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Safe Chemical Handling by Agrochemical Users in Plateau State, Nigeria

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2019

Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Agrochemical use has been increasing in both developing and the developed nations. The unsafe handling and use of agrochemicals can lead to accumulation of hazardous chemicals in the body, causing adverse effects on health. This quantitative cross sectional study sought to understand the level of awareness, practices, and perceptions of safe chemical handling by agrochemical using the Theory of Planned Behavior. This study was conducted among 260 farmers in Plateau State, Nigeria. Data on background knowledge and practices of safe agrochemical handling by farmers were collected using a structured paper based, interviewer-administered questionnaire. Descriptive statistics revealed that the most practiced precautions by participants were washing work clothes separately (56.9%) and taking a shower soon after application of agrochemicals (53.6%). Findings from this study suggest that farmers had good knowledge of safe use of agrochemicals and majority of them 91.9% were knowledgeable about the possible effects of these chemicals on health. .A Chi square test showed a statistically significant association between marital status and engagement in safe agrochemical handling X^2 (2, N = 260) = 7.34, p <. 05 and level of education X^2 (4, N = 260) = 35.12, p <. 05. Results of Binary logistic regression indicated that the variable training on safe agrochemical handling with an odds ratio 8.31 was a good predictor for safe agrochemical handling An important finding in this study however was a low level of adoption for the use of Personal Protective Equipment. Priority should be given to developing safety educational and certification programs for farmers with emphasis on the safe handling practices.

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Dedication

This research work is dedicated to my loving and caring husband Dr Chinedu Chika Ekwempu for his patience, encouragement, support and love.

And

To my lovely children Somtochukwu, Akachukwu, Kosisochukwu, Victor, and my daughter-in-law Phyllis.

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May the good Lord bless and reward you all in Jesus name.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Chemicals sold for medical diagnostics, agricultural interventions, research, households, and general purposes are associated with health challenges, ranging from cancers, male and female infertility disorders, and chronic noncommunicable life-threatening public health concerns (Abu Bakar, 2015; Cruz-Morató, 2014; World Health Organization [WHO], 2017). Since the 1940s, agrochemical use has been increasing in both developing and developed nations (Saina, Odimu, & Otara, 2017). Their use has been linked to several health and environmental hazards for people, due to direct contact during application, pesticide drift from fields, or contamination of food or drinking water. Globally, there are significant health problems associated with the inappropriate handling of agrochemicals. On an annual basis, the European Union uses more than 200,000 tons of agrochemicals (Eurostat Statistical Books, 2007). Africa uses about 75,000-100,000 tons of agrochemicals, which is about 4% of the global agrochemical market (Alabi et al., 2014).

The unsafe handling and use of agrochemicals can lead to excessive exposures and accumulation of hazardous chemicals in the body; this accumulation can lead to adverse effects on health and different symptoms associated with these effects have been reported by agrochemical users (Ojo, 2016). Globally, there has been a growing concern about the detection of and monitoring of the environment for the identification of chemicals such as agrochemicals, which pose a significant public health challenge (Febbraio, 2017).

In Nigeria, agrochemicals are used for various agricultural services such as weed control, pest control, and improvement in farm produce; these are usually applied by farmers who have little or no knowledge regarding some of the health implications of these chemicals (Ndaghu, 2017). The use of agrochemicals has helped with meeting the food needs of a growing global population for many countries, including Nigeria, because these chemicals eliminate various pests that prevent crop growth (Jaabiri Kamoun, 2018). Some of the health issues associated with this group of compounds range from cancers, male/female infertility disorders, and chronic noncommunicable life-threatening public health issues, such as endocrine disorders (Cruz-Morató, 2014, WHO, 2017). While researchers have reported on various effects that agrochemicals have on different organs, little is known on the attitudes and perceptions of the agrochemical users regarding the safe handling of these chemicals. There is more emphasis on the need for the physical self-protection against unnecessary contact with the agrochemicals through the education on the use of personal protective equipment (PPE, Akinpelu, 2011).

To prevent chronic health effects of pesticides and agrochemicals on health, the National Centre for Farmer Health (NCFH) proposed the need to educate farmers to observe safe handling guidelines as a measure for preventing health issues from the use of agrochemicals (Ågerstrand, 2017). Currently, this is being emphasized in the developed countries but has not been implemented in Nigeria. The current study was centered on understanding the knowledge, attitudes, and perceptions of safe chemical handling at the community level, with a focus on agrochemical users, specifically farmers, in the Plateau State. Based on the outcome of the study, various activities such

as educational media campaigns, legislative actions, and community engagement will be embarked upon as a community development program. This study was designed to address the need for safe handling of agrochemical by users in Plateau State, Nigeria, which are known for the production of different food commodities, such as vegetables and tubers all year. An understanding of knowledge of agrochemical users regarding safe chemical handling will be useful for implementation of public health educational programs in this community. These new reviewed programs will be designed to attempt to prevent health issues arising from the use of agrochemicals in addition to providing information for the training and retraining of community members on the importance of safe agrochemical handling. This chapter includes the background of the study, problem statement, purpose of the study, research questions, hypothesis, nature of the study, theoretical framework, assumptions and limitations, delimitations, significance, and summary.

Background

Chemicals, in general, have been associated with different health challenges and they pose a risk for specific occupations that use them on a daily basis. Various literatures abound on some of these health challenges, such as the teratogenicity impact and need for proper handling of agrochemicals. Rim (2017) used PubMed, Google Scholar, and Science Direct to carry out literature searches based on author expertise with 100 articles selected for analysis; most of them were descriptive. Results from the literature review searches showed the need for more actions to be carried out by public health organizations in the areas of hazard surveillance and primary prevention activities, such

as the use of protective equipment and sufficient ventilation. Rim (2017) pointed out that chemicals have an impact on the reproductive system of humans resulting in the alterations of fertility hormonal profiles with resultant infertility in both males and females. Understanding the knowledge and attitudes of agrochemical users regarding the safe handling of products will assist in public health education, which will assist in provision of different intervention strategies.

Regarding safe agrochemical handling practices, the work of Saina et al. (2017) suggested the need for strict enforcement and supervision of regulations for agrochemicals in an attempt to reduce chemical exposures. Saina et al. (2017) recommended the need for consistent medical check-ups to diagnose and treat illnesses that may have resulted from agrochemical exposures. Saina et al. (2017) also encouraged more research to be done to assess emergency preparedness among farms to handle accidental exposures. The need for monitoring safety procedures set by regulatory bodies in the prevention of hazards is highlighted by the authors (Saina et al., 2017).

Other researchers, such as Mazlan (2017), reviewed the status of persistent residues of pesticides in the Nigerian environment. Their findings indicated that Nigeria is a significant consumer of agrochemicals in sub-Saharan Africa, and yet policies on the proper utilization of these agrochemicals are not in place. Mazlan suggested the need for environmentally friendly approaches to agrochemicals, such as Integrated Pest Management (IPM), adopted to reduce the health challenges associated with the use of these chemicals. Other recommendations also included sharing of information regarding the proper handling of agrochemicals and the use of advanced technology for farmers and

agrochemical users. Monitoring the health of the exposed agrochemical workers is an essential component for the reduction of health risks from persistent organic pesticides in all 36 States of the Federation in Nigeria.

The findings from this work may provide information necessary for the education of agrochemical users on the importance of safe chemical handling. Factors that could improve the prevention of risks associated with the use of agrochemicals as identified by the users will be considered in the development of policies and guidelines for the safe handling of agrochemicals.

Problem Statement

Many organizations and individuals involved in agricultural activities in Nigeria pay little attention to safe chemical handling (Ågerstrand, 2017). Researchers have noted the importance of safe chemical handling for the prevention of chronic noncommunicable diseases (Ågerstrand, 2017) and injury (Anderson, 2015). Most agrochemical users and agricultural-based organizations do not understand the importance of safe chemical handling. A recent review of the literature revealed that the nature of the relationship between primary prevention activities and knowledge of chemical handling is unclear (Moradhaseli, 2017). Little is known about factors that may influence the attitudes of agrochemical users towards the prevention of health-related injury associated with the administration of agrochemicals (Saina et al., 2017). The mortality rate associated with the handling of agrochemicals has been shown to be high in developing countries, such as Nigeria (Ojo, 2016). The problem is that while the potential importance of safe handling of chemicals is known, in addition to the health issues resulting from the use of

agrochemicals, nothing is known about the possible mechanisms by which attitudes and knowledge agrochemical handling can influence safe chemical handling. I sought to understand the level of awareness, practices, and perceptions of safe chemical handling by agrochemical users (i.e., farmers) in Plateau State, Nigeria.

Purpose of the Study

The importance of safe chemical handling to help prevent health issues associated with the use of agrochemicals is documented by researchers (Shahzad, 2016; Zakhary, 2011). This is as a result of the knowledge that educational promotion programs are vital in public health as they provide information that, if well adhered to, are necessary for intervention for public health-related issues (Kataria, 2015). This quantitative study described the knowledge, attitudes, and perceptions of safe handling of agrochemicals by farmers. It also compared the level of awareness, practices, and opinions of agrochemical handlers regarding the safe handling with regards to demographic factors. This study may provide necessary information for implementation of educational programs and guidelines on prevention and early intervention on agrochemical related injuries.

Research Questions and Hypothesis

The following research questions guided this study:

RQ1. Does engagement in the safe handling of agrochemicals have any relationship with the professional and individual characteristics of farmers that use agrochemicals in Plateau State?

$H1_o$: There is no difference in engagement in the safe handling of agrochemicals and the professional and individual characteristics of farmers that use agrochemicals in Plateau State.

$H1_a$: There is a difference in engagement in the safe handling of agrochemicals and the professional and individual characteristics of farmers in Plateau State.

RQ2. What is the relationship between the experience of farmers regarding agrochemical safety and their level of education?

$H2_o$: There is no statistically significant relationship between the experience of farmers regarding agrochemical safety and their level of education.

$H2_a$: There is a statistically significant relationship between the experience of farmers regarding agrochemical safety and their level of education.

RQ3. What are the perceptions of farmers regarding the safety of agrochemicals based on their years of experience?

$H3_o$: There is no statistical relationship between the perceptions of farmers regarding the safety of agrochemicals and their years of practice in Plateau State.

$H3_a$: There is a statistically significant relationship between the perceptions of farmers regarding the safety of agrochemicals and their years of practice in Plateau State.

RQ4. What are the attitudes of farmers regarding the safe handling of agrochemicals?

$H4_o$: There is no statistically significant relationship between the attitudes of farmers and safe handling of agrochemicals by users in Plateau State.

$H4_a$: There is a statistically significant relationship between the attitudes of farmers and safe handling of agrochemicals by users in Plateau State.

RQ5. What are the actual practices of farmers regarding the safe handling of agrochemicals?

$H5_o$: There is no statistically significant relationship between the actual practices of farmers and safe handling of agrochemicals among agrochemical handlers in Plateau State.

$H5_a$: There is a statistically significant relationship between the actual practices of farmers and safe handling of agrochemicals among agrochemical handlers in Plateau State.

Theoretical and Conceptual Framework for the Study

The framework for this study was the theory of planned behavior (TPB) which predicts that planned behaviors are determined by behavioral intentions which are primarily influenced by an individual's attitude toward a practice, the subjective norms explaining the execution of the routine, and the individual's perception of their control over the action (Ajzen, 1991). The purpose of the TPB is to predict and understand consumer behavior across a range of backgrounds (Gangal, 2013). According to the theory, a person's behavior can be predicted by intention, which is predicted by the person's attitude towards the action, subjective norms, and perceived control (Ajzen, 1991; Fishbein, 1967). This theory provided insight for presenting a systematic

explanation of the phenomena of safe handling and the knowledge of chemical toxicity associated with agrochemical use (Moradhaseli, 2017). The deductive theory helped identify the relationship between variables such as (a) age, gender, level of education and years of handling agrochemicals and (b) knowledge and practice of safe handling of agrochemicals.

Some of the variables that were considered included knowledge of safe chemical handling and how adherence is related to the period of chemical exposure use of protective equipment, level of education, and awareness regarding the toxicity of chemicals. Ajzen's (1991) TPB aligned with comparing the levels of knowledge, perception, and attitude of agrochemical users regarding safe handling. The problem was that even though agricultural workers know the importance of safe handling procedures and potential health effects, there was a failure to implement safe chemical use and handling procedures (i.e., better health behaviors). The TPB addressed this type of study, which was used for this research.

In recent years, the concept of self-efficacy was added to the TPB model (Ajzen, 2011). Self-efficacy, an idea initially from the work of Bandura et al. (1997), which refers to efficacy as one's confidence in his or her ability to perform a specific behavior. This model was used in this work to understand injury prevention and predicting how agrochemical users' attitudes might influence their injury prevention modifications through the use of biochemical blood testing as a predictor variable.

Looking at the conceptual framework for this study based on the premise of various studies have shown that looking at the knowledge, practice, and attitude towards

agrochemicals such as pesticides are more beneficial. A phenomenon that was pointed out through the work of Yassin et al. (2002) was the fact that even though farmers in the Gaza Strip had high levels of knowledge on the health impact of pesticides, they did not practice this knowledge. Understanding the perspectives of agrochemical users regarding the safe handling of chemicals may provide interventions for educational programs that will ensure that agrochemical users are aware of importance and practice of safe chemical handling. This can also help in giving guidelines that make it easier to take action where it is needed. This may, over time, minimize the hazards of occupational pesticide exposure (Yassin, 2002).

This framework relates to the study approach a quantitative cross-sectional study aimed at determining the relationship between the knowledge of safe chemical handling among agrochemical users and various demographic characteristics of the users. A well-structured and tested questionnaire was used to obtain data on the demographics of the farmers in addition to information regarding types of agrochemicals used and knowledge and awareness of safe agrochemical handling practices.

Nature of the Study

This quantitative study incorporated a nonexperimental, cross-sectional research design. This choice of study design was ideal because the study participants were chosen from a separate geographical area (Levin, 2006). The dependent variables for the study included involvement in safe chemical handling by agrochemical users and knowledge of safe agrochemical use as a preventive measure for health-related injuries arising from cases of chemical toxicity, in addition to the preservation of the environment. Other

variables included attitudes towards the provision of chemical safe handling services to communities involved with agricultural services.

Independent variables for the study included age, gender, duration of agrochemical utilization, level of education, prior prevention education, geographical location, average number of hospital visits due to ill health in the last 4 years, and barriers to involvement in safe chemical handling procedures. Confounding variables that could influence the associations between some of the dependent and independent variables were identified. The study sample included farmers that were involved with the utilization of agrochemicals, such as pesticides and herbicides in Plateau State.

A survey instrument was modified from a similar work done in Kenya by Saina (2017) for the collection of data. The instrument was designed and used to obtain information about the knowledge and practices of agrochemical users regarding safe handling procedures and the attitudes of farmers. It was also designed for collecting data from the potential roles of agricultural organizations in the promotion of safety for the environment and users of agrochemicals, in addition to determining the level of knowledge that the farmers already possess. A section of the survey instrument helped to identify farmers who have been trained and those not educated on various safety precautions and the importance of health monitoring for early detection of toxicity in handling agrochemicals. The survey instrument used was a questionnaire, which was reviewed and approved by the Walden University Institutional Review Board (IRB).

Data collection was based on the use of paper-administered questionnaires, which were administered to participants who fulfilled inclusion criteria. The questionnaires

were administered personally after instructions were given to the farmers. For those who could not read, research assistants were trained on explaining the questions to them. Details of the data collection are expounded in Chapter 3. Data generated from the surveys were analyzed using the SPSS Version 23 for descriptive and bi/multivariate analysis for the inferential study.

