021).

Proper handling practices can help to reduce the risk of pesticide exposure and protect the health of individuals who work with pesticides. The type of equipment used, the use of

protective equipment, and other handling practices can all impact pesticide exposure (ZHANG et al., 2022). Access to protective equipment and training on best practices may be important factors that influence handling practices (Tessema et al., 2021). Targeted interventions may be needed to ensure that all individuals who work with pesticides have access to the information and resources needed to protect themselves from exposure.

2.5 Pesticide Exposure and Its Health Effects

Over 50% of people in Africa define exposure to pesticide as pesticide poisoning (Degrendele et al., 2022). In reality, pesticide poisoning and pesticide exposure are closely related but very different in meaning. Exposure to pesticide means that an individual is within the environment where pesticides are present regardless of the dosage absorbed (Amoatey et al., 2020). Very many people are exposed to pesticides but they think they have never been exposed to pesticides because of their twisted understanding of being exposed to a pesticide (Buralli et al., 2020).

Exposure to pesticides can be discussed as acute exposure and chronic exposure. Acute exposure is being in contact with the pesticide at either high doses or low doses and lasts less than 24 hours (Ali et al., 2021). Chronic exposure is long term exposure to a pesticide (Leonel et al., 2021). This means that the exposure is continuous and repeated over time. Such kind of exposure leads to build up of the pesticide in the body of the exposed individual to cause long term health effects (Eddleston, 2020).

Effects of acute and chronic exposure to pesticides manifest as acutely, sub-chronically or chronically (Ali et al., 2021). Acute effects mean the effects that an individual develops after less than 24 hours of exposure to a particular pesticide (Leonel et al., 2021). The sub-chronic effects of pesticide exposure are the effects that are experienced after a period of not more than 3 months after exposure to a particular pesticide while chronic effects are the effects that are experienced after more than 3 months of exposure to a particular pesticide (Ali et al., 2021).

Acute effects of exposure to pesticides are irritation of the contact part, respiratory problems, sneezing, vomiting, severe headache and even coma depending on the type of pesticide (Afshari et al., 2021). Acute effects usually manifest very quickly because the threshold dose has been surpassed. The dosage needed to cause such acute effects might not cause death but is enough to interfere with normal biochemical processes (Amoatey et al., 2020).

Sub-chronic effects of exposure to pesticides will usually occur as a result of repeated exposure. Such effects which occur under a period of 3months usually are mostly sensory and behavioral (Eddleston, 2020). The central nervous system is the target organ system of most pesticides. Sensory and behavioral interferences are observed because some pesticide hinder the acetylcholinesterase from breaking down acetylcholine (Leonel et al., 2021). This will lead to neurological problems such as disrupted motor function, reduced mental activity, fading memory and sometimes suppressed immunity. Chronic effects which manifest after a period of a long time of exposure occur over a period of above three months to years after exposure. Mostly these effects have no symptoms at all until when their effects are optimal (Amoatey et al., 2020). Some effects of long-term exposure to pesticides mainly are mutagenicity, carcinogenicity, and teratogenicity (Ali et al., 2021). Mutagenicity is the ability of a toxicant to cause mutations and genetic alterations. These are toxicants that can damage the DNA resulting in mutations (de Oliveira et al., 2020). An example of a mutagenic pesticide is a defoliant herbicide known as agent blue. Mutagenic effects could lead to the occurrence of metabolic diseases like diabetes mellitus to those exposed later in life (Stellman & Stellman, 2018)

Carcinogenicity is the ability of a toxicant to induce cancer (Berni et al., 2021). This causes the uncontrolled growth of cells and making others have the ability to metastasize. Examples of carcinogenic pesticides are arsenic-based pesticides (Ali et al., 2021). Agent Orange is also a good carcinogenic pesticide that affected most of the war veterans who were exposed to this pesticide even acutely (Patel & Sangeeta, 2019). Pesticides are also teratogenic and cause harm

to an unborn child without affecting the mother (Patel & Sangeeta, 2019). Exposure to some pesticides has proven to cause congenital birth defects. Such pesticides include the glyphosatebased herbicides (Ali et al., 2021). Pregnant women in their first trimester should stay clear of such pesticides even in the smallest doses possible.

2.6 Summary of Literature Review

Pesticides are chemicals used in agriculture to control pests and increase crop production. However, they pose significant risks to human health and the environment. A literature review was conducted to identify the risk factors associated with pesticide exposure, knowledge and practices associated with handling pesticides, and the health effects of exposure to pesticides. Regarding the risk factors associated with pesticide exposure, several studies have shown that age, gender, income, marital status, and education level are risk factors (Afshari et al., 2021). For example, children are more vulnerable to pesticide exposure due to their developing bodies, while women who work in agriculture are more likely to experience adverse effects from pesticide exposure. Additionally, low-income individuals who work in agriculture are more likely to be exposed to pesticides due to their work environment.

Regarding knowledge and practices associated with handling pesticides, research indicates that there are gaps in knowledge and practices related to pesticide use and handling (Ali et al., 2021). For example, many farmers and agricultural workers lack proper training on how to safely use and handle pesticides. This lack of knowledge and training can result in increased exposure to pesticides and subsequent health effects (ZHANG et al., 2022). Finally, research has shown that exposure to pesticides can have significant adverse health effects (Afshari et al., 2021). These effects can range from short-term effects such as skin irritation and nausea to long-term effects such as cancer and reproductive problems (Patel & Sangeeta, 2019).

Additionally, individuals who are regularly exposed to pesticides are more likely to experience chronic health problems, such as neurological disorders and respiratory problems (Patel & Sangeeta, 2019).

The literature review highlights the risk factors associated with pesticide exposure, including age, gender, income, marital status, and education level (Afata et al., 2021). It also highlights the gaps in knowledge and practices associated with handling pesticides and the adverse health effects of exposure to pesticides (Afata et al., 2021). This information is critical in identifying strategies to mitigate the risks associated with pesticide exposure and protect human health and the environment. The study aims to Protect human life and environment by identifying the gaps that have been left out in policy regulations on pesticide use and agriculture and coming up with strategies and research programs to curb the identified gaps in policy application and research findings.

CHAPTER THREE: MATERIALS AND METHODS

3.0 Introduction

This chapter addressed all the methodological procedures that were employed to ensure that the objectives of this study are achieved. The chapter described the research design, variables of the study and the study area. Additionally, this chapter described the sampling methods, study population and methods of data collection inclusive of the study piloting, data analysis and finally the logistical and ethical consideration of the study.

3.1 Research Design

A cross-sectional study design was utilized in this study. This research design allowed for the reporting of matters as they were at that point in time, therefore, giving the actual situation of an event within study population. This study design was preferred since it permits the researcher to look into numerous characteristics at once in a population (Mackey & Gass, 2015). This applied to this study because the socio demographic factors were looked at in a bid

to find the significant ones in relation to pesticide exposure. Additionally, the study design enabled the researcher to look at the prevailing characteristics in the study population like behavior in terms of practice and knowledge towards pesticides among the farmers of Kwanza sub county.

3.2 Independent and Dependent Variables

The independent variables of the study were socio demographic factors, knowledge, and practice of a farmer. The dependent variable was pesticide exposure. The independent variables were evaluated to ascertain how they impacted on the dependent variable. The following are the ways in which the variables were operationalized in this study.

Pesticide exposure: This dependent variable was operationalized by observing, documenting and checking against the acute classification template for pesticide exposure as approved by WHO. This was done after using observation checklists, including health professionals in hospitals to identify known treated cases and perceived health effects from farmers as reported.

Knowledge on pesticides: This independent variable was operationalized by measuring the level of knowledge that farmers have about the risks associated with pesticide use, as well as their understanding of safe handling and disposal practices. This was done using surveys and questionnaires that assessed farmers' knowledge of pesticides and their safe use.

Practices associated with handling pesticides: This independent variable was operationalized by measuring the actual practices that farmers use when handling, storing, and disposing of pesticides. This was done using observations and surveys that assessed the use of protective clothing, storage practices, and disposal methods.

Perceived health effects of pesticide exposure: This independent variable was operationalized by measuring farmers' perceptions of the health effects of pesticide exposure. This was done using surveys or interviews that ask farmers about their experiences and concerns related to pesticide exposure before and after application to establish a baseline and eliminate bias.

Socio-demographic factors: These independent variables were operationalized by collecting information on age, gender, income, and education level of the farmers.

3.3 Location of the Study

This study was carried out in Kwanza Sub County. This is one of the five sub-counties of TransNzoia County. This county is found on the western region of Kenya with a population of 1.3 million people and measures 2,483 square kilometers. Kwanza Sub County has a population of 203,813 people and measures approximately 466.9 square kilometer. Kwanza Sub County is located in the coordinates 1.0191^0 N, 35.0023^0 E. This study area was purposively chosen because it has 16,650 households from which 70% depend on agriculture as their source of economic sustenance and livelihood.

