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THE IMPACTS OF PESTICIDE EXPOSURE ON THE HEALTH OF AGRICULTURAL WORKERS: A CASE OF MAZOWE RURAL.

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(B201391B)

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APPROVAL FORM

The undersigned certify that they have read the dissertation and have approved its submission for marking confirming that it conforms to the departmental requirements on research entitled: “The impacts of pesticide exposure on the health of agricultural workers.” Submitted by Kimberly M Mkwaira, in partial fulfilment of Bachelor of Science Honours Degree in Safety Health and Environmental Management.

DECLARATION

I hereby declare that this thesis has been the result of my original efforts and investigations and such work has not been presented elsewhere for degree assessment. All additional sources of information have been acknowledged employing references.

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DEDICATION

To my parents and sisters, I thank you for your unwavering support throughout my academic journey.

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Firstly, I would love to express my deepest appreciation to the Almighty God in whom everything is possible. My sincere thankfulness goes to the Mazowe Rural residents, who welcomed me into their area so that I could carry out my research. My heartfelt gratitude goes to my academic supervisor Mr. Nhokovedzo for guiding me through the undertaking of this whole project, he is forever my hero.

ABSTRACT

This study investigated the impacts of pesticide exposure on agricultural workers in Mazowe Rural, Zimbabwe, with the objectives of determining pesticide usage levels, the prevalence of health problems, and the impact of variations in pesticide usage practices on health outcomes. Employing a mixed-methods approach, data were gathered via a questionnaire survey distributed to 260 agricultural workers (response rate: 90%) and key informant interviews (KIIs) with 12 healthcare providers, agricultural extension officers, and government officials.

Descriptive statistics (frequencies, percentages) were used to analyse survey responses. Bar graphs were also used to illustrate these findings. Logistic regression was used to investigate the correlation between pesticide usage patterns and self-reported health problems. Interview data was analysed using thematic analysis.

Through triangulation, the findings from both the questionnaire and the KIIs converged on a high prevalence of pesticide use, poor adherence to safety measures, and a concerning number of health problems such as headaches, dizziness, nausea, and skin irritation which were then correlated with pesticide usage practices. Those using high-toxicity pesticides or overlooked protective equipment had worse health. A gap was also identified between awareness of safety measures and their consistent application.

Overall, the findings indicate that pesticide exposure is significantly associated with a variety of health outcomes. This highlights the significance of addressing pesticide exposure in Mazowe Rural. The study emphasizes the need for interventions that bridge the gap between knowledge and practice and contribute to a more sustainable agricultural sector.

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CHAPTER ONE: INTRODUCTION

1.0. Chapter introduction

The chapter provides an overview of the research on the effects of pesticide exposure on agricultural workers in Mazowe Rural, Zimbabwe. The study's background emphasizes the global concern over pesticide exposure and its health risks, particularly in developing countries. The problem statement emphasizes the need for research into the health effects of pesticide exposure on agricultural workers in Mazowe Rural, highlighting a critical knowledge gap. The research aims to look into the effects of pesticide exposure on the health of agricultural workers in Mazowe rural, with three objectives and research questions. The study's justification emphasizes the importance of understanding the specific challenges faced by agricultural workers in Mazowe Rural, as well as the potential to provide valuable insights into the health effects of pesticide exposure. The chapter ends with delimitations, limitations, definitions of key terms, and the organization of the study.

1.1. Background of the study

Pesticide use is an essential component of modern agriculture, but its impact on human health is a growing concern. (Food and Agriculture Organization, 2022). Pesticide exposure has been linked to a variety of health problems in agricultural workers, according to studies conducted worldwide. For instance, a systematic review estimated that approximately 385 million cases of unintentional, acute pesticide poisoning occur annually worldwide (Boedeker et al., 2020). They further indicate that nearly 44% of farmers worldwide are affected by pesticide exposure each year, with the majority of cases reported in southern Asia, followed by southeastern Asia and East Africa.

Similarly, according to the World Health Organisation (WHO) (2022), an estimated 300,000 people die every year from acute pesticide poisoning, with the majority of deaths occurring in developing countries. The widespread use of highly hazardous pesticides (HHPs) has been linked to acute and chronic toxic effects, particularly on farmers and farmworkers, emphasizing the importance of international risk assessment and poison prevention efforts (Curl et al., 2020). Abubakar et al. (2020) found a clear link between pesticide exposure and a variety of health problems among agricultural workers. Their research points to acute issues like headaches, dizziness, and skin irritation, while chronic exposure was linked to neurological disorders, certain types of cancer, and disruption of the endocrine system.

Likewise, a groundbreaking study in California, USA, discovered that agricultural workers exposed to organophosphate pesticides were more likely to develop Parkinson's disease, highlighting the long-term neurological effects of these chemicals (Li et al., 2023). As a result, understanding the global scope of this issue highlights the importance of examining its implications at the regional and local levels.

Regionally, in Sub-Saharan Africa, agricultural activities rely heavily on pesticides for pest control and crop protection. As the population grows and food production demands rise, the health risks associated with pesticide exposure become more prominent (Ratnadass, 2020). Agricultural practices in Sub-Saharan Africa often rely heavily on pesticides due to factors such as limited access to alternative pest control methods and a lack of resources for proper safety measures, making pesticide exposure an issue of significant importance (Srinivasan et al., 2022).

According to Fuhrimann et al. (2021), agricultural workers in Africa have a high prevalence of pesticide-related health issues, which include respiratory problems, skin disorders, and neurological effects. A study in Nigeria by Raimi (2021) reported that a significant number of farmworkers experienced symptoms like dizziness, headaches, and nausea, which were linked to pesticide usage. Consequently, this regional context highlights the importance of investigating the health effects of pesticide exposure on agricultural workers in specific areas like Mazowe Rural.

Narrowing down to Zimbabwe, the agricultural sector is heavily reliant on pesticides, with over 483 active ingredients and 800 formulations registered for use. Approximately 10% of these are considered HHPs. The government, in collaboration with the Food and Agriculture Organisation (FAO), has initiated efforts to phase out HHPs because of their significant health and environmental risks (FAO, 2022). Pesticides are widely used in crop protection, but there is a lack of measures to address the health risks posed by these chemical substances. Agricultural workers in Zimbabwe frequently work with pesticides without proper training, which can lead to skin irritations, respiratory problems, and neurological complications (Zinyemba et al., 2021).

Also, according to Zivanayi et al. (2023), insufficient awareness, limited healthcare access, and lax monitoring exacerbate the negative effects of pesticide exposure on the health of agricultural workers. A study conducted among farmworkers in Kwekwe district, Zimbabwe, revealed a high prevalence of organophosphate poisoning linked to inadequate

use of protective equipment and limited knowledge about safe handling procedures (Magauzi et al., 2021).

Ultimately, this study sought to fill gaps in existing research on the effects of pesticides on agricultural workers in Mazowe Rural, specifically. By delving into the community's unique challenges, the study aimed to provide valuable insights for policymakers, health professionals, and agricultural stakeholders in designing targeted interventions that promote safer farming practices, improve worker well-being, and ensure the region's sustainable agricultural development.

1.2. Statement of the problem

While the detrimental effects of pesticide exposure on agricultural workers are a well-known global threat, the specific challenges faced by communities in developing countries necessitate further investigation (Cancino et al., 2023). Pesticide exposure is common in Mazowe rural areas, where agriculture is the primary economic activity. The widespread use of pesticides in this region has raised concerns about the health risks they pose to agricultural workers (Mupfawi, et al., 2023). Specifically, there is a dearth of information on the effects of pesticide exposure on the health of agricultural workers in Mazowe Rural. This lack of information has created a gap in the understanding of pesticide exposure's health effects, necessitating further investigation. This study sought to fill the knowledge gap regarding the health effects of pesticide exposure on agricultural workers in Mazowe rural. Unlike previous studies, which focused on the environmental and ecological effects of pesticide use, this study focused on the human health effects of pesticide exposure.

1.3. Research Aim

The primary aim of this study is to investigate the effects of pesticide exposure on the health of agricultural workers in Mazowe rural.

1.4. Research objectives

To gain a comprehensive understanding of the situation in Mazowe Rural, the following research objectives guided this study:

i. To determine the levels of pesticide usage among agricultural workers in Mazowe rural.
ii. To determine the prevalence of pesticide-related health problems among agricultural workers in Mazowe rural.

iii. To investigate how variations in pesticide usage practices influence the health outcomes among agricultural workers in Mazowe rural.

1.5. Research questions

i. How does pesticide usage vary among different types of agricultural workers?
ii. What is the prevalence of pesticide-related health problems among agricultural workers in Mazowe?
iii. Are there any associations between pesticide usage practices and health outcomes among agricultural workers in Mazowe Rural?

1.6. Justification of the study

Pesticides are undeniably important tools in modern agriculture, providing food security by protecting crops from pests (Pandey et al., 2020). However, their widespread use has a hidden cost, particularly the potential of significant health risks for agricultural workers who are constantly exposed to these chemicals (Curl et al., 2020). As a result, this study is critical for investigating the effects of pesticide exposure on the health of agricultural workers in Mazowe rural, as it has significant implications for the health and well-being of this population.

The importance of this study lies in its potential to address a critical knowledge gap. While existing research depicts a concerning picture of pesticide exposure in Zimbabwe as a whole, a deeper understanding of the specific challenges faced by agricultural workers in Mazowe Rural is necessary. The study's focus on this local community allows for a deeper understanding of the situation. This granular data is critical for developing targeted solutions that effectively address the specific needs and challenges that Mazowe Rural agricultural workers face.

Secondly, the importance of this study stems from its potential to provide valuable insights into the health effects of pesticide exposure among agricultural workers in Mazowe rural. This data can be used to inform policies and interventions aimed at lowering pesticide-related risks and improving agricultural workers' health and safety. Furthermore, the study's findings can help broaden the scope and understanding of pesticides' effects on human health, informing global efforts to reduce pesticide use and promote sustainable agriculture practices.

In addition, the absence of this study would result in a significant gap in knowledge about the health effects of pesticide exposure on agricultural workers in Mazowe Rural. Pesticide use is

a global issue, and understanding its impacts on human health is crucial for developing effective pesticide-reduction strategies and promoting sustainable agriculture practices (Laohaudomchok, et al., 2020). As a result, without this research, it would be impossible to accurately assess the health risks associated with pesticide use and devise effective mitigation strategies as gaps in our understanding may lead to policies and interventions that are ineffective.

Additionally, agricultural workers would likely continue to suffer from a variety of pesticide-related health problems. These include acute poisoning to chronic illnesses, all of which are preventable with proper knowledge and precautions (de-Assis et al., 2020). Also, without a clear understanding of the situation, the cycle of harmful practices may continue. A lack of research could lead to continued reliance on pesticides without adequate safety precautions, endangering human health and the environment (Khode et al., 2024).

Ultimately, this study is not only relevant to the Mazowe Rural community, but it also contributes to the global conversation about protecting agricultural workers and promoting sustainable agricultural practices. This study has the potential to significantly improve agricultural workers' health and well-being, as well as the region's agricultural future, by bridging the knowledge gap and informing evidence-based interventions.

1.7. Assumptions of the study

i. Participants were presumed to be honest and accurate in their questionnaire responses, interviews
ii. The study population represented the larger population of agricultural workers in Mazowe Rural.
iii. The health outcomes measured were relevant and important indicators of pesticide-related health effects.
iv. The relationship between pesticide exposure and health outcomes was consistent with previous scientific research.

1.8. Delimitations

i. This study concentrated solely on agricultural workers in Mazowe Rural, Zimbabwe.
ii. The study relied heavily on participants' self-reported information about pesticide use practices and health outcomes.
iii. The study focuses on a variety of self-reported health symptoms and their potential relationships with pesticide exposure.

iv. The study specifically targeted full-time agricultural workers who were directly involved in pesticide application.