Definitions

Agrochemicals: Chemicals used in agriculture, such as a pesticide, herbicide, fungicide, or a fertilizer.

Agrochemical users: Individuals that use agricultural chemicals for different farming processes

Knowledge: The theoretical or practical understanding of a subject (Merriam-Webster Dictionary, 2018) the subject of this research will be safe chemical handling.

Attitude: the way that one feels or thinks about something (Merriam-Webster Dictionary, 2018), such as safe handling of agrochemicals.

Perception: The way in which safe chemical handling is regarded, understood or interpreted (Moradhaseli, 2017).

Safe chemical handling: This is the application of best practices in handling chemicals such as agrochemicals in farming to minimize risk to persons, environment, and community. It involves understanding the physical, chemical, and toxicological effects of agrochemicals (Moradhaseli, 2017).

Assumptions

For this study, it was assumed that chemicals are toxic and hazardous to health and the environment and should be handled with extra precautions by users. Agrochemicals are a group of compounds that should be controlled safely by agricultural workers to prevent adverse health and environmental issues, which are of public health interest. Agricultural workers, such as farmers, use agrochemicals for different purposes such as the prevention of pests, weeds, and crop enrichment. It was assumed that not all agrochemical users in Plateau State, Nigeria, have training on the safe handling of chemicals and their implications for health. It was also assumed that participants in the study were selected based on the participants' free will and responses were as truthful as possible.

Scope and Delimitations

Delimitation for this study may be the geographic limit of the survey, that is, Plateau State, which is one of 36 states that comprise Nigeria. Due to time, logistics, and financial constraints, it was not impossible to incorporate or survey more than one state. Another delimitation for this study was the scope of the research, which engaged only farmers involved in dry season farming. However, these are not the only group of workers that use agrochemicals in Nigeria. In Nigeria, there are other agrochemical users such as horticulturists who use agrochemicals for nurturing flowers and plants used for the beautification of the environment. These groups of agrochemical users were not included in the study.

Limitations

This study was a cross-sectional design and was limited in not being able to establish the sequence of events from the agrochemical users. Sequence of events is defined as the level of exposure. This limitation was addressed by ensuring that the survey instrument used captured the needed constructs for the study. The research questions for this study did not require a temporal association to answer them. Although this design was limited because it maybe prone to bias, such as measurement and recall bias (Levin, 2006), this challenge was addressed by accessing the farmers individually during their course of practice, because this could improve response level. Although all farmers that use agrochemicals in the state consisting of 17 local government areas may be approached for the study, however, only those total numbers that consented to participate were enrolled for the study.

Significance

This research may fill a gap by determining the level of understanding and perception of safe handling of agrochemicals by farmers in Plateau State, Nigeria, a developing country with high utilization of agrochemicals known to be associated with health issues related to toxicity. The findings of this study may provide relevant information regarding safe handling of agrochemicals in this environment and may also provide a basis for a health promotion program for individuals that use agrochemicals. Farmers in their routine activities, use reagents and solvents whose chemical composition or proper use, handling and storage, they might not be aware of, thereby resulting in potential adverse health hazards both to them and others. This work may highlight the

type of exposure (oral, inhalation or dermal contact) and measures put in place by employers to avert possible health hazards to users of agrochemicals. This could serve to reduce the chemical hazards faced by workers due to improper handling of agrochemicals and may also help in the potential identification of individuals at risk of these effects. The findings of this research have implications for positive social change in that the attitude of both agrochemical users and government maybe directed towards creating an environment that minimizes the effects of diverse agrochemicals on all workers and the future generation.

Summary

Agrochemicals have been used for over several decades, and they are known to cause diverse health challenges as a result of toxicity to the human system and the environment. The WHO (2017) and the Centers for Disease Control and Prevention (CDC, 2017) have made efforts towards reducing the health issues associated with chemical toxicity through the implementation of guidelines for proper handling of chemicals. However, there are still many challenges arising from the unsafe handling of chemicals that have resulted in an increase in noncommunicable diseases in this environment (Anderson, 2015). This may be as a result of poor budgetary allocation to routine health monitoring of individuals at risk of chemical toxicity and lack of training on the safe use of agrochemicals by their users. Though there is inadequate knowledge on safe handling of agrochemicals in Nigeria, it is more pronounced among agrochemical users due to the disproportionate distribution of agricultural and health services in the country (Issa, 2015; Ojo, 2016). This has made this part of the country have problems

with monitoring the effects of safe handling of agrochemicals on health and the environment.

An approach towards addressing inequality in the safe handling of agrochemicals is a paradigm shift from the traditional downstream approach to the more innovative upstream approach, which has a prevention focus. It was hoped that by engaging the community agrochemical users, specifically farmers, the desired preventive health outcomes would be achieved. I sought to identify the knowledge, attitudes, and perceptions of safe handling of chemicals by farmers in Plateau State. Information from this study could serve to provide the baseline for planning a health education program that could create awareness of agrochemicals and proper handling and prevention of health challenges arising from the use of agrochemicals. In the evolving healthcare field, public health officers have roles that are advanced and include health promotion and prevention. This development has provided a source of information for the public and potential medium through which much-needed information on health can be conveyed to the disadvantaged population.

Chapter 2 provides a detailed review of the literature on the agrochemicals and their use in Plateau State. It details the portal of entry for these agrochemicals and the different types of agrochemicals commonly used in Plateau State by farmers. It also reviews other research on agrochemicals and their health implications.

Chapter 2: Literature Review

Introduction

There has been a steady increase in the use of agrochemicals globally since the 1940s with associated health hazards— a result of direct contact during the application process or from contamination of foods and sources of drinking water due to leakage of such agrochemicals into food products (Saina, 2017). More than 200,000 tons of agrochemicals are used in European countries annually, while Africa uses about 75,000-100,000 tons annually (Alabi, 2014; Eurostat Statistical Books, 2007, PAN, 2003).

Some innovations required for the promotion of agriculture includes the use of the Crop Protection Compendium (CPC), which allows for improved crop production. Commonly used CPCs in Nigeria include varieties of insecticides, fungicides, herbicides, rodenticides, nematicides, and seed treatment chemicals (Issa, 2015). These agrochemicals are either produced locally or imported. The research by Jallow (2017) in Kuwait and Rijal (2018) in Nepal highlighted an increasing misuse of agrochemicals for crop protection. The high prevalence of misuse and its attendant health challenges has become a significant public health problem requiring urgent attention (Abdullahi, 2008; Food and Agriculture Organization, 1998). This challenge is compounded by a demand-supply system, which encourages adulteration of these chemicals, use of expired agrochemicals, inefficient use, improper storage habits, and lack of proper safety measures (Akinyosoye, 2005). This problem is irrespective of the Recommended Agrochemical Practices (RAPs, Asogwa & Dango, 2009; Kishi, 2005; Laary, 2012; Zyoud et al., 2010).

In developing countries, like Nigeria, the effects of unsafe handling of agrochemicals have resulted in acute poisoning due to exposure to dangerous levels of pesticides in food. For example, Nigeria reported in 2008 that pesticide-contaminated food had poisoned 112 people, out of which two children died as a result (Organic Consumer Association, 2008). Another report from Nigeria recorded 120 cases of poisoning of students who had eaten beans contaminated with the agrochemical lindane , (Integrated Regional Information Network, 2008).

I will describe the knowledge, attitudes, and perceptions about safe handling of agrochemicals by users in Plateau State. Findings of the study may be needed for the training and education of agricultural organizations involved in developing policies for agrochemical handlers, which will, in turn, be of benefit to the health of community members.

Literature Establishing Relevance of the Problem

Despite the recommended agrochemical practices (such as the use of the genuine product, proper calibration of equipment, appropriate application techniques, ensuring personal health and environmental safety), there is still poor adoption of these recommendations, which has resulted in various health challenges such as cancers, chronic diseases, infertility, and poisoning (Olowogbon et al*.,* 2013). There are two sides to the poor safe handling of agrochemicals by users: exposure of farmers to some risks due to the hazardous effects of these chemicals, and the residual effect of the chemicals on crops with their subsequent effect on consumers. Pesticides are toxic and can have serious health hazards on human beings (Atu, 1990; Mokwunye, 2012). To guard against

these dangerous effects, Idowu et al. (1996) recommended precautionary measures in agrochemical application, such as wearing a nose mask (respirator) to avoid inhalation; wearing protective clothing, including rubber gloves and boots; refraining from smoking, eating, and drinking during spraying; and covering food and water to avoid contamination. Some other precautionary measures include good personal hygiene, such as washing hands and face.

The International Program on Chemical Safety/World Federation of Associations of Clinical Toxicology (1993) noted that agrochemicals are usually toxic to both pests and humans. They reported that if adequately handled, they need not be hazardous to humans and non target animal species. Safe agrochemical handling could be defined as observing established standard operating procedures for the handling of chemicals to prevent health and environmental issues associated with these groups of chemicals (Guidelines for the safe and effective use of pesticides, 1998). This implies observation of necessary precautions by agrochemical users bearing in mind that most agrochemicals will cause adverse effects if intentionally or accidentally ingested or if they are in contact with the skin for a long time. These chemicals will also cause adverse effects when they are inhaled.

The WHO (2018a) reported that the primary routes of agrochemical exposure include: inhalation when they are sprayed, and ingestion of contaminated drinking water, food, or soil. The precaution that has been recommended to prevent adverse effects of agrochemical handling by the WHO are all related to proper transport, storage, and handling. For example, spray equipment should be cleaned on a regular basis and also

maintained to prevent leakages; in addition, PPE should also be worn while using the spray equipment to prevent skin contact, and inhalation. The need for proper training and education of agrochemical users on safe use of these products have been identified by researchers as an essential component for the prevention of public health challenges arising from their use.

In Nigeria, the level of adoption of recommended practices for handling of agrochemicals is low, and research has shown the need to have a better understanding regarding the attitude, perception, and knowledge of the agrochemical as this will help in a better education on safe agrochemical handling (Issa, 2015). Saina et al. (2017) highlighted the importance of routine medical check-ups for occupations at risk of toxicity from chemicals such as those used in agricultural services. This further buttresses the health challenges that may be associated with the unsafe handling of chemicals.

Nigeria is a significant consumer of agrochemicals in sub-Saharan Africa and has poor policies for proper utilization of these agrochemicals; this has been linked to an indicator for health issues (challenges) arising from the use of agrochemicals (Mazlan et al., 2017). The health challenges that have been linked to improper use of these agrochemicals include different types of cancers, infertility issues, various endocrine-related abnormalities, and kidney and liver cytotoxicity. These abnormalities are usually diagnosed in the medical laboratory following signs and symptoms of the individuals (Mazlan, 2017; Rim, 2017; Zakhary et al., 2011). An approach that might be used for alleviating the challenges associated with the use of agrochemicals in Nigeria is the

implementation of environmentally friendly approaches such as integrated pest management (IPM) as suggested by Mazlan et al. (2017).

The need for adequate information regarding the proper handling of agrochemicals and the use of advanced technology is vital especially bearing in mind that majority of the agrochemical users have a low level of literacy in this part of the world (Moradhaseli et al., 2017). This will imply that majority of the agrochemical users will find it challenging to abide by safe handling of agrochemical guidelines, which are commonly written, based on the needs of developing countries. To close this gap, training and educational guidelines for safe handling of agrochemicals should be written based on the needs of the Nigerian community (Ankley, 2016)

Preview Significant Sections of the Chapter

In this chapter, the relevance of this study is outlined. In the following sections, I intend to itemize the strategy I used for the literature search, the theoretical framework for the study, a review of the public health issues arising from the use of agrochemicals, the relevance of safe agrochemical handling in the prevention of these health issues, knowledge, perceptions of both agrochemical users and researchers regarding safe handling of agrochemicals. This chapter will also include an overview of safe agrochemical handling and health educational strategy. It will comprise the knowledge of safe agrochemical handling and use, effects of these chemicals on health, different types of agrochemicals used in Nigeria, policy in place for the safe use of agrochemicals, effects of demographic factors on proper implementation of safe chemical handling.

Literature Search

The relevant material for the literature review was obtained from searching electronic databases, dissertations, and theses available electronically, most of which was from the Walden Library. I also used reference lists of identified relevant articles for my research. Others included searches from electronic databases such as CINAHL plus with full text, Medline with full text, Dissertations and Theses at Walden University, and PubMed. The Google Scholar search engine was used as a supplement for electronic databases. The databases were searched from January 1, 2015 to December 30, 2018 to identify relevant citations. The search was restricted to articles published in English, peer-reviewed. The website for World Health Organization and the Centers for Disease Control was also searched for information regarding safe agrochemical use. The reference section of the identified relevant articles was further checked to identify more relevant materials. For identified materials whose full texts were not available in Walden Library, I sent an email to the Walden Library team to assist with full copies. The keywords that were used to search the databases were terms related to my research and they were searched individually or in combination. The keywords included *agrochemicals, safe handling, attitude, public health promotion, perceptions, toxicity, knowledge, agrochemical users,* and *Nigeria.*

Theoretical Foundation

The theoretical framework for this study was the TPB. The TPB is a theory that is well supported by statistical evidence, and it has been applied in health-related studies for predicting and changing behavior in addition to other aspects of life (Gangal, 2013;

Godin et al., 1996). This theory originated from the Theory of Reasoned Action (TRA) in 1980, and it served to predict individual's intention to engage in behavior at a particular place (Cheng, 2017). This theory was originated to help with explaining behaviors over which people can control.

According to Ajzen (1991), the primary theoretical prepositions to this model states that behavioral achievement depends on both motivation (intention) and ability (behavioral control). According to this model, the stronger one's convictions about a positive outcome from a behavior, the stronger the attitude towards it. If one believes that well-accredited authorities or institutions support a particular guideline or behavior, there will be strong subjective norms towards that behavior (Fisher, 1967). The purpose of indulging in behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control; these intentions, together with perceptions of behavioral control, account for considerable variance in actual behavior (Ajzen, 1991; Bandura, 1977; Gangal, 2013). Bandura (1977) described perceived control as originating from the self-efficacy theory (SEI).

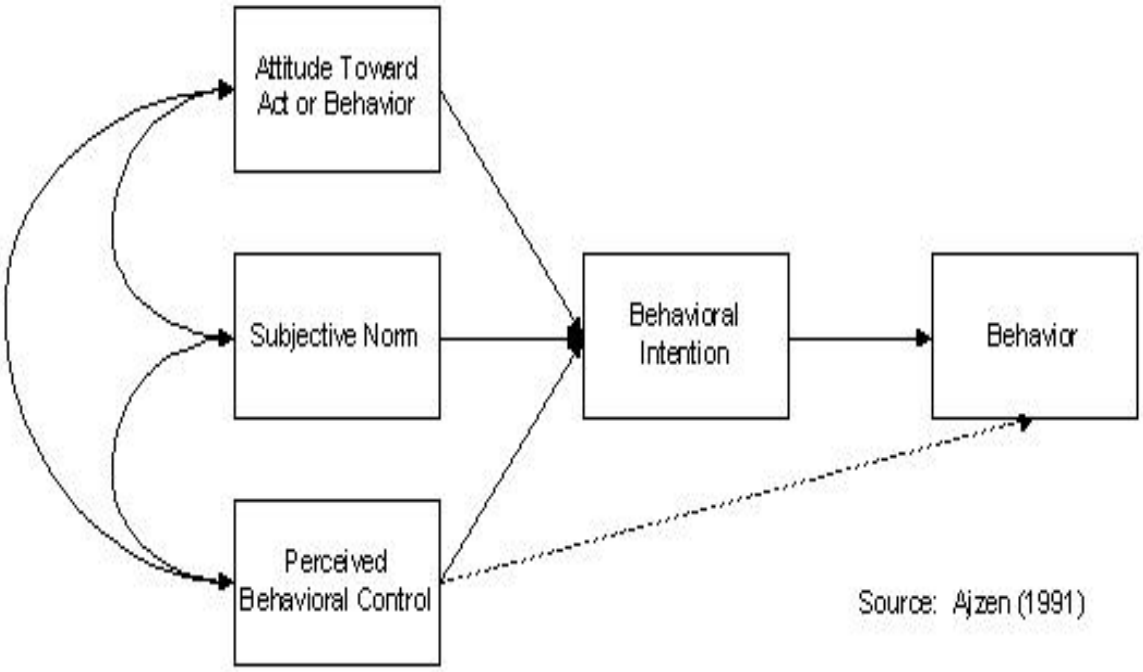

Figure 1. Schematic of theory of planned behavior.

