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Assessment of Commonly Used Pesticides and Frequency of Self-Reported Symptoms on Farmers Health in Kura, Kano State, Nigeria

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Abstract: An astonishing 150 million tons of fertilizers and 6 million tons of pesticides are yearly and routinely applied to fields and crops to increase agricultural production. Today modern agriculture relies heavily on the use of pesticides. Hence, instilling confidence and enriching farmers begins with recognizing the need for pesticide use modification, whether through existing or new technologies, such as efficiency, cost reduction, or effective decision-making. As many types of rapid toxicity or explicit evidence and platforms provide useful information on the symptoms of human risk and pesticide self-poisoning accounts, which offer the promise of aiding decision-making in a variety of areas, including the regulatory management of chemicals, product, environmental assessment, and emergencies. The present study aimed to assess commonly used pesticide application and frequency of farmer's self-reported symptoms in Kano State, Nigeria. A comprehensive questionnaire was established that focuses on sociodemographic characteristics, education, and experience on the adverse health effects associated with the use of the pesticide, description of job practices, and a list of used pesticides on the farms in the study area. Of the 400 copies of the administered questionnaires, 392 copies were retrieved and found useable, which represents 98% of the administered questionnaires. A total of 89.5% of the farmers make use of pesticides; of the 351 farmers that made use of pesticides, 31.3% use Apron plus, 12.0% use Atrazine, 33.6% use [Cypermethrin] while 9.7%, 8.5%, 4.8%, 31.3% and 12.0% of the respondents use Sevin, Thiodan, Fusilade, Primextra, and others respectively, of the farmers 46.2% had been using the pesticide for 1-5 years, 48.1% had used it for 10-15, the regularity of these symptoms reveals that the majority of the respondents experienced these symptoms regularly (56.1% for headache, 53.8% for stomach cramps, 56.5% for muscles weakness, 56.8% for vomiting, 58.3% for dizziness, 40.7% for shortness of breath, 45.5% for blurred vision and 66.7% for eye irritation. It is therefore imperative to focus on chemical pesticides and their toxicity, which should be assessed quickly and new methods should be developed to prioritize human and biological health. Also, structured interventions are required to lessen health risks exposure, as well as training, labeling improvements, and measures to decrease the cost of barriers in the implementation of safety behaviors and promotion of administrative control measures. Likewise, the use of integrated pest management (IPM) strategies in emerging countries such as Nigeria should be encouraged and made possible by a wide variety of public initiatives through translating local data into evidence-based solutions at a grassroots level. Thus, calling for action for local scale participatory citizen science to solve complex chemical pesticides issues at a local, regional, and national scale.

Keywords: *Environmental media, health risk concerns, decision making, evidence-based solutions, regulatory management, biomonitoring, citizen science, emergency response*

Abbreviations:
IPM Integrated pest management
WHO World Health Organization

APP Acute Pesticides Poisoning
PPE Personal Protective Equipment

1. Introduction

Kura farmers need not be left vulnerable due to a lack of data and political capacity, as modern healthcare services and other basic modern infrastructural necessities that are essential to maintain their health are lacking [1,2,3,4]. Whilst remarkable research has been devoted to addressing the health effect of pesticide use on agricultural farming at a national and global scale, action and data at the local level remain elusive. Although the proliferating analysis on important issues regarding pesticide questions, there is a need to offer appropriate frameworks to translate the complex systems thinking concepts into effective policy. Likewise, there is a need to understand the commonly used pesticides and the frequency of self-reported symptoms on farmer's health in Nigeria and stakeholder's interactions across scales. At the root of this problem is the fundamental lack of actionable information about the commonly used pesticides at the local level, which limits the capacity of local decision-makers to understand and manage pesticides in agricultural farming in Nigeria. Adopting a local lens for pesticide management is a necessary step to ensure the sustainability of pesticide management at a tactical and local level. It is believing that local capacity and information are the most fundamental challenges facing pesticide management. This is why, for so many years, Nigerian farmers have been bedeviled by a cankerworm called over-dependence on pesticides as one of the veritable sources to increase yield and has become an albatross due to its health effects.

Rural residents face many repeated environmental threats associated with everyday agricultural risks, including pesticides, solvents, and metals of occupational and environmental origin [5,6,7,8,9,10,11,12,13]. Rather than be misconstrued as an expression of helplessness in the face of a blistering and perilous period of strangulated economy, following concern about how pesticides have only become a problem because of the direct actions to humans. Modifying these actions can often substantially reduce farmer's exposure problems. Longitudinal pesticide exposure has been reported to cause diseases like diabetes, cancer, neurological disorders, and coronary heart disease [14]. Consequently, pesticides that are very harmful to smallholder farmers institutes a typical trans-sectoral 'wicked problem', and concerns about the risks to human health from the risk of exposure to pesticides have increased significantly [15]. Also, exposure to pesticides is one of the main significant threats to the health of farmers in the global south [16,17]. It is estimated that 25 million farmers are exposed to poisoning from acute pesticide yearly in the global south, making poisoning of pesticide a most significant worldwide health problem [17]. Globally, the commonly used pesticides by agricultural farmers include organophosphates, causing chronic chemical poisoning through enzymes inhibiting cholinesterase. This outcome in excess nicotinic stimulation besides muscarinic receptors, leading to symptoms of chronic pesticide poisoning such as diarrhea, weakness, headache, vomiting, ataxia, dizziness, bradycardia, dyspnea, paralysis, and finally death [18].

Pesticides use in agricultural farming in Nigeria, particularly among Kano State farmers, has improved considerably over the past 20 years, as pesticides continue to be the pillar for agricultural control of pests and disease vectors. From the season's beginning to harvest, farmers are faced with a large number of pesticides, which has the potential to induce DNA damage [19]. The resulting mixture of pesticides may be more virulent and pose a greater risk to the public than individual pesticides, and raises concern on their human health impact [20]. However, it is problematic to determine the exact configuration of these combinations. Exposure to pesticides can lead to oxidative stress through the accumulation of unrestricted radicals that can accumulate in the cell, which in turn can damage nuclear acids and DNA protection and improve the immune system from the body defense mechanism [14]. In this case, oxidative stress may be explained by the use of Trolox equivalent antioxidant capacity with peroxidation of serum lipids through thiobarbituric acid with

reactive substances and by acquiring significant occupationally exposed information on populations [21,19].

Interestingly, over the past 30 to 40 years, concerns about environmental pollutants have increased public concern about their exposure to pesticides, which began to gain momentum around the early 2000s. However, although agricultural productivity has increased, the use of agrochemicals, which has a significant adverse impact on aquatic systems and soil with related biotic and abiotic, including the farmer's health and community that consumes food that is chemically grown. Also, the increasing world population and the requirement to regulate pests, including the factors influencing the use of agrochemicals to shield and improve production in agricultural areas. Either way, these substances are harmful to the environment, for example, this pesticide can pollute water reservoirs and act on unwanted organisms. Today, the study of pesticides is an important area of research on environmental pollution and several questions remain unanswered about the safety and toxicity of these products to human health and the environment. It is based on the above problem that this research sought to explore commonly used pesticide application and frequency of clinical symptoms of farmers on selected agricultural farmland in Kano State, Nigeria.

The purpose of this research is to identify the pesticides most commonly used by farmers in Kano State and to identify the impact of pesticides on the health of farmers through monitoring the prevalence of self-reported symptoms in Kano State. The focus on farmers is significant since from the season's beginning to harvest, farmers are often exposed to large amounts of pesticides, which has the potential to induce DNA damage and pose a great risk to the exposed populations raising human health concerns. These health problems can affect health outcomes in years later. The knowledge, attitude, and application of commonly used pesticides and the health indicators of many farmers in Kano State are essential to their health, wellbeing, and future development. Thus, awareness helps to modify attitudes and behavior towards pesticides. While significant research into understanding the health burden of chemical pesticides in Kano State has not been undertaken, a literature review revealed an absence in the research. The current study aims at contributing to the extant literature in this regard.