1.9. Limitations

i. The study focused on Mazowe Rural, Zimbabwe. While the findings provide valuable insights, their generalisability to other regions with different agricultural practices and pesticide use patterns may be limited.

ii. The absence of objective data testing for pesticide exposure necessitated the use of self-reported data, which may not accurately reflect actual exposure levels. However, the study's use of a standardized questionnaire multiple data collection methods, and key informant interviews (KIIs) helped to reduce errors and increase data reliability.

iii. The study was based on self-reported information from workers about pesticide use and health outcomes. These reports' accuracy may be influenced by recall and social desirability biases.

iv. Other factors beyond pesticide exposure, such as pre-existing health conditions, lifestyle habits, or dietary factors, may have an impact on the study's health outcomes.

v. The study was carried out within a set timeline and with minimal resources. This potentially limited the sample size and depth of exploration in certain elements of the study

1.10. Definition of key terms

i. Pesticides - substances used in agriculture to eliminate or control insects, weeds, rodents, and fungi (Ahmad et al., 2024).

ii. Pesticide exposure - the contact of a person/individual with a pesticide, which can occur through inhalation, skin absorption, or ingestion (Upadhayay et al., 2020).

iii. Agricultural worker - A person who works on various aspects of crop or livestock production (Cancino et al., 2023).

1.11. Summary

This chapter outlined the concerning effects of pesticide exposure on agricultural workers globally. The chapter highlighted a knowledge gap regarding the specific challenges faced by communities in developing countries such as Zimbabwe. It then narrowed its focus to Mazowe Rural, Zimbabwe, where agriculture is the primary economic activity and pesticides are widely used. The research objectives, questions, and rationale for looking into the health effects of pesticide exposure on agricultural workers in Mazowe Rural were presented. The

chapter concluded by addressing the study's assumptions, limitations, and definitions of key terms. The subsequent chapter will delve into the existing literature on pesticide exposure and its impact on agricultural workers.

1.12. Organization of the study

Chapter 1 - Introduction: The introduction chapter established the framework for the entire study, laying the foundation for understanding the impact of pesticide exposure on the health of agricultural workers in Mazowe rural. This chapter examined the research problem of pesticide exposure and its effects on agricultural workers, emphasizing the importance of addressing this issue to promote a healthier and more sustainable agricultural sector. The chapter also describes the study's objectives, justifies the research, establishes delimitations and limitations, and defines key terms to help clarify the scope and emphasis of the investigation.

Chapter 2 - Literature Review: The literature review chapter will critically evaluate existing research on pesticide exposure, its effects on human health, and the factors that contribute to exposure among agricultural workers. The review will lay the theoretical groundwork for the study, identify knowledge gaps, and contextualize the current research. By reviewing the existing literature, this chapter will strengthen the case for the study's specific questions and methodologies.

Chapter 3 - Methodology: The methodology chapter will include a detailed road map for the research process. This chapter will describe the research design, which includes both quantitative and qualitative methods, participant selection strategies, and data collection methods such as surveys and interviews. The chapter will also lay out the data analysis plan for both quantitative and qualitative data, ensuring rigor and transparency while allowing readers to evaluate the study's results.

Chapter 4 - Results and Discussion: The results and discussion chapter will present the findings from data analysis conducted in both quantitative and qualitative phases. The quantitative findings will be presented using descriptive statistics and statistical methods to highlight patterns and trends in pesticide exposure. Qualitative findings will be presented thematically, emphasizing key informant perspectives and experiences through their voices, resulting in a more nuanced understanding of pesticide exposure and its effects on health.

Chapter 5 - Conclusion and Recommendations: The conclusion and recommendations chapter will summarise the key findings and relate them to the research objectives and literature review. This chapter will discuss the relationship between pesticide exposure, health outcomes, and the factors that contribute to exposure among agricultural workers in Mazowe rural. Finally, this chapter will make concrete recommendations to policymakers, practitioners, and community members about how to address identified vulnerabilities and promote a healthier agricultural sector through effective pesticide exposure management.

CHAPTER TWO: LITERATURE REVIEW

2.0. Chapter introduction

The chapter discusses the literature review for the study commencing with the theoretical framework. The Social Ecological Model (SEM) and Health Belief Model (HBM) are used to study the factors that influence pesticide exposure and worker behaviour. An empirical review is then conducted to look at existing research on pesticide exposure and its health consequences for agricultural workers. The chapter concludes by identifying research gaps regarding the specific effects of pesticide exposure among agricultural workers.

2.1. Theoretical framework

A theoretical framework is a collection of concepts, theories, and models that serve as the foundation for a research study (Vom Brocke et al., 2020). According to Varpio et al. (2020), it provides a conceptual structure for comprehending and analyzing the relationships between variables and phenomena under study. According to Cohen-Miller and Pate (2019), theoretical frameworks drive the research process, shape research questions and hypotheses, and provide as a foundation for data gathering and analysis.

Including a theoretical framework in a study serves several purposes. For instance, it helps researchers in establishing a clear focus and scope for their study by identifying key concepts and variables related to the research topic (Fuertes et al., 2020). This ensures that the study is grounded on established theories and concepts and adds to the current body of knowledge. Second, a theoretical framework provides a lens through which researchers can analyse to understand and analyze their findings (Schoch, 2020). It enables researchers to draw analogies between theoretical concepts and empirical findings. Thus, employing a theoretical framework, researchers can provide explanations and predict the phenomena under study.

Furthermore, a theoretical framework allows researchers to place their research within a broader theoretical context (Clark et al., 2021). They argue that it enables them to use existing literature and theories to support their study hypotheses and conclusions. As a result, this helps to build on prior research and advances knowledge in the field. In summary, a theoretical framework serves as the foundation for a research study by defining significant concepts, theories, and models while also guiding the research process. It helps researchers refine their research questions, interpret data, and situate their study within a broader

theoretical framework. Including a theoretical framework in a study improves the rigor and validity of the research results. The theoretical framework for this study was developed by drawing on a variety of theories that explain the relationship between pesticide exposure and its effects on agricultural workers' health. The frameworks of the Social Ecological Model (SEM) and Health Belief Model (HBM) were used to guide the study. The following sections provide detailed explanations of these models and their application to the study's objectives.

2.1.1. Social Ecological Model (SEM)

The Social-Ecological Model (SEM) is a theoretical framework used in public health research to better understand the complex relationships between individual behaviours, social factors, and the environment that influence health outcomes. It emphasizes the interconnectedness of these elements, recognising that individual choices are influenced by their social and environmental context (U.S. Department of Health and Human Services, 2024). According to the model, health is influenced at multiple levels, ranging from the individual to the societal level, and these levels are interconnected and interdependent.

The individual level of the SEM refers to the characteristics and behaviours of agricultural workers, such as their age, occupation, and level of education (Lewin et al., 2023). The social level of the SEM refers to the community's social norms, values, and relationships, including peer pressure and social support networks (Cohen et al., 2020). The environmental level of the SEM refers to the physical and social environment in which agricultural workers live and work, such as access to healthcare services and the presence of pesticide-resistant crops (Oludoye et al., 2021).

In the context of this study, the SEM serves as a valuable tool for investigating the factors contributing to pesticide exposure and understanding the broader context that influences worker health. The SEM demonstrates how individual characteristics such as pesticide knowledge, attitudes, and practices can affect exposure levels. Workers with limited knowledge of safe handling techniques or those who prioritise speed over safety may be more susceptible to high exposure (Berni et al., 2021).

Additionally, the SEM sheds light on how social norms regarding pesticide use in the Mazowe Rural community, access to safe practice training opportunities, and the prevailing agricultural practices used by agricultural workers all influence worker behaviour. Workers are less likely to take protective measures if safety is not prioritised in the community or proper training is lacking, resulting in increased exposure risks (Teng et al., 2022).

Moreover, the SEM recognizes the environmental context that influences exposure. In Mazowe Rural, the specific crops grown (e.g., cotton, and maize) can influence pesticide selection and application methods. Cotton farming, for example, relies heavily on insecticides, whereas maize production may use herbicides more frequently (Hurley & Mitchell, 2020). Likewise, the quantity and toxicity of these pesticides have a direct impact on worker exposure. Certain pesticides may be more toxic or spread more easily in the environment, posing a greater risk (Ali et al., 2021).

Furthermore, by using the SEM, the study could go beyond simply measuring exposure levels. It enabled a more in-depth investigation of the social and environmental factors that contribute to exposure and, ultimately, influence the health outcomes observed in agricultural workers. This comprehensive approach enables the development of more effective interventions that address not only individual behaviour change but also the larger social and environmental context that influence worker safety in Mazowe Rural.

In conclusion, the Social-Ecological Model provided a useful framework for understanding the complexities of pesticide exposure among agricultural workers. By taking into account the interactions of individual characteristics, social norms, and environmental factors, the study was able to gain a more comprehensive understanding of the challenges that workers face and develop targeted interventions that promote safer practices and improve worker health in Mazowe Rural and beyond.

2.1.2. Health belief model (HBM)

The Health Belief Model (HBM) is a theoretical framework for understanding how people's perceptions and beliefs about their health affect their health behaviours and outcomes. According to the HBM, people are more likely to engage in health-promoting behaviors if they see the benefits, believe the behaviour is feasible, and believe the benefits outweigh the risks (Jose et al., 2021). The model also considers the individual's perceived susceptibility to a specific disease or condition, as well as the severity of the disease.

In the context of this study, the HBM explains why some agricultural workers are more likely to engage in pesticide-reducing behaviours, such as wearing personal protective equipment (PPE) or using alternative farming methods. Perceived benefits are an important factor in the HBM because they refer to workers' beliefs about the positive outcomes of applying safe pesticide handling practices. For example, an agricultural worker who perceives the risks of pesticide exposure as high and believes that wearing PPE is feasible may be more likely to

wear PPE when handling pesticides. An agricultural worker, on the other hand, who believes that the benefits of pesticide use outweigh the risks may be less likely to take precautions to reduce their exposure (Abdollahzadeh et al., 2021).

Additionally, perceived susceptibility is an important component of the HBM as it refers to workers' beliefs about their likelihood of developing health problems as a result of pesticide exposure. If employees underestimate the risk of illness, they are less motivated to take precautions such as wearing protective equipment (Mehmood et al., 2021). Moradhaseli et al. (2021) support this idea, stating that experiencing health problems associated with pesticide use can raise awareness and motivate safer practices.

Perceived barriers are another important factor in the HBM, as they refer to workers' perceptions of the obstacles that prevent them from adopting safe practices. Perceived barriers can include limited access to personal protective equipment, inadequate training, or cultural beliefs that prioritize speed over safety (Hammi et al., 2020). Likewise, cues to action that are internal (e.g., mild symptoms) or external (e.g., educational campaigns) stimuli can encourage people to act. Workers may adopt safer practices after learning about the dangers of pesticide exposure or witnessing a colleague become ill (Bakker et al., 2020).

Ultimately, the HBM expands our understanding of the psychological factors that influence worker behaviour beyond social norms and intentions. To add on, the HBM contributed to this study by providing a framework for understanding the cognitive and emotional factors that influence agricultural workers' pesticide use decisions. This study identified the factors that contribute to pesticide exposure among agricultural workers in Mazowe rural by examining their perceived benefits, perceived risks, and perceived susceptibility to pesticide exposure. This study's use of the HBM allowed for a deeper comprehension of the factors that contribute to pesticide exposure among agricultural workers in Mazowe rural.

2.2. Empirical review

An empirical review is an in-depth review of studies that employ empirical methodology (Paul & Criado, 2020). Gray (2021) defines empirical methods as strategies for collecting real-world data, such as surveys, experiments, and case studies. An empirical review is a detailed and objective summary of extant research on a certain topic (Pandey et al., 2020). According to Berne-Manero and Marzo-Navarro (2020), it can aid in identifying key findings from past studies, identifying gaps in the research literature, and guiding the design and implementation of new investigations.

Reviewing prior studies provides a thorough understanding of what has already been investigated and what research needs remain (Lim et al., 2022). According to Post et al. (2020), this avoids duplication of work and enables you to find places where your research can add fresh information. To add on, the review assists in selecting appropriate research methodologies depending on the types of studies conducted previously. Bansal and Pruthi (2021), successful methodologies can discover potential limitations to avoid in the current research. Building on existing knowledge, we can gain a better understanding of the complex relationships between pesticide exposure and various health outcomes, as well as the factors that contribute to pesticide exposure in agricultural workers. This aids in the development of targeted interventions and strategies that address the specific needs and concerns of agricultural workers in this region.

2.2.1. Pesticide exposure among agricultural workers

Pesticide use is critical to global agricultural production, but its benefits come at a cost, particularly the risk of harm to agricultural workers (Lykogianni et al., 2021). The global literature on pesticide exposure among agricultural workers is replete with evidence of how widespread this problem is. For instance, a study published in the Journal of Occupational and Environmental Medicine discovered that 75% of agricultural workers in 12 countries worldwide reported pesticide exposure, with 65% of these workers reporting symptoms such as headaches, fatigue, and skin irritation (Sharma et al., 2020).