The TPB has been applied previously for predicting and explaining a wide range of health behaviors and intentions. Tseng et al. (2018) used the TPB for developing the educational program that will help in reducing smoking among the Taiwan populace. Tseng et al. investigated factors that could predict intention to quit smoking in addition to subsequent behavior after a period. TPB was also used for understanding the factors that influenced women in Malaysia to engage in exclusive breastfeeding (Ismail, 2015). The outcome of their study highlighted the need for more health educational talks during the antenatal period on the importance of exclusive breastfeeding (Ismail, 2015).

According to Fleming et al. (2014), TPB was used to assess healthcare professionals' intentions and behaviors such as reporting of adverse drug events, and the provision of medication therapy management. Similarly, to assess the potential

collaboration and barriers between community pharmacists and physicians in their roles as public health agents, Rubio-Valera et al. (2014) utilized TPB to interpret the framework.

While investigating the safety and protective behaviors of farmers, Moradhaseli et al. (2017) used the TPB to highlight factors that influence farmers' behavior in applying safety measures. Findings of their work suggest that certain factors such as age, work experience, socioeconomic status and training influence the behavior of agrochemical users.

One of the main advantages of the TPB is that it assists with the creation of a framework which aids in identifying the motives/intentions of people in addition to providing factors that motivate people to take up the behavior of interest (Ajzen, 1991). It has also been recognized as a relevant theory for the development of policies and public health educational promotion programs. Other areas in the health sector where the TPB has been successfully utilized include the prediction and explanation of several behaviors associated with drinking, health services utilization, substance use, handling of potentially hazardous chemicals among others (Abad, 2017; Ajzen, 1991; Mello, 2016).

The choice of this theory is centered on the rationale that it will provide an insight for presenting a systematic explanation of the phenomena of safe agrochemical handling by users and it will also provide knowledge of chemical toxicity in addition to predicting the behaviors associated with the safe use of agrochemicals (Moradhaseli, 2017). This theory will assist with identifying the relationship between variables such as age, gender, level of education, years of handling agrochemicals, knowledge, and various behaviors

and attitudes associated with the practice of safe handling of agrochemicals. Some other variables to be considered include knowledge of safe chemical handling and how they are related to the period of chemical exposure use of protective equipment, level of education and awareness regarding the toxicity of chemicals. TPB aligned with comparing the levels of awareness, perception, and attitude of agrochemical users regarding safe handling. The problem is that even though agricultural workers know the importance of safe handling procedures and potential health effects, there is a failure to implement safe chemical use and handling procedures (i.e., better health behaviors). The TPB addresses this type of study that was used for this research.

In agrochemical studies utilizing TPB, perceived behavioral control referred to the perception of agrochemical users' ability and the ease or challenges and the extent of control over performing safe behaviors. In line with this, subjective norms in these studies referred to agrochemical users' perception of their views of their different demographic characteristics and how this related to their behaviors (Moradhaseli, 2017).

According to Eades et al. (2011), to understand and assist the behavior changes associated with providing public health educational and promotional programs for agrochemical users, it was essential to establish the beliefs of the agrochemical users regarding their role. Various researchers showed that farmers have a low level of health in the use of agrochemicals with a low level of knowledge and awareness about the harmful effects of agrochemicals on the environment and their safety measures against the potential risks of agrochemicals (Hashemi et al., 2012; Jallow et al., 2017). Low education of rural people, lack of information and training on the safe use of

agrochemicals, lack of spraying technologies, and inadequate protective equipment during agrochemical use have a significant relationship with the diseases and health related issues arising from use of agrochemicals (Bajracharya et al., 2014; Hashemi et al., 2012). Some researchers have suggested that the agrochemical users' safe handling behavior was heavily influenced by their level of knowledge (Fan, 2015). While the main factors associated with the choice of agrochemical use was mainly for economic purposes, that is, to increase yield and income (Zhou, 2010). Hashemi et al. (2012) showed that there was no significant difference between these two groups regarding knowledge about the dangers of agrochemicals and the attitude towards the risks of agrochemicals and safety behavior in the use of agrochemicals.

Agrochemicals

Agrochemicals have been described as chemicals that are used in agricultural activities for the enhancement of crop quality and quantity (Alabi et al., 2014; Saina et al., 2017). These chemicals are produced by chemical reactions, and they act by preventing different pests and insects from attacking the crops. Various researchers have reported these agrochemicals as toxic to the human cells and tissues and they are recognized as hazardous to the human body. Saina et al. (2017) explained that agrochemicals were reported as agents that could have access to the body via inhalation, body contact, ingestion of contaminated sources of drinking water, and food stored or transported in improperly reused chemical containers.

The research carried out by Saina et al. (2017) in Kenya centered on the horticultural industry, which contributes about 10% of agricultural produce in that land

showed that agrochemicals were in high demand for this industry. Saina et al. (2017) noted that the agroindustry provided job opportunity for the vast majority of the population. With the rise in the number of individuals involved in agriculture, Saina et al. sought to reduce the reported health impact of unsafe handling of agrochemicals (Das, 2001; Dasgupta, 2005). This was done by assessing the compliance with legal requirements by large-scale flower farm workers in Uasin Gishu County of Kenya. Saina et al. (2017) had the objective of assessing the knowledge, attitude, safe handling, and disposal of agrochemicals in addition to determining the self-reported health symptoms associated with the use of agrochemicals. Methodological approach for their study utilized a cross-sectional study with the administration of questionnaires, which was analyzed using SPSS Version 21. Findings of their research indicated that even though agrochemical handlers knew the adverse effects of agrochemicals, the majority of them were not using the safety measures that they had been trained to observe. Saina et al. (2017) concluded that agrochemicals do hurt the health and there was need for proper guidelines and policies to reduce these health risks associated with agrochemical utilization.

Safe Handling of Agrochemicals

The review of persistent residues of agrochemicals in the Nigerian environment indicated that the observance of specific safety measures will help in reducing the health risk associated with these agrochemical use (Mazlan et al., 2017). Various researchers have indicated that Nigeria is a significant consumer of agrochemicals in sub-Saharan Africa and yet policies on the proper utilization of these agrochemicals are not in place

(Mazlan, 2017; Ndaghu, 2017). Several studies have reported the high level of indiscriminate/ unsafe use of agrochemicals by farmers in Nigeria. This has been linked to the rising incidence of series of chronic end-points including prostate cancer, neurotoxic, immunotoxic, and endocrine effects, and reproductive defects (Govinda, 2014). Mazlan et al. (2017) suggested the need for environmentally friendly approaches such as integrated pest management (IPM) to be adopted to reduce the health challenges associated with the use of agrochemicals. Information regarding the proper handling of agrochemicals and the use of advanced technology should be disseminated to the farmers and agrochemical users. Monitoring the health of the exposed agrochemical workers is an essential component for the guideline on safe agrochemical handling (Desalu, 2014; Ndaghu, 2017).

Ndaghu et al. (2017) sought to assess the perception of health hazards associated with agrochemicals handling and use among arable crop farmers in Mubi agricultural zone, Adamawa state, Nigeria. Outcome indicated that most farmers were young. The overall objectives for the study set at to investigating farmers (a) socioeconomic characteristics, (b) use of agrochemicals, (c) awareness of safety practices in agrochemicals handling and use, and (d) information sources on agrochemicals handling and use. The study highlighted the need for better policies that will meet the specific needs of each community involved in different agricultural activities in addition to the demographic characteristics of the agrochemical users. The conclusions of Ndaghu et al. were targeted at the necessity for agrochemical companies to ensure the clarity of instructions on the use of such chemical. The role of extension workers as it relates to the

proper training of agrochemical users was also emphasized bearing in mind that these group of workers is meant to be the custodians of agricultural related activities (Adewumi et al., 2001).

Attitude Towards Handling Agrochemicals

Safe agrochemical handling as described by Desalu et al. (2014) stemmed from the use of modern farming techniques that relies on the use of several agrochemicals such as fertilizers, pesticides, and crop preservatives to produce and preserve an abundance of high-quality food. The outstanding benefits of agrochemicals such as improved crop production are also saddled with hazardous effects, which are of public health interest (Govinda, 2014). The improper storage, disposal, and use of these chemicals in agriculture over the years have caused exposure and severe health problems in many developing countries including Nigeria (Desalu et al., 2014; Ibitayo, 2006).

Moradhaseli et al. (2017) in their study on the attitude and practice of farm workers about safety observation used a methodology with a cross-sectional approach that utilized questionnaire to answer their research questions. This study carried out in Iran using research question, which was quantitative in nature sought to understand the perceptions of farmers regarding the use of agrochemicals in addition to their level of understanding and factors that influence the practice of safety when handling agrochemicals. Farmers in this region were not provided with the required/essential protective equipment neither did they have adequate knowledge of alternative protective devices. This is also in line with the work of other researchers in a similar environment who also reported low use of safety measures among farmers when compared with those

engaged in the use of protective devices (Aghili Nejad et al., 2007). The works of other researchers who worked among different crop growers such as cocoa farmers in Pakistan, Nepal, and southwest of Iran are also consistent with Moradhaseli et al. who reported a low use of PPE (Ahmed Khan et al., 2010; Atreya et al., 2012; Hashemi et al., 2012).

Safe handling of agrochemicals was linked to prevention of adverse health effects associated with the use of agrochemical in different environments (Atreya et al., 2012). The work of Li et al. (2014) in China among farmers indicated that there are neurological effects of pesticide handling especially when safety measures are not applied. Hoppin et al. (2017) also reported that the use of pesticides was associated with allergic and non-allergic wheezing among male farmers. With the high rate of health risk associated with the use of agrochemicals, reliance on these chemicals for the improvement of the economy Hashemi et al. (2012) carried out a research in southwest Iran to understand the perception of farmers regarding pesticide use and risk perceptions. Several factors were responsible for safe use of agrochemicals, some of the factors identified by the research included farmers' false belief about the toxicity of pesticides, lack of attention to protective measures, environmental hazards, lack of attention to information on pesticides' containers, defective spray equipment, improper maintenance of spraying equipment, and lack of appropriate protective clothing (Atreya, 2012; Calvert, 2008; Dasgupta, 2005)

Effects of Agrochemicals on Health

Shahzad et al. (2016) explored the effects of insecticides on a group of farmers in Punjab using a mixed study where a structured questionnaire was used to obtain the

demographics and pesticide-related details. Blood samples were collected from the exposed and unexposed groups to determine the biomarkers for liver and kidney function. The results of their biochemical analysis study showed that farmers exposed to pesticide had significantly elevated levels of urea and alanine transaminase and low serum albumin and protein when compared to the control group. Variation in serum creatinine, aspartate transaminase, and albumin, TP was also observed in farmers with poor protective measures. There is justification for the education of agrochemical users on the risk associated with agrochemical use in addition to factors that will help in reducing some of these adverse health effects (Issa et al., 2017).

Kataria et al. (2015) used a documentary to highlight the adverse effects of a wide range of environmental chemicals on cardio renal function. This review was born out of global concern for increasing incidence of chronic kidney disease (CKD) among individuals of all ages. The authors concentrated on compounds that individuals are likely to be exposed to as a consequence of normal consumer activities in addition to chemicals used for agricultural purposes. Results of their review suggested that exposure to environmental chemicals would result in progressive renal dysfunction. Understanding the implications of exposure to chemicals will assist with the provision of regulatory guidelines that will limit individual exposure to environmental chemicals in an attempt to reduce the incidence of cardio renal disease and other diseases associated with the use of chemicals (Goel, 2007; Rim, 2017; Zakhary, 2011).

Health Promotion Program on Safe Agrochemical Use

According to WHO (2018a), health promotion was described as the process of enabling people to increase control over, and to improve, their health. Following the report of an increase in mortality due to use of agrochemicals in developing countries, Ojo et al. (2016) examined pertinent environment-health issues related to the use of (synthetic) chemical pesticides in agriculture and general household in Nigeria. Ojo et al. (2016) focused on a wide range of social and environmental intervention for the health risk associated with agrochemical use. Ojo et al. (2016) examined factors responsible for the well-cited data that 99% of the deaths associated with pesticides occur in developing countries like Nigeria, where only 25% of the world's production of pesticides are used (Asogwa & Dongo, 2009; Ivbijaro, 1990; Ivbijaro, 1998). Some factors that have been identified as responsible for the increasing risk associated with agrochemical use include poor pesticide education leading to extensive misuse; issues with correct, practical, and safe applications of pesticides; the use of the cheaper but deadliest types of pesticides; poor legislation and lack of enforcement of available legislation; lack of adequate information, knowledge, and awareness of the inherent dangers of pesticides; lack of training on correct safe handling of pesticides at home; absence of monitoring for pesticides residues on locally-consumed products, unlike the situation for products meant for export; and inadequacies in medical recognition and responses to pesticide poisoning (Asogwa & Dongo, 2009; United Nations Environment Programme (UNEP), 2004).

Various researchers on agrochemicals and impact on health have sought to address these issues and also proffer solution to the current problem. Ojo et al. (2016)

emphasized that health promotion among the community members will play a vital role in the practical use of guidelines for safe handling of agrochemicals. Other solutions suggested based on the outcome of review by Ojo et al. (2016) included more public education, more intensive promotion of the IPM Scheme, green technology, and adoption of food irradiation by gamma rays to extend shelf lives of agricultural products.

The Nigerian government is expected to play a significant role through the education of various organizations involved with either the production or utilization of agrochemicals. Mechanisms should also be in place to ensure that all banned agrochemicals are not brought into the country. Education of agrochemical users may also include training on testing protocols for safe disposal of expired, obsolete, or otherwise unwanted pesticides which must always be in place and should be well publicized. Relevant research and healthcare institutions may be encouraged and empowered to keep a database on pesticide use and incidents of pesticide poisonings in Nigeria. This may help in developing appropriate and prompt responses to reduce the adverse impacts associated with pesticide use in the country (International Atomic Energy Agency (IAEA), 2003).

Agrochemicals and Toxicity

Agrochemicals, which were described as chemicals with known toxic effects for killing or preventing, unwanted living organisms on crops, could also produce adverse health impacts in humans. Ojo et al. (2016) and Asogwa and Dongo (2009) indicated that the most affected people for adverse health effects associated with agrochemicals are those who directly apply the agrochemicals, such as farmers followed by members of

their immediate family, and the general public who consume food products with high residues of these agrochemicals. Children have been reported as the most vulnerable globally; this is linked to their biological makeup and enhanced exposure circumstances (UNEP, 2004; Zahm & Ward, 1998). Various researches have pointed out that there are approximately 1 million to 5 million cases of pesticide poisoning reported as occurring yearly globally. This resulted in about 20,000 fatalities among agrochemical users globally with 99% of deaths occurring in the developing countries like Nigeria (Jeyaratnam, 1990). The prevention of high toxicity related health issues depends on the safe handling of agrochemicals. This will require developing interventions that will ensure that the agrochemical users practice safe agrochemical use (Ojo et al., 2016).