2. Materials and Methods

2.1 Research Design

The study adopted a descriptive survey research design. The descriptive survey design according to Funmilayo *et al.* is a kind of research design in which the researcher collects data from a cross-section of the study population in respect of variables [22]. This design was considered appropriate for the study since it solicits information from a target group. The design involves the collection and analysis of data gathered. Gift and Obindah described descriptive survey design as a type of design to be employed when a study involves the use of a questionnaire to seek the opinion of the respondents [23]. Gift and Obindah added that the descriptive survey type of design is the most convenient way to obtain real facts and figures in which the results of the analyses will be used for decision making or generalization. This research design is considered suitable for this study because this study's primary objective centers on the assessment of commonly used pesticide application and frequency of farmers' self-reported health symptoms from selected agricultural farmland in Kano State, Nigeria. The choice of a descriptive survey design was premised on its value and facility in addressing the research problem raised in the study.

2.2 The Study Area

2.2.1 Location

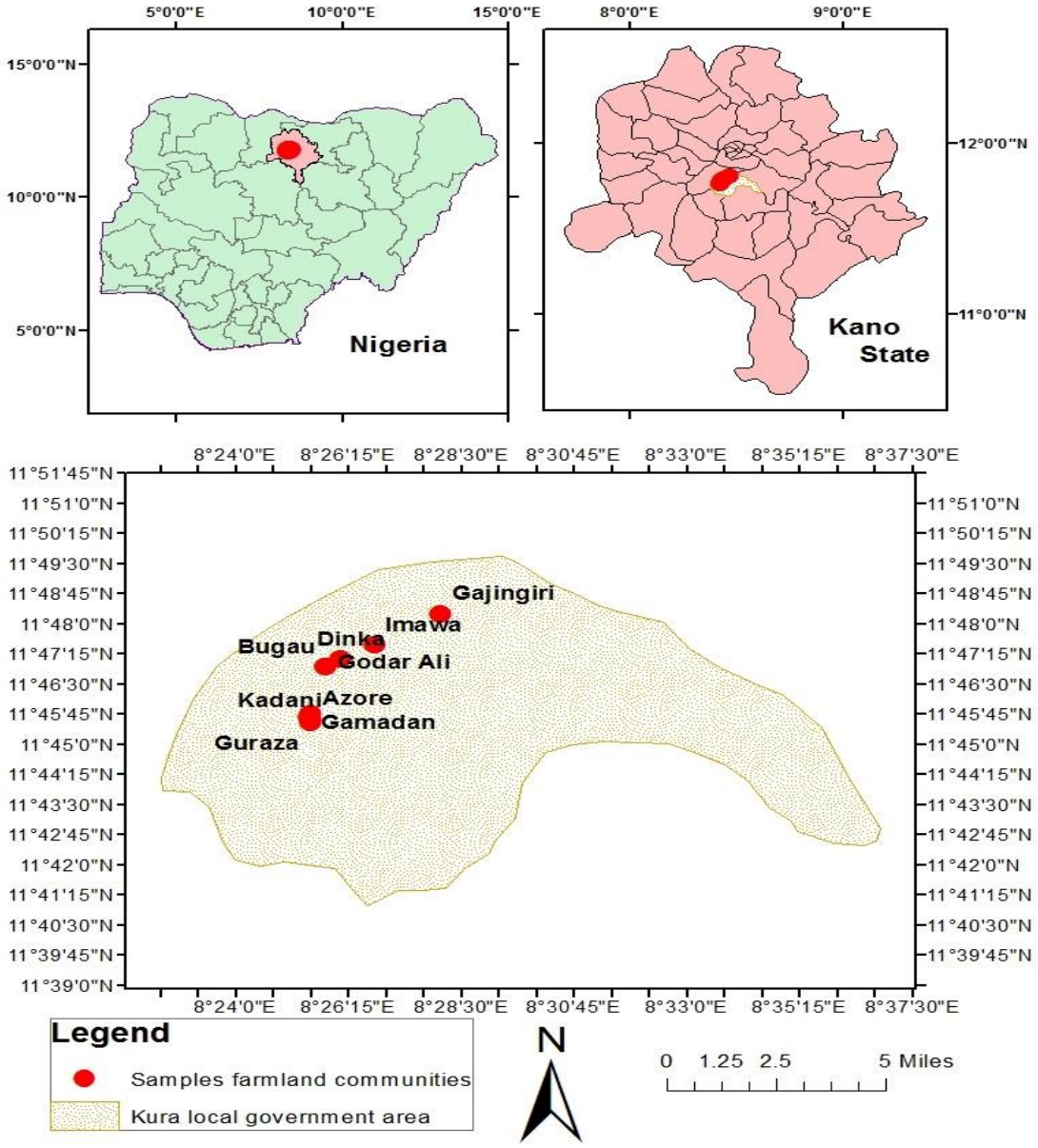

Figure 1: Map of Kano State showing the location of the Study Area in Nigeria. Adapted from Isah *et al*., [69] [DOI: 10.5281/zenodo.4008682]

Kano State is located between latitude 13^0N and 11^0N and longitude 8^0W and 10^0E (Figure 1). It is approximately 840 kilometers away from the Sahara Desert. Kano has a mean height of around 472.45m above sea level. Kano State has 44 provinces: "Ajingi, Albasu, Bagwai, Bebeji, Bichi, Bunkure, Dala, Dambatta, Dawakin Kudu, Dawakin Tofa, Doguwa, Gabasawa, Garko, Garun Mallam, Gaya, Gezawa, Gwale, Gwarzo, Kabo, Karaye, Kibiya, Kiru, Kumbotso, Kura, Kunchi, Madobi, Makoda, Minjibir, Kano Municipal, Nassarawa, Rimin Gado, Rogo, Shanono, Sumaila, Takai, Tarauni, Tsanyawa, Tudun Wada, Tofa, Warawa, and Wudil".

Kano State has an overall land area of 20,760sq kilometers with 9,383,682 population of inhabitants (2006 provisional result) [1]. Kano temperature is always between 33^0C and 15.8^0C even though it occasionally reaches 10^0C during harmattan season. Kano has two seasons, including 4 to 5 months of rain and a prolonged dry spell usually from October through April. The air masses movement from South West maritime, extending out of the Atlantic Ocean with the impact of the rainy season, starting from May to September. The start and duration of the rainy season varied between the northern and southern parts of Kano State. In the southern State of Kano, Riruwai last six (6) months beginning early May through late September. Northern parts of Kano State go from June to early September [1]. The average precipitation ranges from 63.3mm + 48.2mm in May and 133.4 mm + 59mm during August. Air masses from the tropical maritime move from Southwest to North, which regulates the weather of Kano State all through the rainy season. Moisture from the Atlantic Ocean is being transported through the air masses. This humidity is absorbed once it's forced to increase using convection or over a barrier of highland's or a mass of air; and it came like rain. The peak period happens when the sun sets across West Africa amongst March through June. The dry spell begins in October then lasts until April of next year. Low temperatures are usually experienced around this time as the sun faces the Southern Hemisphere as the desiccating continental mass of air movement which extends through the Sahara while blowing through the Northeast and carry the harmattan dust with it. Implying the period of harvest [1].