3.4 Study Population & Target population

The target population for this study were the inhabitants of Kwanza Sub County located in Trans-Nzoia County with approximately 25,000 registered farmers as of the farmers' association register in 2021. The study population were the farmers that were selected to participate in the study and the agricultural extensional farmers and the practitioners working in the agrovets.

3.5 Sample Size Determination

The Sample size determination was done in line with Fishers *et al.* (1998) formula of sample size determination since the number of registered farmers in the association from kwanza Sub County is 25,000. Therefore, n>10,000. Data from the Kenya farmers' association also indicated that 70% of the farmers share a common characteristic which is pesticide use for their agricultural activities (KFA, 2020). Therefore, the sample size was calculated as follows:

$$\mathbf{n = \frac{(Z^2 pq)}{d^2}}$$

Whereby: **n** = the desired sample size (n>10,000)

Z = the standard deviation at the specific required level of confidence (1.96) **p** = given there was current data from the KFA depicting that 70% of the farmers used pesticides for their agricultural activities, the researcher chose this percentage as the proportion estimated to bear similar characteristics in the constituency. **d** = this is the level of statistical significance usually at (0.05) **q =1- p (0.7)**

Therefore: = $\mathbf{\frac{(1.96^2 \times 0.7 \times 0.3)}{0.05^2}}$ **= 323 respondents.**

3.6 Inclusion Criteria

Individuals included in this study were the residents of kwanza Sub County, who carried out their farming activities within Kwanza and who gave consent to participate.

3.7 Exclusion Criteria

Those excluded from this study are those individuals that have a history of diagnosed mental illness, those who fail to consent to partake in the study, those below the legal age in Kenya, those who cannot communicate effectively and those that are not actively engaged in farming.

3.8 Sampling Technique

The researcher referred to the Trans-Nzoia county database on farmers (KFA, 2020) and the Kenya Farmers Association (KFA, 2020) to purposively select the population of farmers with the most similar characteristics, which is the use of pesticides in this constituency. Stratified sampling was utilized to form strata which were the four wards of Kwanza constituency. The wards are Kapomboi, Kwanza, Keiyo, and Bidii. Equal proportions of the total desired sample size were calculated. Finally, simple random sampling was used to select respondents from each ward.

Table 3.1: Sampling Framework Breakdown

Purposive sampling	Stratified sampling	Simple random sampling

25,000 registered farmers	Use of wards to make strata 1.Kapomboi, 2. Kwanza 3. Keiyo 4. Bdii	Used to give selected respondents equal chance of participation from each ward
Total	Bidii-8,000 farmers	8,000/25000x323= **104**
	Keiyo-4790 farmers	4790/25000x323=**61**
	Kwanza -6750 farmers	6750/25000x323=**70**
	Kapomboi-5460 farmers	5460/25000x323=**88**
		323

3.9 Data Collection Instruments

The data collection instruments employed in this study were questionnaires (appendix V), and observational checklist (appendix VII). The research instruments were created and validated through the following processes.

Defining the research question and objectives: The research question and objectives guided the development of the research instrument. This was through clear definition and operationalization of the variables used in the study.

Review existing literature: Reviewed existing literature on the topic objectively to identify existing validated instruments or items that were adapted for the study. This also provide insights into the appropriate response options, question format, and scales to be used. **Pilot test**: Pilot tested the instrument with a small sample of the population to identify any issues or challenges with the instrument, such as ambiguous wording, confusing response options, or missing items.

Revise the instrument: Based on feedback from the pilot test, revised the instrument as needed to ensure accuracy and consistency.

3.9.1 Questionnaires

Questions focused on knowledge and practice were applied through the questionnaires. The questionnaires were interview admitted to all the farmers handling pesticides in kwanza sub county. The questionnaires had sections on demographic data, pesticide exposure and health of

farmers, knowledge, practice and perceived health effects from the exposures. The questions used to evaluate knowledge and practice were measure using a 5-point Likert scale whereby 1 point represents poor knowledge and practice while 5 points represents excellent conduct in knowledge and practice.

3.9.2 Observation Checklist

In assessing the extent to which knowledge, practice and behavior influences the use of pesticides among the framers of Kwanza, a complete observer checklist was employed. This was important in minimizing the Hawthorne effect since participants are more likely to work naturally when they are not aware of any observation. Additionally, for effective results without bias and for the purpose of establishment of a baseline, the checklist was filled before and after the farmers were going to apply pesticides in their farms. The checklist was used to evaluate the use of PPEs while handling and spraying pesticides and the awareness on the health effects as highlighted in the MSDS of the various pesticides both in the farms and in the agro vet shops. The customized checklist was intended to observe the practice of the farmers as they interact with pesticides in their farms. A complete observer scenario was applied to overcome the

Hawthorne effect.

3.10 Data Collection Techniques

3.10.1 Focused Group Discussions

Understanding individual thoughts and knowledge concerning a particular aspect require a conducive environment that gives them the opportunity to express their views freely. Focus group discussions (FGDs) is one of the essential tools that can explore an individual's mind by giving them the opportunity to communicate their ideas. In the FGDs (appendix VI), farmers were provided with an avenue to express their views concerning the use of pesticides and their understanding of the application procedures as well as exchange information according to their understanding of the pesticide use. The technique provided the researcher with a direct contact

with the respondents to help them understand the actual thought concerning the application of pesticides. In this case, the researcher used the opportunity to observe the farmers' vigor as they express their views and understanding of pesticides.

To ensure that the farmers from Trans-Nzoia County engaged in meaningful discussions, the study divided the participants into 3 different focus groups. Each group consisted of between 6 and 8 famers who volunteered to engage in the discussion. In addition, 10 members from agricultural extension officers and 10 from agrovet business enterprises were involved in the discussions. The reason for using 3 FGDs in this study is due to the specificity of the research questions the three FGDs gave quite a clear representation and insight of the target population. Additionally, settling on three was considered just enough response and time saving factor for the KFA because these discussions were held during a high season of planting thus the KFA officials would not be available for longer periods of the discussions being conducted. The agricultural extension officers and agrovet business enterprises joined the discussion as the specialized members whose role was to discuss the issues on pesticides from an expert point of view.to control the bias that could arise due to the difference in background and existence in the line of work, ground rules were established on how questions were to be answered. Additionally, the analysis of the data retrieved was done objectively to ensure no personal opinions are brought into the discussion. Also ensuring the moderator of the discussion is neutral and gives equal chances of participation for all participants was key in controlling for bias. It was also wise not to use the same farmers that partook in the questionnaire since participants may feel pressured to respond to the FGD questions in a way that aligns with their previous survey responses, rather than providing their honest opinions or experiences. This may lead to social desirability bias, where participants give answers they believe are expected or socially acceptable rather than their true opinions. However, their views were also put under scrutiny and farmers had the chance to clarify issues that they did not understand. The 10 agricultural extension officers and the 10 representatives from agrovet business were equally

distributed in the 3 focus discussion groups to aid in creating a meaningful discussion. The discussion topic was guided by the research questions about the study subsection on knowledge as indicated (appendix VI). These questions were generated from the research questions indicated (appendix V).

The discussion in the focus groups was conducted with the full understanding that some farmers had difficulties in understanding the English language. Therefore, to ensure each participant contributed in the discussion, English, Kiswahili, and the local language (Luhya) were used. This was to ensure that some farmers do not feel left out as the discussion continued. Each discussion session was allowed up to 2 hours to ensure that all aspects under discussion are allocated sufficient time to allow each participant to communicate their thoughts. To ensure that there is accuracy in capturing the participants' views on the use of pesticides, all discussions were audio-recorded and the audio file safeguarded for references at the data analysis stage.

3.11 Pilot Study

Designing and testing of instruments of research is key before use in a study.

The pretesting of research tools was carried out in Saboti Sub County, Trans-Nzoia County using 10% of the sample size. This Sub County has similar characteristics as compared to kwanza Sub County in relation to farming activities. The questionnaires were checked for any unquantified questions. Appropriate and accurate instruments for data collection were reviewed by the supervisors to ensure that tools for data collection were up to standard. The observation checklist was also checked to ascertain that it indeed fits the study design and objectives of the study.

3.12 Data Analysis

Statistical analysis of the data was done using the Statistical Package for Social Sciences version 22 of 2018. Descriptive statistics was used to determine the proportion of farmers

exposed to pesticides. Descriptive statistics also presented data from the Likert scale analysis for the farmer's knowledge and practice, the mean and standard deviation were calculated and a chi square test with a cut-off value of $P< 0.05$ used to carry out the statistical significance test to determine the level of knowledge and practice in kwanza sub county as poor or good. An acute pesticide exposure classification chart also used to establish the perceived health effects among farmers with help of health professionals. Inferential statistics via the binary logistic regression used to determine the significant risk factors to pesticide exposure. It was used to determine if there is a significant association between the exposure to a risk factor and the outcome of being exposed to pesticide with the presence of health effect. The qualitative data collected from the FGDs was analyzed through thematic context analysis. The themes used in analysis in relation to the FGD's were (Exposure via interaction, consequences of use, exposure and poisoning, additional education when buying). This was done by the qualitative coding software (Delve) to come up with narratives in relation to the FGD's questions. Responses generated from the discussions were analyzed through the identification of main patterns to find relation in the answers given. Repetitions, conjunctions and filler words were eliminated to help put the responses into specific codes and patterns for easy understanding of the narratives.