Ndaghu (2017), while researching farmers in Northeastern Nigeria, found out that farmers' perception of health hazards associated with agrochemical handling was low. Ndaghu showed that 56.6% of respondents perceived agrochemicals handling and use as nonhazardous, implying that majority of the agrochemical users were unaware of the health hazards associated with the handling and use of agrochemicals. In another study, Issa (2016) found that though there was a high awareness of the health impact of agrochemicals, farmers were still reluctant to utilize safe agrochemical practices. Efforts should be made by researchers to understand some factors that might be responsible for variations in knowledge and application of safe agrochemical practices to prevent health issues arising from the use of agrochemicals. Asogwa et al. (2009) reported high dependence on agrochemicals use by arable crop farmers in Nigeria. Health impacts associated with the use of agrochemicals may likely increase if public health workers and

organizations if preventive measures are not put in place by public health workers and organizations.

Knowledge of Safe Agrochemical Use

Agrochemicals being poisonous may pose some degree of risk to health (Damalas, 2016). The most vulnerable people at risk are farmers and the environment because they are usually in contact with the agrochemicals when mixing these chemicals or during application onto the crops. According to Mew (2017), there have been hundreds of cases of poisoning in the developing world, where information and training on the potential adverse health effects of these agrochemicals are often lacking, these are attributed to pesticides. Acute poisoning with pesticides is a global public health problem, accounting for as many as 300,000 deaths worldwide every year (Goel et al., 2007), including intentional and unintentional exposures. Many of these pesticide poisonings, particularly in the developing world like Nigeria, are intentional (Mew, 2017). A conservative estimate by Mew reported approximately 110,000 pesticide self-poisoning deaths each year from 2010 to 2014, comprising 13.7% of all global suicides. Agrochemicals sprayed on the crop can leave behind residues that can be eaten by consumers, with differing exposure cases between populations in different countries of the world (Goen, 2017).

The safe use of agrochemicals will reduce these incidences of poisoning. Macfarlane et al. (2008) carried out work on training and predictors of safety and personal equipment use among Australian farmers and his findings support training as an essential intervention for reducing farmers' exposure to agrochemicals. Safety training is

defined as instruction in hazard recognition and control measures, learning safe work practices and proper use of personal protective equipment, and acquiring knowledge of emergency procedures and preventive actions (Cohen, 1998). The application of safe practices in farmers' field schools (FFS) in Bolivia had positive effects (e.g., the improvement in the use of PPE and hygiene when handling agrochemicals, knowledge, and application of safety guidelines). A reduction in self-reported symptoms after pesticide handling has however been reported as scarce in most low-income countries like Nigeria (Jørs, 2014). Differences reported between the perceived importance (perception) and knowledge/attitude of farmers on the safety measures will require more research in understanding factors responsible for the differences. One of the factors that might be responsible for the differences is the different demographic characteristic of the farmers (Hashemi et al., 2009). The reported poor uptake of training by farmers on agrochemicals and the consistent public health issues arising from their use are a source of concern. Studies on the relevance and effectiveness of safe agrochemical handling training are limited. Information gained from the evaluation of the perception, attitudes, and knowledge of farmers in Plateau State, Nigeria, regarding agrochemical use and its effects, can be used for guiding decision-making and for designing more effective training components.

Perception of Agrochemical Users

The use of crop protection products all referred to as agrochemicals have been documented to have several benefits such as; improvement in land productivity, reduced need to cultivate more land, and more significant and more stable income for countries

(Damalas, 2009). Globally, the majority of farmers rely on agrochemicals, including toxic chemicals, to a higher degree when compared to traditional pest control methods (e.g., physical and mechanical control) and IPM (Khan, 2015). According to Carvalho (2017), the increase in the use of agrochemicals among farmers is associated with the convenience and high efficacy reported by users. Researchers in different aspects of agrochemical safety have reported concern over the misuse of pesticides particularly in developing countries; this has resulted in severe concerns of personal and environmental safety (Mengistie, 2017).

Several consequences have been linked to the misuse of agrochemicals such as ecological imbalance and environmental pollution. Some of the factors that have been linked to problems related to agrochemical misfortunes include over-reliance of farmers on pesticides, lack of knowledge of proper handling practices, and inadequate access to training on pesticides. The implication of this is a high risk of pesticide exposure for farmers and pesticide residues on crops (Damalas, 2017). With the reported high level of risk exposure to pesticides among farmers, there are calls for immediate intervention aimed at increasing awareness about understanding the perceptions of agrochemical handlers regarding safety when using pest control chemicals (Baharuddin, 2011). Having a perspective that allows for use of appropriate type of spraying equipment, the use of proper protective clothing when handling pesticides, and the adherence to correct spraying practices have been found to be critical factors influencing the degree of pesticide exposure among those applying pesticides (Baharuddin, 2011; Damahas, 2017; Mengistie, 2017).

Overall, there will always be risks associated with the use of agrochemicals by farmers, which will also affect family members since they are always in contact with these poisonous chemicals (Damalas, 2016). With limited information about having the right attitude and perspective towards the potential adverse health effects of agrochemicals, there is often an increase in the number of acute poisoning resulting from agrochemical use in developing countries like Nigeria (Goel, 2007; Mew, 2017). For instance, cases of over application have been reported by Ojo (2016) to be common when he did a review on agrochemical use in Nigeria. Ojo reported that in Nigeria, among government-trained, or agency-trained and assisted small-scale farmers, far greater quantity of pesticides than prescribed is applied with the perception that this action would enhance the function of agrochemicals.

Other common misuses of agrochemicals in Nigeria as reported by Ojo (2016) included:

1. Pouring pesticides into rivers to kill fish, which is sold for human consumption. Many have become poisoned as a result of such practices.
2. Spraying Gamalin 20 on drying cocoa beans to prevent molds and maggot development.
3. Mixing of different classes of pesticides together to reduce the workload of spraying each differently. Apart from affecting effectiveness, such a practice could also dramatically worsen the potential health hazards (Asogwa & Dongo, 2009).

4. Wrong use of nozzles for spraying equipment, making it difficult for the desired quantity of pesticides to be administered. Both over-dispensing and under dispensing could have significant adverse impacts on the environment and on human health.
5. Lack of knowledge on time needed for degradation of pesticides.
6. Use of wrong formulations and doses, and wrong timing of application.

Some examples of problems associated with the use of agrochemicals, which have been reported by various researchers, include increased exposure to pesticides and high chances of pesticide resistance, and pesticides sprayed on the crop can leave behind residues that can be eaten by consumers, with differing exposure cases between populations in different countries of the world (Goen, 2017).

Macfarlane et al. (2008) in a study among Australian farmers reported that training would likely to be a necessary intervention for reducing farmers' unnecessary exposure to agrochemicals. The training would entail understanding the demographic characteristics of farmers, which will help in identifying farmers' perspective, knowledge and attitudes towards safety and the use of agrochemicals. Safety, according to Cohen (1998) could be described as instruction in hazard recognition and control measures, learning safe work practices and proper use of personal protective equipment, and acquiring knowledge of emergency procedures and preventive actions.

Training has been shown to be an essential means for improving the knowledge and perception of members of different occupations. Jors (2014) applied this when he trained smallholder farmers on IPM and good agricultural practices in farmers' field

schools (FFS) in Bolivia. The outcome of the study revealed positive effects among farmers that trained (e.g., improvement on the use of PPE and hygiene when handling pesticides, knowledge, and use of IPM and a reduction in self-reported symptoms after handling agrochemicals), these have been reported as being scarce in most low-income countries like Nigeria (Jors, 2014).

The perspectives of farmers regarding safety measures are considerably different; this was the conclusion of Hashemi (2009) who evaluated the training needs of farmers in Greece. Majority of the needs were attributable to differences in age along with other background characteristics (Hashemi, 2009). The poor implementation of safe pesticide handling taught during training of farmers and the aging farming workforce are causes for concern in addition to being a public health challenge. Studies on the knowledge, perspectives, and attitudes of safe agrochemical use by farmers in Plateau State are limited. Evaluation of this by any available means such as a systematic process of gaining insight into training centered on public health education can be used for guiding decision-making and for designing more effective training components.

Various studies have shown that training was associated with increased farmers' knowledge of agrochemicals and perspectives regarding hazard control; this was accompanied by elevated safety behavior, with resultant lower occupational exposure to pesticides (Damalas, 2016; Hashemi, 2009). Interventions that will enhance knowledge and compliant perspective with safety behaviors are most likely capable of effectively decreasing farmers' exposure to agrochemicals and should become a priority. Promoting the development and facilitation of lifelong learning related to agrochemical use should

be a priority for minimizing risks to human health and the environment (Damalas, 2017). The problem is not whether a farmer receives training or not, but whether that farmer applies the knowledge received on safe agrochemical handling in the use of these toxic chemicals. The current levels of knowledge and perspectives of agrochemical users in Plateau State need to be evaluated when developing policies, training programs, and recommendations for reducing potential hazards associated with the use of agrochemicals. Such programs on agrochemical safe handling when developed will address gaps in farmers' perspectives and knowledge about agrochemicals.

Use of Agrochemicals in Nigeria

Nigeria is located in West Africa sub-region and found between latitudes 40N and 140N of the equator, and between longitudes 30E and 150E of Greenwich Meridian (Atlas of Nigeria, 2018). According to Aviv et al. (2002), about 72 million hectares are available for farmers to cultivate either via irrigation or rainy season farming which usually lasts for a period of between three to four months. Farmers in Nigeria are engaged in the cultivation and other agricultural processes such as planting, weeding, and spraying of agrochemicals including pesticides, herbicides, and application of fertilizers/ manure. Agriculture in Nigeria is the most fundamental form of economic activity, and it is facing severe challenges by biotic components of the environment, particularly parasites, pathogens, fungi, and weeds (Ndaghu, 2017). Farmers play an essential role in the elimination of these agents of diseases to root crops, cereal crops, fibers, fruits, vegetables, stored grains, and livestock. These are controlled by farmers via application of pesticides to control these unwelcome fungi, insects, birds, and weeds to curtail their

losses by applying them to farmlands, crops and stored grains to protect and remedy the farm produce from the ravage of these unfriendly organisms (Maton, 2016). A majority of farmers in West Africa have a low level of education regarding health implications of some of the agrochemicals used, ranging from the principle of their action, concentrations used and personal protective equipment for pesticide handling (Mabe, 2017). The invention of many agrochemicals came after World War II to combat pests of human and animal diseases in tropical areas, and Nigerian farmers used them extensively.

Currently, it is difficult to ascertain the estimate of agrochemical use in Nigeria statistically (Ojo, 2016). According to the Food and Agriculture Organization website which provides such information as agrochemical use for several countries, there are presently no data for Nigeria (Food And Agriculture Organization of the United Nations Statistics Division FAOSTAT, 2015). However, it was estimated that as of 1998, about 125,000-130,000 metric tons of agrochemicals in the form of pesticides were being utilized every year in Nigeria. According to Ikemefuna (1998), cocoa pesticide use accounted for about 31% of the total agrochemical market of which fungicides accounted for 65% and insecticides 35%. Different research works have noted that the two most-used pesticides in the World are the herbicides glyphosate (Roundup) and atrazine (PANA, 2016).

Protection of farmers from the effects of agrochemicals on their health and others will require an understanding of their perspective and knowledge on safe agrochemical use as this will provide information to be used for public health educational and promotional programs. According to Fertman and Allensworth (2017), effective public

health promotional programs will incorporate good communication, which will take into account participants ethnic concerns and one's educational level when developing health material. In developing an intervention health program for promoting safe agrochemical use by farmers, the focus should be on prevention of health challenges associated with the use of pesticides by farmers in Nigeria.

Summary and Conclusions

The unsafe use and handling of agrochemicals among Nigerian farmers continues to constitute health hazards and environmental degradation (Asogwu & Dongo, 2009; Ibitayo, 2006; Ivbijaro, 1998; Ndaghu, 2017). Among the Ethiopian vegetable farmers, Mengistie et al. (2017) reported the unsafe use of agrochemicals practices such as unsafe storage facilities, ignoring risks and safety instructions, not using protective devices when applying pesticides, and dispose of containers unsafely. Several studies have reported the high level of indiscriminate/ unsafe use of agrochemicals by farmers in Nigeria. This has been linked to the rising incidence of series of chronic end-points including prostate cancer, endocrine effects and reproductive defects (Govinda, 2014; Rim, 2017; Zakhary, 2011).

The unsafe use of agrochemicals is worse in Northern Nigeria where the level of education and higher participation in agricultural based activities, such as rainy season and dry season farming, is on the increase (Ndaghu, 2017). It has been difficult to ascertain an estimate of agrochemical use in Nigeria. As at June 2016, the Food and Agriculture Organization website which provides such information for several countries had no data for Nigeria (FAOSTAT, 2015). However, it was estimated that as of 1998,

about 125,000-130,000 metric tons of agrochemicals specifically pesticides were being applied every year in Nigeria. In 1991, cocoa pesticides accounted for about 31% of the total agrochemical market in which fungicides were the mostly used (Ikemefuna et al., 1998).

Agrochemicals are poisons meant to kill or ward off unwanted living organisms on agricultural products and these have been shown to produce adverse health impacts in people. The reported most affected are those who apply the agrochemicals such as farmers, applicators, members of their immediate family, in addition to the general public who consume food products with high residues of pesticides. Children are described as the most vulnerable, due to biological factors (UNEP, 2004; Zahm & Ward, 1998). Health issues associated with agrochemical use are particularly worse in Nigeria because of the mortality rate reported among agrochemical users to the tune of 99% of the deaths (Jeyaratnam, 1990), even though only 25% of the global agrochemicals are used in the developing countries like Nigeria.

The high mortality associated with the use of agrochemicals in Nigeria despite its low use, is attributed to several issues related to the use of these products such as the most deadly chemicals are used in Nigeria due to their being cheaper than newer safer agrochemicals (Erhunmwunse et al., 2012; McConnell & Hruska, 1993), people get unnecessary exposure to these chemicals while applying them. This is due to a combination of economic reasons and ignorance; many fail to put on required personal protective equipment such as gloves, overcoats, and masks (Asogwa & Dongo, 2009; PECAN, 2013). It has been pointed out that it is difficult for farmers working in the

tropics with ambient temperatures reaching 40 ^{0}C to wear protective rubber gloves and respirators, even if they could afford them (McConnell & Hruska, 1993).

Lack of training on the correct handling of agrochemicals by agrochemical users and family members have been reported as a factor also responsible for the health issues relating to the use of these compounds. In some instances, some of those who understand that there are health hazards associated with the use of agrochemicals, still exhibit several dangerous habits and practices which have been innocently learned over the years (Ojo, 2016). A significant issue is the improper disposal of empty pesticide containers. Many people put empty containers to a variety of domestic uses including storage of water and powdered food following casual washing. Few people take time to thoroughly wash their hands with soap after the use of these chemicals (Asogwa & Dongo, 2009; UNEP, 2004). There is a gap in the training on the safe use of these products and disposal of the products and their accessories in the Nigerian community, and an understanding of the knowledge of the users will be vital in developing a guideline for their training (Ojo, 2016).