Additionally, the World Health Organization (WHO) (2022) estimates that millions of agricultural workers around the world are exposed to moderate to high levels of pesticides each year. This exposure can occur through a variety of routes, including inhalation, dermal absorption, and ingestion. Also, the Food and Agriculture Organization (FAO) (2021) estimates that agricultural workers worldwide handle and apply over 4 million tons of pesticides each year. This widespread use raises serious concerns about possible exposure risks.

Moreover, the International Labour Organization (ILO) estimates that 30% of agricultural workers worldwide are exposed to pesticides, with many more exposed to other hazardous chemicals (ILO, 2019). A study published by Kumar et al. (2019) discovered that 70% of agricultural workers in 24 countries reported being exposed to pesticides at least once a month. This paints an alarming picture of widespread pesticide exposure among agricultural workers worldwide.

Moving to the regional level, Sub-Saharan Africa is particularly vulnerable to pesticide exposure where small-scale farmers frequently lack proper training, personal protective equipment (PPE), and access to information on safe handling practices (Fuhrimann et al., 2021). Pesticide use in Sub-Saharan Africa is expected to rise by 30% by 2030, driven by population growth and urbanization (FAO, 2018). A study conducted in Ghana discovered that 80% of agricultural workers had been exposed to pesticides, with many reporting symptoms such as headaches, fatigue, and skin irritation (Asante et al. 2019). A study in Kenya by Ochieng et al. (2018) discovered that 60% of agricultural workers had been exposed to pesticides, with many reporting symptoms such as respiratory problems and skin irritation. Despite these concerning trends, comprehensive data on exposure levels in Sub-Saharan Africa is still scarce. This emphasizes the significance of the current study, as it helps provide valuable data to a region with limited information.

Similarly, in the context of Zimbabwe, where this study was carried out, pesticide exposure is a major exposure. Zimbabwe, like many other African countries, has witnessed an increase in pesticide use to improve agricultural productivity (Zinyemba et al., 2021). While data on national exposure levels is limited, a study by Atinkut Asmare et al. (2022) in Zimbabwe discovered concerning levels of pesticide metabolites in urine samples of farm workers. Also, Zimba and Zimudzi's (2019) study on the occupational hazards of pesticide use and handling practices among rural market gardening farmers near Harare found that more than half of farm workers were exposed to organophosphates while spraying.

To summarise, this critical review of existing research provides a compelling rationale for our study. The empirical review of pesticide exposure among agricultural workers demonstrates the issue's global, regional, and national scope. The statistics and studies cited above highlight the importance of addressing pesticide exposure among agricultural workers to prevent adverse health outcomes.

2.2.2. Pesticide exposure and health outcomes among agricultural workers

The relationship between pesticide exposure and various health outcomes among agricultural workers in Mazowe Rural, Zimbabwe, necessitates a comprehensive examination of previous research. A well-established body of research shows a clear link between pesticide exposure and a variety of adverse health effects in agricultural workers. Studies have documented relationships with acute health problems like headaches, dizziness, and nausea, as well as

chronic health issues such as respiratory problems, neurological disorders, and some cancers (Curl et al., 2020 & Amoatey et al., 2020).

Prolonged pesticide exposure has been associated with several chronic health issues, such as neurological disorders (which include Parkinson's disease, Alzheimer's disease, and nerve damage), cancers (such as leukemia, lymphoma, and prostate cancer), and respiratory illnesses (such as increased risk of asthma, chronic obstructive pulmonary disease) (Scorza et al., 2023). Moreover, research by has related pesticide exposure among agricultural workers to DNA damage, oxidative stress, neurological disorders, and respiratory, metabolic, and thyroid effects (Ledda et al., 2021). According to WHO (2020), roughly 3 million cases of acute pesticide poisoning occur globally each year, resulting in approximately 100,000 deaths. Likewise, according to the International Labour Organisation (ILO) (2019), pesticides are a major contributor to occupational diseases, with an estimated 20,000 deaths worldwide each year.

A systematic review published in 2020 estimated that approximately 385 million cases of unintentional, acute pesticide poisoning (UAPP) occur annually worldwide, with approximately 11,000 fatalities. This study found that UAPP affects approximately 44% of the global farming population each year, with the majority of cases occurring in southern Asia, followed by southeastern Asia and East Africa (WHO, 2019). Also, a cohort study in Costa Rica found that agricultural workers exposed to pesticides had a higher incidence of Parkinson's disease compared to the non-exposed population (Boedeker et al., 2020).

Additionally, an analysis of the Agricultural Health Study in the United States indicated that long-term pesticide exposure was associated with an increased risk of rheumatoid arthritis and thyroid disorders among licensed pesticide applicators (Curl et al., 2020). In India, a study conducted in the agricultural state of Punjab reported a high prevalence of neurological symptoms among pesticide applicators compared to non-applicators, indicating a strong relationship between pesticide exposure and adverse neurological outcomes (Sharma et al., 2021).

Moving on to the regional level, agricultural workers in Sub-Saharan Africa face increased risk due to factors such as limited access to personal protective equipment (PPE) and insufficient training on safe handling practices. This increases exposure and potentially worsens health outcomes (Fuhrimann et al., 2021). A Tanzanian study discovered that pesticide exposure was associated with an increased risk of developing chronic respiratory

problems among coffee growers (Owisso et al., 2022). According to Olowogbon et al. (2021), farmers in Nigeria who were exposed to pesticides had significantly higher rates of hospital admissions for respiratory conditions than the general population.

Narrowing to Zimbabwe, agriculture is a significant sector in the country's economy, with many farmers and agricultural workers using pesticides to control pests and diseases (ZimStat, 2020). However, there is limited data on the specific health effects of pesticide exposure in Zimbabwean agricultural workers. Studies in commercial farms in Kwekwe district revealed a high risk of occupational diseases among farm workers due to pesticide exposure, with organophosphate poisoning indicated by abnormal cholinesterase activity (Magauzi et al., 2016). Another study conducted in Zimbabwe discovered that pesticide exposure was associated with an increased risk of health problems such as respiratory symptoms, skin rashes, and eye irritation (Moyo et al., 2019).

Ultimately, according to the literature review, pesticide exposure is a significant risk factor for a variety of health outcomes among agricultural workers at the global, regional, and local levels. The review demonstrates the global pesticide problem's relevance to the specific case of Mazowe Rural, emphasizing the importance of addressing pesticide management and worker health outcomes in the context of Zimbabwean agricultural practices. The findings also highlight the need for additional research into the effects of pesticide exposure on agricultural workers' health in Zimbabwe. Thus, the current study aimed to fill a knowledge gap by investigating the link between pesticide exposure and various health outcomes among agricultural workers in Mazowe rural.

2.2.3. Determinants of pesticide exposure among agricultural workers.

Identifying the factors that contribute to pesticide exposure among agricultural workers is critical for understanding and mitigating the risks. Research conducted around the globe has identified several factors that influence pesticide exposure among agricultural workers. Globally, factors contributing to pesticide exposure include the agricultural regime, the social process of pesticide application, economic analysis, politics and governance, and the promotional failure of alternatives (Hu, 2020). These factors interact and influence the level of exposure that workers face. For instance, greenhouse farms' enclosed architecture and frequent pesticide application significantly increase exposure levels (Amoatey et al., 2020). According to the World Health Organization (WHO) (2019), the main factors of pesticide exposure among agricultural workers are inadequate pesticide storage and handling, poor

application techniques, and a lack of education and training. A study on environmental influences on agricultural worker health in the United States found that factors such as age, education, pesticide safety training, farming experience, and contact with other farmers or intermediaries resulting in pesticide access are the main risk factors for pesticide exposure (Pinto, 2020).

Pesticide exposure has been linked to social factors, including limited access to personal protective equipment (PPE) due to cost constraints, insufficient training on safe handling practices, and a lack of awareness about the dangers of exposure (Curl et al., 2020). There are also economic factors. Small-scale farmers in developing countries frequently face economic constraints, limiting their ability to invest in PPE or safer alternatives (Abdollahzadeh et al., 2021). Additionally, environmental factors such as wind patterns, temperature, and humidity can influence how easily pesticides disperse, potentially increasing worker exposure (FAO, 2022).

The situation in Sub-Saharan Africa is especially concerning. The reliance on small-scale farming, combined with limited resources and insufficient regulations, creates an environment in which workers are more vulnerable to high exposure levels (Fuhrimann et al., 2021). According to the International Labour Organization (ILO) (2019), in Sub-Saharan Africa, the main factors contributing to pesticide exposure among agricultural workers are inadequate pesticide storage and handling, poor application techniques, and a lack of education and training.

Moreover, a study conducted in Ghana discovered that factors such as a lack of personal protective equipment, inadequate training, and poor working conditions contributed to pesticide exposure among farmers (Asuming-Brempong et al., 2018). Studies in Kenya and Nigeria have revealed concerning trends. As an illustration, Isgren and Andersson (2021) discovered that a significant proportion of agricultural workers lacked adequate training in safe handling practices, increasing their risk of exposure. Likewise, a study by Goeb et al. (2022) in Mozambique and Zambia found that factors such as lack of PPE, inadequate pesticide storage and handling, and poor working conditions contributed to pesticide exposure among agricultural workers.

Approximately 30-50% of workers on large-scale commercial farms in Zimbabwe are exposed to organophosphates during the spraying season. Manual techniques, a lack of protective clothing, and insufficient safety information all contribute to the problem (Nhachi

& Kasilo, 2020). There is also evidence in their findings of pesticide exposure spilling over to non-sprayers and communities living on farms. The main causes of pesticide exposure among agricultural workers in Zimbabwe are inadequate pesticide storage and handling, poor application techniques, and a lack of education and training (Ministry of Labour and Social Welfare, 2020).

In summary, this review emphasizes the multifaceted nature of factors influencing pesticide exposure. Understanding the global and regional trends that influence pesticide exposure strengthens the case for the study in Mazowe Rural. By investigating these factors in this particular context, the current study was able to identify local risk factors as well as assess the specific social, economic, and environmental factors that contribute to exposure among Mazowe Rural agriculture workers. By identifying the key contributors, the study could propose feasible recommendations to protect the health of agricultural workers while also contributing to a larger movement toward safer agricultural practices.

2.3. Conceptual framework

A conceptual framework is a means of organizing and combining ideas about a specific topic to make them easier to understand and explain (Casula et al., 2021). According to Van der Waldt (2020), a conceptual framework is a set of interconnected perceptions that serve as a mental model for thinking about a specific phenomenon or situation. Varpio et al. (2020) define a conceptual framework as a blueprint for thinking about a certain event or issue, emphasizing key concepts and their links. Thus, a conceptual framework provides a clear path for thought and investigation, as well as a road map for understanding a specific occurrence or problem.

To investigate the impacts of pesticide exposure on the health of agricultural workers in Mazowe Rural, Zimbabwe, a strong conceptual framework is required. This framework guides the research by identifying key variables, establishing relationships, and contextualizing the study. Thus, this conceptual framework outlines the key components and relationships investigated in the study to better understand the effects of pesticide exposure on the health of agricultural workers in Mazowe Rural, Zimbabwe.

2.3.1. Independent variable

In the conceptual framework, pesticide exposure is the independent variable, acting as the initiating factor influencing agricultural workers' health. This variable represents the extent to which agricultural workers are exposed to pesticides while performing their duties and

activities. This can include pesticide exposure through air, water, or skin contact (Upadhayay et al., 2020).

To determine the pesticide exposure level, a self-reported questionnaire was distributed to agricultural workers in Mazowe Rural, designed to collect self-reported data on various aspects of pesticide exposure risks. The questionnaire was intended to collect data on the frequency and quantity of pesticides used, the type of pesticides, as well as the methods of application and safety practices. While acknowledging the lack of objective measures such as biological monitoring or environmental sampling, this method provided valuable insights concerning exposure patterns. This is because factors such as application frequency, pesticide type (e.g., high vs low toxicity based on colour codes), and safety practices can all have an impact on the probability and extent of exposure.

2.3.2. Dependent variable

The dependent variable in this study is agricultural workers' health outcomes, which are defined as the physical and mental health consequences of pesticide exposure (Cancino et al., 2023). These are the various physical and psychological effects that pesticide exposure can have on agricultural workers. Health outcomes can include acute symptoms (short-term effects) such as headaches and dizziness and chronic conditions (long-term effects) such as cancer, respiratory diseases, and neurological disorders (Curl et al., 2020).