3.13 Ethical Consideration

After the approval of this proposal study by Kenyatta University Graduate School, clearance was sought from the Kenyatta University Ethical and Review Committee (appendix X), National Commission for Science, Technology, and Innovation (NACOSTI) (appendix VII) and the County government of Trans-Nzoia (CGTN) (appendix VIII). Consequently, all participants were provided with a written form of informed consent to which they signed when they agreed to participate voluntarily. Assurance of confidentiality was that the data obtained from this study was only used for research purposes. The participants were also made to

understand through the informed consent that there were no monetary benefits of any kind for participating in this study. However, they were informed of the purpose of this study and the benefits that their data will bring in terms of pesticide safety.

CHAPTER FOUR: RESULTS

4.0 Introduction

This chapter contains the results of the outcome documented from the data obtained through questionnaires, FGDs and observational checklist from the farmers of Kwanza Sub-County. The results have been presented in line with the objectives of this study, respectively.

4.1 Proportion of Farmers Exposed to Pesticides

The use of pesticides leads to the exhibition of various health effects that are displayed differently in individuals. The effects largely range from gastro intestinal issues, neural effects, and muscle weakness depending with the type of pesticide one has been exposed to acutely. The effects act to affect specific target organs that otherwise affect how different systems of the body work. To verify that there has been some level of exposure is that the farmers will have to exhibit some kind of effect that has been checked against the acute pesticide classification tool. Therefore, to determine the proportion of farmers that has been exposed in kwanza Sub County, using the effects noted by farmers from the perceived health effects is key. The multi morbidity scenario is very important in ensuring that no farmer is counted twice since there are those that had more than one effect from pesticide exposure.

Therefore, as indicated 198 participants in total each had at least one perceived effect as noted from the figure below. From the total participants of 323 farmers, 198 of them showed an outcome of exposure from the exhibition of symptoms that were established from the classification tool on acute pesticide exposure. Multi morbidity and co morbidity was experienced and to avoid overlapping and counting of participants twice was avoided thus registering all those had at least one outcome on exposure since there were different symptoms

ranging from GIT, Nervous system disruption and those associated with muscle weakness. Therefore, it is clear to now say that 61% of farmers from kwanza Sub County are exposed to pesticide and have shown an outcome from their perceived health effects while 39% have not shown any outcome in terms of the symptoms associated with pesticide exposure. The 61% is within the calculated confidence interval of 51.6% and 70.4%. Thus making it an appropriate representation.

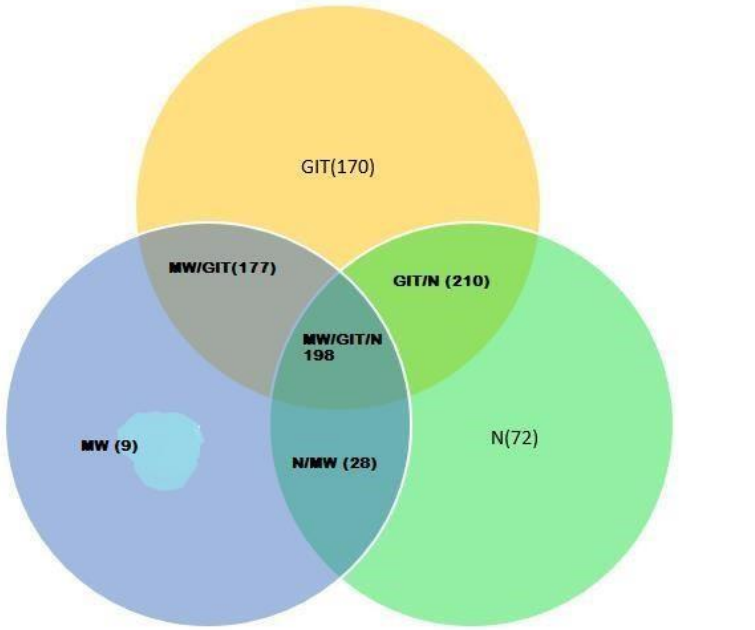

Figure 2: A representation of the multi morbidity noted from farmers on those who exhibited symptoms after exposure to pesticides.

The noted effects were classified as GIT, muscle weakness, neural problems. Effects classifying is courtesy of the acute pesticide classification tool and verification of classification from kwanza sub county hospital health personnel.

The proportion of farmers exposed was arrived at by dividing the number of participants that were exposed to the total number of participants in the study. This gives 198 participants divided by 323. This gives 0.61. Multiplying 0.61 by 100 gives 61%. Therefore, it is evident

that the proportion of farmers exposed to pesticide in kwanza Sub County is 61%. In order to prove the authenticity of this exposure rate, confidence interval shall be calculated:

Standard error = sqrt[(p*(1-p))/n]
Standard error = sqrt[(0.61*(1-0.61))/100] = 0.048

The margin of error is calculated by multiplying the standard error by a critical value based on the level of confidence and the distribution of the data. For a 95% confidence level, the critical value for a normal distribution is approximately 1.96. Thus, the margin of error would be:

Margin of error = 1.96 * 0.048 = 0.094

The confidence interval is calculated by adding and subtracting the margin of error to the point estimate. In this case, the confidence interval would be:

Confidence interval = 0.61 ± 0.094

Confidence interval = (0.516, 0.704)

This means that we are 95% confident that the true proportion of farmers exposed to the pesticide in the population lies between **51.6% and 70.4%.**

Thus indicating that the exposure proportion among the farmers (61%) is within the calculated range of exposure.

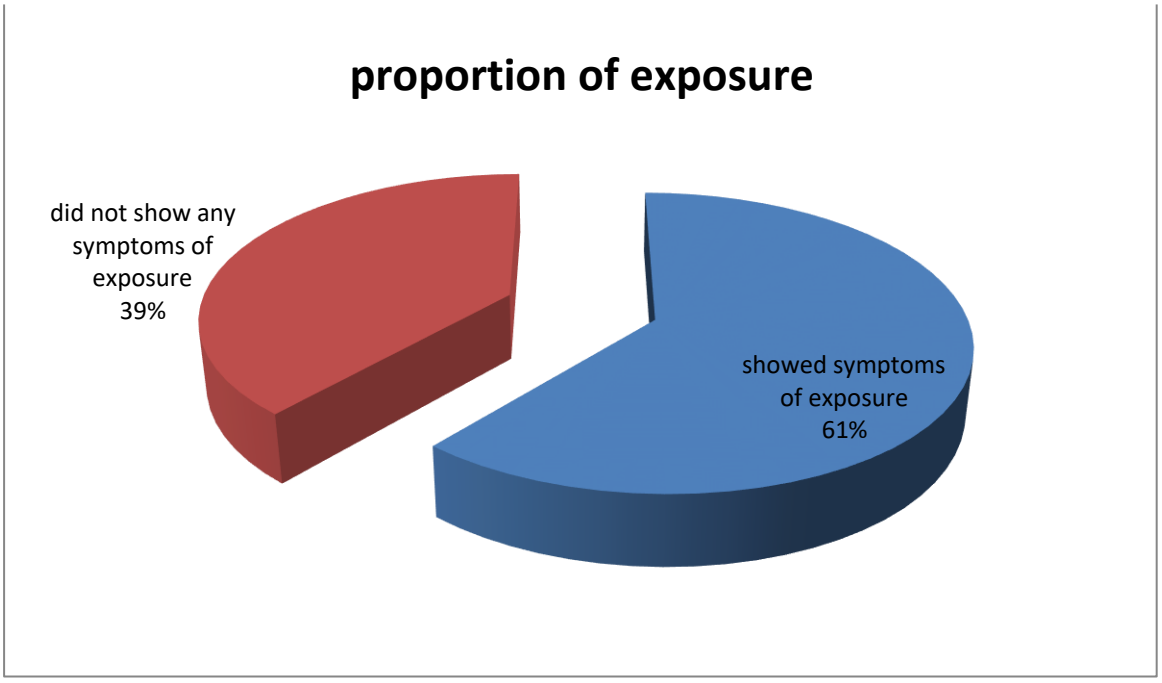

Figure 3: The percentage of farmers that were exposed to pesticide and displayed symptoms of exposure within kwanza Sub County

4.2 Knowledge on Pesticides in Kwanza Sub County

On understanding the label on pesticides (46.4%) strongly agreed that it is necessary for farmers. Conversely, on the importance of applying pesticides to plants, 200 (61.9%). Farmers strongly disagreed. Majority of the farmers 160 (49.5%) strongly agreed that pesticide is harmful to health. On matters of getting exposed to pesticides when being applied in close proximity 180 (55.7%) farmers strongly agreed that close handling of pesticides exposes them. On the question of applying pesticides to crop all the time 150 (46.4%) strongly disagreed and disagreed 139 (43%) respectively. On the importance of attending training, 127(39.3%) farmers strongly agreed and 149 (46.1%) agreed on the matter respectively.