The effectiveness, relevance, and challenges of the safe use of agrochemicals among Nigerian farmers have been examined in different agricultural, environmental and public health disciplines. Some studies were conducted to answer series of questions about health promotion and agrochemical use and the provision of preventive health services. However, these studies were conducted in locations with highly mechanized agricultural tools such as planes or tractors in developed countries and applied with the hand in developing countries like Nigeria (McConnell & Hruska, 1993). There is no

record of any study to describe the knowledge, attitudes, and practices of safe agrochemical use by users in Plateau State. This research will fill these gaps by ascertaining the knowledge and attitudes of agrochemical users in this environment with the aim of promoting environmental and public health in Plateau State.

In Chapter 3, I will describe the research methodology for this study, in addition to highlighting the settings, study population, instrumentation, data collection and analytical techniques used. Chapter 3 will also include an outline of the ethical considerations for the study and a description of both the independent and dependent variables in the study.

Chapter 3: Research Method

Introduction

Agrochemicals have been used for several decades in the field of agriculture and they are known to have several effects on both health and the environment (Abu Bakar, 2015; Cruz-Morató, 2014; WHO, 2017). Conventional agriculture that includes the intensive use of agrochemicals has been introduced in many countries, including Nigeria, to meet the food needs of the population (Kamoun, 2018). There is a rising demand for the use of agrochemicals in Nigeria due to the growing population and its attendant economic benefits. The use of these chemicals is associated with high cases of mortality, ironically in developing countries that utilize lower amounts of these compounds (Saina, 2017; Eurostat Statistical Books, 2007). This mortality is related to the unsafe handling and misuse of agrochemicals leading to accumulation of hazardous wastes in the body. These chemicals may be carcinogenic, immunogenic, and possess the ability to alter normal metabolic activities (Kataria, 2015).

Training in proper use of agrochemicals is key in the prevention of health-related issues arising from the use of these compounds (Hashemi, 2009). Understanding the demographic characteristics of farmers in Nigeria and their attitudes towards the use of agrochemicals will be valuable for developing health promotion programs (NCFH, 2012). There has been much emphasis on the need for physical self-protection against unnecessary contact with agrochemicals through education and the use of PPE (Akinpelu, 2011). To date, in Nigeria, there is no record of any study describing the knowledge and attitudes of agrochemical users on the safe handling of these chemicals.

The purpose of this study was to describe the knowledge, attitudes, and practices of farmers in Plateau State, Nigeria, regarding safe handling of agrochemicals. This would serve as a platform upon which policies for health promotion programs on training would be developed for agrochemical users. This work would also provide the needed empowerment for the propagation of safe health care practices and awareness in their communities.

This chapter describes the research design for this study and the rationale for its choice. I also describe the study population and how participants were recruited. It includes the instrument for the study, the data collection methods, and how the data were analyzed (the different statistical analyses that were used to address the research questions). The potential threats to both the internal and external validity of the study were discussed and ethical issues were addressed. The chapter ends with a summary of the research methods.

Research Design and Rationale

This study was quantitative, and described the knowledge, attitudes, and practices of farmers in Plateau State on safe handling of agrochemicals. This study was carried out to provide source of information for developing a program on health education for farmers. I assessed the background knowledge of farmers and their practices (dependent variables) of safe handling of agrochemicals in relation with their demographic characteristics (independent variables). The independent variables included age, gender, duration of agrochemical use, geographical location, educational level, types of agrochemicals used, and average number of visits to a health facility for health issues

related to agrochemical use. Other independent variables were prior training on safe agrochemical handling and the use of PPE.

Quantitative research was the most appropriate research design for this study in view of the fact that I tested hypotheses based on assessing relationships between the independent and dependent variables and the strength of such relationships. This study used a cross-sectional study design because the study population was described based on both exposure and outcome measures simultaneously and the research questions required a single evaluation of the study population. The study did not require comparison of two or more groups to assess the effects of an intervention as would have been for an experimental or quasi-experimental design.

An advantage of cross sectional study design for this study is that it was readily conducted in the natural setting, thereby increasing the external validity of findings from the research. It also had the advantage of immediate outcome assessment; with no attrition or loss to follow up. With the large population of research participants that were scattered over a wide geographical area, as was the case in this study, the choice of cross-sectional study design was most ideal.

Research Questions and Hypotheses

The following research questions guided this study:

RQ1. Does engagement in the safe handling of agrochemicals have any relationship with the professional and individual characteristics of farmers that use agrochemicals in Plateau State?

$H1_o$: There is no difference in engagement in the safe handling of agrochemicals and the professional and individual characteristics of farmers that use agrochemicals in Plateau State.

$H1_a$: There is a difference in engagement in the safe handling of agrochemicals and the professional and individual characteristics of farmers in Plateau State.

RQ2. What is the relationship between the experience of farmers regarding agrochemical safety and their level of education?

$H2_o$: There is no statistically significant relationship between the experience of farmers regarding agrochemical safety and their level of education.

$H2_a$: There is a statistically significant relationship between the experience of farmers regarding agrochemical safety and their level of education.

RQ3. What are the perceptions of farmers regarding the safety of agrochemicals and their years of practice?

$H3_o$: There is no statistical relationship between the perceptions of farmers regarding the safety of agrochemicals and their years of practice in Plateau State.

$H3_a$: There is a statistically significant relationship between the perceptions of farmers regarding the safety of agrochemicals and their years of practice in Plateau State.

RQ4. What are the attitudes of farmers regarding the safe handling of agrochemicals?

$H4_o$: There is no statistically significant relationship between the attitudes of farmers and safe handling of agrochemicals by users in Plateau State.

$H4_a$: There is a statistically significant relationship between the attitudes of farmers and safe handling of agrochemicals by users in Plateau State.

RQ5. What are the actual practices of farmers regarding the safe handling of agrochemicals?

$H5_o$: There is no statistically significant relationship between the actual practices of farmers and safe handling of agrochemicals among agrochemical handlers in Plateau State.

$H5_a$: There is a statistically significant relationship between the actual practices of farmers and safe handling of agrochemicals among agrochemical handlers in Plateau State.

Methodology

Study Location

Plateau State is one of the states in the North-Central geopolitical zone of Nigeria with Jos town as its capital. The state is divided into three senatorial zones, which are Northern, Southern and Central zones. These zones comprise a total of seventeen Local Government Areas (LGAs), that is, six LGAs each for the northern and southern zones with five for the central zone. It lies between the latitude of 800 241 and longitude of 800 32I and 100 38I East of the Greenwich Meridian. It is situated in the tropical zone, with a higher altitude ranging from 12 meters about 400 feet to a peak of 1829 meters above sea level. The state covers a total land area of 53,585 square kilometers (Federal Office of

Statistics, 2006). It has a population of 3,178,712 persons consisting of 1,593,033 males and 1,585,679 females with a population-growing rate of 2.7 % per annum (National Population Commission, 2006).

Study Population

This study was conducted among farmers in Plateau State, Nigeria. They were considered for this work based on their geographical spread. However, because of logistics, financial considerations, and time allocated for this study, all farmers in the state were not reflected in this work. The population of farmers for this study was defined as those engaged in agricultural (arable) farming excluding pastoral and mixed farming.

Sampling and Sampling Procedures

The Plateau State Government via the Ministry of Agriculture recently registered more than 100,000 farmers spanning the 17 LGAs of the state for a federal government agricultural bank loan (Jtown Forum, 2018). This list served as the sampling frame. Farmers were selected via a multistage sampling technique. All the three senatorial zones of Plateau State were included in the study. Simple random sampling was used to select one LGAs each from the senatorial zones and the sample for this study was proportionately derived from the sample frame using the table of random numbers from the lists corresponding to the selected LGAs. Permission to access and use the list was sought from the relevant authorities in the State's Ministry of Agriculture.

Sample Size Analysis

Working with Raosoft sample size calculator (Raosoft Inc., 2004), with an estimated population of farmers in Plateau State as 150,000 while accepting a 5% random

error, 95% confidence interval and 80% response distribution, the recommended minimum sample size was given as 246. Considering the need to accommodate unforeseen challenges with recruitment, questionnaire administration, collation, poor response, and possibly badly filled questionnaires, this figure was buffered to 260 farmers from Plateau State.

Inclusion and Exclusion Criteria

Farmers included in this study fulfilled the following inclusion criteria:

- Must have been conducting arable farming before the 30th of September 2018 (i.e., grow crops).
- Must have been in practice for about 6 months before the commencement of this study.
- Must have been involved in the use of agrochemicals for farming purposes.
- Must have consented to participate in the study.
- Must have been practicing farmers.

Farmers who did not fulfill the conditions listed above were excluded from participating in the study.

Recruitment and Participants

The list of selected farmers and their contact details was retrieved from the Plateau State Ministry of Agriculture. Farmers were located by contact tracing in each of the selected LGA from the senatorial zone of the state. Local staff from the Directorate of Agriculture in each LGA was engaged with identifying the farmers. An interpreter was involved with interpreting the questions into the local language (Hausa) for farmers that

did not understand English. The farmers were recruited with no personal identifiers except for the study identity numbers, which was indicated on each questionnaire to help identify farmers that had been visited. Before administering the instrument to the farmers, I (alongside my research assistants) met the training requirements established by the Walden University IRB for the protection of human subjects before the collection of data. I introduced myself and the purpose of the research work. The farmers indicated their willingness to participate in the study by consenting. Those that consented for the study signed (or thumb printed) a consent form as an agreement for participation. In addition, the total number of farmers that were approached for the study and those that consented to the study was documented.

A step-by-step approach was used for the recruitment of participants as follows:

- I visited the responsible officer of the Ministry of Agriculture Plateau State to introduce myself, made my intentions known, and also sought permission to carry out the research in the selected LGAs of the state.
- After securing permission, I visited the Directorate of Agriculture in the selected LGAs and introduced myself. I also sought for a community mobilization officer who served as my logistics officer in identifying the farmers and interpreting the questionnaire into their local dialect (Hausa).
- On meeting the farmers, I introduced myself and the purpose of coming. I ascertained their potentials for inclusion in the study. If they were eligible, I sought their consent to participate in the study by answering my questions.

- The estimated duration of the questionnaire administration was spelled out and a conducive location was identified for the process.
- For those that did not consent to the study, I appreciated their time and moved on to the next participant.

Data Collection

This study was carried out using a structured paper based, interviewer-administered questionnaire. The questions were read out to the farmers that consented to participate. Questions that the participants had regarding the research was addressed. For those that did not understand English, the interpreter interpreted the questions into their local language (Hausa). Data collection was carried out between the hours of 9am-5pm Mondays through Saturdays for a period of 3 weeks at the locations of the farmers in the LGAs. At the end of each day of data collection, the information generated on the questionnaires was entered into my personal laptop computer. This was secured with a password to protect the information while the hard copies were kept in a filing cabinet in my office and locked for safety.

This process was repeated until all of the farmers in the selected LGAs had been visited and all data collected. At the end of data collection period, I entered the data generated from the questionnaires into my computer as a duplicate entry. I collected the data alongside two research assistants. The hard copies will be shredded after some period of storage (5 years).

Instrument

A modified survey instrument developed by Saina et al. (2017) was used for data collection. The questionnaire was pilot tested to ascertain its suitability for the local population of farmers in Plateau State. The questionnaire contained four sections. The first generated information on demographic characteristics of the farmers including age, educational level, training or education on agrochemical use, and years of farming experience. The second section focused on farmers' level of awareness of agrochemicals laws and regulations, and knowledge and understanding of agrochemicals with respect to the environmental and human health. The third section included questions regarding agrochemical handling and safety practices including reading and following label instructions, use of PPE and other protective practices, storing and disposing of agrochemicals empty containers etc. Data on self-reported health related issues and toxicity symptoms associated with agrochemical use, as well as farmers' knowledge about exposure routes was also collected. A sample of the questionnaire is attached in Appendix A.

Types of Variables and Measurement

The variables of interest in this study were the dependent and independent variables. The independent variables considered in this study-included location of farming practice, gender, age, duration of farming, and highest educational level. Others were the type of farming activity carried out, frequency and average number of times agrochemicals were used. Dependent variables included were practice of safe agrochemical handling by farmers, knowledge of safe agrochemical use and attitudes

towards the practice of safe chemical handling among others. Some confounding variables that may influence the associations between some of the independent variables and dependent variables may be prior education or training on the effects of agrochemicals on health, prior visit to an agricultural training center.

The measurement of the dependent variables: attitudes towards safe agrochemical handling were achieved by the use of a composite questionnaire that was designed. A five-point Likert scale was used with scores ranging from 1 (*disagree*) to 5(*strongly agree*). Scoring for this scale was by the use of mean opinion score (MOS) for ordinal scale data for each farmer. Every respondent's MOS for attitude with a score ≤ 3 was interpreted as having poor attributes while all those with scores > 3 denoted good attributes. The questions on knowledge of safe agrochemical use were used to compute a knowledge score for each farmer based on the number of correct answers given. Correct responses were scored 2 while incorrect ones were scored 0. The maximum possible score was set at 24. The possible scores were graded as follows: and a score of 8 and below was considered poor knowledge, 9-16 average knowledge while 17-24 was taken as good knowledge (Braimoh et al., 2014). Table 1 shows the variables of interest and their operationalization.

Table 1

Variables and Operationalization

Independent variables	How variable would be measured	Measurement scale
Age	Number in years	Interval
Gender	Male or female	Nominal
Geographical location	Name of the LGAs	Nominal
Duration of farming	Number in years	Interval
Highest educational level	Primary, secondary, tertiary	Nominal
Training on agrochemical use	Yes/No	Nominal
Membership of farmers association	Yes/No	Nominal
Dependent variables		
Attitudes towards safe agrochemical use	A five-point Likert scale was used with scores ranging from 1 (*disagree*) to 5 (*strongly agree*).	Ordinal
Knowledge of safe chemical use	Yes or No	Nominal
Application of safety guidelines	Yes or No	Nominal
Interested in using safety measure	Yes or No	Nominal
Confounding variables		
Previous education on chemical safety	Yes or No	Nominal
Previous visit to agricultural extension service	Yes or No	Nominal

Data Analysis Plan

After data collection, each questionnaire was verified for completeness and suitability for analysis. The data from the questionnaires was entered into the computer and analyzed with SPSS Version 23. Frequency distributions were first carried out on the database to check for missing fields, omissions, entry errors and double entries. This was repeated on the second data entry to confirm correctness of the entry. In places where there were errors, the questionnaires were revisited and comparisons were made for the entries. Analysis was based on the stated research questions, measurement scale of data collected and the research hypothesis.

The demographic characteristics of farmers were analyzed using descriptive statistics. Frequency distribution, cross-tabulation, and bar charts was used to represent qualitative data. For the continuous measurements, measures of central tendencies were used to describe the data. In order to check the attitude of farmers towards safe agrochemical handling, a one-sample *t*-test was used for statistical analysis. This was done by assuming a standard pass score of 3.01 for the analysis based on the mean opinion score for the Likert scale data. The comparison of these variables (attitude of the farmers towards safe agrochemical handling and the level of education) between binary independent variables such as gender, prior education on safe agrochemical handling was done by using an independent-sample t-test. This test was necessary and estimated difference(s) between the means of two independent groups. However, in cases in which the comparison involved more than two groups, for example, location of the farmers, one-way analysis of variance (ANOVA) was used.

RQ1 was analyzed using multiple linear regressions. A linear regression analysis was used to determine relationship between one dependent variable and several independent variables. The dependent variable was continuous while the independent was either continuous or discreet. This statistical test was used to ascertain the strength of relationship between the dependent and the independent variable and the importance of each independent variable on the dependent variable. The dependent variable was the score of each farmer on knowledge of safe agrochemical handling. The independent variables were the stated demographic characteristics. A *t* test was used to estimate the difference(s) between the means of two independent groups.