2.3 Population and Sample Size

The study population comprised farmers in Kura's local government area of Kano State, North West, Nigeria. Available statistics, based on the 2006 population census, showed that Kura has a total population of 143 094 people and 80% of them were farmers [24]. Hence, the population of the farmers was estimated to be 114 475. The population of the study was projected in 2018 using a population growth rate of 2.47% as provided by the Nigerian population commission [25]. The projected population was obtained using the following equation:

Equation 1: $P_t = P_0\left(1+r\right)^t$

where, P_t is the projected population, P_o was the population in 2006 (114475), r is the population growth rate (2.47% = 0.0247), and t is the number of years (12).

$$P_t = P_0\left(1+r\right)^t = 114475\left(1+\frac{2.47}{100}\right)^{12} = 114475\left(1+0.0247\right)^{12}$$

$$= 114475\left(1+0.0247\right)^{12} = 114475\left(1.0247\right)^{12} = 114475\left(1.3402\right) = 153417$$

Hence, the projected population of 153 417 farmers in Kura of Kano State was estimated.

2.4 Sample Size

A sample size of 399 farmers in Kura was estimated using an equation described by Yamane [26]. The sample size was estimated as:

Equation 2: $N = \frac{N}{1+N\left(e\right)^2}$

where n is the sample **size** to be determined, e is the level of significance, and N is the population size.

$$N = \frac{N}{1+N(e)^2},\ N = 153417,\quad e = 0.05$$

$$N = \frac{153417}{1+153417\ (0.05)^2}$$

$$N = \frac{153417}{1+153417\ (0.0025)} = \frac{153417}{1+383.5425} = \frac{153417}{384.5425} = 398.9$$

$$n = 399$$

2.5 Sampling Techniques

The study adopted a multi-stage random sampling technique in the sample selection process. In the first stage of the sampling, random sampling was used to sample 10 villages out of a total of 26 villages in Kura's local government area. Randomization was done through balloting. The selected villages were Sarkin Kura, Gamadan, Azore, Kadani, Guraza, Imawa, and Godar Ali. During the second stage of sampling, a random sample was selected to select farmers from 10 villages. To give each of the selected villages a uniform number of farmers, the sample size was divided equally across the 10 selected villages and a sample of 40 farmers was selected from each of the villages.

2.6 Instruments for Data Collection

Researchers developed a questionnaire entitled "Risk Assessment Associated with Pesticides Application Questionnaire" (see appendix 1 below) that was used in data collection. It was comprised of 25 sections which focus on different demographics including sex, marital status, age, educational qualification, farming experience, farm size, land ownership status, use of pesticides, commonly used pesticides, the effect of pesticides, health problem associated with the exposure to pesticide use and the effect of the pesticide's application on the environment. The study also assesses the safety measures farmers use to control pesticides and the behaviors when using pesticides.

2.7 Validity of Instrument

The research questionnaire was presented to experts for validation. Copies of the questionnaire were presented to three experts, two from Environmental Health Science, Kwara State University, and one expert in research and statistics (statistician). These experts were required to examine the validity of the research instrument (questionnaire) in terms of language, clarity, and content in line with the purpose of the study, research questions, and the hypotheses it would measure.

2.8 Method of Data Collection

To facilitate data collection, the researchers employed four research assistants. Two of the research assistants helped in the administration of the data. The research assistants were properly briefed on how to administer the questionnaire. The questionnaire was administered within a four-week period. Each of the research assistants covered two communities while the researcher also covered two communities. Of the 400 copies of the administered instruments, 392 copies were retrieved and found useable, representing 98% of the administered questionnaire.

2.9 Methods of Data Analysis

Entered questionnaires information were rechecked for quality assurance in an Excel sheet before analysis was done. All submission requests from the semi-structured and comprehensive questions were summarized from all respondents using statistics that are analyzed descriptively such as simple percentages and frequency distribution were used to analyze the demographics of the respondents and to answer the research questions. Also, some vital results of the analysis were presented using pictorial representation like a bar chart, cluster bar charts, and other forms of pictorial representation. To enhance data analysis and computation of results, version 20.0 of the SPSS was used.

3. Results

Table 1 shows the demographics of the respondents. Results of the distribution of the respondents based on sex reveal that 54.6% of the farmers were male and 45.4% were female. The results showed that 60.7% were married, 33.9% were single and 5.4% were divorced. The distributions of the respondents based on age were as follows: 17.6% were between ages 16-25 years, 20.9% were between 26-35 years, 26.3% were between 36-45 years, 19.9% were between 46-55 years whereas the remaining 15.3% of the participants were above 55 years. In terms **of** their educational qualification, 20.2% of the farmers had no formal education, 31.6% had primary education, 36.2% of the farmers had secondary education, 6.4% were Ordinary National Diploma/National Certificate Examination holders, 4.6% were Bachelor of Science/Higher National Diploma holders while 1.0% had postgraduate degrees. Results also show that 46.2% of the respondents had 1-10 years of farming experience, 47.7% had 11-20 years of farming experience and 6.1% of the farmers had above 20 years of farming experience. The distribution of the farmers based on farm size reveals that 43.4% of the respondents had 0.5-2.0 ha of land, 38.5% had 2.5-4.0 ha of land and only 18.1% of the farmers had above 4 ha of land. With ownership of land status, 52.3% of the land acquired by farmers is through inheritance while 47.7% of the farmers acquired their lands through leasing.

Table 1. Demographics of the Respondents

Demographic variables	No. of respondents	Percentage (%)
Sex		
Male	214	54.6
Female	178	45.4
Marital status		
Married	238	60.7
Single	133	33.9
Divorced	21	5.4
Age (years)		
16-25 years	69	17.6
26-35 years	82	20.9
36-45 years	103	26.3
46-55 years	78	19.9
Above 55 years	60	15.3
Education		
No formal education	79	20.2
Primary	124	31.6
Secondary (SSCE or equivalent)	142	36.2
OND/NCE	25	6.4
B.Sc/HND	18	4.6
Post graduate degree	4	1.0
Farming experience (years)		
1-10 years	181	46.2

11-20 years	187	47.7
Above 20 years	24	6.1
Farm size (ha)		
0.5-2	170	43.4
2.5-4	151	38.5
Above 4	71	18.1
Land ownership		
Inheritance	205	52.3
Lease	187	47.7

Source: Field survey (2019).

Abbreviations: OND/NCE, Ordinary National Diploma/National Certificate Examination; SSCE, Senior Secondary School Certificate Examination; B.Sc/HND, Bachelor of Science/Higher National Diploma.

Table 2 is the World Health Organization's (WHO) classifications of the pesticides presented. The pesticides most commonly used (mainly pyrethroids, phenylamide, and s-metolachlor compounds) by small scale farmers in Kura are categorized by WHO as moderately hazardous and slightly hazardous [27]. The classification of the pesticides shows that insecticides and herbicides are mostly used group, followed by fungicides (31.2%). However, 12% of the other (unidentified), pesticides were used multi-purposely. The insecticides used belonged to the chemical groups of pyrethroids, carbamates, and organochlorines. The herbicides belonged to the groups of triazines, aryloxyphenoxypropionate, and chloroacetanilide.