Table

4.1: Responses for the knowledge and understanding of pesticide use in kwanza

Sub County

Knowledge	Category	Number	Percentage (%)
Understand Label written	Disagree	10	3.1
	Undecided	43	13.3
	Agree	120	37.2
	Strongly agree	150	46.4
Total		323	100
Applying to plants important?	Agree	122	37.8
	Undecided	1	0.3
	Strongly disagree	200	61.9
Total		323	100
Harmful to health			
	Undecided	12	3.7
	Agree	151	46.7
	Strongly agree	160	49.5
Total		323	100
Close proximity exposure	Disagree	16	5.0
	Undecided	30	9.3
	Agree	97	30.0
	Strongly agree	180	55.7
		323	100
Pesticide all time good for crops?	Disagree	139	43.0
	Undecided	14	4.3
	Agree	20	6.2
	Strongly disagree	150	46.4
Total		323	100
Importance on attending training	Disagree	12	3.7
	Undecided	35	10.8
	Agree	149	46.1
	Strongly agree	127	39.3

Table

Total	323	100

4.2: Chi square values from chi square test of significance to determine the p value as a cut off point for knowledge being good average or below average

Knowledge	Value	Df	P value
Understand label written	242.22	9	.000
Applying to plants important?	150.89	6	.000
Harmful to health	182.76	6	.000
Close proximity exposure	199.23	9	.000
Pesticide all time good for crops?	43.65	9	.000
Training importance	192.07	9	.000

4.3 Practice on handling pesticides in kwanza Sub County

The results indicated that the majority of the farmers 157 (48.6%) agreed that PPE's were critical when handling pesticides. Additionally, concerning application of pesticides on a windy day the majority 198 (61.3%) strongly agreed that it was wrong to do that. The majority 168 (52%) strongly agreed and 132(40.8%) agreed that it was important to clean both tools and body after using pesticides. Results also indicated that (83%) of respondents both strongly agreed and agreed that is important to store pesticides away from house. On mixing pesticides, 139(43%) farmers strongly disagreed and 143(44.2%) disagreed respectively. Majority of

Table

farmers 161(49.8%) strongly agreed and 96(29.7%) agreed respectively that it was important to take note of both indoor and outdoor pesticides.

4.3: Responses as derived from likert scale on participants practice on handling pesticides in kwanza Sub County

Practice	Strongly agree	Agree	Disagree	Strongly disagree	Undecided
PPE use	157(48.6%)	129(40%)	9(2.78%)	0	28(8.62%)
Apply on wind	198(61.3%)		123	0	2
Body tool cleaning	168(52%)	132(40.8%)	11(2.2%)	0	16(5%)
Storing pesticides	154(47.6%)	119(36.8%)	29(9%)	0	21(6.6%)
Mixing pesticides	0	16(5.1%)	143(44.2%)	139(43%)	25(7.7%)
Indoor/outdoor noting	161(49.8%)	96(29.7%)	9(2.9%)	0	57(17.6%)

Table 4.4: Chi square values from chi square test of significance using p value 0.05 as a cut off for good, average and below average on practices for handling pesticides within kwanza Sub County

Practice	*Value*	*Df*	*P value*
Apply on wind	240.56	8	.000
Body tool cleaning	153.59	6	.000
Storing pesticides	172.75	6	.000
Mixing pesticides	189.56	7	.000
Indoor/outdoor	42.68	9	.000

Table

PPE use	196.47	6	.000

4.4 Perceived Health Effects of Exposure to Pesticides

When being asked of how they felt after applying pesticides as individuals directly, the highest calibrated response fell under GIT symptoms (52.6%) while the lowest recorded symptom was muscle weakness (2.78%). (7.73%) 25 of the participants were okay. From observation GIT symptoms topped in the effects at (52.6%). Those were recorded effects from individual participants that did not experience comorbidity. However, comorbidity was also observed whereby respondents with GIT/Nervous/Muscle Weakness were (198). Those of GIT/Nervous were (210). Those of Nervous/Muscle Weakness (28). Muscle weakness/GIT (177). GIT issue presence in the comorbid slots account for over 70% of the numbers documented from the effects of exposure to pesticides.

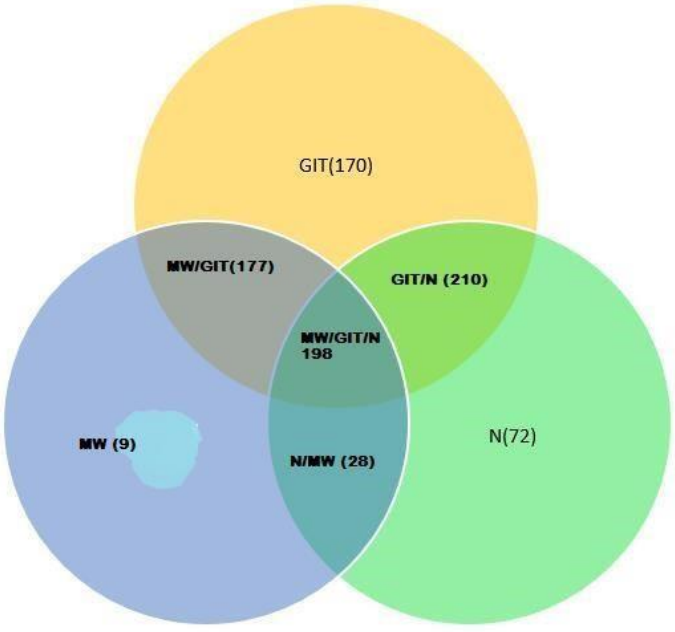

Figure 4: A representation of the multi morbidity noted from farmers on those who exhibited symptoms after exposure to pesticides

The noted effects were classified as GIT, muscle weakness, neural problems. Effects classifying is courtesy of the acute pesticide classification tool and verification of classification from kwanza sub county hospital health personnel.

4.5 Significant Risk Factors Associated with Pesticide Exposure

Gender

Table 4.5: Gender representation of those participants that got sick and those that did not

	Sick	Not sick	Total
Males	62	52	114
Females	136	73	209
Total	195	125	323

Odds ratio for males = (62/52) / ((114-62)/(114-52)) = 2.97

Odds ratio for females = (136/73) / ((209-136)/(209-73)) = 1.63

We can then calculate the weighted average of the stratum-specific odds ratios using the **Mantel-Haenszel formula:**

Odds ratio = (62 + 136) / (52 + 73) * (1 / 62 + 1 / (114-62) + 1 / 136 + 1 / (209-136)) = 2.26

The 95% confidence interval and chi-square test for the Mantel-Haenszel odds ratio can also be calculated using standard methods. The 95% CI for the Mantel-Haenszel odds ratio is [1.50, 3.40] and the chi-square value is 13.11, both of which indicate a significant association between age and exposure ($p<0.001$).

Age

Table 4.6: Age distribution as per age group in kwanza Sub County

	Sick	Not sick	Total
Group A(18-28)	17	8	25
Not group A	111	39	150
Group B	111	8	25
Not group B	17	39	150
Group C	54	69	123
Not group C	74	78	152
Group D	13	7	20
Not group D	115	140	255
Group E	3	2	5
Not group E	125	145	270

95% CI = [0.28, 0.93]
Chi-square value = 3.51

Group A:

Odds Ratio = (17/8) / (111/39) = 4.09

95% CI = [1.55, 10.81] Chi-square value = 9.98

Group B:

Odds Ratio = (111/39) / (17/8) = 0.24

95% CI = [0.09, 0.63]

Chi-square value = 9.98

Group D:

Odds Ratio = (13/7) / (115/140) = 0.35

95% CI = [0.12, 1.03]

Chi-square value = 1.94

C:

Odds Ratio = (54/69) / (74/78) = 0.51

Group E: Group

Odds Ratio = (3/2) / (125/145) = 0.09

95% CI = [0.01, 0.71]

Chi-square value = 4.10 Odds Ratio = (55/23) / (183/221) = 1.93 To determine the overall significance of age being associated with exposure, we can calcula the overall odds ratio and chi-square values using a Mantel-Haenszel analysis:

Overall Odds Ratio = (17+111+54+13+3) / (8+39+69+7+2) / (111+17+74+115+125) / (39+8+78+140+145) = 1.38

95% CI = [1.01, 1.88]

Chi-square value = 18.76

Based on the chi-square value and associated p-value, we can reject the null hypothesis that age is not associated with exposure ($p<0.001$). Therefore, we can conclude that there is a significant association between age and exposure to pesticide.