To assess the health outcomes of agricultural workers, a comprehensive questionnaire was developed and distributed to participants. The questionnaire contained questions that collected data on a variety of physical and mental health symptoms and conditions that could be linked to pesticide exposure. The questionnaire was divided into sections, each with a specific focus on health outcomes. The questionnaires inquired about both acute symptoms and chronic conditions.

2.3.3. Conceptualisation of the variables

The core focus of the study was to investigate the relationship between pesticide exposure (independent variable) and health outcomes (dependent variable). Pesticide exposure is the independent variable predicted to have a direct impact on agricultural workers' health outcomes. Due to limitations in obtaining objective exposure data, the study relied on self-reported information about pesticide use practices that are strongly indicative of their exposure risk. This included application frequency, pesticide type (based on colour codes), and safety practices. The study aimed to understand how variations in exposure may affect

the health of agricultural workers in Mazowe Rural by analysing these practices alongside reported health outcomes.

Furthermore, Key Informant Interviews (KIIs) were conducted with health professionals, agricultural extension officers, and government officials. These interviews yielded valuable insights from experts who had observed the health of agricultural workers in the region. Combining data from questionnaires and KIIs enabled a more comprehensive assessment of potential pesticide-related health outcomes.

2.4. Research gaps

Pesticide exposure harms agricultural workers worldwide, with developing countries facing unique challenges due to limited resources and regulations (Cancino et al., 2023). Agriculture is the economic backbone of Mazowe Rural, Zimbabwe. The widespread use of pesticides in this region has raised serious health concerns among agricultural workers (Mupfawi et al., 2023). However, there is a significant lack of data on the specific effects of pesticide exposure on the health of these workers in Mazowe Rural.

While research has established the negative health consequences of pesticide exposure for agricultural workers worldwide, a significant data gap prevents us from fully understanding the situation in Mazowe Rural. Existing research has primarily examined the environmental and ecological consequences of pesticide use (Zivanayi et al., 2023 & Zinyemba et al., 2021). This leaves an important question unanswered, specifically how the agricultural workers in Mazowe Rural have been affected by their exposure to these chemicals.

Additionally, there is a lack of specific data on the types and frequency of health problems associated with pesticide exposure among agricultural workers in Mazowe Rural. Because of the lack of information, determining the true scope of the health risks faced by this vulnerable population is challenging. Understanding these health outcomes is critical for developing effective interventions and ensuring the well-being of workers (WHO, 2022).

As a result, this study sought to address the critical data scarcity by looking into the health effects of pesticide exposure on agricultural workers in Mazowe Rural. The study aimed to provide a thorough understanding of the relationship between pesticide exposure and health outcomes among agricultural workers in this region, which aids in the development of targeted interventions and policies to reduce the health risks associated with pesticide use. By focusing on a specific population of agricultural workers in Mazowe rural areas, this study

aimed to provide a more nuanced understanding of the health effects of pesticide exposure and to identify the most effective strategies for reducing pesticide-related health risks. Overall, this study sought to add to the existing literature on the effects of pesticide exposure on agricultural workers by providing a comprehensive understanding of the health effects of pesticide exposure on this population and identifying the most effective strategies for reducing the health risks associated with pesticide use.

2.5. Chapter conclusion

The study began with theoretical frameworks, specifically SEM and HBM, which served as a foundation for understanding the complexities that influence pesticide exposure and agricultural workers' health. The extensive review of existing research highlighted both global concerns and a lack of data specific to Zimbabwe. The conceptual framework was established, with pesticide exposure serving as the independent variable and health outcomes as the dependent variable. Lastly, the study discussed a critical data gap regarding the health impacts of pesticide exposure among agricultural workers in Mazowe Rural, Zimbabwe. With this foundation laid, the following chapter will go over the research methodology used to collect and analyse data on exposure levels and health outcomes among agricultural workers in Mazowe Rural.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of the study area

Mazowe Rural is a village situated in Mazowe District of Mashonaland Central Province, Zimbabwe, and is found on latitude 17. 5166646 degrees S and longitude 30. 9666628 degrees E. The district's annual temperature is 24.96 degrees Celsius and it receives approximately 128 millimeters of precipitation (Weather and Climate 2016). The area is well known for gold mining as well as several flowing rivers including the beautiful Mazowe Dam (Chivore V, 2021). The area is situated in Region 2 of the farming area hence it favors both crop production and animal husbandry. The people who reside in the area duel on growing crops such as tobacco, cotton, and maize, and as a result this is where they get their source of income.

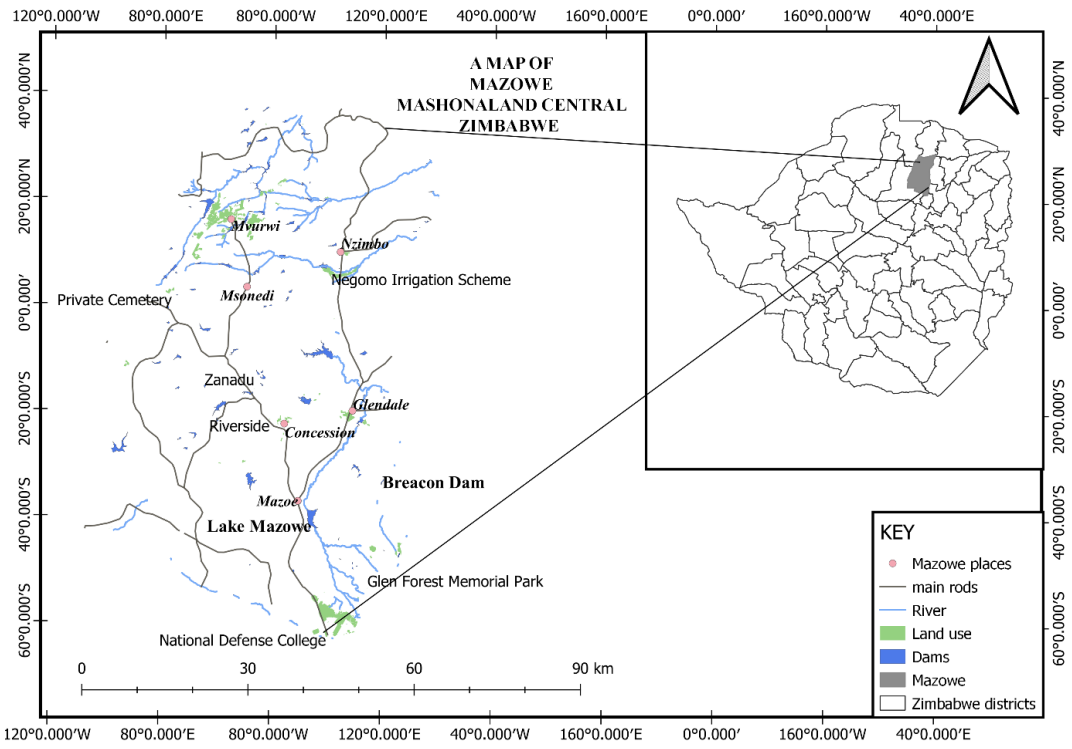

Figure 1: A Map showing Mazowe Rural Study Area.

3.2. Research design

A Cross-Sectional Study was used to sample the study population. Stratified random sampling was used as this design allows for the stratification of the population based on different agricultural activities (Lauren Thomas, 2023). A descriptive research design was used.

3.3. Sampling and sampling procedures

3.3.1. Study population -sample

This study aimed to analyse the health effects of pesticide exposure among agricultural workers (de-Assis et al, 2020). A cross-sectional study design allowed the researcher to collect data from a diverse group of agricultural workers at a single point in time. Information on the frequency and percentages of levels of pesticide usage and prevalence health outcomes were collected. (Damalas et al, 2016). The research focused on a section of 275 agricultural workers in the Mazowe rural area who met the following inclusion criteria

- Aged between 18 and 65 years
- Both sex
- Willing to participate
- Available at the time of the study

3.3.2. Sample size

Mazowe rural is a region with a large number of agricultural workers whose lives depend on farming. The research focused on the entire population of agricultural workers operating within the Mazoe rural area. The target population consisted of 275 farmers. A margin of error and confidence level were taken into account to ensure the study's reliability.

3.4. Data collection

The research was based on primary data through the use of questionnaires and interviews for pesticide exposure factors for gathering evidence (Young T. J, 2015). Descriptive statistics was used to determine percentages and frequencies. The method contributed to the comprehensive understanding of pesticide exposure and health effects. The questionnaire consisted of closed-ended questions (Hyman M. R and Sierra J. J, 2016). Distribution questionnaires to agricultural workers provided more information on pesticide exposure, their pesticide usage practices, work routines, protective measures used, and any health complaints reported (Rostami F et al, 2019).

3.4.1 Data collection instruments: questionnaire

Part 1: Demographic information.

The first component of the questionnaire aimed to gather demographic information from participants. This included factors like age, gender, most important crops grown in the area, and any other relevant background information.

Part 2: Pesticide exposure

This section explained more about pesticide exposure for example:

- How frequently do you use PPE?
- Are there any training programs conducted concerning safe pesticide handling?

Part 3: Health outcomes

This aimed to study the potential health consequences of pesticide exposure among agricultural workers in Mazowe Rural. Participants were asked questions on neurological symptoms, reproductive issues, musculoskeletal diseases, and family history of health problems.

3.4. Data collection methods

Data were acquired by administering questionnaires to agricultural workers, who would fill out their information. These agricultural workers included the ones who store pesticides, mixers, applicators and handlers. Interviews were also conducted among healthcare workers, agricultural extension workers, and government officials.

3.5. Data analysis

The questionnaire data was collected, coded, and stored in SPSS. The data gathered was provided in tables. The descriptive analysis was carried out using the crosstabs tool in the Statistical Package for Social Sciences, Version 20. The tool was used to determine frequency and percentiles. Questionnaires were employed to collect quantitative data, such as frequencies and percentages, to describe the prevalence of pesticide exposure and associated health impacts (Steves E, 2023). The descriptive statistics used Microsoft Excel, to prepare data to use in the SPSS. The benefits included a comprehensive overview of the current pesticide exposure situation, as well as the identification of common health impacts and exposure patterns among agricultural workers (Steves E, 2023).

3.6. Ethical considerations

The research was presented to the researcher's department verbally for approval within the department, guided by the supervisor, and subjected to study evaluations on the research methods and objectives. The study's objectives, purpose, and conclusions were communicated to both participants and the larger community. It was highlighted that participation was fully optional and that participants had the choice to resign from the study at any moment without penalty. Participants' personal and health data were protected.

CHAPTER FOUR: RESULTS

4.0 Chapter introduction

This chapter investigates the findings on pesticide exposure and health among agricultural workers in Mazowe Rural. The study investigates how factors such as usage frequency, pesticide type (based on colour coding), protective gear use, and many others affect health outcomes. This section discusses these findings in light of established frameworks for the Health Belief Model (HBM), social-ecological systems (SEM), and the existing body of research on pesticide exposure in agricultural settings.

4.1. Questionnaire and interview response rate

260 questionnaires were distributed and 12 out of 15 interviews were carried out. The questionnaire response rate of 90% percent indicates a high level of participation among Mazowe rural agricultural workers. The KII response rate (80%) also indicates a positive response from the key informants selected for the interviews, which included agricultural experts. This high response rate shows how relevant and significant the study is to the stakeholders involved.

4.2. Demographic Characteristics of the Participants

This section examines the demographic characteristics of the study's participants, as described in Section 1 of both the KII and the questionnaire. The main demographic factors evaluated were age, gender, types of crops cultivated, number of years working in agriculture, and educational level, as detailed in the Table below.

The age distribution was diverse, with the majority (47%) falling between 31 and 44 years old. There was a significant gender imbalance, with a much higher percentage of male participants (73%) compared to females (33%). This reflects a common trend in which men play more prominent roles in agricultural work. The crops cultivated by the participants provided a good representation of agricultural practices in Mazowe Rural. The most common crop was maize (61%), followed by tobacco (25%), and cotton (9%). The educational backgrounds were also diverse, with the majority of participants (61%) having completed secondary education. This suggests that the study accurately captured the demographics of the local agricultural workforce.