Table 2. Products Reported as Used by Farmers in Kura

Type of pesticide used (trade name)	Active ingredient	Main use	Chemical Hazardous Class (WHO)
Apron Plus	Metalaxyl (phenylamide)	Fungicide	II
Atrazine	Triazines	Herbicides	III
Polythrine	Cypermethrin (pyrethroids)	Insecticides	II
Sevin	Carbaryl (carbamate)	Insecticides	II
Thiodan	Endosulfan (organochlorine)	Insecticide	II
Fusilade	Fluazifop-p-βutyl (aryloxyphenoxypropionate)	Herbicides	III
Primextra	S-Metolachlor (chloroacetanilide)	Herbicides	Has no known WHO hazard classification
Others/unidentified			

Note: I, extremely hazardous; II, moderately hazardous; III, slightly hazardous; IV, unlikely to present acute hazards under normal use condition.[27]

Answering of Objective Questions

Table 3 presents the use of pesticides among farmers in Kura of Kano State. The result reveals that 89.5% of the farmers make use of pesticides while only 10.5% of the respondents do not use pesticides. Of the 351 farmers that use pesticides, 31.3% use Apron plus, 12.0% use Atrazine, 33.6% use Cypermethrin while 9.7%, 8.5%, 4.8%, 31.3% and 12.0% of the respondents use Sevin, Thiodan, Fusilade, Primextra and others (unidentified) respectively. The results showed that 46.2% of the farmers had been using the pesticide for 1-5 years, 48.1% had used it for 10-15, 2.3% had used it for 16-20 years and 3.4% of the respondents had use pesticides for more than 20 years. A total of 158 respondents (45%) knew about the use of pesticides through retailers, 36.8% heard about it from

co-farmers and 18.2% of the respondents heard about pesticide use through consultancies. One hundred and nine (109) respondents representing 31.1% of the respondents stated that their main purpose of using pesticide was for weed control, 14.5%, 14.5% and 39.9% of the respondents said that their main purpose of using pesticides was for pest control, rodent control and fungi control, respectively. The most common pesticides used by farmers in Kura are presented using a bar chart shown in Figure 2.

Table 3. Pesticide Use among Farmers in Kura

Questions	No. of respondents	Percentage (%)
Do you use pesticides		
Yes	351	89.5
No	41	10.5
If yes, what type of pesticide do you use?		
Apron Plus (phenylamide)	110	31.3
Atrazine (triazines)	42	12.0
Cypermethrin (polythrine)	118	33.6
Sevin (carbamate)	34	9.7
Thiodan (organochlorine)	30	8.5
Fusilade (aryloxyphenoxypropionate)	17	4.8
Primextra (chloroacetanilide)	110	31.3
Others	42	12.0
Years of pesticides use		
1-5 years	162	46.2
10-15 years	169	48.1
16-20 years	8	2.3
Above 20 years	12	3.4
How do you know about pesticides usage		
Retailers	158	45.0
Co-farmers	129	36.8
Consultancies	64	18.2
What is your main purpose of using pesticides		
Weed control	109	31.1
Pest control	51	14.5
Rodent control	51	14.5
Fungi control	140	39.9

Source: Field survey (2019)

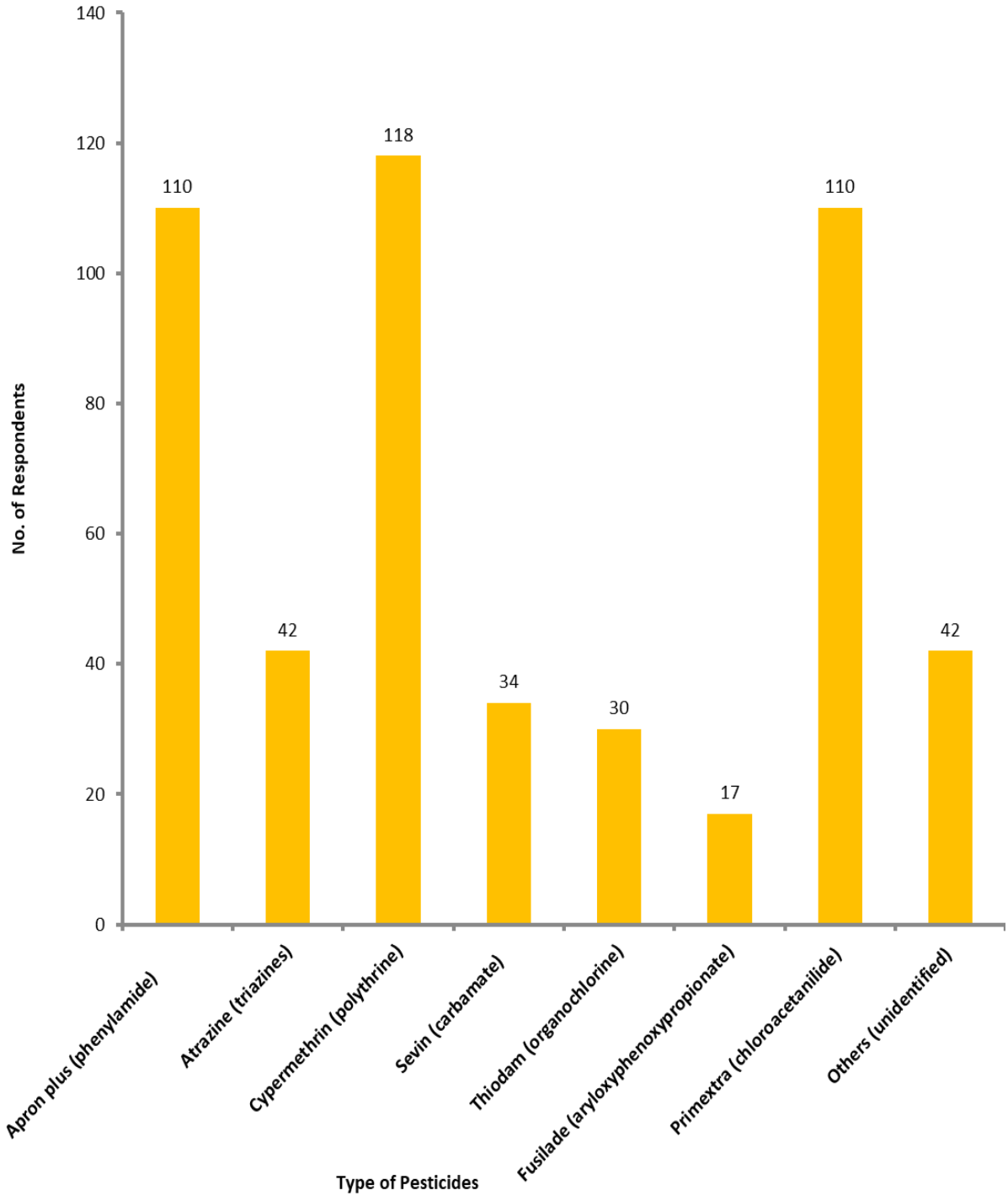

Figure 2. Chart showing the different types of pesticides used by farmers in Kura

Table 4 shows that 41.4% of the respondents who complained of pesticides related problems had a headache, 39.4% had stomach cramps, 46.5% complained of muscle weakness, 37.4% complained

of vomiting, 36.4% complained of dizziness, 27.3% complained of shortness of breath, 11.1% complained of blurred vision while 54.5% complained of eye irritation. Results of the analysis of the regularity of these symptoms reveal that the majority of the respondents experienced these symptoms regularly: 56.1% for headache, 53.8% for stomach cramps, 56.5% for muscles weakness, 56.8% for vomiting, 58.3% for dizziness, 40.7% for shortness of breath, 45.5% for blurred vision and 66.7% for eye irritation.