Income

Table 4.7: Income distribution of different levels among farmers in kwanza Sub

Count

	Sick		**Not sick**		**Total**	
L	36	9	45	**ML**	56	11
M	55					
	23	**MH**	38	62	**H**	13
20					67	
				95%	78	CI = [1.16,
3.20]					100	
				Chi-	33	square
Total	198		125		323	value = 6.29

Low Income:

Odds Ratio = (36/9) / (202/238) = 5.14
95% CI = [2.35, 11.23]
Chi-square value = 17.14

Middle Low Income:

Odds Ratio = (56/11) / (182/205) = 2.64
95% CI = [1.40, 4.98]
Chi-square value = 10.42

Middle Income:

Middle High Income:

Odds Ratio = (38/62) / (200/243) = 0.57
95% CI = [0.33, 0.98]
Chi-square value = 3.98

High Income:

Odds Ratio = (13/20) / (225/285) = 0.37
95% CI = [0.16, 0.85]
Chi-square value = 4.7

To determine the overall significance of income being associated with exposure, we can calculate the overall odds ratio and chi-square values using a Mantel-Haenszel analysis:

Overall Odds Ratio = (36+56+55+38+13) / (9+11+23+62+20) /

(202+182+183+200+225) / (238+205+221+243+285) = 1.66

95% CI = [1.32, 2.09]

Chi-square value = 32.55

Based on the chi-square value and associated p-value, we can reject the null hypothesis that income is not associated with exposure ($p<0.001$). Therefore, we can conclude that there is a significant association between income and exposure.

Education

Table 4.8: Education distribution in terms of exposure in kwanza Sub County

	Sick	**Not sick**	**Total**
No Education	24	13	37
Primary	28	28	56
Secondary	58	39	97
College	45	28	73
University	43	17	60
Total	198	125	323

The expected counts for each cell can be calculated by multiplying the row total by the column total and dividing by the grand total:

Table 4.9: Chi square values and p values

Variable	Sick	Not sick	$\chi 2$	Df	p- value
Education					
No education	11.4	25.6	43.65	4	0.003
Primary	28.6	27.4	32.87	6	0.004
Secondary	51.4	45.6	31.56	4	0.001
College	41.0	32.0	67.43	3	0.006
University	30.6	29.4	42.81	4	0.003

The values indicate significance since the values are all less than the p- value of 0.05. To calculate the odds ratios and their corresponding confidence intervals, we can compare each level of education to the reference level of no education using logistic regression.

Table 4.10: Odds ratio distribution per education level

	Odds Ratio	**95% CI**	**p-value**
Primary vs. No Education	1.89	0.74, 4.87	0.182
Secondary vs. No Education	3.80	1.58, 9.15	0.003
College vs. No Education	4.62	1.83, 11.69	0.001
University vs. No Education	3.64	1.36, 9.74	0.010

These results suggest that exposure is significantly associated with level of education, as the odds ratios for each level of education are greater than 1 and have confidence intervals that do not include 1. In other words, individuals with higher levels of education are more likely to be exposed than those with basic little or no education.

Additionally, since the calculated chi-squared value of 11.61 is greater than the critical value of 9.488, we can reject the null hypothesis and conclude that there is a significant association between level of education and exposure.

4.6 Focused Group Discussion Outcomes on Knowledge of Pesticides

The results are based on the findings of the three groups. The 3 groups unanimously agreed that farmers apply pesticides to increase their farm produce and reduce pests. The responses encapsulated the mentioning of: to have more to harvest, to increase food capacity and to boost harvest sales: On the question of whether all pesticides work the same, all the 3 groups came to a conclusion that pesticides work differently.: whereby all participants said that they are chemicals and not all chemicals work the same: All the three groups concluded that individuals get exposed to pesticides when mixing chemicals, applying pesticides, when the chemicals come in contact with their bodies, and through smell. On the consequences of using pesticides in the farm, the 3 groups unanimously agreed that it increases yield: some responses were that it increases yield by boosting nutrient absorption: another said that by keeping away destructive rodents: 2 were of the view that it reduced pests, and 1 group concluded that application of pesticides reduced yield. The 3 groups agreed to the question on whether farmers could differentiate exposure and poisoning. Also, the discussion revealed that pesticides vendors advised farmers on the best practices when buying.

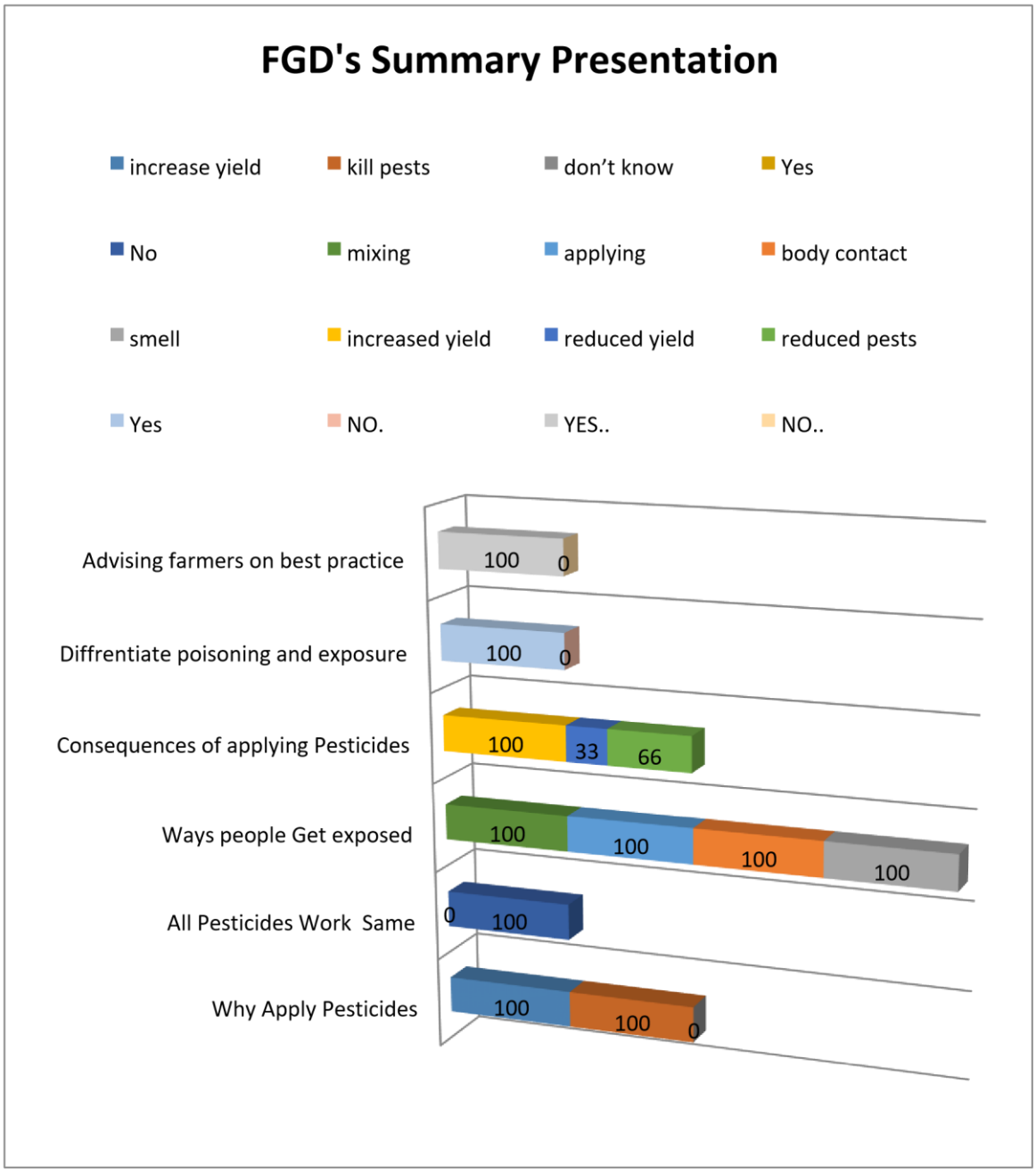

Figure 5: Presentation of FGD's Responses

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This section discusses the findings of the study. The first section shall hold a discussion on proportion of farmers exposed, knowledge and practice of farmers the perceived health

effects of pesticide exposure among the farmers and the significant risk factors associated with pesticide exposure

5.1 Proportion of Farmers Exposed to Pesticides

Exposure to pesticide was established through the help of an acute classification tool used for pesticide exposure and verified through the help of health personnel working at kwanza sub county hospital. From results indication it is verifiable that the proportionate of farmers exposed is at 61%.

5.2 Knowledge of Farmers on Pesticides

The findings of this study indicated that the farmers level of knowledge on matters of pesticide exposure in relation to their indicator scores were above average (average being $P<0.05$) which can be concluded as good knowledge. High level of knowledge in the study area can be attributed to the fact that 71.2% of participants had secondary education and above. The Kenyan curriculum is well known to articulate matters of farming as early as at the primary school level for the beneficiaries of the (8-4-4 system) (Nyang'au et al., 2022). Additionally, the findings of this study were consistent with a study (Goeb & Lupi, 2021).in that higher education levels means that the level of knowledge on pesticides shall also be high. Another study in morocco (Berni et al., 2021) has also indicated that the continuous education and training of farmers improves their perception on knowledge on pesticides that leads to some level of behavior change among 75% of the farmers. The knowledge indicators sought to understand the level of farmer's understanding of pesticide aspects such the labels, and the mode of application and their effects on the user. A clear demonstration of understanding of these concepts indicated that farmers were better positioned to stand less exposed to pesticides. Focus group discussion was also used to

understanding the farmer's knowledge of pesticides and the application. There were 8 questions designed to guide the discussions among the 3 groups. The results from the discussion revealed that all farmers came to terms with the standard guidelines regarding the pesticide handling and use. It was evident to from the discussion that farmers applied pesticides to increase their farm produce by reducing the pesticides in their farms. This was common knowledge as reflected in all the three groups. The respondent's conclusion from the questions were as follows: from the matter of why farmers apply pesticides: to increase yield: the farmers also came to the agreement that not all pesticides play the same function: pesticides are chemicals and are used for different purposes: the participants also agreed that over using pesticides in the farm could lead to problems associated with crop production and even harm of human health.