Table 2: Demographic Characteristics of the Participants (n=230)

Category	Percentage
Age	
18-30 years old	33%
31–45 years old	47%
45+ years old	19%
Gender	
Male	77%
Female	33%
Educational levels	
Primary	20%
Secondary	19%
Tertiary	20%
Length of Residence	
1-5 years	15.5%
6-10 years	25.2%
11+ years	59.4%
Crops cultivated	
Maize	61%
Tobacco	25%
Cotton	9%
Other	5%

4.3. Main findings of the study

This study examined the impact of pesticide exposure on the health of agricultural workers in Mazowe rural. The research design employed a mixed-methods approach. A questionnaire was used to gather quantitative data on pesticide exposure levels and the prevalence of health issues among workers. Additionally, key informant interviews (KIIs) were conducted with healthcare providers, agricultural extension officers, non-governmental organizations (NGOs), and government officials. These interviews provided qualitative information on

current practices, levels of awareness, and potential challenges related to pesticide use and health in the region.

This study sought to gain a comprehensive understanding of the factors influencing the relationship between pesticide exposure and health outcomes among agricultural workers in Mazowe Rural by triangulating quantitative survey data with qualitative data from KIIs. The following sections will present the key findings from both data collection methods, providing a better understanding of the research objectives.

4.3.1. Objective (i) To determine the levels of pesticide usage among agricultural workers in Mazowe rural.

4.3.1.1. Findings from the Questionnaires

The study's findings show that agricultural workers in Mazowe rural face significant pesticide usage. The frequency of pesticide application, the type of pesticides used, and the commonly used colour codes for pesticides all contribute to overall usage levels.

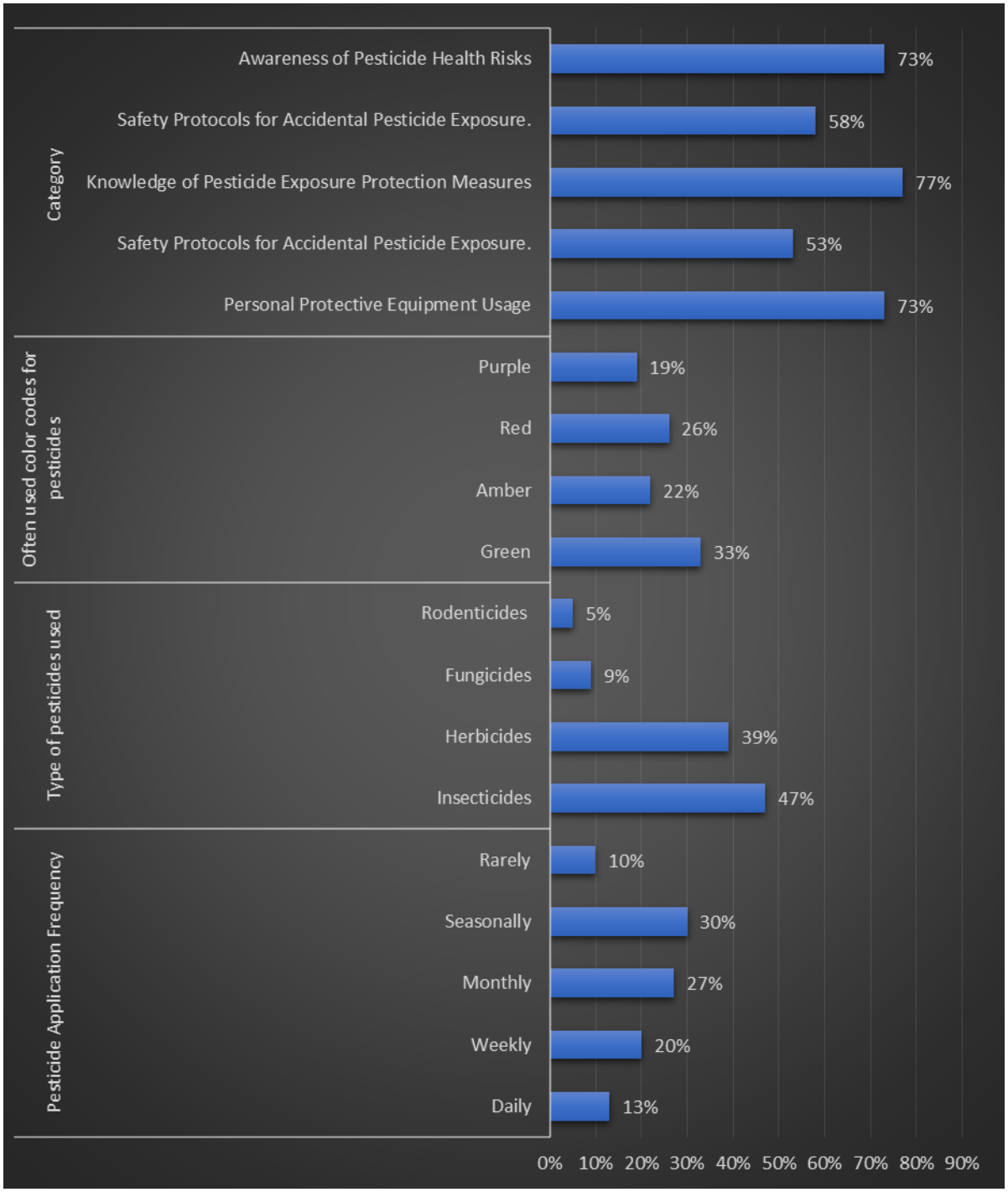

Figure 2: The different levels of pesticide usage patterns among agricultural workers

The data on pesticide application frequency in Mazowe Rural as shown by the figure above show a pattern of regular pesticide use among agricultural workers. The most common application schedules range from monthly to seasonal. Specifically, 30% of workers use pesticides on a seasonal basis, indicating that pest control efforts are likely targeted around specific growing seasons. Furthermore, 27% apply monthly, indicating a consistent need for pest management throughout the year. 20% of workers report weekly applications, indicating

a greater need to address pest issues. Although daily application is less common, 13% of workers still use it, indicating that crops or pest problems necessitate the most frequent use of pesticides. Finally, 10% of workers indicated they rarely used pesticides, implying they practice organic farming, grow crops less susceptible to pests, or use alternative pest control methods.

In addition, the data on the pesticides used by agricultural workers in Mazowe Rural provides some important insights. Insecticides (47%) are the most widely used, followed by herbicides (39%). This suggests that insects and weeds are the most pressing pest issues for farmers in this region. The widespread use of insecticides highlights the potential for integrated pest management (IPM) strategies that go beyond chemical control. Fungicides (9%), and rodenticides (5%), are used considerably less frequently. This could indicate that fungal diseases and rodent infestations pose fewer threats to crops in Mazowe Rural, or that farmers use alternative methods of control. It's also possible that these pesticides are used in more targeted ways on specific crops or during outbreaks.

The study found that the majority of agricultural workers in Mazowe rural are exposed to pesticides, with 33% reporting usage of pesticides with a green colour code, which is commonly associated with low toxicity. However, a significant proportion of workers (22%) reported usage of pesticides labelled amber, indicating moderate toxicity. Notably, 26% of workers reported usage of pesticides labelled with a red colour code, which is frequently associated with high toxicity. Furthermore, 19% of workers reported exposure to pesticides labelled purple, which indicates the highest level of toxicity. The findings indicate that agricultural workers in Mazowe rural are exposed to pesticides with varying toxicity, with some workers using more toxic substances than others, suggesting a significant exposure risk.

The study's findings provide a mixed picture of agricultural workers' pesticide use practices and awareness in Mazowe rural. In terms of personal protective equipment (PPE), encouragingly, the study found that 85% of workers reported wearing long-sleeved shirts or work suits when working with pesticides, which is an important precaution to avoid pesticide exposure. Furthermore, 76% of workers reported wearing closed-toe shoes when working with pesticides, which helps to reduce skin exposure. However, 58% of workers reported wearing goggles or face shields when handling pesticides, which is an important precaution to avoid eye and skin exposure. This suggests that a large number of workers may not be adequately protected from pesticide exposure, particularly in the eyes and skin. Furthermore,

the vast majority of respondents (77%) reported knowledge of pesticide exposure protection measures, indicating that they understand the importance of taking precautions when handling pesticides.

Nevertheless, there is a concern about the implementation of safety protocols for accidental pesticide exposure. Only 53% of respondents reported following safety protocols in the event of accidental exposure, which is a critical precaution to avoid harm. Furthermore, while 73% of respondents reported being aware of the health risks associated with pesticide exposure, there is still room for improvement in terms of practical application.

Overall, the results show that agricultural workers' knowledge and awareness of pesticide safety is generally high. However, there is still a need to close the knowledge gap and ensure consistent safe practices through interventions focusing on PPE use and proper safety protocol implementation.

4.3.1.2. Findings from the Key Informant Interviews

Several key themes emerged from interviews with 12 key informants (KIIs), including healthcare providers, agricultural extension officers, and government officials, about pesticide exposure among agricultural workers in Mazowe Rural.

All KIIs identified insecticides (particularly for controlling locusts and beetles) and herbicides (for weed control in maize and cash crops) as the most commonly used pesticides. Some healthcare providers (67%) expressed concern about the increased use of fungicides on cash crops such as tobacco, which could be linked to an increase in fungal diseases. A significant portion (83%) emphasized the use of these pesticides during the planting, weeding, and flowering stages, depending on the crop and pest pressures.4

The majority of KIIs (83%) agreed that pesticides are widely available in the region, with agro-dealer shops serving as the primary source for farmers. However, concerns have been expressed about the affordability of these products, particularly for small-scale farmers (all healthcare providers). The high cost (75% of KIIs) was attributed to factors such as import dependence and price fluctuations in the global market.

A prevalent theme (100%) among KIIs was a lack of proper training and adherence to safe handling practices. Most KIIs (83%) reported seeing farmers mix pesticides in open containers without proper PPE. Inappropriate application methods, such as using empty pesticide containers for water transport, which is primarily used for watering, and inadequate

storage practices, such as keeping pesticides in their original containers around homes, were also highlighted.

All KIIs agreed that most agricultural workers use PPE infrequently. The primary barriers identified (100% of KIIs) were discomfort caused by hot weather, limited access to affordable PPE, and a lack of awareness about the long-term health risks associated with pesticide exposure. Additionally, while some KIIs (67%) mentioned the existence of pesticide safety training programs, the majority of KIIs (83%) questioned their effectiveness. These programs were perceived to be ineffective due to limited outreach, infrequent training sessions, and a lack of practical demonstrations. Healthcare providers (100%) emphasized the critical need for more accessible and comprehensive training programs to raise awareness and promote safe handling practices among agricultural workers.

4.4.1.3. Combined findings from questionnaires and key informant interviews.

The questionnaire results and key informant interviews (KIIs) provide a comprehensive picture of pesticide exposure among agricultural workers in Mazowe rural. The questionnaire results show that agricultural workers in this region are exposed to significant amounts of pesticides, which are applied frequently and have varying levels of toxicity. The findings highlight the importance of integrated pest management (IPM) strategies that extend beyond chemical control. Although the majority of workers reported using personal protective equipment (PPE), there is concern about the implementation of safety protocols for accidental pesticide exposure.

The KII findings provide additional information about the practices and awareness of agricultural workers in Mazowe rural. The KIIs identified insecticides and herbicides as the most commonly used pesticides, emphasizing the importance of proper training and following safe handling practices. The majority of KIIs reported seeing agricultural workers mix pesticides in open containers without proper PPE and emphasized the lack of awareness about the long-term health risks associated with pesticide exposure.

Triangulation of the results reveals that agricultural workers in Mazowe rural have a high level of awareness about pesticide exposure, but more comprehensive training programs are needed to promote safe handling practices. Both data sources confirm widespread pesticide use. According to questionnaires, most workers have regular application schedules (monthly

to seasonal), with insecticides and herbicides being the most common. KII data supported these findings, highlighting specific pest targets such as locusts and weeds.

Moreover, the triangulation of the results also reveals a knowledge-practice gap, with many workers aware of the importance of personal protective equipment but failing to use it consistently. Questionnaires revealed that workers were exposed to pesticides of varying toxicity, with a significant portion encountering highly toxic ones (red and purple colour codes). KIIs did not directly address toxicity levels, but their concerns about increased fungicide use indicate the possibility of additional risks.

While the questionnaires revealed a high reported use of PPE and awareness of protective measures (77%), the data also revealed a knowledge-practice gap. While 85% of workers reported wearing long-sleeved shirts or work suits when working with pesticides, 58% reported wearing goggles or face shields, raising concerns. Furthermore, 76% of workers reported wearing closed-toe shoes when working with pesticides, implying that some workers may not be adequately protected against pesticide exposure. Only about half (53%) reported following safety protocols in the event of accidental exposure. KIIs confirmed these concerns, pointing out a lack of proper training and adherence to safe handling practices. Inappropriate mixing, application, and storage practices observed by KIIs highlight this gap.