RQ2 was analyzed using logistic regression. In this type of statistical regression analysis the outcome variable was categorical (attitude of farmers regarding safe use of chemical) and the predictor (or independent) variables, were continuous or categorical. The prediction was on the outcome categorical variable which was dichotomous, binary logistic regression was used in modeling a response for the dependent variable using the independent variables stated in RQ2. The use of the binary logistic regression helped to check for effects of confounding variables. RQ3 and RQ4 were evaluated using descriptive statistics.

Threats to External Validity

A treat to external validity in this study was non-participation of some farmers due to their unavailability during the course of this study. Another source of treat was fraudulent responses by farmers who consented to participate. Findings of such could affect the outcome of the research that may not be a true reflection of the overall

community. One of the strategies that were used to prevent threats to external validity was provision of adequate explanation of the purpose of the study to encourage participation. In addition, duplicate data entry was done during computerizing so as to ensure validation of the accuracy of data entry. To reduce external validity, there was calibration of the research assistants with myself to ensure consistency and similarities with questionnaire administration.

Threats to Internal Validity

There are issues that might have risen in the course of the research that posed as threats to internal validity thereby reducing the confidence in saying there was a relationship between the independent and dependent variables. Some of these errors might have been from different sources such as varied sources including measuring the wrong attributes possibly as a result of poor interpretation of the questions into local dialect (Hausa), duplicated data entry, differences in study setting, and lack of uniformity in coding.

For the cases of measurement, three basic types of validity were cited which included; content validity, empirical validity and construct validity. Giving my committee members my survey instrument, which they confirmed that the measurement covered all the attributes, that was measured checked the content validity. The empirical validity was checked by comparing the survey instrument with similar instrument for measuring the constructs of the study (use of safe agrochemical handling) in the literature (Jallow, 2017; Saina et al., 2017).

The same questionnaire was administered to all the respondents personally in order to address any other issues relating to threats arising from measurement errors. For the case of interpretation errors, a third party was required to repeat the interpreted questions in English to ascertain consistency. Administering the study questionnaire personally ensured that the issue of dissimilar administration was addressed; this also ensured reduced attrition.

Information bias was another threat to internal validity in this study, an important possible source of these bias maybe faulty data collection methods. Another possible source of information bias could be the recall biases a situation where the participant could not be able to recall information especially information of the past. All information generated was assumed to be truthful

Ethical Concerns

The study proposal was submitted to Walden University IRB for review and approval was received before commencement of the study. This was done to ensure adequate protection of all participants that were enrolled. This also allowed the IRB opportunity to ascertain the merits and possible harm posed by the research. The IRB helped in evaluating if any risk was associated with the study. The study design (cross sectional) helped in providing equity among the selected participants and this allowed for recruitment of only those who fulfilled the inclusion criteria. Consent forms were administered and explanation was given regarding the purpose and aim of the study and those that consented were enrolled for the study. The participants were made to consent as an evidence of willing agreement to participate in the study. The data collection was

done using survey method that employed the use of interviewer-administered questionnaires. The questionnaires were without identifiers and the information was entered into a personal computer that was password protected. This allowed only me to have access to all data entered into the system. The hard copy questionnaires were kept in a filing cabinet under lock and key for a period of 5 years after which they will be destroyed by burning.

Summary

The study was cross-sectional a study that was carried out in Plateau State. The study populations for the study were farmers involved in arable agriculture. All the selected farmers who fulfilled the inclusion criteria were enrolled in the study. Data collection method was survey using paper-based questionnaires. The instrument was developed by Saina, 2017 and modified before use. Two research assistants and I were involved with the data collection. Analysis was done using the SPSS software version 23. Data generated was analyzed using various statistical analysis strategies such as; descriptive statistics, one-sample *t* test, independent sample *t* test, ANOVA, linear multiple regressions and binary logistic regression.

This chapter concluded by evaluating ethical issues that arose from the research study and steps that were in place that ensured validity of the research. Chapter 4 describes the results and findings from the research.

Chapter 4: Results

Introduction

Health problems for farmers who may handle agrochemicals used for agricultural purposes such as weed control, pest control, and improvement of farm produce are on the rise (Ndaghu, 2017). In Nigeria, with a growing population and need for abundant food, the use of these chemicals has been of great importance in the elimination of various pests that prevent crop growth, thereby resulting in increased food production and improvement of economic output (Kamoun, 2018). Various researchers have identified health and environmental issues associated with the unsafe use of agrochemicals to include cancers of different origins, male/female infertility disorders and chronic noncommunicable life-threatening public health issues, such as endocrine disorders (Cruz-Morató, 2014, WHO, 2017). Despite the reports of different researchers on various adverse health effects of these agrochemicals, little is known concerning the attitudes and perceptions of the agrochemical users regarding the safe handling of these chemicals. The purpose of this study was to gain insight into the knowledge, attitude, and practice of safe agrochemical handling by farmers in Plateau State, Nigeria.

There were five main research questions the study sought to answer; the first assessed the relationship between demographic characteristics of the farmers and their engagement in safe agrochemical handling. The second investigated the awareness of farmers regarding safe agrochemical handling. The third, examined the relationship between perceptions of farmers (dependent variable) regarding predisposing factors for safe agrochemical use and years of experience (categorical independent variable). The

fourth and fifth research questions centered on evaluating the attitudes and actual practices of agrochemical users regarding safe agrochemical handling respectively.

Findings from these research questions are presented in this chapter. In addition, this chapter describes all the procedures used during the data collection together with the statistical analyses that were employed for answering the research questions. The chapter concludes with a summary of the results generated from the collected data.

Data Collection

After securing approval from Walden IRB (Approval Number: 02-13-19-0421191), I visited the three senatorial zones comprising 17 local government areas (LGAs) of Plateau State. Data collection started on the 18th of February 2019 and lasted until 8th March 2019. During this period, a total of 260 farmers who consented to the study and fulfilled the inclusion criteria were recruited. There were no major discrepancies observed during data collection using the methodology described in Chapter 3.

Demographic Characteristics of Study Participants

Table 2 is a summary of the demographics of the study participants, i.e., farmers enrolled in the study. Of the study group, 23 farmers (8.8%) were less than 20 years, 50 (19.2%) were between the age group 21-30 years, while age groups 31-40, 41-50 and > 50 years had a total number of 77 (29.6%), 52 (20%) and 58 (22.3%) farmers respectively. Most of the farmers were males 192 (73.8%) while females were 68 (26.2%). In addition, out of the 260 that consented to the study, a total of 199 (76.5%) were married, 55 (21.2%) were single, only 1 (0.4%) was separated and 5 (1.9%) had lost

their spouse. A total of 46 farmers (17.7%) had no formal education, 43 (16.5%) had elementary school education, 101 (38.8%) had secondary school education, 51 (19.6%) had attended tertiary institution for obtaining a first degree while 19 (7.3%) had undertaken a postgraduate education. The farmers involved in the study had varying years of experience in the use of agrochemicals, 78 (30%) had <10 years' experience with agrochemicals, 85 (32.7%) had between 11-20 years experience while 51 (19.6%) and 25 (9.6%) had between 21-30 and 31-40 years experience in the use of agrochemicals.

Table 2

Demographic Characteristics of Study Participants

Demographic characteristics	Frequency (N=260)	Percentage (%)
Age group		
≤20	23	8.8
21-30	50	19.2
31-40	77	29.6
41-50	52	20.0
>50	58	22.3
Gender		
Male	192	73.8
Female	68	26.2
Marital status		
Single	55	21.2
Married	199	76.5
Separated	1	0.4
Widow/widower	5	1.9
Educational level		
Non formal	46	17.7
Elementary	43	16.5
Secondary	101	38.8
Tertiary	51	19.6
Post graduate	19	7.3
Senatorial district		
Plateau North	88	33.8
Plateau Central	86	33.1

Plateau South	86	33.1
Years of experience as a farmer		
≤10	78	30.0
11-20	85	32.7
21-30	51	19.6
31-40	25	9.6
>40	21	8.1

More than half of the farmers (61.9%) indicated they were aware of possible hazards with unsafe use of agrochemical use while 99 (38.1%) were not aware of any associated risk with unsafe agrochemical use. On the other hand, 241 (92.7%) had knowledge that inhalation of agrochemicals could lead to a hazardous effect on health and 19 (7.3%) did not have any knowledge that such actions were hazardous. Majority of the farmers were knowledgeable and aware of the hazardous nature of the agrochemicals as shown in Table 3.

Table 3

Knowledge and Awareness of Possible Hazards Associated with Agrochemical Handling

Items	Frequency	Percentage
Do you think you are at risk of agrochemical-associated hazards?		
Yes	161	61.9
No	99	38.1
Inhalation of agrochemical hazardous		
Yes	241	92.7
No	19	7.3
Body contact with agrochemical is hazardous		
Yes	227	87.3
No	33	12.7
Exposure to agrochemical is hazardous		
Yes	209	80.4
No	51	19.6
Use of water contaminated with agrochemical hazardous		
Yes	223	85.8

No	37	14.2
Direct contact with crops exposed to agrochemical hazardous		
Yes	210	80.8
No	50	19.2
Use of washed empty agrochemical containers for household purposes hazardous		
Yes	177	68.1
No	83	31.9
Routine screening for agrochemical exposure could prevent hazardous effects		
Yes	146	56.2
No	114	43.8
Prolonged use of agrochemical hazardous		
Yes	190	73.1
No	70	26.9

Research Question 1

This question addressed the relationship between engagement in the safe handling of agrochemicals and the demographic characteristics of farmers that use agrochemicals in Plateau State. The results from Chi square tests for independence show that 156 (81.3%) of male farmers engaged in safe agrochemical use while 57 (83.8%) female farmers engaged in safe agrochemical handling ($p = 0.636$). On the other hand, 22 (95.7%) of farmers that were less than 20 years engaged in safe agrochemical handling while those older than 50 years had the highest number of farmers who did not engage in safe agrochemical handling 13 (22.4%) with $p = 0.412$. Based on the marital status of the farmers, 51 (92.7%) of the farmers that were single engaged in the safe handling of agrochemicals while 4 (7.3%) of the farmers that were not married did not engage in safe handling of agrochemicals. This work also revealed that 156 (78.4%) of married farmers

were engaged in safe agrochemical handling when compared with 43 (21.6%) that were not engaged in safe agrochemical handling (p = 0.026).

A Chi-square test of independence was performed to examine the relationship between engagement in the safe handling of agrochemicals and demographic characteristics of the farmers. There was a statistically significant relationship between marital status and engagement in safe agrochemical handling X^2 (2, N = 260) = 7.34, p <. 05 and level of education X^2 (4, N = 260) = 35.12, p <. 05. However, there was no statistically significant relationship between engagement in safe agrochemical handling and gender X^2 (1, N = 260) = 0.225, p > .05, age group X^2 (4, N = 260) = 3.959, p > .05, professional training as a farmer X^2 (1, N = 260) = 0.046, p < .05 and training on the use of agrochemicals X^2 (1, N = 260) = 0.885, p > .05 respectively as shown in training on the use of agrochemicals as shown in Table 4.

Table 4

Relationship between Individual and Professional Characteristics and Engagement in the Safe Handling of Agrochemicals among Farmers

Demographic Characteristics	Engagement in the safe handling of agrochemicals		X^2	Df	P
	Yes	No			
Gender					
Male	156 (81.3)	36 (18.8)	0.225	1	0.636
Female	57 (83.8)	11(16.2)			
Age group					
≤20	22 (95.7)	1 (4.3)	3.959	4	0.412
21-30	42 (84.0)	8 (16.0)			
31-40	62 (80.5)	15 (19.5)			
41-50	42(80.8)	10 (19.2)			
>50	45 (77.6)	13 (22.4)			
Marital status					
Single	51 (92.7)	4 (7.3)	7.335	2	0.026
Married	156 (78.4)	43 (21.6)			
Others	6 (100.0)	0 (0.0)			

Educational level					
Non formal	24 (52.2)	22 (47.8)	35.121	4	0.000
Elementary	38 (88.4)	5 (11.6)			
Secondary	86 (85.1)	15 (14.9)			
Tertiary	47 (92.2)	4 (7.8)			
Postgraduate	18 (94.7)	1 (5.3)			
Professional training as farmer					
Yes	87 (81.3)	20 (18.7)	0.046	1	0.829
No	126(82.4)	27(17.6)			
Trained on use of agrochemicals					
Yes	93 (84.5)	17 (15.5)	0.885	1	0.347
No	120 (80.0)	30 (20.0)			

A multiple regression analysis was carried out to evaluate the relationship between the following demographic characteristics: age, gender, marital status, years of experience as a farmer, educational level, training on agrochemical use and senatorial zone as a predictor of attitude towards safe agrochemical handling. The results of the regression indicated that the model explained 7.4% of the variance and that the model was a significant predictor of attitude towards safe agrochemical handling, F (7, 252) = 2.873, p = .007. While gender and senatorial zone contributed significantly to the model (B = .13, p <. 05 and B= .07, p < .05), age, marital status, years of experience, educational level and training on the use of agrochemicals did not Table 5.

Table 5

Relationship between Demographic Characteristics of Farmers and Attitude Towards Agrochemical Handling

Model	Coefficient			*T*	*P*	95% CI of B	
						LL	UL
	Unstandardized		Standardized				
	Beta	SE	*Beta* (β)				
(Constant)	4.345	.176		24.723	.000	3.999	4.691
Age in yrs.	-.003	.002	-.121	-1.348	.179	-.008	.001
Gender	.126	.054	.148	2.330	.021	.020	.233

Marital status	-.049	.041	-.080	-1.187	.237	-.131	.032
Years of experience as a farmer	.000	.002	.017	.200	.842	-.004	.005
Educational level	.006	.021	.020	.297	.767	-.036	.049
Have you been trained on the use of agrochemicals?	-.065	.050	-.086	-1.293	.197	-.164	.034
Senatorial zone	.073	.028	.159	2.594	.010	.018	.129

Note. SE = Standard Error. * $p < .05$; LL = Lower level, UL = Upper Level

Research Question 2

Binary logistic regression was performed to predict the impact of a number of factors on the likelihood that farmers will be aware of safe agrochemical handling. The model contained three independent variables (gender, training as a farmer and training on the safe use of agrochemicals). The full model containing all predictors was statistically significant, X^2 (3, N = 260) = 16.14, p <. 05, indicating that the model was able to distinguish between farmers who reported that they knew and did not know about safe agrochemical handling. The model as a whole explained between 6% (Cox and Snell R square) and 13.1% (Nagelkerke R squared) of the variance agrochemical safe handling awareness, and correctly classified 90.8% of cases. As shown in Table 4, only one of the independent variables made a statistically significant contribution to the model (Training on safe handling of agrochemicals) with an odds ratio of 8.31. This indicated that farmers who had undergone safety in handling of agrochemicals were over 8 times more likely to be current with safe handling of agrochemicals when compared to those who were not aware (Table 6).

Table 5

Relationship between Gender, Training on Agrochemical Use and Professional Training on Awareness of Safe Agrochemical Handling

	B	SE	Wald	df	*P*	e^B	95% CI of e^B	
							LL	UL
Gender	-.482	.509	.899	1	.343	.617	.228	1.674
Training on safe agrochemical use	2.117	.848	6.234	1	.013	8.306	1.576	43.768
Trained as a Professional farmers	.327	.653	.251	1	.616	1.387	.385	4.992
Constant	-4.013	.737	29.633	1	.000	.018		

Note. SE = Standard Error, LL = lower level, UL = upper levels and CI = confidence interval, e^B = Exponential of B

Research Question 3

This study also examined the relationship between perceptions of farmers (dependent variable) regarding predisposing factors for safe agrochemical use and years of experience (categorical independent variable). A Chi-square test for independence (with Yates continuity correction) indicated no significant association between level of perception of predisposing factors for safe agrochemical handling and years of experience as a farmer, X^2 (8, *N*-= 260) = 8.44, p = 39 (Table 7).

