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# Exploring health hazards of pesticide exposure among irrigation farmers in Jere Local Government Area of Borno State, Nigeria

Mukhtar, F.[1], Gaya, S. S.[2], Ishaq, A. B.[3], Muhammad B. I.[4], Lawan, A. M[5], Dahiru, A. U[6], & Abdullahi, A. S[7]

[1&6]*Department of Sociology and Anthropology, University of Maiduguri, Nigeria.*
[2]*Department of Crop Protection, University of Maiduguri, Nigeria.*
[3]*Department of Geography, Federal University of Technology Minna, Nigeria.*
[4]*Department of Geography, University of Maiduguri, Nigeria.*
[5]*Department of Family Medicine, University of Maiduguri Teaching Hospital, Nigeria.*
[7]*Department of Environmental Management, Bayero University Kano, Nigeria.*

Corresponding Email: falmatamukhtar@unimaid.edu.ng

**Abstract**
*The study explores health hazards associated with pesticide use among dry-season commercial vegetable farmers. Research questions and objectives for the study were set to explore health hazards due to pesticide exposure and the level of risk awareness among the farmers. The study used an inductive qualitative research approach and the interpretivist approach to gain a deeper understanding of social phenomena from human experiences and perspectives. Data were collected using an in-depth interview and focus group discussions in four farming communities through purposive and convenience sampling techniques. Forty participants were used for the Focus Group Discussions, and four were used for the in-depth interviews. A qualitative data analysis technique was used to analyse the data. All themes were selected using a thematic approach, and interviews were digitally recorded. Verbatim transcriptions were made, and the accuracy of the transcriptions was verified. The socioeconomic characteristics revealed that most participants were uneducated and fell within the age range of 27 to 67 years. Furthermore, the findings revealed that even though they know the health hazards associated with pesticide use, they do not see the magnitude involved, which was attested to how they handle the pesticides without using any personal protective equipment while preparing, spraying, and disposing of containers. The study further revealed that apart from headaches and sneezing, the farmers face no health challenges; they do not seek assistance from farm officials and use water from the wash boreholes for their irrigation activities. The study, therefore, recommends that authorities monitor and educate irrigation farmers on the proper handling and use of pesticides. Furthermore, awareness campaigns among farmers on the health hazards associated with pesticide use and when to harvest their produce after spraying with pesticides are also recommended.*

**Keywords:** Environmental impacts, Health hazard, Irrigation farmers, Jere, Pesticide use

## 1. Introduction

In Nigeria, irrigation farming has become increasingly popular, particularly in the north, because of the current global economic downturn prioritising dry season farming. In Maiduguri and the surrounding areas, pesticides are widely used to meet the high demand for crop production. According to Nguyen, Ranamukhaarachchi, & Nguyen (2017), pesticides are essential for increasing agricultural output by reducing the impact of insects and diseases. Agriculture is a crucial component of many countries' economies and the livelihoods of local communities (Ghafari, Cheraghi, & Doosti-

Irani, 2017). Ghafari, Cheraghi, & Doosti-Irani (2017) further state that it provides steady employment and income to numerous families. In Maiduguri and other parts of the state, various types of vegetables are grown, essential for a balanced diet and a source of many nutrients. However, because of frequent contamination by pests and illnesses, comprehensive pest management utilising different techniques is necessary. Recent research conducted by de-Assis et al. (2020) highlights global concern over the impact of pesticides on the health of agricultural workers. Farmers with low education and knowledge may be less aware of pesticides' health and environmental implications and are likelier to store pesticides in their homesteads (Lekei, Ngowi, & London, 2014).

A recent study in Magumeri by Shehu, Mohammed, & Mohammed (2021) revealed that most survey respondents demonstrated a need for more awareness regarding the negative impacts of pesticides. The study also revealed that even those with basic literacy skills may need help understanding the technical jargon on pesticide labels. Surprisingly, 88.4% of respondents reported not seeking guidance from local extension officers regarding pesticide usage and application. Furthermore, farmers in Magumeri were found to be largely uninformed about the potential for pesticide contamination in food and drink products. Only a small minority knew the risks associated with pesticide use on crops (Shehu, Mohammed, & Mohammed, 2021).