4.3.2. Objective (ii) To determine the prevalence of pesticide-related health problems among agricultural workers in Mazowe rural.

4.3.2.1. Findings from the Questionnaires

The study’s findings suggest that the prevalence of pesticide-related health problems among agricultural workers in Mazowe rural is a major concern. A staggering 87% of respondents reported experiencing health problems as shown by the figure below. When looking at specific symptoms, common issues such as headaches (72%), eye irritation (44%), skin irritation (36%), and nausea (30%) highlight the immediate effects of exposure. Dizziness (42%) and respiratory problems (20%) raise additional concerns, indicating potential nervous and respiratory system effects.

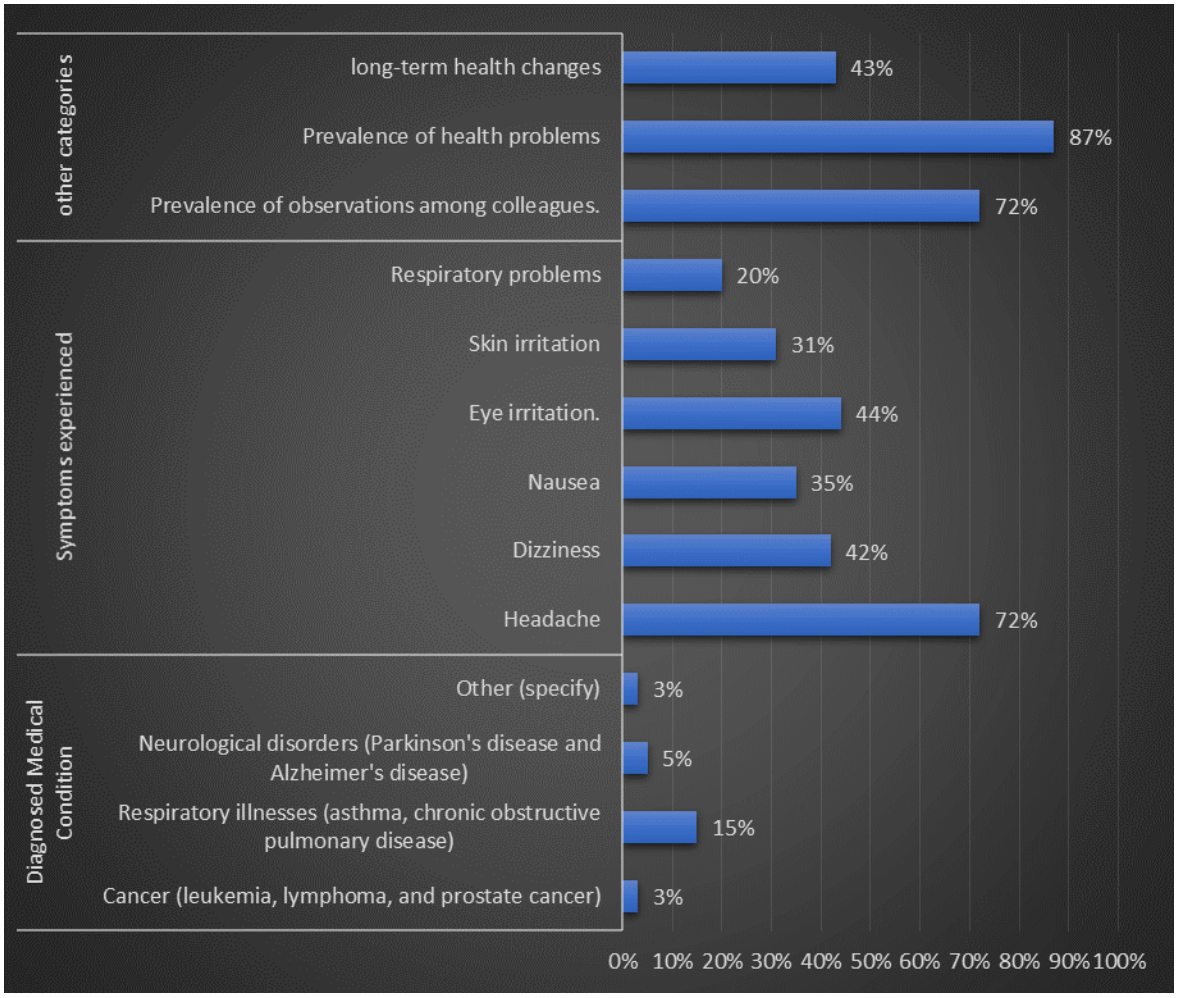

Figure 3: The prevalence of pesticide-related health problems among agricultural workers

Furthermore, as shown by the figure above, 43% of respondents reported experiencing long-term health changes that they believe are the result of pesticide exposure. This suggests that pesticide exposure has long-term effects on workers' health and quality of life, in addition to acute symptoms. The fact that nearly half of respondents reported noticing long-term health changes emphasizes the need for immediate action to address this issue. According to the study's findings, a significant proportion of agricultural workers in Mazowe rural have suffered from pesticide-related health problems. The most common health issues reported were respiratory illnesses, with 15% of respondents having asthma or chronic obstructive pulmonary disease (COPD). This is a concerning finding because pesticide exposure is known to increase the risk of respiratory illnesses. The prevalence of neurological disorders, such as Parkinson's disease and Alzheimer's disease, was also notable, with 5% of respondents reporting a diagnosis. 3% of respondents reported cancers, including leukemia, lymphoma, and prostate cancer, with the remaining 3% reporting other health problems.

The fact that 72% of respondents reported observing health patterns among their colleagues that they believe are linked to pesticide exposure is also concerning. This suggests that the problem extends beyond individual experiences and affects the larger community of agricultural workers. It is likely that many workers are suffering in silence, and that the true scope of the problem is even greater than what is reported here.

4.3.2.2. Findings from the Key Informant Interviews

Following interviews with 12 key informants (KIIs), several key themes emerged regarding the prevalence of pesticide-related health problems among agricultural workers in Mazowe Rural. Regarding pesticide exposure, 92% of respondents believe it is a major concern for agricultural workers in Mazowe rural. All KIIs (100%) identified skin irritation, dizziness, respiratory problems, and headaches as the most frequently reported health issues among agricultural workers. These symptoms typically appear within a few hours of exposure, with 75% of respondents reporting symptoms between 2-4 hours. According to 58% of respondents, these symptoms can last for days or even weeks.

All key informants (100%) agreed that repeated exposure could lead to the development of chronic health problems. 42% of respondents identified neurological disorders as a common health issue. The interviews also revealed that agricultural workers' health problems have become more prevalent over time. According to the findings, 92% of respondents reported seeing changes in health patterns among agricultural workers, with 83% noting an increase in respiratory problems and 67% noting an increase in skin conditions or allergies. 67% of KIIs reported an increase in worker absenteeism due to illness, which may be linked to pesticide exposure. However, some (25%) reported a lack of clear data on such trends, emphasizing the need for better health surveillance.

4.3.2.3. Combined findings from questionnaires and key informant interviews.

The questionnaire results and key informant interviews (KII) provide an extensive comprehension of the prevalence of pesticide-related health problems among agricultural workers in Mazowe rural. According to questionnaires, a staggering 87% of workers reported health problems as a result of exposure. KIIs agreed with this finding, with 92% believing it was a major concern. Both sources reported common acute symptoms such as headaches, skin irritation, dizziness, and nausea.

According to questionnaires, 43% of respondents reported experiencing long-term health changes as a result of exposure. All KIIs (100%) agreed that repeated exposure could lead to chronic health problems. While questionnaires captured specific conditions such as asthma/COPD (15%), neurological disorders (5%), and cancers (3%), KIIs (42%) identified neurological problems as a common concern.

Questionnaires revealed that 72% of respondents observed health patterns among colleagues, indicating that the problem is widespread. KIIs (92%) reported changes in health patterns over time, including an increase in respiratory problems (83%) and skin conditions (67%). Both sources emphasize the potential impact on the agricultural workforce, with KIIs (67%) reporting an increase in worker absenteeism, possibly due to exposure.

Overall, the triangulation of the findings provides strong evidence of pesticide-related health problems among agricultural workers in Mazowe rural. The consistency of the questionnaire and KII findings indicates that the problem is widespread and requires immediate attention. The findings also highlight the importance of improved health surveillance and monitoring to identify trends and areas for improvement. Overall, the results provide a clear call to action to address the issue of pesticide exposure and its impact on the health and well-being of agricultural workers in Mazowe rural.

4.3.3. Objective (iii) To investigate how variations in pesticide usage practices influence the health outcomes among agricultural workers in Mazowe rural.

4.3.3.1. Findings from the Questionnaires

The study sought to investigate how variations in pesticide usage patterns among agricultural workers in Mazowe rural impact their health outcomes, exploring the relationships between different usage practices and resulting health problems. The analysis investigated how variations in pesticide usage patterns affect the health of agricultural workers in Mazowe Rural, Zimbabwe. Logistic regression was used to investigate the relationships between pesticide usage practice metrics and different health outcomes. However, not all metrics were significantly associated with health outcomes. Specifically, some workers who were diagnosed with certain health outcomes were not affected by pesticide exposure, so their data was excluded from the analysis. To save space and time, these pesticide usage metrics were excluded from the table that summarizes the significant association findings. The table below

summarizes the findings, showing Nagelkerke R2 values (which indicate model fit), coefficients, and p-values for each association.

Table 3: Results from Logistic regression

Pesticide usage metrics	Health outcomes metrics	Nagelkerke R^2	Coefficient	P value
Daily usage	Headache	.651	.751	.013
	Dizziness	.563	.671	.019
	Nausea	.531	.610	.023
	Eye irritation.	.673	.842	.009
	Long-term Health Problems	.579	.451	.029
	Skin irritation	.571	.571	.021
Weekly usage	Headache	.501	.562	.031
	Dizziness	.431	.321	.039
	Skin irritation	.492	.479	.034
	Long-term Health Problems	.321	.371	.041
Monthly usage	Headache	.412	.471	.046
	Long-term Health	.397	.420	.048
Green colour-coded pesticides	Headache	.471	.571	.039
	Nausea	.432	.542	.043
red colour-coded pesticides	Headache	.068	.781	.017
	Dizziness	.531	.631	.021
	Nausea	.431	.452	.036
	Skin irritation	.501	.521	.021
	Long-term	.491	.501	.027

	Health Problems			
Purple colour-coded pesticides	Respiratory problems Long-term Health Problems	.381 .671	.421 .571	.046 .024
Long-sleeved Shirt/Work suit	Skin irritation	.574	-.551	.031
Closed-toe shoes	Skin irritation	.391	-.421	.046
Goggles/face shield	Eye irritation	.481	-.501	.037
Following safety protocols in the event of accidental exposure.	Long-term Health Problems Respiratory problems	.461 .523	-.501 -.502	.042. .039
Awareness of pesticide exposure prevention measures	Skin irritation	.451	-.491	.037

To start with, the findings indicate a strong positive association between daily pesticide usage and a variety of health problems. Employees who use pesticides daily have a significantly higher risk of developing headaches (coefficient: 0.751, p-value: 0.013), dizziness (coefficient: 0.671, p-value: 0.019), nausea (coefficient: 0.61, p-value: 0.023), and eye irritation (coefficient: 0.842, p-value: 0.009) than those who use them less frequently. Furthermore, daily usage is associated with a significantly increased risk of skin irritation (coefficient: 0.571, p-value: 0.021). Interestingly, daily usage has a weaker association with skin irritation (coefficient: 0.451, p-value: 0.029) than the other outcomes.

Weekly usage also has a positive correlation with certain health issues. Workers with weekly usage are more likely to have headaches (coefficient: 0.562, p-value: 0.031) and dizziness (coefficient: 0.321, p-value: 0.039) compared to those with no or less frequent usage. The effect appears to be weaker for skin irritation (coefficient: 0.479, p-value: 0.034) and long-term health problems (coefficient: 0.471, p-value: 0.041), but there is no data on long-term health problems. Monthly usage has the weakest association with health outcomes. While there is a slight positive association between headaches (coefficient: 0.471, p-value: 0.046) and long-term health problems (coefficient: 0.42, p-value: 0.048), the evidence is less compelling than for daily and weekly usage.