Table 4. Symptoms and Frequency of Symptoms Among Farmers who use Pesticides and Experience Some Effects

Health related self-reported symptoms	Frequency of self-reported symptoms			
	Regularly n (%)	Occasionally n (%)	Rarely n (%)	Total
Headache	23(56.1)	13(31.7)	5(12.2)	41 (41.4)
Stomach cramps	21(53.8)	14(35.9)	4(10.3)	39(39.4)
Muscles weakness	26(56.5)	15(32.6)	5(10.9)	46(46.5)
Vomiting	21(56.8)	12(32.4)	4(10.8)	37(37.4)
Dizziness	21(58.3)	13(36.1)	2(5.6)	36(36.4)
Shortness of breath	11(40.7)	11(40.7)	5(18.5)	27(27.3)
Blurred vision	5(45.5)	2(18.2)	4(36.4)	11(11.1)
Eye irritation	36(66.7)	13(24.1)	5(9.3)	54(54.5)

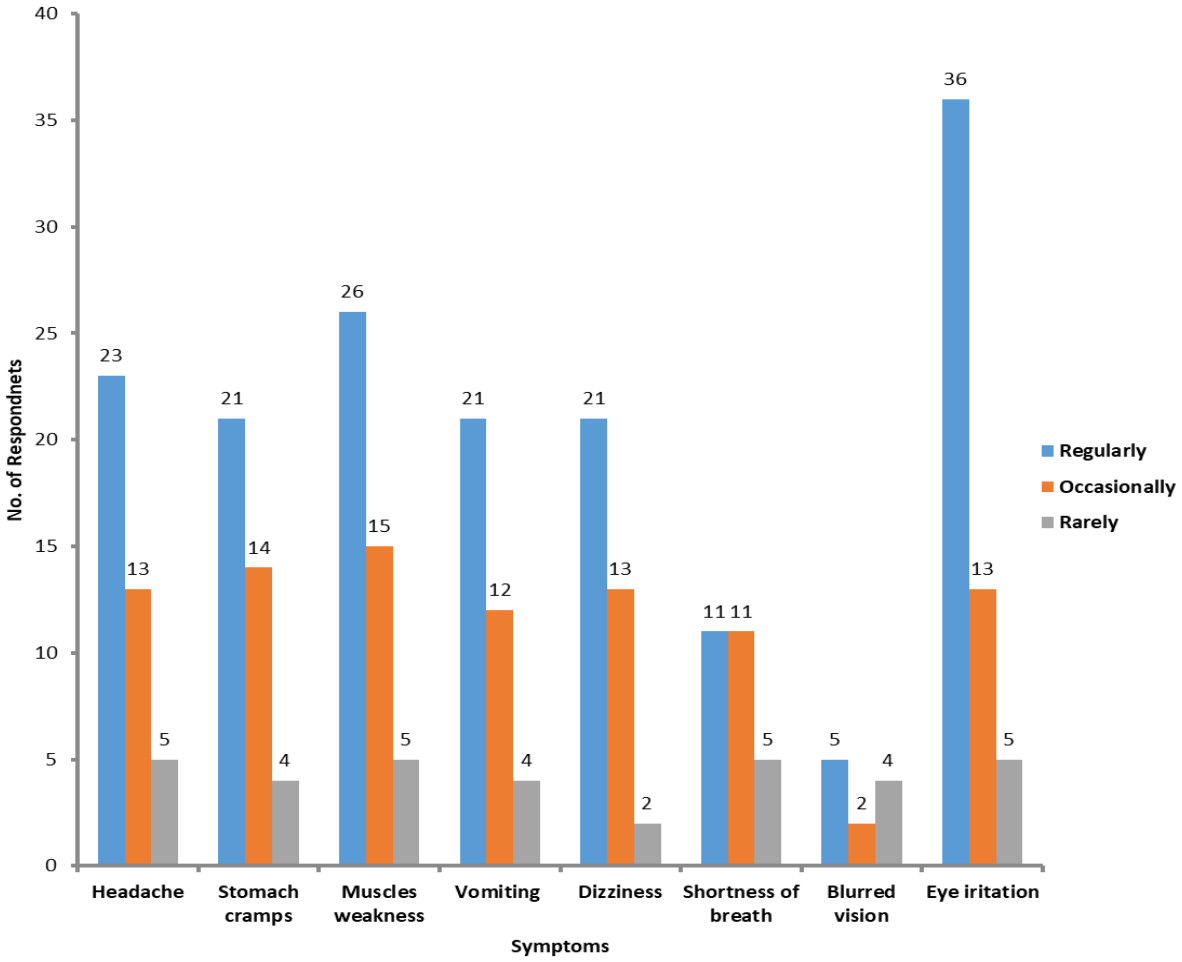

Figure 3. Cluster bar ch0art showing the distribution of the symptoms of pesticide use and frequency of self-reported symptoms in Kano

4. Discussion

4.1 A Review of the Samples in Question

Before the statistical analysis's outcomes were observed, the reviewed samples needed to be ascertained through the specific population the outcomes were generated.

The socio-demographic characteristic, including sex, marital status, age, farm size, land ownership, levels of education, and farmers farming experience concerning the handling of pesticide is revealed in Table 1. There are observed a significant difference between the gender distribution of respondents in their classification. The male proportion of respondents was 54.6%, somewhat larger than the number of female respondents. The majority of male farmer's participants may perhaps remain the outcome of males having more farmland access than females. It might also happen because farming is labor-intensive, and women may struggle to meet the needed effort to cultivate significant crops. This view is supported through Abubakar *et al.* who found that most male farmers 93%, while 7% were female, and Bhandari and others who indicate that around 90% of farmers interviewed were males [28,29]. But is contrary to the study conducted by Prince *et al.* who found less male farmers (21.7%) than female (78.3%), and Pornpimo *et al.*, who states that most Thai agricultural workers in their study were women (60%) and that the agricultural worker's characteristics in this research varied in terms of farm type [30,31]. The present study was different from the World Bank report of 2007 with a comparable number of female and male agricultural workers in Southeast Asia in 2007 [32], indicating that the agricultural labor force constitutes 60 to 80 percent of females in emerging countries.

The report postulated that the recent increase in the number of women agricultural farmers are due to drivers of the economy that force more men to migrate to urban centers where their services are needed in the industrial or other money economy jobs; though, it may perhaps remain that women are more willing than men to be subjects in their study. However, as demographics shift and turn out to be more technologically advanced, adolescents are realizing that farm products due to hard work and high cost depend on uncertain income because of the dependence on crop prices and weather patterns. It is interesting to note that there has been a shift in the people involved in agriculture in Kano State. Gradually adolescents leave the rural areas and migrate to the urban centers to find jobs in the service or manufacturing segment. They arrived home to provide agricultural assistance on the farm and in the family garden once required. The study participants were young people between the ages of 36 and 45. Meaning that the mean age reflects the positive attitude of labor in agricultural production. While, this is very useful on productivity for positive effects, as adolescent farmers are very active and tend to use novel technologies. These findings are consistent with the study was done by Bhandari *et al.* who found that 47% were between the age range of 30-49 years and 50 years old were more than 23% [29].

This Bhandari study was an outcome of a stratified sampling technique to minimize its impacts on the sizes of the small cell by tilting the frequency distributions in the Bhandari study. Similarly, this view is contrary to the study conducted by Prince *et al.* who found that 46-55 years (34.8%) was the largest group in the study who engaged in farming activities [30]. In our study farmers' education levels ranged from no formal education to a doctorate, the majority of farmers had an education level of SSCE or its equivalent (36.2%), whereas the least had a post-graduate degree (1%). This shows that the educational level of the responding farmers is strongly influenced since most of them have at least a secondary education. Education revolutionizes human attitudes. It supports people to know their environment to solve numerous snags. Meanwhile, these results are similar to those of Bhandari *et al.* who estimated that around 30% of farmers are uneducated and the remaining farmers have different education levels, which include primary (23%), junior secondary (20%), secondary (19%) and college (8.7%) [29]. Research shows that farmers who are educated are better positioned to accept and understand the health effects of pesticide information, likened to those with low education and that human capital studies have also shown that farmer education plays a remarkable role in the allocative and skills development of farmers [33,1]. However, this view is

contrary to the study conducted by Islam *et al.* who found that the majority of respondents (51.7%) had no education knowledge [34]. They could neither read nor write and 35.0% of the participants had basic education. Approximately 11.7% of the participants have completed secondary education, and only 1.7% of the participants have completed higher school [34]. Similarly, Prince *et al.* found that 48.9% of the farmers had no formal education [30]. Hanif also stated that farmers who are educated were extra careful with the use of pesticides and their environmental impact [35]. A significantly higher proportion of the participants in the present study were married (60.7%) compared to single participants (33.9%).