Furthermore, most farmers (60.5%) dispose of their pesticide containers by discarding them in the bush, while 32.6% deposit them in nearby water bodies. Merely 7% of respondents bury their containers after use (Shehu, Mohammed, & Mohammed, 2021). Younger farmers are more cognizant of advisable pesticide use practices than their older counterparts. Despite this, only a small fraction of farmers in the study area disposed of their containers adequately (Tijjani, Tijjani, & Audu, 2018). A newer study revealed that farmers who use pesticides for irrigation take precautions such as avoiding eating or drinking during application and correctly disposing of their containers (Bwala et al., 2022).

Several studies have been conducted in Borno State, including the Socioeconomic determinants of vegetable farmers' awareness of safety measures in pesticide use in Jere Local Government Area (Tijjani et al., 2018), Monguno et al. (2019), who investigated 'Perception of Risk and Awareness of Pesticide Residues in Vegetables Consumed in Maiduguri, Borno State, Analysis of cowpea farmers' awareness on pesticide usage and safety measures in Magumeri Local Government Area, Borno State (Shehu, Mohammed, & Mohammed, 2021), and Information sources, risk perception and response to the usage of pesticides among irrigational farmers along the bank of River Ngadda, Maiduguri, (Bwala et al., 2022). However, they were survey-based and did not explore qualitative research on the health hazards of pesticide exposure. This study aims to address this gap by exploring the health effects of pesticide exposure on dry-season commercial vegetable farmers while assessing their understanding of the risks associated with pesticide use. The research seeks to answer the following questions: What are the health effects of pesticide exposure on dry-season commercial vegetable farmers, and how much knowledge do they have on risks associated with pesticide use?

## 2. Literature Review

Irrigation farming is a crucial practice worldwide, but it also poses several challenges, particularly health hazards resulting from pesticide use. Although farmers use pesticides for various reasons, their unsafe handling practices and lack of knowledge may cause contamination and poisoning. Pesticides are agrochemical

substances that protect plants and people from diseases in agricultural lands, public health initiatives, and urban green spaces (Nicolopoulou-Stamati et al., 2016). However, because of their well-known propensity to have several harmful effects on human health and the environment, these side effects can pose a significant threat to human health and the environment (Nicolopoulou-Stamati et al., 2016). In less-developed countries, many farmers believe that spraying pesticides is the best method to protect their crops from pests. Because pesticides are highly toxic and may be purposefully dispersed in the environment, they are one of the significant causes of mortality due to self-poisoning, especially in low- and middle-income countries (WHO, 2018). They can have both short- and long-term health effects. According to the World Health Organisation (1990), exposure to pesticides can have several long-term consequences on human health, including immune system damage, cancer, neurologic and reproductive effects, respiratory and skin problems, and cancer.

According to Adeleye, Sosan, & Oyekunle (2019), the pest control procedures used in vegetable production in Nigeria involve the application of highly toxic pesticides, whose improper use could lead to pesticide contamination of agricultural produce and severe environmental and public health risks. Improper disposal of unused pesticides and empty containers can lead to hazardous pesticide exposure (Lekei, Ngowi, & London, 2014). Furthermore, pesticide residues can be found on crops and absorbed into plant systems from the soil, making them the primary source of pesticide exposure for people consuming them (Motshabi, Ncube, Nindi, Khetsha, & Malebo, 2021). Following proper safety guidelines when disposing of these chemicals is imperative to avoid potential environmental or human health risks. Pesticide exposure can occur through ingestion, inhalation, or skin contact (Nicolopoulou-Stamati et al., 2016). According to estimates from the World Health Organisation and the UN Environmental Programme, three million agricultural labourers in underdeveloped countries experience severe pesticide poisoning, with about 18000 of them passing away each year (Dad et al., 2022).