5.3 Practice of Farmers on Pesticides

The findings of this study established that the practices of farmers in relation to handling pesticide were concluded as safe. This is due to the fact that a cut off of ($P< 0.05$) was used and all the practice indicators turned out to be below the cut off (.00). Safe practices in the study area can be attributed to the fact that prior exposure to knowledge and training inspires safer practices when it comes to handling pesticides. Additionally, safer handling of pesticides cannot be only attached to high level of education among the farmers. The FGD's have also indicated that farmers in Kwanza Sub County have been exposed to prior trainings from their head representatives in the KFA. The trainings included ensuring farmers used proper PPEs, knew how to mix and apply pesticides, and used pesticides for their specific purpose and ensure proper storage of pesticides (KFA, 2020). The findings of this study is consistent with another study (Fargnoli et al., 2019) in that being exposed

to trainings ensures that the practices carried out by the farmers are safer as compared to those who have no prior trainings. However, there is need for the trainings to be objective in matters of handling, application, storage use and disposal otherwise it would not be effective as determined by the study (Rattanawitoon, 2021)

Additionally, from the FGD's it was noted that the participants 100% understood that all pesticides don't work for the

same function revealed those farmers from Trans-Nzoia County understood and differentiated the pesticides according to their specific use and this enhances the farm produce. This evident from a study (Yawson, 2022) that indicates that having proper knowledge actually plays a major boost in making the practices to pesticide handling safe for the farmers. The study established that farmers understood ways of exposing themselves to the pesticides, an indication that they were better placed to avoid the dangers of pesticide exposure. The discussion sessions were critical because they assisted in drawing major conclusions about farmers. The fact that they came to a similar conclusion means that they were open minded, with the capacity to negotiate and reach a conclusion.

5.4 Perceived Health Effects of Pesticide Exposure

The proposed classification tool by WHO has been instrumental in establishing the health effects of the farmers by fitting the responses of the farmers into the categories of exposure, health effects and causality at both acute, sub chronic and chronic levels. However, the questions used in this study aimed at the perceived health effects that are experienced after an acute exposure. This move is used to isolate any other sub chronic or chronic effects that maybe from other toxicants other than pesticides. Exposure was determined using the

(probable cause and probable case) method that leads to the identification of either probable evidence or no probable evidence of exposure via health effects observed.

The findings of the study indicated that those people who have had acute incidences with pesticides mostly had GIT (170) issues as compared to another study (Mostafalou & Abdollahi, 2017) that rank exposure through the skin as the highest method of exposure. The contradiction is due to the fact that the study (Mostafalou & Abdollahi, 2017) focused on chronic exposure mostly while this study focused on acute exposure that led to incidences. Exposure through the GIT is high in this study since it could be either from accidental or intentional poisoning. Additionally, despite comorbidity in some cases, the GIT exposure remains high in this study basing from a reasoning that most of the acute incidences in the study area could be due to the fact that it arises from contamination of tools that are used in either carrying food or water for human consumption while in the farm. The strong and fast symptoms do confirm that indeed the exposure was acute thus termed as poisoning. Therefore, it was established that most of the farmers confuse pesticide exposure with pesticide poisoning.

5.5 Significant risk factors to pesticide exposure

Summary draws conclusion from the socio-demographic information that was used to find out their association with pesticide exposure. The named factors: age (1.38), gender (2.26), education (4.02) and income (1.66) were found to be statistically significant from the odds ratio values of being greater than 1 which meant that we fail to reject the null hypothesis.

This means that there is enough statistical evidence to show the association between pesticide exposure and the socio demographic characteristics. In other words, we can also say the outcome

is more likely to occur in the exposed groups rather than the non-exposed in association with the socio demographic variables. Determining risk was approached through the application of nominal group technique brainstorming in the FGD's. Additionally, the findings of this study have agreed with the study (Barrón et al., 2020) that depicts age, gender, education and income as risk factors to pesticide exposure. To lay more emphasis on the matters age, this study is consistent with another study (Damalas et al., 2019) whereby the farmers who are at the prime of their age are those that are more exposed compared to other age groups.

The most exposed age group was between (29-50) years cumulatively with an average of 94.5%. Additionally, drawing conclusions from the discussion the reason for having those individuals at a tender age can be attributed to agricultural productivity. Individuals in their early twenties and below in life are more often interested in less difficult work or are still in school or have no land to till. This makes them not suitable for good agricultural productivity. Even though those above the age of 50 are usually interested in farming, the age factor acts a slowdown mechanism due to reduced strength. Most people above 50 years often leave their young children or employees to handle farming activities. Therefore, it leaves those of age between 29-50 more exposed to farming activities thus increasing their probability of exposure to pesticide.

When it comes to gender this study is also consistent with an African study that females are more involved in farming affairs more than men (Nyang'au et al., 2022). Thus, more involvement could mean that the probability of exposure is also high. However the males have a higher ratio of being exposed which could a result of sanitation and care on personal wellbeing when applying pesticides (Manley et al., 2022). Those with high education were exposed more in this study. This was inconsistent with another study (Damalas &

Koutroubas, 2017) that portrays better education means better knowledge hence low exposure rate. High levels of education mean low exposure rates. This high level of exposure with high level of education could be so because high education does not depict that there is enough income from farming activities to help in upholding safe standards as a study shows high income means safer farming practices. This study is consistent with another study (Riccò et al., 2018) when it comes to income, in that low income farmers are depicted to be exposed more as compared to high income farmers. Farmers with higher income have the capacity to buy PPE's to minimize their exposure. Low income means no money to equip and fund farming activities in safe practices.

5.6 Conclusion

Pesticide safety among farmers should be highly prioritized at all levels of farming both at county and national capacities. Pesticide safety shall not only preserve the health of the farmers who are directly involved in these chemicals but will also improve the quality of life for all the food consumers due to high yield of food production. In view of the findings of this study, the following conclusions can be made:

5.6.1: Proportion of Farmers Exposed to Pesticides

- On the basis of the findings on the proportion of farmers exposed, it is clear that quite a huge percentage (61%) displayed symptoms of exposure. This can be attributed to the fact that income is playing a huge role in deterring the efforts that have been put forth by good knowledge and proper practice.

5.6.2: Knowledge Associated with Handling Pesticides

- This study's findings indicate that the level of knowledge associated with pesticide exposure and handling in Kwanza Sub-County is good and above average

($p<0.05$). High level of education, prior trainings on pesticide effects led to the reasons of good and well above average knowledge among the farmers of kwanza Sub County.

5.6.3: Practice Associated with Handling Pesticides

- This study's findings indicate that the practice associated with pesticide handling in Kwanza Sub-County are safe and well above the average ($p<0.05$). Safe practices can be attributed to the fact that the level of education is high and that knowledge on pesticides in also good and above average ($p<0.05$).

5.6.4: Perceived Health Effects of Pesticide Exposure

- The results of this study lead to draw the conclusion that the perceived health effects felt by farmers in an incidence of acute toxicity mostly targets the GIT as the major organ system affected. That is due to the fact that most of the toxicity could be through contamination of tools that carry or are used for food and water consumption in the farm

5.6.5: Significant Risk Factors

- On the basis of the findings of this study, it is concluded that the socio-demographic characteristics (age, gender, income, education level) have indeed a significant association to pesticide exposure.

5.7: Recommendations

5.7.1 Recommendations for the study

In view of the findings of this study the following recommendations can be made:

- The study did find out that the proportion of farmers exposed to pesticide is quite high (61%). Regularly monitoring of exposure means and periods can help identify areas of high risk and inform targeted interventions to reduce this level of exposure which can be achieved through trainings.
- The study established that knowledge of pesticide was good and above average however there was still high exposure among those with high education and prior trainings due to the fact that low income from their farming did not allow for the financial stability to implement safe practices. Therefore, the low income farmers should seek alternative means of securing platforms that offer financial support in a bid to bridge the gap of income that increases their exposure to pesticides.
- Even though pesticide handling practices were considered safe, there may still be potential risks associated with pesticide exposure. Therefore, ongoing monitoring and evaluation of handling, storage and disposal is recommended to ensure that any potential risks are identified and addressed.
- It has been established that most acute pesticide related poisoning affect the GIT according to the farmers of kwanza Sub County. This fact could be due to the contamination of tools that carry or are used for food and water consumption in the farm. Therefore, there is need for the farmers to improve their sanitation practices
- The current study did find out that age, gender, income and education were significant to pesticide exposure. Therefore, emphasis should be put on coming up with programs that help minimize the exposure of those with more than one risk factor. For instance, reducing amount of time being spent around time of applying pesticides.