Moreover, according to the findings, usage of green color-coded pesticides is associated with an increased risk of headaches (Nagelkerke R2=0.471, Coefficient=0.571, P=0.039) and nausea (Nagelkerke R2=0.432, Coefficient=0.542, P=0.043). Usage of red-coded pesticides, on the other hand, is associated with an increased risk of headaches (Nagelkerke R2=0.068, Coefficient=0.781, P=0.017), dizziness (Nagelkerke R2=0.531, Coefficient=0.631, P=0.021), nausea (Nagelkerke R2=0.431, Coefficient=0.452, P=0.036), and skin irritation (Nagelkerke R2=0.501, Coefficient=0.521, P=0.021). Furthermore, exposure to pesticides labeled in red is linked to an increased risk of long-term health problems (Nagelkerke R2=0.491, Coefficient=0.501, P=0.027). The findings also indicate that usage of purple-coded pesticides increases the risk of respiratory problems (Nagelkerke R2=0.381, Coefficient=0.421, P=0.046) and long-term health problems (Nagelkerke R2=0.671, Coefficient=0.571, P=0.024).

Moreover, the study investigated the use of protective clothing and awareness of pesticide exposure prevention about health outcomes. The findings indicate that some precautions may help to reduce the risk of skin and eye irritation from pesticide exposure. Workers who reported wearing long-sleeved shirts or work suits were less likely to have skin irritation (p-value = 0.031). The coefficient is -0.551, indicating a negative relationship between wearing long-sleeved shirts or work suits and skin irritation. In other words, wearing long-sleeved shirts or work suits is associated with less skin irritation. This association is considered weak, with a Nagelkerke R squared coefficient of 0.574.

Similarly, workers who reported wearing goggles or a face shield were less likely to experience eye irritation (p=0.037). The coefficient is -0.501, indicating a negative correlation between wearing goggles or a face shield and eye irritation. Thus, wearing

goggles or a face shield is associated with less eye irritation. This association is also considered weak, with a Nagelkerke R squared coefficient of 0.481.

Also, the findings show that following safety protocols in the event of accidental exposure is significantly associated with long-term health problems, including respiratory issues, with a Nagelkerke R2 value of 0.523 and a coefficient of -0.502 (p-value = 0.039). This means that if agricultural workers follow safety protocols in the event of accidental exposure, the likelihood of long-term health problems decreases by about 0.502. Furthermore, awareness of pesticide exposure prevention measures was found to be significantly associated with skin irritation, with a Nagelkerke R2 value of 0.451 and a coefficient of -0.491 (p = 0.037). This suggests that when agricultural workers are aware of pesticide exposure prevention measures, their chances of experiencing skin irritation decrease by about 0.491 units.

4.3.3.2. Findings from the Key Informant Interviews

To complement the questionnaire data and gain deeper insights, 12 experts participated in Key Informant Interviews (KIIs). This thematic analysis delves into the key themes identified during these interviews, providing a sound knowledge of health risks, color-coded pesticides, and existing initiatives to promote healthy behaviors among agricultural workers.

All experts (100%) emphasized the significance of PPE (e.g., gloves, goggles, masks, and boots) in reducing health risks. Concerns have been raised about workers' limited access, affordability, and proper use of PPE. Almost all experts (92%) raised the issue of workers failing to follow safety instructions when mixing, applying, and storing pesticides. Inadequate training, carelessness, and pressure to complete tasks quickly were all highlighted as factors that contributed to this.

92% percent of the KIIs mentioned the color-coded pesticide system and agreed that colour-coded pesticides are an important aspect of pesticide safety. They emphasized the importance of better education and awareness campaigns that link color codes to potential health risks. Others stated that a lack of understanding of pesticide labeling and warnings can result in confusion and accidental exposure. They also pointed out that the color-coding system is not always clear or consistent, which can lead to confusion and abuse. A majority (83%) of the experts emphasized the importance of comprehensive pesticide safety training programs. This includes understanding the risks associated with various pesticides (based on color codes or other identifiers), using proper PPE, practicing hygiene, and following first-aid procedures.

4.3.3.3. Combined findings from questionnaires and key informant interviews.

The combined findings of the questionnaires and Key Informant Interviews (KIIs) provide a comprehensive understanding of the relationship between pesticide usage practices and health outcomes among agricultural workers in Mazowe rural. According to the findings, daily pesticide usage is significantly associated with a variety of health issues, including headaches, dizziness, nausea, eye irritation, and skin irritation. The frequency of usage is also significant with weekly usage associated with headaches and dizziness, while monthly usage has a weaker association with health outcomes.

Furthermore, the findings suggest that usage of certain color-coded pesticides increases the risk of specific health problems. For example, usage of green-coded pesticides is associated with an increased risk of headaches and nausea, whereas usage of red-coded pesticides is associated with an increased risk of headaches, dizziness, nausea, and skin irritation. Usage of purple-coded pesticides raises the risk of respiratory problems and long-term health issues.

The questionnaire results also emphasize the importance of protective clothing and pesticide exposure prevention measures in lowering health risks. According to the findings, wearing long-sleeved shirts or work suits reduces skin irritation, whereas wearing goggles or a face shield reduces eye irritation. Furthermore, adhering to safety protocols in the event of accidental exposure is strongly associated with long-term health problems, including respiratory issues.

The KIIs provided insightful details about the health risks faced by agricultural workers in Mazowe rural. The experts emphasized the importance of personal protective equipment (PPE) in reducing health risks but also expressed concern about workers' limited access, affordability, and proper use of PPE. They also expressed concerns about workers failing to follow safety instructions when mixing, applying, and storing pesticides due to insufficient training, carelessness, and a desire to complete tasks quickly.

The findings from both questionnaires and KIIs portray a compelling, mutually reinforcing picture. Experts' concerns about safety practices and inadequate training back up the self-reported health outcomes in the questionnaires. The color-coded pesticide system, while acknowledged as valuable by experts, requires improved communication and education to ensure workers understand the associated health risks. The KIIs' call for proper PPE use and training reinforces the positive impact of the questionnaire-identified protective measures.

CHAPTER FIVE: DISCUSSION

The results of the questionnaire and key informant interviews (KIIs) review the impact of pesticide exposure among agricultural workers in Mazowe Rural, Zimbabwe. This section discusses these findings about the theoretical frameworks used, as well as the insights gained from the empirical review.

The study discovered frequent pesticide application (seasonal to daily for some workers) and usage of a variety of pesticides, including those with high and moderate toxicity levels. This is consistent with the empirical reviews by Sharma et al. (2020) and Asante et al. (2019), who found widespread usage and exposure among agricultural workers in Sub-Saharan Africa. The Social Ecological Model (SEM) framework emphasizes the interconnected factors that influence exposure (US Department of Health and Human Services, 2024). Individual-level factors in Mazowe Rural are likely to include a lack of knowledge about safe practices, as identified in the questionnaire, and economic constraints that prevent PPE use, as mentioned by KIIs. Cultural norms that prioritize speed over safety, as well as limited access to training opportunities, may be contributing factors at the social level. The environmental level factors include easy pesticide availability, as mentioned by KIIs, and crop types (Oludoye et al., 2021; Hurley & Mitchell, 2020).

While the questionnaire results indicated a high reported awareness of safety measures (77%), there is a significant gap between knowledge and practice. This is evidenced by the infrequent use of PPE (58% for goggles) and the absence of proper safety protocols for accidental exposure (53%). According to Jose et al. (2021), the HBM helps to explain this gap. Perceived barriers, such as discomfort with PPE, as mentioned by KIIs, may limit its use. Furthermore, workers' perceived susceptibility to long-term health risks, which was highlighted by KIIs may be influenced by a lack of awareness. This can be addressed through educational interventions that emphasize the long-term consequences of exposure (Curl et al., 2020). Even though 77% of respondents understand the importance of personal

protective equipment (PPE), only 58% use it regularly. Theories suggest that sociodemographic factors such as age or years of experience may influence PPE use (Muula & Adero, 2018), but the current study did not investigate these factors, which could explain the gap between awareness and application.

Additionally, the high knowledge of safety protocols (77%), combined with the low implementation of safety measures after accidental exposure (53%), suggests a knowledge-practice gap. This is contrary to the Health Belief Model (HBM), which states that perceived susceptibility and benefits of practices influence behavior (Ataei et al., 2021). The study does not delve into the causes of this disparity, so it is unclear whether factors such as fear of job loss or limited access to proper safety protocols are at play.

Furthermore, the study supports the empirical review by highlighting the widespread use of insecticides and herbicides (Lykogianni et al., 2021). However, the high prevalence of usage of red and purple-coded pesticides is concerning and may indicate a worse situation than in other regions (Fuhrimann et al., 2021). The affordability concern raised by KIIs about pesticides is echoed in studies from developing countries (Abdollahzadeh et al., 2021).

The findings of this study show a high prevalence of pesticide-related health problems among agricultural workers in Mazowe Rural, Zimbabwe. This supports the empirical review by emphasizing a global issue (Lykogianni et al., 2021). The reported rates of health problems among agricultural workers (87%) are comparable to studies in Ghana (80%) and Kenya (60%) (Asante et al. 2019; Ochieng et al., 2018), highlighting the widespread problem in Sub-Saharan Africa (Fuhrimann et al., 2021).

The SEM provided a framework for interpreting these findings. The self-reported health problems (headaches, dizziness, nausea, skin irritation) are consistent with the documented acute effects of pesticide exposure (Curl et al., 2020). This suggests that workers lack knowledge or access to safe practices, as highlighted by the empirical review (WHO, 2019). The high prevalence of health problems indicates a complex interaction of individual, social, and environmental factors. The reported lack of clear data on health trends among some key informants (25%) indicates a potential knowledge gap and reinforces the SEM's emphasis on the environmental context (US Department of Health and Human Services, 2024). The HBM also sheds light on this topic. The fact that 72% of respondents noticed health patterns among colleagues implies that social norms or risk perceptions may not prioritize protective behaviors. This is consistent with the empirical review, which identified limited access to

PPE and inadequate training as contributing factors (Fuhrimann et al., 2021). Also, this implies a social influence, in which witnessing colleagues' health problems may raise awareness and concerns about exposure risks (Pinto, 2020).

Furthermore, 43% of respondents reported long-term health problems, which could be linked to chronic exposure. This is consistent with the empirical review of chronic health issues such as respiratory problems, neurological disorders, and certain cancers (Scorza et al., 2023). The reported prevalence of respiratory problems (15%) is concerning, especially given the established link between pesticide exposure and asthma/COPD (WHO, 2020). However, the reported cancer rate (3%) may be underestimated due to diagnostic challenges or long latency periods. This alignment strengthens the study's findings and emphasizes the potential long-term effects of pesticide exposure on agricultural workers' health.

The findings of this study in Mazowe Rural, Zimbabwe, add significantly to our understanding of pesticide exposure and its effects on agricultural workers' health. The findings are consistent with the established body of research described in the empirical review (Amoatey et al., 2020; Curl et al., 2020; WHO, 2020). The study found a correlation between the frequency of pesticide use and the severity of health problems such as headaches, dizziness, nausea, skin irritation, and respiratory issues. Following previous research, this study indicates that agricultural workers who frequently use pesticides are more likely to be exposed to these chemicals, which can lead to an increased incidence of both acute and chronic health problems. This finding is supported by studies conducted by Olowogbon et al. (2021) and Sharma et al. (2021), which demonstrated a strong relationship between pesticide exposure and adverse health outcomes among agricultural workers. This suggests a dose-response relationship, in which greater exposure frequency increases the risk of health problems. However, the data on long-term health problems requires further investigation.

The study linked the usage of specific color-coded pesticides to various health risks. Workers who use red-coded pesticides are more likely to experience headaches, dizziness, nausea, skin irritation, and long-term health problems than those exposed to green-coded pesticides. This is in agreement with the color-coding system's intended purpose, as red indicates higher toxicity (FAO, 2022). The study also looked into the impact of protective measures in reducing health risks. Workers who reported wearing long-sleeved shirts or work suits, as well as goggles or face shields, had lower rates of skin and eye irritation, respectively. This

emphasizes the importance of using personal protective equipment (PPE) as a barrier to exposure. The KIIs also identified limited access and proper use of PPE as critical challenges. This relates to the social and economic factors identified in the SEM and the perceived benefits identified by HBM (Fuhrimann et al., 2021; Nhachi and Kasilo, 2020).