Research conducted in developing nations has indicated that farmers often seek advice on pesticides from vendors and other farmers, even though these sources may lack the required knowledge about pesticide risks (Sodavy et al., 2000; Lekei, Ngowi, & London, 2014). A survey examining sources of information on pesticide usage practices in the Jere local government area (LGA) by Tijjani, Tijjani, & Audu, (2018) found that 48% of farmers polled obtained their information from their peers, 33% relied on pesticide dealers or vendors, and 20% turned to extension agents for guidance. Comparatively, 15% of respondents received advice from friends or family, and 6% used NGOs as a source of information on pesticide usage practices (Tijjani, Tijjani, & Audu, 2018). In Magumeri LGA, it was discovered that most respondents did not approach their local extension officers for clarification (Shehu, Mohammed, & Mohammed, 2021).

**Conceptualisation**

Irrigation farming can increase productivity, but pests and diseases can harm vegetable farming. To counteract this, pest management techniques, including pesticides, are necessary to ensure optimal productivity and avoid crop yield or quality reduction. It is essential to safeguard crops to prevent food shortages and economic setbacks.

Pesticides used in irrigation can harm the health of farmers and the environment. Regular exposure puts farmers at higher risk of experiencing symptoms of pesticide toxicity. To mitigate these risks, farmers must follow proper safety measures like using PPE, avoiding direct contact with pesticides, and properly storing and disposing of them.

Although irrigation farming and pesticides have successfully boosted agricultural productivity, it is imperative to prioritise the safety of farmers and the environment. By adhering to appropriate safety protocols and implementing effective public health strategies, farmers can mitigate the risks associated with pesticide exposure and ensure sustainable and safe farming practices.

## 3. Methodology

This study used an inductive, qualitative approach. A qualitative method was chosen because most studies on irrigation farming were of a survey-based nature. Additionally, it is essential to employ a qualitative method to gain an in-depth understanding of farmers' knowledge of health hazards associated with pesticide use. The study included a Focus Group Discussion (FGD) and an in-depth interview in the four farming communities between April 14-18, 2023. Three people participated in the data collection. Before our visit, we contacted the heads of the dry-season farmers' associations in each community after obtaining ethical approval.

### Study design

This study employs an interpretive approach to gain a deeper understanding of social phenomena from the perspective of human experience. This approach has yielded more robust findings that can significantly advance knowledge in the field. The study adhered to the Consolidated Criteria for Reporting Qualitative Research (COREQ), as outlined in Tong, Sainsbury, & Craig (2007), and drew upon the methodology used by Effat lbarazi et al. (2022). This study used an interpretivist approach to gain valuable insights into subjective meanings and experiences. The researchers took excellent care to ensure the reliability and representativeness of the qualitative data collection and interpretation.

### Study Area

The study was carried out in Jere Local Government Area, which covers a land mass of 160 square kilometres and is located between Longitude 11° 53′ 57'N and Latitude 13° 17′ 29'E (Ministry of Land and Survey (MLS), 2013). The area borders the Mafa LGA to the east, Maiduguri Metropolitan to the north, and Konduga LGA to the south. The climate of the region is characterised by a hot season, with day temperatures ranging from 37 °C to 45 °C. The annual rainfall varies between 500 mm and 700 mm, and the rainy season typically lasts from May to October and is characterised by low relative humidity. The topography is generally low and plain, and the soil is generally sandy, with short grasses and thorny shrubs. Jere L.G.A. has a population of 306,400 (NPC, 2022 population projected), and most of the population consists of farmers, traders, and government employees. The main crops farmed in the study area are rice, maize, guinea corn, and vegetables, such as tomatoes, onions, spinach, lettuce, and okra. According to the Borno State Agricultural Development Programme (BOSADP, 2008), the two largest ethnic groups in the area are Shuwa Arab and Kanuri. The Kanuri people live in settled villages and towns, and are known for their advanced internal trading networks. They trade dairy items with Fulani and Shuwa Arab pastoralists while exporting cowhide and goatskin (Britannica, 2010). Shuwa Arabs are a nomadic ethnic group with ancestral links to the Arab people (Modu, Mohammed, & Warasini, 2021). Other ethnic groups include Margi, Babur-bura, Glavda, Mandara, and Hausa. Significant occupations include trading, farming, and civil services. Traders and civil servants are spread widely throughout the LGA, while farmers are located mainly on the outskirts of the metropolis (comprising Jere and Konduga LGAs).