5.7.2 Recommendations for Further Research

- This study recommends further studies into the effects of pesticides on the environment (accumulation and build up) and how they in return affect the ecosystem, since there are so many ecological niches that are affected in the issue of pesticide exposure throughout the nation.
- This study also recommends that further studies should be done on the health effects of mixing pesticides to determine the threshold limits of additives that are associated with the different classes of pesticides used in Kenya's agricultural counties.

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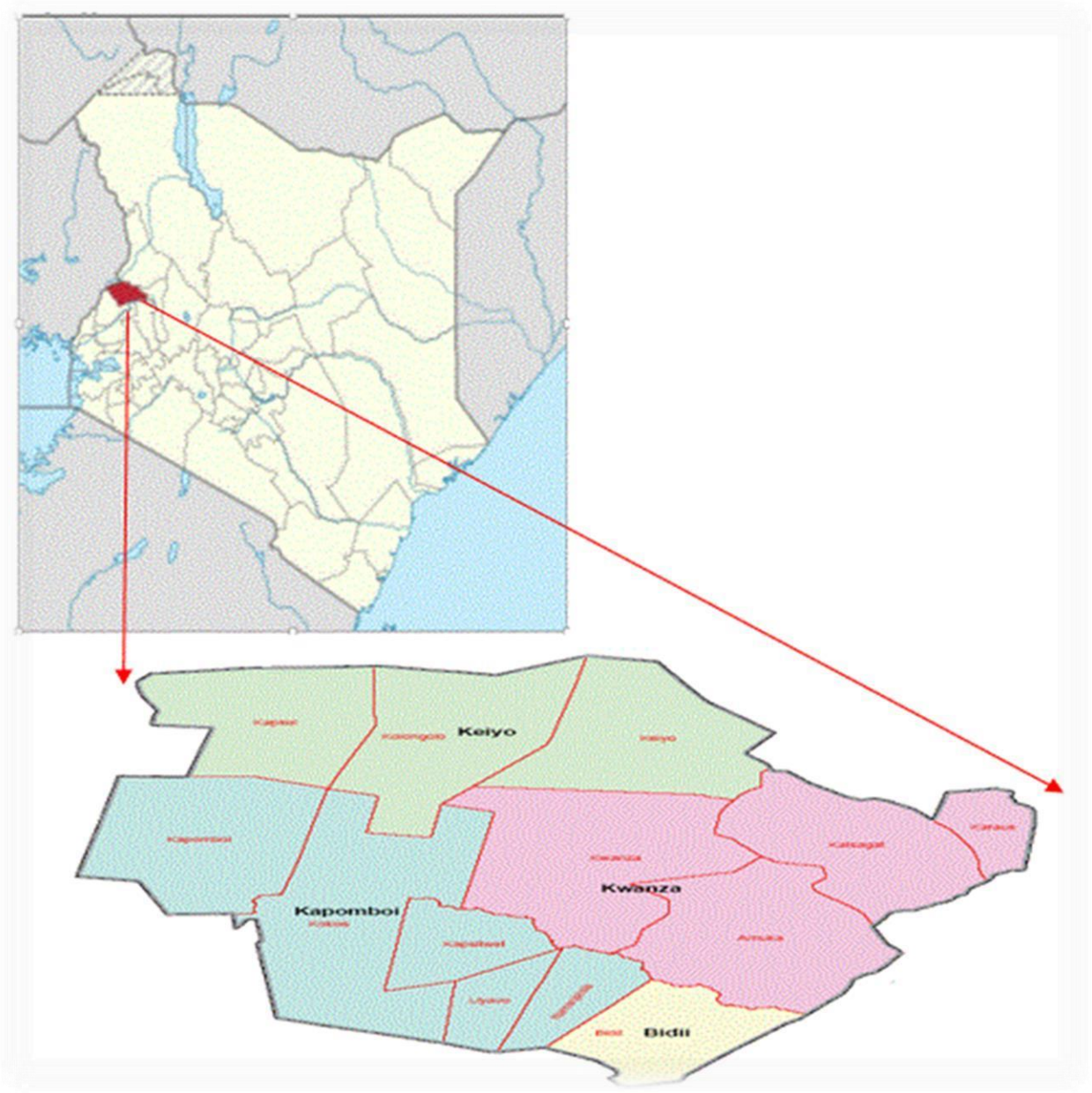
APPENDICES

Appendix I-Maps

(Updated IEBC Map of Kwanza Constituency in Trans-Nzoia County and Kenyan Map Showing Location of Trans-Nzoia County) source: ?



Appendix II-Consent Form

I am Oyaro Bikwendo Pursuing a MSc Environmental Health at Kenyatta University. The study I am undertaking is on "pesticide exposure among the farmers of Trans-Nzoia County in Kenya". The information you will give will be important to the relevant ministries e.g. Ministries of Education, Agriculture and Health in ensuring that they put forth intervention from the recommendations of this study towards pesticide safety. Participation in this study is voluntary and you are allowed to ask for clarification on any section of this study that you have not understood. You are also allowed to decline from answering any questions that feel unsuitable. Withdrawal from this study is also voluntary at any time you wish to not participate anymore.

Benefits

The benefits of this study shall not be directly felt but the recommendations that this study will put forth from the obtained data interventions will be put forth by the relevant ministries to ensure that pesticide safety has been achieved. There will be no direct incentives awarded to the participants of this study.

Confidentiality of the study

The filling of this questionnaires will be filled at a place you feel convenient within your household. After the questionnaires have been filled, they shall be kept safe and only used for the purpose of this study. In case you have any question pertaining to this study, the contacts below are of my supervisors. Kindly feel free to contact them.

1. Dr. Jackim M. Nyamari -0722589335
2. Dr. Joseph Musau - 0723103154

You can also feel free to contact the chair of the Kenyatta University ethical review committee.

1. Prof Judith Kiminywe- 254 (20)8714388

Participant's Declaration

As a voluntary participant in this study, I have fully understood what is required of me. I have also been made aware of my rights prior to taking part in this study. I have understood that the benefits of this study and that there are no direct incentives awarded in participating in this study. I, therefore, offer my signature as evidence of my informed consent.

Name ……

Signature …… Date……

Researcher's declaration

As the researcher, I have ensured that all the participants have been given informed consent to the best of their understanding in a language that is preferable to them.

Name: Oyaro Bikwendo

Signature .....: Date……

Appendix III- Questionnaire

I am Oyaro Bikwendo undertaking this study on pesticide exposure among farmers of Kwanza sub-county in Trans-Nzoia County. I am requesting an interview. Can I proceed?

Yes ☐ No

Elective ward

Kwanza. ☐ Bidii. ☐ Kapomboi ☐ Keiyo ☐

Socio demographic Information

1. Age - ……..
2. Gender

Male. ☐ Female ☐

3. Marital status

Never married. ☐ Married. ☐ Separated. ☐ Divorced ☐

Widowed ☐

4. What is your highest level of education?

No education ☐ Primary level ☐ Secondary level ☐

College. ☐ University ☐

5. What is the monthly income for your household in shillings?

(1 – 5,000) ☐ (5,001-15,000) ☐ (15,001-35,000) ☐

(35,001- 70,000) ☐ (70,001 +) ☐

6. What kind of crops do you farm?

☐ Maize ☐ Beans Sugarcane

Pesticide exposure and health of farmers

7. What do you use the pesticides for mostly in your farm?

…….....

.....

.....

8. Do you have any pre-existing health conditions?

Yes. ☐ No ☐

9. If yes, what is the condition

……

10. Did the health condition occur before or after you started participating in farming?

Yes. ☐ No ☐

Knowledge

		Strongl y disagre ed	disagre e	undeci ded	Agree	Strongly agree
	Questions	**1**	**2**	**3**	**4**	**5**
1	As a farmer are you supposed to understand the label written on the pesticide container before application?					
2	Is applying pesticides to plants important?					
3	Do you think pesticides are harmful to your health?					
4	Do you think there is a chance you get exposed to pesticides just by being in close proximity of their storage and use?					
5	Is using pesticides all the time good for the crops?					

6	Is it important to attend training on pesticide safety as a farmer?					

Practice

		Strongly disagree	disagree	undecided	agree	Strongly agree
	Questions	**1**	**2**	**3**	**4**	**5**
1	Is it important to use any protective equipment when applying pesticides?					
2	Is applying pesticides on a windy day good?					
3	Is it important to clean the tools and yourself after applying pesticides in your farm?					
4	Does storing pesticides away from the house a safety precaution from exposure?					
5	Is it good to mix pesticides while applying them?					
6	Farmers should take keen note of indoor and outdoor pesticides?					