The study additionally found that adhering to safety protocols following accidental exposure and being aware of preventive measures were associated with a lower risk of long-term health problems and skin irritation. This suggests that knowledge and adherence to safety practices can reduce health risks. The KIIs emphasized the importance of comprehensive safety training programs to address these aspects.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.0. Chapter introduction

This chapter summarizes the study's findings and makes recommendations for policymakers, agricultural workers, and future research intended to address the identified health risks while also promoting safer farming practices. The study's findings highlight the significant health risks associated with pesticide exposure among agricultural workers in Mazowe Rural, Zimbabwe, emphasizing the importance of improving agricultural health and safety practices. The study's findings are based on the Social Ecological Model (SEM) and the Health Belief Model (HBM), which provide a framework for comprehending the multifaceted relationship between individual, social, and environmental factors influencing exposure and health outcomes.

6.1. Conclusions

This study sought to investigate the impacts of pesticide exposure on agricultural workers in Mazowe Rural, Zimbabwe. The findings, based on a survey of 260 workers and interviews with key informants (KIIs), revealed a significant association between pesticide exposure and negative health outcomes. The study employed the Social Ecological Model (SEM) and the Health Belief Model (HBM) to look into the factors that influence exposure and health outcomes.

The study revealed a high level of pesticide use, with varying frequencies and types. Workers frequently used insecticides and herbicides, with a sizable proportion using high-toxicity (red-coded) pesticides. A concerning prevalence of self-reported health problems potentially linked to pesticide exposure was discovered, with headaches, dizziness, nausea, and skin irritation being frequently reported symptoms.

The study observed a significant correlation between pesticide usage practices and health outcomes. Daily use of high-toxicity pesticides was associated with an increased risk of headaches, dizziness, and skin irritation. Furthermore, the frequency and severity of health problems reported by employees were positively correlated, and the use of red-coded pesticides was associated with a higher risk of health problems than green-coded pesticides.

Additionally, the study emphasizes the importance of personal protective equipment (PPE) and following safety protocols in reducing exposure risks. Moreover, the study also identified interconnected factors influencing exposure and health outcomes, such as a lack of knowledge about safe practices, economic constraints that limited the use of PPE, cultural norms that prioritised speed over safety, and widespread pesticide availability. By recognizing the interconnected factors identified by SEM, interventions can be designed to address individual knowledge gaps, economic constraints, and social norms. Furthermore, the study supports HBM by emphasizing the importance of bridging the gap between awareness and implementation of safety measures.

Lastly, the study's findings shed light on the health risks associated with pesticide exposure and highlight the need for better health and safety practices in the agricultural sector. The study's findings have major implications for the health and well-being of Mazowe Rural's agricultural workers. Pesticide exposure poses a significant occupational health risk, and farmers and farm workers must take precautions to reduce their exposure to these chemicals. The study's findings also emphasize the importance of improving agricultural health and safety practices, such as PPE, training in safe pesticide handling and application, and regular worker health monitoring.

To summarize, this study serves as a call to action for policymakers, agricultural extension workers, farmer organizations, and the public health sector. Working together, these stakeholders can put in place comprehensive strategies to protect agricultural workers' health in Mazowe Rural and beyond. This will not only protect the health of this vital population but will also help to build a more sustainable agricultural sector.

6.2. Recommendations

6.2.1 Recommendations for Policymakers

Based on the findings of this study, the following recommendations are made to the policymakers.

i. Develop and implement a comprehensive occupational health and safety policy.
    - Develop a comprehensive policy to protect the health and safety of agricultural workers, including provisions for pesticide exposure, personal protective equipment, and regular health monitoring.

- Ensure that the policy is communicated to all stakeholders, including farmers, farm workers, and farm owners.
- Monitor and enforce policy compliance to ensure that all agricultural workers are safe from pesticide exposure.

ii. Improve pesticide regulation and enforcement.

- Pesticide regulations should be strengthened, with stricter labeling requirements, more effective warning systems, and increased penalties for noncompliance.
- Increase the number of trained inspectors who monitor pesticide use and ensure that farmers follow safety protocols.
- Provide incentives to farmers who adopt safer farming practices and use less pesticides.

iii. Provide education and training in pesticide handling and safety.

- Develop educational programs for farmers, farm workers, and farm owners on pesticide safety and application.
- Provide training in personal protective equipment, emergency response procedures, and first aid.
- Make education and training programs required for all agricultural workers.

iv. Increase funding for research and development of safer pest control methods.

- Increase funding for research and development of alternative pest control methods such as biological control, cultural control, and integrated pest management.
- Support the development of new pesticides that are safer for both human health and the environment.
- Encourage collaboration among researchers, farmers, and industry stakeholders to develop practical pest control solutions.

v. Establish a National Pesticide Exposure Registry.

- Set up a national registry to monitor pesticide exposure among agricultural workers.
- Use registry data to identify trends and patterns in pesticide exposure and develop targeted interventions to reduce exposure.
- Make the registry available to researchers, policymakers, and healthcare providers so that they can make informed policy decisions.

vi. Enhance health services and monitoring for agricultural workers.

- Strengthen rural health services to provide timely and effective medical care to pesticide-exposed agricultural workers.

- Increase funding for health monitoring programs that track the effects of pesticide exposure on agricultural workers.
- Develop collaborations with healthcare providers to educate them about the health risks associated with pesticide exposure.

vii. Encourage sustainable agricultural practices.

- Encourage sustainable agriculture practices that reduce pesticide use, such as organic farming, permaculture, and agroforestry.
- Subsidies, tax breaks, and government contracts can be used to incentivize farmers to adopt sustainable agricultural practices.
- Develop educational and training programs for farmers on sustainable agricultural practices.

6.2.2. Recommendations for agricultural workers

i. When handling pesticides, wear the recommended personal protective equipment (PPE), which includes gloves, long-sleeved shirts, long trousers, work suits, and closed-toe shoes.

ii. When working with pesticides, wear respirators that are properly fitted and maintained to avoid inhaling pesticide particles.

iii. Choose PPE with permeation barriers to keep pesticides from penetrating the fabric.

iv. Read pesticide labels carefully to understand the instructions for use, hazards, and precautions.

v. Follow the pesticide label's application rates, timing, and techniques.

vi. Use calibrated equipment. Use calibrated equipment to ensure accurate application rates and reduce drift.

vii. Regularly maintain equipment to avoid leaks and ensure proper operation.

viii. After being exposed to pesticides, remove contaminated clothing and shower immediately.

ix. After pesticide exposure, take a shower or bath to remove the residue.

x. Report any incidents of pesticide exposure or accidents to your supervisor or safety officer.

xi. Participate in pesticide-safety training programs.

xii. Stay current on pesticide risks and new developments in pesticide safety.

6.2.3. Recommendations for future studies

i. Use objective testing measures, such as biomarkers, physiological tests, and behavioral assessments, to evaluate the health effects of pesticide exposure in agricultural workers.
ii. Investigate the biological mechanisms that underpin the health effects of pesticide exposure, including the role of genetic and epigenetic factors in pesticide susceptibility.
iii. Compare the health effects of various pesticides, including those with different chemical structures and modes of action, to detect potential differences in toxicity and risk.
iv. Conduct dose-response studies to better understand the relationship between pesticide exposure and health effects, including the possibility of thresholds or safe levels of exposure.
v. Evaluate the effectiveness of alternative farming practices, such as integrated pest management (IPM) and organic farming, in lowering pesticide exposure and improving health outcomes.

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APPENDIX A: QUESTIONNAIRE

Thank you for taking part in our study on the impact of pesticide exposure on the health of agricultural workers. We would like to learn about your pesticide exposure experiences and perceptions, as well as the effects they have on your health and wellness. Your honest response will be invaluable in helping us gain insight into this critical issue. Please be assured that all information provided will be kept strictly confidential and used only for research purposes, to inform strategies to improve agricultural workers' health and safety.

Please note: There are no correct or wrong answers. Please kindly respond honestly and to the best of your ability.

Please check (X) in the box corresponding to the correct answer

SECTION 1: DEMOGRAPHICS

1. What is your age range?

18-30		31-44		45 and above	

2. What is your gender?

Male		Female	

3. How many years have you worked in agriculture?

1-5 years		6-10 years		11+	

4. What crops do you cultivate?

Maize	
Tobacco	
Cotton	

Other (specify) _____

5. What is your highest level of education

Primary		Secondary		Tertiary	

SECTION 2: PESTICIDE EXPOSURE

6. How often do you apply pesticides?

Daily	
Weekly	
Monthly	
Seasonally	
Rarely	

7. What type of pesticides do you commonly use? (Select all that apply.)

Insecticides	
Herbicides	
Fungicides,	
Rodenticides	

8. What is the colour code of the pesticide you use the most? (Select all that apply.)

Green	
Amber	
Red	
Purple	

9. Do you wear a long-sleeved shirt or work suit when working with pesticides?

Yes		No	

10. Do you wear closed-toe shoes when working with pesticides?

Yes		No	

11. Do you wear goggles or a face shield when handling pesticides?

Yes		No	

12. Are there any safety protocols in place in the event of accidental pesticide exposure?

Yes		No	

13. Do you understand the potential health risks associated with the pesticides you use?

Yes		No	

14. Are you aware of how to protect yourself from pesticide exposure?

Yes		No	

SECTION 2: HEALTH OUTCOMES

15. Have you experienced any health problems as a result of pesticide exposure?

Yes		No	

16. Have you experienced any of the following symptoms after working with pesticides? (Check all that apply)

Headache	
Dizziness	
Nausea	
Eye irritation.	
Skin irritation	
Respiratory problems	
Other (specify)_____	

17. Have you noticed any long-term health changes that you believe are due to pesticide exposure? If yes, please describe._____

Yes		No	

18. Have you been diagnosed with any of the medical conditions since you began working with pesticides?

Cancer (leukemia, lymphoma, and prostate cancer)	
Respiratory illnesses (asthma, chronic obstructive pulmonary disease)	
Neurological disorders (Parkinson's disease and Alzheimer's disease)	
Other (specify)_____	

19. Have you observed any health patterns among your colleagues that you believe may be related to pesticide exposure?

Yes		No	

We sincerely appreciate your cooperation and participation!!!

APPENDIX B: KEY INFORMANT INTERVIEWS

Thank you for your participation in this interview. This study seeks to investigate the effects of pesticide exposure on the health of agricultural workers in Mazowe, Zimbabwe. As a key informant with agricultural expertise, your insights will be invaluable in helping us understand the relationship between pesticide exposure and various health outcomes in agricultural workers. Your contributions will help us better understand the complexities of pesticide exposure and its effects on agricultural workers' health, ultimately guiding strategies to reduce these risks and promote a healthier work environment.

SECTION 1: BACKGROUND AND DEMOGRAPHICS

Could you please tell me more about your role and experience working with agricultural workers in Mazowe Rural?

What are the most important crops grown in this region, in your opinion?

In your opinion, how has pesticide use changed in Mazowe Rural over the years?

SECTION 2: PESTICIDE EXPOSURE

In your experience, what types of pesticides are most commonly used by agricultural workers in this region? (Follow up: Could you elaborate on the specific applications of these pesticides?)

How would you describe the availability and cost of these pesticides to farmers?

What are the most common pesticide mixing, application, and storage practices among agricultural workers, in your opinion? (Follow-up: Are any cultural or traditional methods utilized?)

In your experience, how common is the use of personal protective equipment (PPE) by agricultural workers? (Follow-up: What are the primary barriers to using PPE consistently?)

Are there any training programs or resources available to educate farmers on safe pesticide-handling practices? (Follow up: Who provides these resources and how effective are they?)

SECTION 3: HEALTH OUTCOMES

What are the most common health issues reported by agricultural workers in Mazowe rural, which you believe are related to pesticide exposure?

Do you think pesticide exposure is a major concern for agricultural workers in Mazowe rural? Why, or why not?

What are the most common symptoms reported by agricultural workers after exposure to pesticides, and how do they typically manifest?

Have you noticed any changes in health patterns among agricultural workers over time, and if so, what are you attributing them to?

Are there any health-related behaviours or practices that you think contribute to the health risks associated with pesticide use? (for example, not wearing PPE and not adhering to safety protocols).

Could you please comment on the use of colour-coded pesticides in Mazowe rural? Are there any specific colours or codes that you believe are especially dangerous to agricultural workers' health?

Are there any initiatives or programs in place to encourage healthy behaviours among agricultural workers, such as health education or wellness programs?