The objectives of this study were to assess health hazards due to pesticide exposure among dry-season commercial vegetable farmers and determine their level of awareness of the risks of pesticide use. Furthermore, the research answered the following questions: What are the health effects of pesticide exposure on dry-season commercial vegetable farmers, and how much knowledge do they have on the risks associated with pesticide use?

**Sampling Techniques and Data Collection**

A multi-stage sampling technique was used in this study. Four wards (Dala Lawanti, Dusuman, Gongulong, and Zabarmari) were conveniently selected in the first stage. In the second stage, ten participants from each ward were selected using a convenient sampling technique. Four participants were selected for in-depth interviews in the final stage using a purposive sampling technique. They were introduced to the research objectives and were asked to voluntarily participate in the study. The participants' data were collected through 30–45 minutes of focused group discussions (FGDs) and 30–35-minute one-on-one interviews. An experienced participant from each irrigation site was purposively selected for the in-depth interviews. The interviews and FGDs were conducted using pre-developed interview guide explicitly created for the FGD and in-depth interviews.

**Ethics**

Face-to-face interviews were conducted for each interview. Each interview lasted for 30-35 minutes. Before enrolment in the study, each participant provided informed consent. All participants were fully informed of the aim and objectives of the study, their right to withdraw from the study at any time, and the confidentiality of their personal identifiable information. Participants in the interviews provided verbal consent to participate. All participants were assigned numbers to maintain anonymity and confidentiality.

**Interview Guide**

The research team agreed to the final set of topics and questions covered in the interviews. The interviews were performed in both Hausa and Kanuri and audio-recorded with the participant's permission. When the same remarks were repeated without any fresh information being offered, saturation was attained during the interview. All similarities were minimised and combined into new themes.

## 4. Results and Discussion

**Data Analysis**

All themes were selected using a thematic approach, and coded using a general inductive approach. All interviews were digitally recorded, verbatim transcriptions were conducted, and the accuracy of the transcriptions was verified. According to accepted ethical standards, all audio recordings were deleted after transcription. The analysis of the transcripts revealed five themes as follows:

**Themes:** Five themes were used in this study: 1) Knowledge of safety measures using pesticides; 2) Health implications of pesticide use; 3) Usage of the pesticides; 4) Benefits of pesticides; and 5) Access and Availability. Each of these themes is discussed below. When FGD and in-depth interviews reached a consensus, their narratives were presented as one.

**Table 1: In-depth interview (n=4)**

| Location | Age | Education | Occupation | Farming years | Code no. |
|---|---|---|---|---|---|
| Dala Lawanti | 46 | SSCE | Farming/fishing | 10 | 1 |
| Dusuman | 59 | Quranic education | Farming | 12 | 2 |
| Gongulong | 44 | Primary school cert | Trading/farming | 11 | 3 |
| Zabarmari | 55 | Quranic education | Trading/farming | 18 | 4 |

**Source: Field work (2023)**

Four participants were enrolled in in-depth interviews (Table 1). Among them were two farmers and two traders, but Code (1) also engaged in fishing activities. Furthermore, their irrigation farming experience ranged from 10 to 18 years old. Four participants had Quranic education, one had a secondary education, and one had a primary education.