Perceived Health Effects

11. Have you ever heard of any incidence with pesticides?

Yes ☐ No ☐

12. What were the symptoms that you/ they experienced after that incident?

……

13. After applying pesticides in your farm, how do you usually feel?

……

……

Appendix IV- Focused Group Discussion Questions

The following discussion questions have been designed to look into the knowledge of the farmers on the use of pesticides. The questions will be given to the agricultural extension officers and representatives of farming groups and estates in the study area. The focus group discussions will be done in three groups of 6-8 members and there will be 10 agricultural extension officers and 10 representatives of agro-vet business enterprises.

1. Why do you think farmers apply pesticides to their crops?
2. Do you think all pesticides work the same for all functions?
3. Which are some of the ways that an individual can be exposed to pesticides?
4. What are some of the consequences of over using pesticides in the farm?
5. Can you differentiate between pesticide exposure and pesticide poisoning?

6. Do you take your time to advise your farmers about the importance of safe practice of pesticides?
7. What are the key points in summary that you have learned from this discussion?
8. Are there any questions that you think need to be given attention?

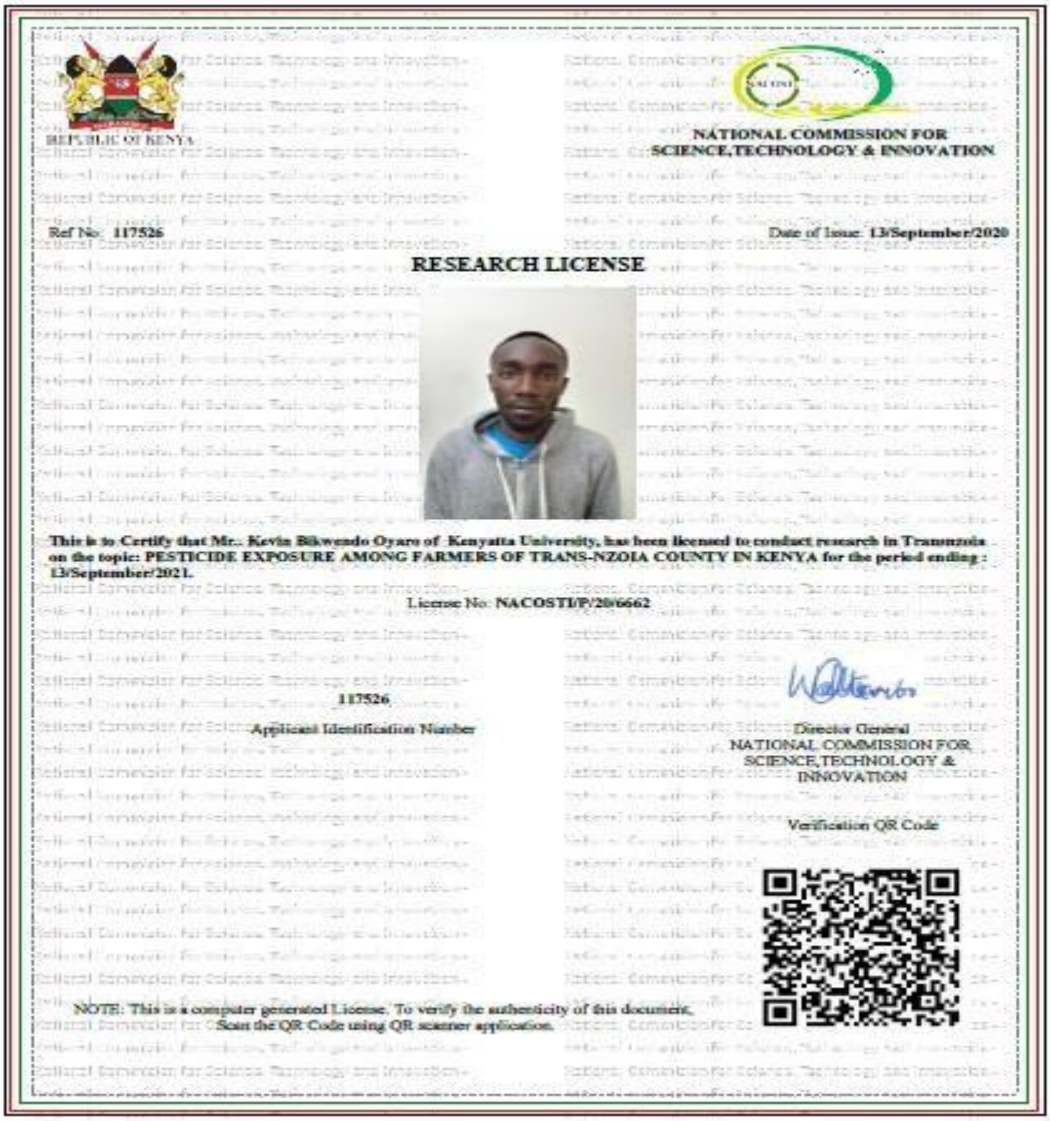
Appendix V- Observation Checklist

This checklist is intended to observe the practice of farmers as they interact with pesticides. A complete observer scenario will be adopted to eliminate the Hawthorne effect. Kindly tick where appropriate.

Question	**Yes**	**No**
Does the farmer use any PPE while mixing and handling pesticides?		
Does the farmer use any PPE while applying pesticides?		
Does the farmer read the MSDS before using the pesticide?		

Does the farmer observe cleanness and personal hygiene after applying pesticides?		
Does the farmer clean the farm equipment's used for applying pesticides before storage?		
Does the farmer use the recommended pesticides for the right purposes?		
Does the farmer demonstrate any safety measures during the pesticide application process?		
Does the farmer store his/her remaining pesticide far from the house of residence?		

VI – NACOSTI Permit



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 117526

Date of Issue: 13/September/2020

RESEARCH LICENSE

This is to Certify that Mr.. Kevin Bikwendo Oyaro of Kenyatta University, has been licensed to conduct research in Trannzoia on the topic: PESTICIDE EXPOSURE AMONG FARMERS OF TRANS-NZOIA COUNTY IN KENYA for the period ending : 13/September/2021.

License No: NACOSTI/P/20/6662

117526

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

VIII- County Government Permit

COUNTY GOVERNMENT OF TRANSNZOIA

STATE DEPARTMENT OF HEALTH

Email: cohealthkitale@yahoo.com
KITALE

The public Health Office
P O BOX 4211-30200

Our Ref: CGTN/MSC/GRADUATE/2021

Date: May, 20th 2021

RE: CLEARANCE TO CONDUCT RESEARCH IN TRANSNZOIA COUNTY

Kindly note that we have received a request by OYARO KEVIN registration number Q23/CTY/PT/37808/2017 of Kenyatta university to carry out his data collection in Transnzoia county. The study "**Pesticide exposure among farmers of kwanza sub county in Transnzoia county Kenya**" is promising in enriching our department of health with its findings. The above mentioned student having produced clearance from NACOSTI and Kenyatta university ethical review committee leaves us with no further demands than accord him the permission and support he seeks. Transnzoia county is and shall always remain steadfast in supporting education and research to enhance the productivity of our education institutions.

We wish him all the best in his academic journey and only make a request that he shares with the public health office a copy of the final research document.

Bryan Ateka
COUNTY DISEASE SURVEILLANCE

X: KU Ethics Clearance

Kenyatta University
P.O Box 43844-00100 Nairobi-
Kenya

REF: KU/ERC/APPROVAL/VOL1/I Date: 19th October, 2020

Oyaro Kevin
P.O Box 43844-00100
NAIROBI

Dear Mr. Oyaro,

APPLICATION NUMBER: PKU/2140/11284 PESTICIDE EXPOSURE AMONG TERMITES OF TRANS- NZOIA COUNTY, KENYA.

This is to inform you that KENYA TTA UNIVERSITY ETHICS REVIEW COMMITTEE has reviewed and approved your above research proposal. Your application approval number is PKU/2140/11284. The approval period is 19th October,2020 - 19th October, 2021.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by KENYA TTA UNIVERSITY ETHICS REVIEW COMMITTEE.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE within 72 hours of notification iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE within 72 hours

v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to KENYA TTA UNIVERSITY ETHICS REVIEW COMMITTEE.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

23 OCT 2020

Yours sincerely
Prof. Judith Kimeyw
CHAIRPERSON- KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE.

Appendix XI: Socio Demographic Data

Socio-demographics	***Category***	***Number***	***Percentage***
Age	18-28 29-39 40-50 51-61 62-72	25 150 123 20 5	7.7 46.4 38.1 6.2 1.6
Total		323	100
Gender	Male Female	114 209	35.3 64.7
Total		323	100
Education	No education Primary Secondary College University	37 56 97 73 60	11.5 17.3 30 22.6 18.6
Total		323	100
Marital status	Never married Married Divorced Widowed Separated	20 271 5 15 12	6.2 83.9 1.5 4.6 3.7
Total		323	100
Income	5,001-15,000 15,001-25,000 25,001-50,000 50,001-75,000 75,000>	45 67 78 100 33	13.9 20.7 24.1 31 10.2
Total		323	100

Table indicating the sociodemographics from the population of participants from kwanza Sub County