Table 6

Relationship between Perceptions of Farmers Regarding Predisposing Factors of Safety of Agrochemicals and their Years of Experience

Years of experience as a farmer	Perceptions of farmers regarding the safety of agrochemicals			X^2	df	P
	Agree	Disagree	Not sure			
≤10	76 (97.4)	2 (2.6)	0 (0.0)	8.438	8	0.392
11-20	82 (95.5)	3 (3.5)	0 (0.0)			

21-30	49 (96.1)	1(2.0)	1(2.0)
31-40	25 (100.0)	0 (0.0)	0 (0.0)
>40	20 (95.2)	0 (0.0)	1(4.8)

Research Question 4

Working with a standard pass score of 3.01 (as stated in the data analysis plan) for the attitudes of farmers regarding safe agrochemical handling, the role of the community and government agents, a one-sample *t* test of the attitudes of farmers towards safe handling of agrochemicals, the role of the community and government agents reported a positive attitude: $M = 4.35$, $SD = .38$, $t\ (259) = 57.53$, $p < .001$ as shown in Table 8. All the farmers had statistically significant differences in the mean opinion scores for attitudes towards safe handling of agrochemicals, the role of the community and government agents in ensuring safe attitudes towards safe handling of agrochemicals.

Table 7

Attitude Score of Farmers Towards Safe Agrochemicals Handling

Attitudes statements	Mean ±SD	t-test	df	P
Safe agrochemical handling is an issue that should be taken seriously and given prompt attention by health care providers	4.65±0.62	42.906	259	.000
Prevention of hazards associated with agrochemical use is a joint responsibility of the users, public health officers and agricultural organization	4.59±0.64	39.605	259	.000
Paying extra attention to safe agrochemical handling is an unnecessary burden on me	3.60±1.38	6.914	259	.000

Training of farmers and provision of personal protective equipment is necessary to reduce the risk of exposure to agrochemicals.	4.62±0.63	41.086	259	.000
Overalls and facemasks should be worn in procedures where splash/spill of agrochemicals is likely.	4.53±0.73	33.654	259	.000
Gloves should always be worn when using agrochemicals	4.53±0.73	33.747	259	.000
Hands should be properly washed after each contact with agrochemicals	4.70±0.56	49.083	259	.000
Used agrochemical containers can be washed with detergent and used in the home	3.47±1.47	5.093	259	.000
Empty containers of agrochemicals should be discarded	4.06±1.11	15.278	259	.000
Disposal containers should be located within a few feet of farm location	3.85±1.18	11.534	259	.000
Farmers should be educated on health issues associated with agrochemical use	4.74±0.47	59.823	259	.000
Prolonged exposure to agrochemicals should be avoided by all farm workers.	4.35±0.92	23.597	259	.000
Inappropriate exposure/contact with agrochemicals should be reported and appropriately documented by appropriate authorities.	4.48±0.75	31.489	259	.000
Adequate manpower and mechanization is a way of reducing hazards associated with	4.53±0.70	34.956	259	.000

agrochemicals.				
There should be provision of incentives for adherence to universal safety precautions.	4.57±0.64	39.346	259	.000
Punitive actions should be taken against violators of safety practices	4.13±1.01	17.847	259	.000
The agricultural management team should regularly review exposure and control policies.	4.57±0.59	42.572	259	.000
Overall attitude score towards agrochemical safe handling	4.35±0.38	57.531	259	.000

Research Question 5

The actual practices of farmers regarding safe agrochemical handling was analyzed using descriptive statistics i.e. frequencies and percentages. The results show that a few farmers (6.6%) were sometimes involved with smoking while applying agrochemicals; however, (51.9%) ensured that they always avoided smoking while spraying agrochemicals. Table 8 shows that the most practiced precautions for agrochemical users were washing work clothes separately (56.9%) and taking a shower soon after application of agrochemicals (53.6%). On the need for the use of other personal protective equipment, (64.6%) had never used eye goggles neither had (61.2%) worn a hat while applying agrochemicals. Although only (30.4%) always wore an overall (protective coats), (33.5%) wore their boots and (33.8%) wore gloves while using agrochemicals (Table 9).

Table 8

Actual Practices of Farmers Regarding Agrochemical Handling

Practice	Never (N/%)	Always (N/%)	Sometimes (N/%)
Practice of overalls while using agrochemicals?	121(46.5)	79 (30.4)	60 (23.1)
Practice of use of protective boots?	109 (41.9)	87 (33.5)	64 (24.6)
Practice of use of gloves?	116 (44.6)	88 (33.8)	56 (21.5)
Practice of use of respirator/Nose masks?	119 (45.8)	78 (30.0)	63 (24.2)
Practice of use of eye goggles?	168 (64.6)	43 (16.5)	49 (18.8)
Practice of use of hat?	159 (61.2)	61 (23.5)	40 (15.4)
Practice no eating while spraying/mixing agrochemicals?	107 (41.2)	121 (46.5)	32 (12.3)
Practice of no drinking while spraying/mixing agrochemicals?	107 (41.2)	130 (50.0)	23 (8.8)
Practice of no smoking while spraying/mixing agrochemicals?	109 (41.9)	135 (51.9)	16 (6.2)
Practice of sprayed with the direction of the wind?	99 (38.1)	133 (51.2)	28 (10.8)
Practice of showering immediately after mixing or spraying?	74 (28.5)	140 (53.8)	46 (17.7)
Practice of washing work clothes separately?	81 (31.2)	148 (56.9)	31 (11.9)

Awareness of Safe Handling of Agrochemicals and Engagement in Safe Practices

A chi-square goodness-of-fit test indicates that there was a significant difference in the proportion of farmers that were aware of safe agrochemical handling in this study 89.4% as compared with those that practiced safe agrochemical application precautions 18.1% that was obtained in this study, X^2 (1, N=260) = 96.68, p = 0.000 as shown in Table 10.

Table 9

Relationship between Awareness of Safe Handling of Agrochemicals and Actual Practice of Agrochemical Handling

Are you aware of safety precautions while handling agrochemicals?	Practice safety precautions			X^2	df	P
	Yes	No	Total			
Yes	221(89.4)	25(10.6)	236(100.0)	96.689	1	0.000
No	2(8.3)	22(91.7)	24(100.0)			
Total	47(18.1)	213(81.9)	260(100.0)			

Self-Reported Health Issues Related to Agrochemical Use

This result indicates that (85.8%) of farmers in this study reported at least one related health problem after the use of agrochemicals while (14.2%) did not have any health-related issue. Based on this study, the most frequently reported health-related issues were headaches (80.4%) and fatigue (56.5%). Other health-related issues reported were coughing 129 (49.6%), dizziness (49.2%), skin irritation (47.7%) and itchy eyes (42.3%). Other health issues reported by respondents were poor vision (31.2%), stomach ache (36.5%), shortness of breath (28.1%), and vomiting (24.2%).

Table 10

Distribution of Farmers Based on Reported Health Issues

Health issue	Number (%)	
	Yes	No
Headache	209 (80.4)	51 (39.6)
Dizziness	128 (49.2)	132 (50.8)
Skin irritation	124 (47.7)	136 (52.3)

Nausea	94 (36.2)	166 (63.8)
Itchy eyes	110 (42.3)	150 (57.7)
Vomiting	63 (24.2)	197 (75.8)
Coughing	129 (49.6)	131(50.4)
Shortness of breath	73 (28.1)	187 (71.9)
Fatigue	147 (56.5)	113 (43.5)
Stomach ache	95 (36.5)	165 (63.5)
Poor vision	81 (31.2)	179 (68.8)
No impairment of health	37 (14.2)	223 (85.8)

Summary

This chapter gave an explanation of how data was collected and the process involved for the data analysis and result presentations. The findings based on the research questions were also enumerated. Overall, 260 practicing farmers from the three (3) senatorial zones consented to participate in the study and they were enrolled. A total of 6 local government areas were identified to represent the senatorial zones of the state and all were registered with the Ministry of Agriculture. This study showed a statistically significant relationship between marital status and engagement in safe agrochemical handling $X2\ (2, N = 260) = 7.34, p <. 05$ and level of education $X2\ (4, N =260) = 35.12, p <0.05,$ there was no statistical relationship between engagement in safe agrochemical handling and gender $X2\ (1, N = 260) =0.225, p >.05,$ age group $X2\ (4, N =260) =3.959, p >0.05,$ professional training as a farmer $X2\ (1, N =260)=0.046, p <0.05$ and training on the use of agrochemicals $X2\ (1, N =260)=0.885, p >0.05$ respectively.

The results of the regression indicated that the model explained 7.4% of the variance and that the model was a significant predictor of attitude towards safe agrochemical handling, $F(7,252) = 2.873$, $p = .007$. While gender and senatorial zone contributed significantly to the model ($B = .13$, $p < .05$ and $B = .07$, $p < .05$), age, marital status, years of experience, educational level and training on use of agrochemicals did not.

Also, an assessment of which demographic factor (gender, training as a farmer and training on the safe use of agrochemicals) would predict the farmers that reported knowledge of safe agrochemical use revealed that training on the safe use of agrochemicals was statistically significant $\chi 2\ (3, N=260)=16.14$, $p < 0.05$, Cox and Snell $R2 = 13.1\%$.

The meaning of these results and other findings are provided in Chapter 5. Chapter 5 will also discuss limitations of this study, avenues for further research, recommendations, and the study's implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Safe agrochemical handling is of importance to both users of agrochemicals and the community, bearing in mind the reported public health issues that may arise from its unsafe use (Saina, 2017). Education, awareness, and training of agrochemical users on safe handling can provide measures for the prevention of some of the public health issues. In Nigeria, health issues associated with agrochemical use are particularly concerning because of the high mortality rate (10,000 people/year) reported among agrochemical users (Jeyaratnam, 1990), This is despite the fact that only a few of the global agrochemicals are used in Nigeria. The high mortality has been attributed to several factors such as the use of the cheap and lethal agrochemicals in this environment and unnecessary exposure to these chemicals while applying them (Erhunmwunse et al., 2012; McConnell & Hruska, 1993; Ojo, 2016; PECAN, 2013).

Many types of research have been conducted in locations where highly mechanized agricultural tools, such as planes or tractors, were used and the findings then applied to countries like Nigeria, were these agrochemicals are applied manually (McConnell & Hruska, 1993). Currently, in Plateau State, Nigeria, there is no record of any study to describe the knowledge, attitudes, and practices of safe agrochemical use by farmers in Plateau State. This study was therefore conducted to fill this knowledge regarding the knowledge, attitudes, and practices of agrochemical users in this environment with the aim of providing insight into the development of health promotion program for farmers.

Interpretations of Findings

Characteristics of Farmers

Findings from this study suggest that most farmers in this state are young, i.e., between 30-40 years. This is in line with the work of other researchers who carried out similar research in other environments and reported a high prevalence of young farmers in agriculture (Desalu, 2014; Ndaghu, 2017 & Saina, 2017). The preponderance of young farmers may be related to the fact that they are usually more active and energetic and therefore, they are more easily able to adapt to farming. Additionally, the rise in the younger population may also be attributed to the unavailability of jobs in Nigeria, which now leads more of the younger ones to seek ways of generating income. The Nigerian government has also emphasized agriculture as a means for improving the economy of the land. This work also revealed that majority of the farmers were males who were married, which is similar to the study carried out by Ndaghu et al. (2017) in Adamawa state (another state in Nigeria) among farmers and reported a high number of male farmers compared to female farmers. This suggests that males may have a greater contribution to farming activities. The finding of more farmers with secondary school education is however different from the work of Ndaghu et al. (2017) who reported more farmers with primary school certificate in the far North. This study also suggests that a vast number of the farmers had been involved with the use of agrochemical for between 11-20 years, which was the same as the work of Ndaghu et al. (2017).

Knowledge of Safe Agrochemical Use

Results of this study suggest that farmers in this environment had a good knowledge of the safe use of agrochemicals, as the majority of them were knowledgeable about the possible effects of these chemicals on health and environment. This was also the case for Saina et al. (2017) who carried out a similar study in Kenya and observed that majority of the farmers had a good knowledge of safe agrochemical handling which was attributable to participation in training courses taken by the farmers. The work of Moradhaseli et al. (2017) in Iran also supports the findings of good knowledge of safe agrochemical handling although his work reported some level of negligence by the farmers in applying the knowledge. Although this study reported good knowledge of safe agrochemical use, the work of Ndaghu et al. (2017) in Nigeria and that of Jallow et al. (2017) in Kuwait reported poor knowledge of safe agrochemical handling. In addition, Jallow et al. (2017) reported that majority of farmers in Kuwait knew that pesticides were harmful to health; however, the level of education of farmers regarding handling of pesticides was still very poor.

The high level of knowledge reported in my work may be attributable to the fact that majority of the farmers had reported they received training on the use of agrochemicals while working as farmers in Nigeria. In addition, having the knowledge of the names of different agrochemicals being used as reported in this work by 81.5% and 85.8% of farmers respectively suggests that farmers were knowledgeable and 67% of farmers read the instructions for each agrochemical before its use. This good knowledge reported in my work may also be due to the level of education of the farmers enrolled in

this study as more than half: 38.8% and 19.9% had completed secondary and post graduate studies respectively.

Awareness of Possible Hazards Associated with Unsafe Agrochemical Handling

The majority of farmers (91.9%) in this study believed that they were at risk of hazards associated with the use of agrochemicals implying that they believe that these chemicals may have a negative effect on their health. This negative effect of agrochemicals was shown to impact both health and environment as reported by Olowogbon et al. (2013) who worked in the Southern part of Nigeria. In regards to the possible routes for the entry of the agrochemicals, only a few of them (10.8%) were not sure of the route. Inhalation of agrochemicals was reported by less than half of the farmers (46.2%) as the path through which agrochemicals can get into the human body. The report from this work also revealed that farmers also had knowledge that body contact, use of water contaminated with agrochemicals and eye contact with these agrochemicals were potential routes for the hazardous nature of these chemicals. This finding agrees with the report by WHO (2018a) on the risks and paths through which agrochemicals gain entry into the body and affect health. The findings by Demos et al. (2013) that farmers face hazards suggests that measures should be in place for its prevention, as my study shows that most of the farmers (74.7%) were aware of hazards associated with the use of these agrochemicals.

Practices of Farmers Regarding Safety Precautions in Agrochemical Use

The use of appropriate PPE, such as coveralls, hats, eye goggles, use of gloves, nose masks and the adoption of personal hygiene such as showering, not smoking, eating

or drinking, washing farm clothes separately while handling agrochemicals have been reported as practices that reduce hazards associated with agrochemical use (Jallow et al. 2017). An important finding in this study was a low level of adoption of the use of PPE, which was also reported by various researchers (Damalas, 2010 & Jallow, 2017 & Ojo, 2016). The low level of adoption of PPE utilization, especially the use of goggles and hats, maybe associated with the hot sunny weather, which makes it uncomfortable for farmers. The failure of the majority of farmers to use PPE is a predisposing factor for dermal and respiratory contact with agrochemicals as indicated by Jeyaratnam et al. (1990). However, this study indicated that most of the farmers observed personal hygiene as about half of them (53.8%) showered soon after using the agrochemicals, 56.9% also washed their farm clothes separately, thus avoiding contact with other house clothes.