**Table 2: Sociodemographic Characteristics (n=40)**

| Location | Age | Education | Secondary occupation | Farming years' experience | Marital status | Household size |
|---|---|---|---|---|---|---|
| Dala Lawanti | 45 | Primary school cert | Trading | 6 | Married | 3 |
| Dala Lawanti | 43 | Quranic education | Tricycle driver | 4 | Married | 4 |
| Dala Lawanti | 61 | Quranic education | Farming | 12 | Married | 12 |
| Dala Lawanti | 38 | SSCE | Commercial driver | 2 | Married | 2 |
| Dala Lawanti | 67 | Quranic education | Trading | 5 | Married | 9 |
| Dala Lawanti | 48 | NCE | Teacher | 3 | Married | 6 |
| Dala Lawanti | 33 | B.SC. | Not employed | 2 | Single | 0 |
| Dala Lawanti | 56 | Quranic education | Farming | 9 | Married | 8 |
| Dala Lawanti | 52 | Quranic education | Trading | 5 | Married | 5 |
| Dala Lawanti | 61 | Quranic education | Farming | 7 | Married | 8 |
| Dusuman | 54 | Quranic education | Not employed | 7 | Married | 3 |
| Dusuman | 39 | SSCE | Farming | 3 | Married | 1 |
| Dusuman | 56 | Quranic education | Farming | 10 | Married | 4 |
| Dusuman | 65 | GCE | Retired C.S. | 15 | Married | 11 |
| Dusuman | 63 | Quranic education | Farming | 13 | Married | 6 |
| Dusuman | 51 | Quranic education | Farming | 7 | Married | 7 |
| Dusuman | 44 | Quranic education | Trading | 4 | Married | 4 |
| Dusuman | 50 | Quranic education | Farming | 6 | Married | 6 |
| Dusuman | 59 | Quranic education | Trading | 6 | Married | 2 |
| Dusuman | 46 | SSCE | Farming | 5 | Married | 4 |
| Gongulong | 56 | Quranic education | Farming | 8 | Married | 6 |
| Gongulong | 40 | Quranic education | Trading | 3 | Married | 5 |
| Gongulong | 35 | Quranic education | Trading | 2 | Married | 2 |
| Gongulong | 27 | SSCE | Trading | 2 | Married | 1 |
| Gongulong | 45 | SSCE | Trading | 4 | Married | 5 |
| Gongulong | 55 | Quranic education | Trading | 6 | Married | 7 |
| Gongulong | 49 | SSCE | Trading | 6 | Married | 3 |
| Gongulong | 65 | Quranic education | Farming | 10 | Married | 13 |

| Location | Age | Education | Secondary occupation | Farming years' experience | Marital status | Household size |
|---|---|---|---|---|---|---|
| Gongulong | 54 | Quranic education | Farming | 8 | Married | 7 |
| Gongulong | 34 | Primary sch. certificate | Trading | 4 | Married | 3 |
| Zabarmari | 60 | Quranic education | Trading | 19 | Married | 13 |
| Zabarmari | 56 | Quranic education | Trading | 6 | Married | 8 |
| Zabarmari | 66 | Quranic education | Farming | 13 | Married | 10 |
| Zabarmari | 54 | Quranic education | Farming | 7 | Married | 3 |
| Zabarmari | 51 | Quranic education | Farming | 8 | Married | 4 |
| Zabarmari | 59 | SSCE | Trading | 6 | Married | 3 |
| Zabarmari | 43 | Quranic education | Trading | 5 | Married | 3 |
| Zabarmari | 40 | Primary Sch. certificate | Farming | 5 | Married | 5 |
| Zabarmari | 38 | SSCE | Tricycle driver | 4 | Married | 2 |
| Zabarmari | 47 | Quranic education | Tricycle driver | 4 | Married | 4 |

**Source: Field work (2023)**

**Characteristics of the study participants:** Forty farmers were enrolled in the FGD (Table 1). They were all males between the ages of 27 and 67 years. Among them were seventeen traders, sixteen farmers, three tricycle drivers and a commercial driver, one retired civil servant, one teacher, and two unemployed. Furthermore, their irrigation farming experience ranged from two to nineteen years. Twenty-six participants had a Quranic education, one participant each had a degree and an NCE certificate, nine had secondary education, and three had primary education. The FGDs were categorised into four codes: Dala Lawanti FGD code 1, Dusuman FGD code 2, Gongulong FGD code 3, and Zabarmari FGD code 4.