This finding is similar to that of Bammeke, who argued in his study, that people who take on agricultural practices were married [36]. Similarly, this view is consistent with Prince *et al.*, who found that 25.0% of farmers are single while 69.6% were married and 5.4% were divorced [30]. This suggests that married respondents were more likely to experience the problem than those who responded from other groups, and therefore the example was **a** demonstrative model of the community configuration Our results showed that 46.2% of the farmers had between 1 and 10 years of experience while 47.7% had between 11 and 20 years' experience and 6.1% have above 20 years of experience. This indicated that the individuals engaged in farming activities were experienced in farming.

This view is contrary to the study by Prince et al. In which it was noted that 72.8% of the agricultural farmers had between 1 and 10 years' experience while 27.2% had between 11 and 20 years' experience [30]. Also, Islam *et al.* found that the majority of respondents (60.0%) had farming experience between 16-20 years, whereas 23.3% of the respondents had the farming experience of 10-15 years, 6.7% of the farmers had 21-25 years' experience in farming, 6.7% of the farmers had obtained 25-26 years of agricultural farming knowledge, and only 3.3% of the farmers had 36-40 years' of farming experience [34]. Research by Islam *et al.* shows that experienced farmers have a good knowledge of agriculture and they know a lot about the effects of pesticides on the environment [37]. The size of the farm varied from one individual to the other and farm size is measured in ha in the area studied. The highest percentage (43.4%) of farmers had a farm size of 0.5-2 ha, while 38.5% of respondents had between 2.5-4 ha, 18.1% of respondents had above 4 ha.

4.2. Most Commonly Used Pesticides by Farmers in Kano State

Globally pesticides are an important and growing component of the 21st century, which is widely used for pests' control, weeds, diseases, and other pathogens of plant, to decrease or eradicate crop losses and to sustain high quality product. Even if pesticides are considered poisonous and a high risk to farmers who are exposed, pesticide use among farmers in Kano is relatively high and farmers in Kano practice farming involving both subsistence and commercial, while using huge pesticide quantities. It was noticed that the most commonly used pesticide Cypermethrin (33.6%) was applied often in Kano, followed by Apron plus (31.3%) and Primextra (31.3%), Atrazine (12.0), Sevin (9.7%), Thiodan (8.5%), Fusilade (4.8%) and Other (unidentified) (12.0%). Unexpectedly, in some parts of Kano State, it was observed that people consumed pesticide-treated seedlings copiously knowing that these seedlings could be harmful to their health. This view was contrary to a study conducted by Abubakar *et al.*, who found that the pesticides mostly used by agricultural farmers were known as Apron Plus (93.8%), followed by Sevin used by 80.5% of farmers [28]. The other pesticides include Cypermethrin (73.4%), Fusillade (59.4%), Primextra (51.6%), Atrozine (19.5%), and Thiodan (19.5%). All this suggests pesticides play a remarkable part in the control of pests and growth efficiency.

Even though, the pesticide's detrimental effects on human health and the environment in the global south have been around for more than a decade, despite the concern that has been expressed. Also, this view is contrary to the study conducted by Denkyirah *et al.*, who found that most (85%) of the participants showed they used chemicals for pests' and diseases control, whereas 15% of the agricultural farmers used other pesticides to control pest, which includes integrated pest management (IPM) and integrated crop management [38]. The farmers who depend on pesticides

for pests and disease control (85%), both used pesticides approved and recommended by the Ghana Cocoa Board and pesticides that are not approved by the Ghana Cocoa Board. The choice of farmers' unapproved pesticides was founded on its usefulness in pest and disease control (43.1%), market accessibility (25.5%), affordability (18.1%), and fellow farmer's suggestions (13.2%) [38]. In addition to the commonly reported pesticides used by farmers in Kura Local Government are due to poisoning (Table 2), many substances were listed as moderately hazardous and slightly hazardous, mostly pyrethroids, phenylamide and s-metolachlor compounds, and are frequently used or stockpiled in homes. This shows a consistent relationship between the distribution of pesticide and successive human exposure, and also shows the value of distributed information on pesticide constituents as a potentially useful means of surveillance through an exposure proxy. Notably; at least three (3) commonly agents responsible for the poisoning in this research include [cypermethrin (pyrethroids), apron plus (phenylamide), and endosulfan (organochlorine)] were hitherto reported in Tanzania due to pesticide poisoning [39].

Likewise, the WHO class I products were not reported as a key source of toxicity in this research, probably since such products are now registered in Nigeria for "restricted use" and therefore were not used by farmers on small scale. A highly toxic pesticide ban has proven to be an effective approach for mortality reduction in Sri Lanka [40]. Reported Endosulfan, in this research, and seen been stored in households, belonging to the persistent organic pollutants (POPs) group. It is previously remained restricted in over 56 countries due to its major environmental impact and toxicity [41]. About chronic toxicity, extremely harmful endosulfan is lethal to aquatic life and endosulfan exposure has resulted in lives lost, especially in the global south [42,43]. The Sri Lanka intervention studies emphasize a ban on endosulfan since 1998, deaths due to Acute Pesticide Poisoning (APP) over a 3year period following the ban that has been reduced by 15 times in designated community hospitals [40]. Regarding acute toxicity, endosulfan is an endocrine disruptor, that mimics oestrogen with extremely low levels of exposure and is present in breast cancer.

It's a neurotoxin and is associated with Parkinson's disease, immune toxicity, and birth defects [42]. Endosulfan has been linked with children exposed to increased growth and reproduction effects on environmental plantations on cashew nut in India [40]. Built on this "accumulating evidence base", in 2011, the Review Committee met with the PIC and decided that endosulfan fulfills the inclusion criteria for the PIC treaty (Rotterdam). However, many nations engage in pesticide exportation, like India, have banned its inclusion to the "prior informed consent" (PIC) schedule [43,44]. Even with, India having half of nearly 9000 tonnes of endosulfan in its yearly production. The court banned delivery in June 2020 by order of the Supreme Court of India at the request of the "Democratic Youth Federation of India" to quantify the toxic health effects of pesticides [44]. Which is why the study makes available further evidence. to give support to the endosulfan introduction into the list of PIC. Additionally, nations such as "Burkina Faso, Cape Verde, Gambia, Mali, Mauritania, Niger and Senegal" etc., are affiliates that include Sahelian Pesticides Committee (CSP), have banned the use of endosulfan since 2008 end.