Attitudes of Farmers Towards Safe Agrochemical Use

Farmers in this study generally had a good attitude towards safe handling of agrochemicals as indicated in the mean opinion score for the attitude which was greater than 3.00. This finding is different from that of Jallow (2017) who reported a poor attitude towards the use of pesticides among farmers in Iran. The difference in opinion might be due to the different locality of study in addition to socioeconomic status. Further, this work suggests that farmers in this environment had a positive attitude towards safe handling of agrochemicals that will, in turn, help to prevent environmental contamination and also reduce risk to human health (Atreya et al., 2012; Hashemi et al., 2012 & Khan et al., 2010;). Furthermore, with the non utilization of the PPE by these farmers, it will be worthwhile to develop programs that will enforce their use in addition

to having certification programs that will provide information on the level of compliance to the use of PPE.

Health Issues Associated with the Use of Agrochemicals

This study revealed the experience of health-related issues by the farmers while handling agrochemicals, and this represents a challenge in the design of appropriate training programs. Various researchers reported health issues such as skin irritations, headaches, nasal congestion, etc., while other hazards posed by agrochemicals use include cancers, kidney and liver cell death. These were confirmed through biochemical analysis of body fluids such as blood and urine (Saina, 2017; Gesesew, 2016, Sudjaroen, 2017).

Policy regarding biochemical and hematological testing needs to be in place as this will allow monitoring of physiological functions and early detection of any toxicity. Management of early toxicity will prevent hazardous injury to health (Sudjaroen et al. 2017), bearing in mind that these toxicity tests might be expensive; the government might need to have a policy for such occupational hazards. Given that most farmers reported at least one form of health challenge, a more interactive and participatory training model is required, for example, by using pictograms to describe steps needed for reporting such issues to healthcare facilities, as the majority of the farmers do not report the health issue to the appropriate authority.

In addition, policy should be developed for routine medicals check-ups for all farmers involved with handling agrochemicals which should be consistent and illnesses suffered should be treated to save life. Bearing in mind that farmers were of the opinion

that prolonged use of these agrochemicals are sources of health hazards, there should be a change of duties to reduce prolonged exposure to agrochemicals, which can cause major harm. Occupational hazards associated agrochemicals have been reported in both developing and developed countries as a major cause of mortality (Gesesew, 2016)

Finally, the study suggests that exposure to agrochemicals may result in symptoms such as skin irritation, headache, extreme tiredness, blurred vision, and dizziness. Other researchers have also asserted that exposure to agrochemicals leads to reproductive abnormalities such as miscarriage, stillbirth, and inability to conceive among female farm workers; further studies will be required to ascertain these claims.

Findings of this study will provide information necessary for public health organizations and regulatory agencies to make better-informed decisions and policy recommendations focused on preventing health and environmental hazards associated with the use of agrochemicals. The knowledge and practice gaps identified in this study could be used for designing knowledge-based training programs for farmers. Participation in training programs would lead to increased levels of knowledge about safety precautions while handling agrochemicals. It is necessary to have in place training programs that will help the farmers practice safe agrochemical handling and the use of PPE. In addition, the Ministry of Health could play a key role in health monitoring of the farmers involved with the handling of agrochemical, which have been known for their toxicity to health. (Atreya et al., 2012; Li et al., 2014)

Limitations of the Study

Although those engaged in crop farming who use agrochemicals were involved in this study, there are other groups of people who handle these agrochemicals that are of public health concern. In Nigeria, horticulturists and various veterinarians also use these chemicals. The implication of this is that findings from this study cannot be generalized to cover safe agrochemical handling from these other sources.

It was assumed that the farmers answered the questions truthfully; however, this could never be fully guaranteed. It is possible that some of the farmers may have fallen victim of providing some inaccurate data due to their desire to report socially desirable behaviors thereby leading to information bias. For example, the report on the use of PPE and the adoption of other safety practices may be influenced by the respondents' desire to indicate that they comply with protective measures against occupational agrochemical exposure.

Another possible limitation may be associated with the inability to directly link health symptoms experienced by respondents to agrochemical exposure. Some of the health symptoms reported to have been experienced by farmers, such as headaches and fatigue, were not specific, and in some of the cases, these symptoms might have been due to causes other than exposure to agrochemicals, such as prolonged exposure to the sun in the course of routine agricultural activities. Finally, based on the number of respondents (260 farmers), I cannot claim that the results are representative of all farmers in Plateau State. It was not feasible to interview all farmers in Plateau State. However, the goal of this study is not to generalize, but to understand the knowledge, attitudes, and practices of

agrochemical users. Despite its limitation, this study provides an overview of agrochemical safety knowledge and practices among farmers in Plateau State, Nigeria and can contribute to educational and policy recommendations that aim at preventing or reducing the hazards associated with agrochemicals.

Recommendations

This study demonstrates that farmers have a major responsibility for reducing the risks associated with unsafe handling of agrochemicals. The following are recommendations that should be considered for ensuring compliance with safe agrochemical handling for the prevention of community and environmental hazards.

1. Incorporation of health education regarding agrochemical safe handling in both elementary and secondary school curriculum with emphasis on PPE.
2. Provision of funds by the government/ farmers for the purchase of PPE for all farmers in the state with regular supervision by extension workers.
3. Farmers could also be educated on using simple less expensive PPE such as simple disposable hospital facemasks and impervious hair covers instead of the very expensive respirators.
4. There is a need for continuous education about agrochemical safety and health. Farm workers at large should be offered additional education on appropriate methods that can be used to prevent or reduce agrochemical exposure such as mechanized farming.

5. Setting up a system by the Ministry of Health that will allow for routine health checks and biochemical monitoring of the health of agrochemical users for prevention of health-related issues arising from the use of agrochemicals.
6. Implementation of structured health promotion programs for farmers in the different communities.
7. Further research to assess the roles of public health and healthcare providers in improving safe agrochemical use and development of intervention measures to reduce the health and environmental risks associated with agrochemicals.

Implications for Social Change

Safe agrochemical handling is an important practice that should form the routine for all agrochemical users, as this will prevent health and environmental issues arising from unsafe use of these products. Health issues that may result from unsafe use of agrochemicals can be diagnosed in health care facilities that have access to ~~a~~ medical or environmental health laboratory services (CDC, 2013). Safe use of agrochemicals is necessary for the prevention of environmental and public health hazards and this can be achieved through the application of improved knowledge on agrochemicals

In addition, when policies regarding biochemical and hematological testing are in place it will allow monitoring of farmers physiological function and early detection of any toxicity arising from agrochemical use as early toxicity management will prevent hazardous injury to health. Nigeria with a growing population and high demand for food relies on agrochemicals for increased productivity; application of safe precautions will reduce adverse effects of these chemicals on the environment and health. In addition,

inclusion of knowledge of safe agrochemical handling and hazards associated with them in elementary and secondary school health education curriculum will provide an early education in safe practices bearing in mind that most families in Nigeria are involved with farming. Finally, since there are still challenges with the use of basic PPE in this environment, and farmers have indicated that this equipment are necessary for the prevention of hazards, the Nigerian government can provide these materials at a subsidized rate. Review and modification of training programs to include some of the health benefits and issues arising from the utilization of agrochemicals will also provide motivation for farmers to engage in safe agrochemical use.

Conclusion

The use of agrochemicals has adverse effects on both health and environment; it has contributed to an increase in acute and chronic non-communicable diseases and accidents during agricultural operations, which threatens the farmers' health. These adverse effects have been widely documented. Despite this, awareness among farmers of the safe handling, use, and the importance of protecting themselves and the environment from hazards associated with handling agrochemicals is still lacking. This study evaluated the level of knowledge, attitudes, and practices of Plateau State farmers regarding the safe use of agrochemicals.

Findings from the study suggest that farmers had good knowledge of agrochemicals including their hazardous nature to both humans and the environment, in addition to precautions that should be taken to prevent health issues. However, in spite of the good knowledge reported, farmers failed to use the appropriate PPE when handling

these chemicals. To increase farmers' engagement in the use of PPE, priority should be given to developing and implementing agrochemical safety educational and certification programs for farmers with emphasis on the safe handling practices, including the use of PPE such as hospital masks that are not expensive.

The attitude of farmers may serve as a motivating factor for the adoption of protective measures. Based on the findings of this work, farmers believe that proper disposal of used agrochemical containers help in reducing health risks as well as the use of PPE.

Furthermore, it is unclear why farmers fail to practice safe handling of agrochemicals. This is evidenced by the non-utilization of protective equipment such as gloves, coveralls, boots, and hats. The protective equipment protects the farmers from the adverse health effects of agrochemicals. In addition, farmers' level of education has enabled them to read and understand information written on agro-chemical containers. With regards to safe handling practices of agrochemicals, there should be a strict set of regulations to reduce exposure while handling agrochemicals. Finally, a program should be established for routine medical check-ups for farm workers that handle agrochemicals.

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Appendix A: Questionnaire on Knowledge, Attitude, and Practices of Safe Chemical Handling by Farmers in Plateau State, Nigeria

SECTION A: (**SOCIO – DEMOGRAPHIC CHARACTERISTICS)**

1. Age (in years).....
2. Sex: 1. Male [ ] 2. Female [ ]
3. Ethnicity;.....
4. Marital Status: 1. Single [ ] 2.Married [ ] 3. Divorced [ ] 4. Separated [ ] Widow/widower [ ]
5. Years of experience as a farmer.....
6. Highest educational qualification: 1. No formal education [ ] 2.Elementary School [ ] 3.Secondary school [ ]
7. Do you use agrochemicals? 1.Yes 2.No
8. What do you use the agrochemical for? 1.Weed control only[ ] 2. Insecticide control only [ ] 3,Enhanced crop production (fertilizer)[ ] 4.All of the above [ ]

SECTION B: (KNOWLEDGE, AWARENESS AND UNDERSTANDING)

9. Do you know about hazards associated with the use of agrochemicals? 1. Yes [] 2. No []
10. Do you think that agrochemicals affect human life? 1.Agree [] 2.Strongly agree [] 3.Disagree [] 4.Strongly Disagree []
11. Do you think that agrochemicals affect the environment? 1.Agree[ ] 2.Strongly agree[ ] 3.Disagree[ ] 4.Strongly Disagree [ ]
12. Do you think that agrochemicals are indispensible for high crop yield? 1.Agree [] 2.Strongly agree [] 3.Disagree [] 4.Strongly Disagree []
13. Do you read, understand and follow agrochemical labels? Yes [] No []
14. How do agrochemicals enter the human body? 1.Dermal[ ] 2.Inhalation[ ] 3.Oral[ ] 4. Eye contact[ ] 5. Do not know[ ]
15. Do you know some agrochemicals are banned and restricted for use? Yes[[No[ ]
16. Do you know the agrochemicals that are banned or restricted for use? Yes[ ] No[ ]

17. Do you know the reason for banning and restricting these agrochemicals?
1.Highly toxic[ ] 2.Not effective[ ] 3.Expensive[ ] 4. Do not know[ ]

Awareness/practice of safety precautions

18. Are you aware of safety precautions while handling agrochemicals? 1. Yes [ ] 2. No [ ]

If yes, which of the following precautions are you aware of and which do you practice?

Precautions	Awareness		Use/Practice		
	Yes	No	Always	Sometimes	Never
19. Use of overalls while using agrochemicals					
20 Use of protective boots					
21. Use of Gloves					
22. Use of Respirator/ Nose Masks					
23. Use of Eye goggles					
24. Use of Hat					
25.No eating while spraying/mixing agrochemicals					
26. No drinking while mixing/spraying of agrochemicals.					
27.No smoking while mixing /spraying of agrochemicals.					
28.Sprayed with the direction of the wind.					
29. Showering immediately after mixing or spraying					
30.Washing work clothes separately.					

Understanding of hazard associated with agrochemical handling

31.Do you think you are at risk of agrochemical associated hazards 1.Yes [] 2. No []
32. If yes, to what degree 1. High [] 2.Medium [] 3. Low [ ]
Do the following constitute hazards to you? *Please tick as appropriate.*

Description	1. YES	2. NO
33. Inhalation of agrochemical		
34. Body contact with Agrochemicals		
35. Exposure to agrochemicals		
36. Use of water contaminated with agrochemicals		
37. Direct contact with crops exposed to agrochemicals.		
38. Use washed empty agrochemical containers for household purposes		
39. involvement in routine screening for agrochemical exposure		

40. prolong use of agrochemicals		

SECTION C: (ATTITUDE TOWARDS SAFE AGROCHEMICAL HANDLING)
INSTRUCTION: *Please, tick as appropriate*

DIRECTIONS	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
41. Safe agrochemical handling is an issue that should be taken seriously and given prompt attention in the hospital					
42. Prevention of hazards associated with agrochemical use is a joint responsibility of the hospital management and the staff					
43. Paying extra attention to safe agrochemical handling is an unnecessary burden on me?					
44. Training of farmers and provision of personal protective equipment is necessary to reduce the risk of exposure to agrochemicals.					
45. Overalls and face masks should be worn in procedures where splash/spill of agrochemicals is likely					
46. Gloves should always be worn when using agrochemicals.					
47. Hands should be properly washed after each contact with agrochemicals.					
48. Used agrochemical containers can be washed with detergent and used in the home.					
49. Empty containers of agrochemicals should be discarded.					
50. Disposal containers should be located within a few feet of farm location.					
51. Farmers should be educated on health issues associated with agrochemical use.					
52. Prolonged exposure to agrochemicals should be avoided by all farm workers					
53.Inappropriate exposures/contact with agrochemicals should be reported and appropriately documented by appropriate authorities					
54. Adequate man power and mechanization is a way of reducing					

hazards associated with agrochemicals.					
55. There should be provision of incentives for adherence to universal safety precautions					
56. Punitive actions should be taken against violators of safety practices					
57. Exposure and Control policies should be regularly reviewed by the agricultural management team.					

SECTION D: (HEALTH RELATED ISSUES AND VISIT TO HEALTH FACILITY)

1.Health related issues

How many times have you had any health related issue/sigs after handling agrochemicals in the LAST 1 YEAR? (p*lease tick as appropriate).*

Health issue	Once	Two times	Three times	More than three times	Never
58. Headache					
59. Dizziness					
60. Skin irritation					
61. Nausea					
62.Itchy eyes					
63.Vomitting					
64. Coughing					
65. Shortness of breath					
66. Fatigue					
67. Stomach ache					
68. Poor vision					
69. No impairment of health					

70. When was the last time that you had a health issue related to agrochemical handling on the farm? 1. Within the last two months( ) 2. Within two to six months( ) 3. Within six to 12 months ( )
4. > 1 year ( )

71. When you had the health issue, did you report the incidence to the appropriate healthcare facility? 1. Yes ( ) 2. No ( ) [*If No, skip 72 and 73*]

72. Did you receive any post-exposure treatment? 1. Yes ( ) 2. No ( ) [*If No, skip 73*]

73. Were you satisfied with the post exposure treatment? 1. Yes ( ) 2. No ( )

74. How many times have you visited the kospital in the last 1 year for agrochemical related issue?

II. Predisposing factors for unsafe agrochemical handling in your farm settings

INSTRUCTION: (*Please tick as appropriate)*

Factors	Agree	Disagree	Not sure
75. Inadequate hand washing facility			
76. Lack of awareness about safety practices when			

handling agrochemicals			
77.. Lack of commitment on the part of the government hazard control programs			
78. Individual farmers negligence and carelessness			
79.. Lack of adequate protective aids and equipment			
80. Shortage of farmers			
81. Poor awareness on hazards associated with unsafe agrochemical handling.			
82. Inadequate knowledge of usage of modern facilities			

Thank you.