**Table 3: Themes**

| Major themes |
|---|
| Knowledge of safety measures using pesticides |
| Health implications of pesticides use |
| Usage of the pesticides |
| Benefits of pesticide |
| Availability of pesticide |

All the interviewed farmers had knowledge of safety measures but did not follow them appropriately.

**Knowledge of safety measures using pesticides:**

*"We were advised by the Ministry of Agriculture staff always to use a facemask and hand gloves, but we sometimes use them, and other times we do not. As for the empty containers, we dispose of them anywhere, either inside the farm or along the road to home. We do not have a specific place to dispose of it". (FGD codes 1-4, IDI codes 1-4).*

From the result of the FGD and the in-depth interview, it is evident that they are ignorant of the health implications of pesticide use. Most of the farmers apply pesticides without help from experts. Furthermore, they have no idea of the type of pesticide-related illnesses.

**Health implications of pesticide use:**

> *"Over the years, we have learned how to apply pesticides on our farms; therefore, we usually refrain from engaging the services of farm officials. The instructions for use are on the levels, so those who can read can help us. Moreover, we have mastered applying pesticides on our farms". (FGD codes 1-4)*
>
> *"I do not know the types of sickness associated with the use of pesticides apart from sneezing and headaches that we experience after applying pesticides, which is normal, but I can tell you that no one has fallen sick because of pesticides used apart from other sicknesses that can happen to anyone. We usually wash our hands thoroughly after applying the pesticides, so I do not think there is any problem". (IDI code 1)*

On the types of pesticides they use, all participants acknowledged that they use both organic and inorganic fertilisers. From their narratives, they have ideas on the uses of each type of fertiliser.

**Usage of the pesticides:**

> *"We use both organic and inorganic fertilisers such as Abamectin, Imidacloprid (DD Force, Emi Force), Optimum Powder, Force Up, DDT, and MPK fertiliser. We apply it immediately after planting. There are two types: one is used to kill the weeds and allow the vegetables to grow, and the other protects the vegetables from pest infestation. We also use it again immediately before harvesting it (FGD codes 1-4)*
>
> *Usually, we wait for at least ten to fourteen days before harvesting. However, if the demand is high, we do not wait for longer days; we harvest it and sell it immediately" (IDI codes 1-4)*

There is a consensus among the participants on the benefits of pesticide use, which can be attested by observing their vegetables.

**Benefits of pesticide**:

> *"There are many benefits to using pesticides in our farms; for example, 24D and Force-Up destroy the leaves; Butter Force will not allow leaves to grow; and Super Grow doubles the effects of fertiliser and pesticides. Using pesticides helps grow our vegetables fast and yield more profits". (FGD codes 1-4, IDI codes 1-4)*

All participants agreed that pesticides are available all over the town but are expensive.

**Access and availability of pesticides:**

> *"According to our financial capabilities, we buy it from shops where they sell agrochemical products. It is available all over the metropolis; the only problem is the cost, especially of*

*chemicals."(FGD codes 1-4, IDI codes 1-4)*

When asked how the government could help their farming activities, they requested subsidized fertilizers and more water pumps.

*"We want the government to provide more water pump machines and dig more boreholes. We also want the government to sell the pesticides at a subsidised rate so that we can afford them. Furthermore, we want more assistance from the non-governmental organisations, and even though FAO helps provide wash boreholes in some farming communities, we are yet to enjoy such a gesture" (IDI codes 1-4).*