This is the final regulatory action to be carried out to guard the health of humans and the milieu. This activity is based on the risk appraisals of hazard, taking into consideration, local situational exposure for pesticide operators, including the aquatic ecosystems. These substances were found to pose an unacceptable risk for operators, families inhabiting in or close to cotton fields, including the aquatic ecosystems. The supporting notice's credentials indicate precise risks. The risk assessments associated with the Sahelian countries such as hazards assessment to the health of humans (high acute toxicity) and to human contact (occupational exposure), produced in the USA and Australia using examples, taking into consideration the prevailing context in the Sahel (hot climate, inadequate training, lack of PPE). Hence, the assessments meet the risk appraisal criteria [45]. The prevalence of WHO Class II pesticides use (33.6%, 31.3%, 9.7%, and 8.5% respectively) in this research is less than hitherto reported (64% and 76% correspondingly) through a conducted study by Tanzanian farmers' [39]. An earlier conducted research in 1991 – 1993, besides the observed changes that could be due to different conditions in Tanzanian practice of agriculture through the introduction of products that are novel, especially pyrethroids. Cypermethrin is known as a synthetic pyrethroid widely used in

agricultural insecticide at large-scale. In soil and plants, it easily degrades. Pyrethroid pesticides have a shorter life duration with toxicity that is relatively low. They have easy compounds degradability with the risk that is low on the milieu [46]. Though, pesticide misuse, abuse, or overuse can stockpile in the soil and make them harmful to the soil born micro-organisms, even at lower levels. Pyrethroid is a set of pesticides that can cause "diarrhea, headache, convulsion, excessive nasal mucous discharge, sudden swelling of face, vomiting, sweating, eyelids, lips, mouth and throat tissues, hey-fever such as signs and reduced release of brain hormone" [47]. Many of these products are used in export crops [48].

This condition is reflected in the same components in the structure of the substances most frequently considered as poisoning causing. Alternatively, some agricultural farmers can use other methods of pest control like "Integrated Pest Management (IPM)" which decreases their dependence on other chemical pesticides that are toxic. In Tanzania after 1993, IPM control management was presented and comprise of the airtight containers use for storage, botanicals, and inert materials like dust, cow dung, and ashes to shield maize that is harvested and powdered neem seed, pyrethrum dust, and synergized pyrethrum for universal pest's storage and pheromones use in trapping field insects [43, 49,50]. Triazines are also a cluster of chemicals that breaks down the vitamin metabolism that causes skin and eye irritation, vomiting, nausea, diarrhea, salivation, and muscular weakness. Its longitudinal effects comprise disturbance in sperm production, liver and kidney damage, adrenal damage, a carcinogen, kidney, and urinary tract stone formation, lungs, and groundwater that is contaminated [51]. The results of the analysis revealed that 46.2% of the farmers had been using the pesticide for 1-5 years, 48.1% had used it for 10-15, 2.3% for 16-20 years, and 3.4% of the respondents had used pesticides for more than 20 years. This view is contrary to a study conducted by Kofod *et al.* who state that (42.9) of the agricultural farmers indicated they had been using the pesticides for 1-10 years, 31% had used it for 11-20 years, 11.9% had used it for 21-30 years and 14.3% had used it for over 30 years [52]. In the current study, 45% of the farmers knew about the use of pesticides through retailers, 36.8% heard about it from co-farmers and 18.2% of the respondents heard about pesticide use through consultancies.

These data were buttressed through research conducted by Philbert *et al.*, who found that the majority (85.7%) of the respondents knew about the use of pesticides through retailer shops and 14.3% heard about it through other means [53]. During the survey, some farmers were asked on pesticide's information, however, it was noticed that they did not understand the labeling in English, and others are unaware that it was branded in two languages (Swahili and English). A total of 109 farmers, representing 31.1% of the respondents, stated that their main purpose of using pesticide was for weed control, 14.5%, 14.5% and 39.9% of the respondents said that their main purpose of using pesticides was for pest control, rodent control and fungi control, respectively. This view is contrary to the study conducted by Sapbamrer and Nata, who found that the majority of frequently used pesticide in rice field remained insecticides (84.6%), followed by herbicides (63.2%), fungicides (7.1%), and acaricides (6.6%), respectively [54]. Insecticides and herbicides, with several trade names, including the most frequently used pesticides in the current study (data shown in Table 2).

4.3. Effects of Pesticides use on Farmers' Health by Monitoring the Frequency of Self-reported Symptoms in Kano

Health is one of the most significant components of the human capital for rural people in emerging countries. The study participants highlighted the potential risks of the use of pesticides and their adverse effects on the environment and health. The farmers associate the potential symptoms from the exposure of pesticides linked to the acute poisoning toxicological effects. This could be as a result of the majority of them were knowledgeable and several of them had experienced some of these mentioned symptoms. Results of the analysis of the regularity of these symptoms reveal that the majority of the respondents experienced these symptoms regularly: 56.1% for headache, 53.8% for stomach cramps, 56.5% for muscles weakness, 56.8% for vomiting, 58.3% for dizziness, 40.7% for shortness of breath, 45.5% for blurred vision and 66.7% for eye irritation. These results are not in

tandem with the Bhandari *et al.* study which showed that nearly all agricultural farmers alleged having symptoms of acute health after using pesticide [29]. In the study, self-reported toxicity is the most often symptoms linked to pesticides, which include headache (73.8%), skin irritation (62.3%), eye irritation (32.8%), weakness (22.4%), and muscle pain (19.1%). His results are in agreement with previous research in Nepal and Vietnam [55,56].

Conversely, this result is not consistent with the research of Maria *et al.*, which shows the majority of common symptoms include cephalea (77 persons or 51.7% of 149 intoxicated patients) trailed by dizziness (48 people) and vomiting (42 people) [57]. Below half of the farm employees identified cephalea (29 people) considered this sign by way of the physical appearance of pesticide intoxication (self-examination intoxication). On one hand, over 50% of all people who report diarrhea and those who report dizziness, vomiting, and stomach discomfort identified themselves as intoxicated. Further signs identified by the farm employees in their study included blurred vision, loss of appetite, burning face, fatigue, body itching, fever, ringing in the ears, and spots on the body. Also, less than half of the 149 people who identify signs after pesticides use identified themselves highly intoxicated through these products. Cases of self-reported intoxication with a higher incidence among younger workers have been reported by Yassin *et al.* and recommended that these people could express themselves through the interviews better [58].

Some recent studies have shown an applicator with illness or symptoms leading to visiting the health care provider which may not be possible to remember this incident than others who ensured not to seek care [59,60]. Symptoms identified in this study include dizziness, cephalea (headache), abdominal pain, and vomiting are specific pesticide exposure, such as the organophosphorus and Carbamate insecticides [61,62]. Similarly, the finding is not consistent with a study conducted by Gurung and Kunwar [63], which showed 96% of the respondents knew skin irritation as a poisoning symptom from pesticides use, which is not consistent with the study of Lekki *et al*., which shows 66% of the respondents had awareness regarding skin irritation [64]. The findings of Gurung and Kunwar showed that 98% and 96% of the respondents knew dizziness and headache as poisoning symptoms of pesticide use in the nervous system [63].

This is contrary to what happened in this current research, as the findings of Lekei *et al.,* is not consistent with the study which shows 49% had awareness regarding dizziness and 66% about headache [64]. 84% of respondents were aware of nausea as poisoning symptoms of pesticide use in the gastro-intestinal system which is not consistent with Lekei *et al.*, which shows 34% had awareness regarding nausea [64]. The high frequency of the regularity of self-reported symptoms among farmers in Kano State reveals that the majority of the respondents experienced these symptoms regularly. This is less than what was stated in Kenya, due to the prevalence of episodes of poisoning (61.1% of agricultural workers reported four (4) or more prior poisonings) [65]. These data most probably indicate non-severe conditions because they go unidentified in the absence of an Acute Pesticides Poisoning (APP) surveillance program since they do not appear at the health center. These APP cases are closely monitored by the community based on self-reporting systems. The above-re-affirmed pesticide exposure to be one of the main remarkable occupational risks for farmers in the global south and to identify the risks associated with pesticides use and develop pesticide safe methods while handling pesticides.