**Discussion**

This study explored the level of awareness of risks associated with pesticide use among irrigation farmers. The sociodemographic characteristics of the participants for the FGD revealed that all participants were males between the ages of 27 and 67. This finding conforms to that of Jean et al. (2017), who reported that pesticide applicators in the Santa area are primarily married men and have a low educational level. The findings of this study were further attested by Jean, Benoit, Edouard, & Srivastava (2017), who documented that pesticide applicators are primarily holders of the First School Leaving Certificate. This study revealed that most participants lacked formal education, which affected how they handled farm pesticides. Their lack of knowledge further contributes to their inability to read container labels. This was corroborated by the findings of Govinda et al. (2018) and Isah et al. (2020) that the most significant levels of education were the SSCE or its equivalent. However, Huyena et al. (2020) posited that there were no illiterate participants in their study. Moreover, Lekei, Ngowi, & London (2014) reported that farmers with low education and knowledge may have less awareness of pesticide health and environmental implications and may store them in their homesteads. Likewise, de-Assis et al. (2020) revealed in their review article that a study in Tanzania found that pesticide exposure caused 220,000 annual deaths in low- and middle-income countries owing to a lack of knowledge and inadequate education.

Analysis of the FGD and in-depth interviews revealed that most farmers were ignorant of the dangers of using pesticides and disposing of empty containers. This finding is corroborated by Jean, Benoit, Edouard, & Srivastava (2017), who found that pesticide applicators exhibit a knowledge gap regarding pesticide toxicity, manufacturer instructions, application techniques, safety measures, and dosage. The study sample comprised four experienced farmers with a minimum of ten years of experience in irrigation farming. Despite their expertise, farmers need to be more aware of crucial safety practices. For instance, although most participants acknowledged the significance of wearing face masks and hand gloves, they did not practice them. The prevalent use of pesticides among farmers can be attributed to their inadequate education and lack of awareness regarding associated health and environmental risks. This observation aligns with the findings of Asongwe, Yerima, & Tening (2014), who found that 95% of farmers in Bamenda Municipality do not take protective measures during pesticide application.

Moreover, Gesesew, Woldemichael, Massa, & Mwanri (2016) discovered that inadequate knowledge of correct pesticide use, difficulty in comprehending product labels, improper storage conditions, and underestimation of health risks associated with pesticides are the primary drivers of

pesticide exposure. Although safety practices are critical in agriculture, education and knowledge about the subject sometimes leads to better safety practices. By contrast, Lekei, Ngowi, & London (2017) documented that a recent study revealed no direct correlation between PPE use and education or knowledge. However, farmers are aware of the health effects and routes of pesticide absorption, with over three-quarters acknowledging the primary routes of absorption. Farmers may be aware of the risks of the chemicals they use, but factors other than their control can increase their risk of poisoning. For example, economic pressures to increase production or disincentives related to PPE and safe storage costs can lead to risky practices, such as unsafe storage and omission of PPE use (Lekei, Ngowi, & London, 2017).

Another essential theme associated with this study was the need for knowledge about the health risks associated with pesticide application by farmers. Furthermore, the interviewees were confident that thoroughly washing their hands was sufficient to protect them from health implications. While sneezing and headaches were commonly reported in this study, Gesesew, Woldemichael, Massa, & Mwanri (2016) found that nausea, vomiting, shortness of breath, bradycardia, dermatitis, burns, and eye irritation were also prevalent. Research by Lyu et al. (2018) in China and Koh et al. (2017) in Korea revealed that handling pesticides can lead to increased levels of aggression, impulsivity, and suicide attempts as well as an increased risk of depression and other mental and behavioural disorders. Factors such as farmers' literacy, pesticide quantities, age, use of safety measures, awareness, toxicity, exposure, training (experience), and pesticide interactions have all been found to affect health indicators (Khan, Ejaz, Khan, & Bibi, 2018). In this study, some farmers believed that washing their hands was sufficient to protect themselves against health issues. However, Huyena et al. (2020) documented significant effects of pesticide exposure on the nervous, liver, and kidney systems. In addition to physical health challenges, Zhang et al. (2016) demonstrated that inadequate use of pesticides can also have neurobehavioural effects.

Furthermore, the study revealed that farmers dispose of empty containers anywhere, either inside the farm or along the road to their homes. The indiscriminate disposal of empty containers can pose a significant challenge to the health and well-being of individuals. This finding is supported by Tinyami et al. (2014), who documented that farmers and pesticide users must safely handle, apply, and discard residual pesticides to reduce their hazards to non-target animals, themselves, and plant species. In addition, Shehu et al. (2021) posited that the majority (60.5%) of the respondents throw the pesticide container in the bush, 32.6% deposited the container in a nearby water body, and only 7.0% took time to bury the container after usage (Shehu, Mohammed, & Mohammed, 2021). Furthermore, Lekei, Ngowi, & London (2014) documented that the unsafe disposal of unwanted pesticides and empty pesticide containers may be an essential source of pesticide exposure.

Furthermore, the study's findings revealed that the participants used different types of pesticides, such as Abamectin and Imidacloprid; they also used NPK fertiliser for those who could afford it. The results of this study support previous findings by Abubakar et al. (2017), who used a variety of pesticides on their crops. However, Bwala et al. (2022) reported that the DD-force is the most commonly used pesticide. Furthermore, uniformity is required to spray the pesticides. They were harvested immediately after spraying with the pesticide and did not wait for the waiting period. Selling vegetables immediately after spraying pesticides affects human health. This finding is corroborated by Agaba (2018), who found that consuming

sprayed plants or crops with toxic chemical residues without waiting for the stipulated time leads to ill health and eventually death. Likewise, Monguno, Modu, & Bukar (2019) asserted that most participants did not know or perceive that consuming vegetables contaminated with pesticide residues can harm human health. Another vital piece of evidence from this study was the need to determine the application parameters, such as the pre-harvesting time, spraying frequency, and period. Jean, Benoit, Edouard, & Srivastava (2017) posited that it will lead to many residues in harvested foods. The spraying period and frequency also contributed significantly to the presence of residues.

In Ghana, urban farmers who cultivate vegetables and require water for irrigation frequently rely on wastewater for year-round production (Ackerson & Awuah, 2010). Surprisingly, this study revealed that none of the irrigation farming sites visited utilised wastewater for their irrigation activities. All farmers used water pumps to irrigate their farms based on the observations made in this study. Nevertheless, a few respondents acknowledged that the irrigation site behind the Maiduguri abattoir is reputed to use the wastewater discharged from the abattoir. According to the farmers, it can pose a danger to the populace if left unchecked. In addition, the findings revealed the benefits of using pesticides on their farms, confirmed by the consensus among the participants from the theme, "There are many benefits to using pesticides in our farms. Using pesticides helps grow our vegetables fast and yield more profits." Finally, regarding the availability of pesticides, the study revealed that, according to their financial capabilities, they buy pesticides from shops where they sell agrochemical products. It is available all over the metropolis; the only problem is the cost, especially for chemicals.

## 5. Conclusion and Recommendations

Most participants lacked formal education and were ignorant of the magnitude of the health effects of pesticides used on their farms. Even though they know the health hazards associated with pesticide use, they do not see the magnitude of the danger involved. Furthermore, farmers use pesticides without the assistance of government officials, and the majority of them need to be educated. In addition, most farmers do not use personal protective equipment (PPE) while preparing and spraying their farms. The study also revealed that the treatment of pesticide waste and containers left in the environment caused further health challenges. Finally, the study showed that they harvested immediately after spraying the pesticide and did not wait for the waiting period. Selling vegetables immediately after spraying pesticides has an impact on human health.

Based on the findings of this study, there is a need for the authorities concerned to monitor and educate irrigation farmers on how to spray their farms with pesticides and the safety measures involved. Therefore, we recommend additional interdisciplinary studies on the associations between pesticide use and health implications for farmers on the one hand and the effects of vegetables harvested immediately after spraying with pesticide (pesticide residues) without waiting for the waiting period by consumers on the other. Furthermore, awareness of health and safety for irrigation farmers is needed, including the type and quantity of pesticides and when to use them. Since most studies conducted on health safety and the use of pesticides reveal that farmers do not follow preventive measures, the government and farm officials must come together and create awareness right from the grassroots for sustainable development.

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