However, most farmers in the study area do not have formal education and without any form of training, so they must be exposed to training and education on the dangers of pesticide usage. This is in tandem with Prince *et al.* who found that most of the agricultural workers were ignorant, and only an insignificant cluster are educated/ literate [30]. It was also shown that 48.9% of the agricultural workers are illiterate and lack knowledge on the appropriate use of agrochemicals, they merely use through learning from their seniors, which possibly will not always be right. Additionally, controlling pesticide usage through the regulatory system of proffered is well-known. Studies have shown that residual pesticide is a major concern for consumers that fears frequently when they buy farmed products and community concern around pesticides in their milieu, that their effects on human health are steadily increasing.

5. Conclusion and Recommendations

Smallholder farmers using highly toxic pesticides, particularly from the global south have become a trans-sectoral definitive 'wicked problem'. Wicked snags are an issue of effective advertising marketing methods, which are hard-hitting to accomplish due to variances amongst development partners in media outreach, response, and understanding by smallholder farmers to the problem ranging from 0.2 to 2.0 hectares [66]. For several smallholder farmers, pesticides that are cheap and hazardous in the short term have been effective and profitable thereby improving agricultural production, wages for temporary contract workers, and the survival of family [67,68]. This study highlights the potentially high risks of pesticide exposure to humans and the environment in a certain rural community in Kano State. This highlights the potential to exacerbate serious public health snag that could be prevalent in the state. This result finds has remarkable policy implications in adding to sound advocacy interventions particularly for policymakers in Kano State. Firstly, it is important to inform farmers about the pesticide's effects on human health and to improve farmers' education about issues of pesticide safety and pest management.

The Nigerian government must do its best to convince agricultural farmers to lessen pesticide use. Disseminating more detailed information about pest management and associated information, including better education, extension services for agricultural farmers, and training. Subsequently, identifying alternative sources of chemical pesticides using lessening the farmer's health risk, which is also of grave significant in Nigeria. Pesticides substitution and improving seed quality and resistance to host plants can lead to less use of pesticides without reducing the yield of the crop [1]. Lastly, whereas the integrated pest management (IPM) concept has received robust support, the IPM expansion technology is, after all, a major issue for millions of households in Nigeria. Henceforth, the government ought to do its best to facilitate the development of short-term local pesticide spraying services, although the use of pesticides may still be necessary, however, the development of integrated pest management (IPM) strategies would reduce, if not completely stamp out pesticides use in the long term.

It can be said that the use of pesticides in agriculture has been increasing daily to cultivate and produce agricultural products. Kano State Farmers are more likely to use pesticides in their farming, regardless of the duration of their impact, whether they know it or not. Pesticide use knowledge and environmental impact are very significant. A few farmers in this study reported that they had other side effects such as dizziness, headache, blurred vision, skin irritation, vomiting, and the problem of eyesight irritation, etc. There is evidence that accumulating self-poisoning pesticide are among the most common approaches of suicide globally, nonetheless, the snag magnitude and the distribution of the worldwide death is unknown. In conclusion, the results of this study may be useful for different organizations in the design, implementation, and appraisal of ongoing development relating to a high extent impute based on agriculture and environment issues in terms of pesticide approaches. However, safety standards can solve many of the problems associated with pesticide use and handling. This comprises sales, storage, application, and disposal. The best way to define these standards is through proper labeling-verbal or pictograms. Labels can help agricultural workers distinguish chemicals and aid accurate and reliable information on suitable usage and disposal. Regulation through verbal labels is ideal for people/ societies who can write and read. Pictograms are an alternative for people/societies without writing skills; nevertheless, since this universal knowledge cannot be understood, particularly in the emerging countries such as Nigeria, multicultural mass communication and education is required.

Henceforth, the regulation of labels remains effective only if complementary investments are made towards training agricultural workers to read and interpret them. In the global south, substantially greater resources should be used to analyze and monitor the quality of products at the level of the retailer. Regulatory control of dealers, with a proper license, training, and supervision, not only advance the efficacy of the compound but also monitor human and environmental health. Likewise, application equipment must meet the minimum global standards. This would decrease the peril of unnecessary farmer's exposure to pesticides and good nozzles equipment that is appropriately

calibrated promotes effective chemicals use and avoids drift. However, pesticide use is increasing in the global south particularly through advances in agricultural practices. Undoubtedly, this area is considered a critical area of significant public concern, with farmers seriously considering controlling it, and an understanding of the truth about the use of pesticides and regulation will support the farmer's make a rational decision about their agricultural farming practices. After all, it is essential to improve the balance between the agricultural system and the production of better and healthier food, quantity, and quality. The benefits of this global diet and food security must be weighed against the risk of pesticide use. Improved theories established in all of these cases can begin to alleviate the situation. Similarly, community-led solutions are the most efficient way to provide researchers with remarkable last mile data for the networks they inhabit, especially in Kura community which may lack local professional science support.

This study suggests that the solution is to deploy participatory citizen-led initiatives that directly collect the missing "last mile" on commonly used pesticide data while simultaneously building local political capacity to manage complex systems through education, data collection and networking, visualization, and dialogue teaching. This study further recommends community-led initiatives to build an evidence-based dialogue teaching and data-driven capacity to solve complex local pesticides problem. Thus, "Eco-social policies" aim to shift behaviors or provide incentives for more sustainable pesticide management, while strengthening the resilience or adaptive capacities of individuals and communities while also achieving social goals. It is therefore crucial for both fair decision-making and fair outcomes, and thus to sustainable pesticide management.

Also, a crucial pillar in the considerations of pesticides is the "precautionary principle" and ought to be an important guide in policymaking regarding pesticide safety. Therefore, the following are recommended:

i Governments should provide literary education on all levels of organic agriculture and in relevant research centers.
ii Advocating for community awareness on pesticide safety measures through approaches including the community, legislators, private sector, decision-makers, and the administrators.
iii Endorsement of sound farming practices that is organic and ecological, holistic and suitable for local farming practices that remain undisruptive to the social, economic, gender, and cultural considerations.
iv Regulating the dependence of agricultural farmers on artificial products like the use of harmful pesticides to the milieu.
v Promoting and supporting agricultural practices that encourage biodiversity preservation and guarantees wholesome food and quality products that are good.
vi Provide appropriate risk criteria for evaluation and necessitate that such evaluation is carried out in Nigeria and not overseas.
vii Requires that farmers should be represented throughout the boards that are associated with agriculture pesticides.
viii Promote agriculture production patterns that have minimal environmental footprints.

6. Study Limitation

The chief limitation of this research is the use of self-report to describe the case. Even though it is frequently applied in several countries, this method is probably to overemphasize the problem triggered by exposure to pesticides. Also, long-term studies will require providing additional evidence to the causality of associations assessed in this research. Another snag may be related to the incentives (financial or otherwise) for research respondents, based on a past understanding of farmers' in large foreign financial research projects. The inability to pay compensation could have prevented some farmers from partaking. In contrast, farmers with previous pesticide histories of poisoning are more likely to participate.

However, the magnitude of the non-participation was low so was improbable to make an immense change to the findings. Moreover, participants knowledge of pesticides is poor, which include the failure to identify pesticide product by its trade name or common name and classification, which could have contributed to poisoning agents misreporting or improved the number of poisonings as a result of unknown agents. Therefore, the classification snag due to WHO Class I and II pesticides could be noticeably underreported. What the farmers show about the symptoms of the disease cannot be recalled if the details are forgotten. Even with having some hazards awareness and exposure routes, farmers will not be able to combine all the signs with specific exposure. As a result, this may have resulted in an underestimation of the reported pesticide linked with the association of poisoning symptoms and products handled.

Competing interests: We affirm that we have no conflict of interest that may be alleged as prejudicing the impartiality of the study reported. This researcher did not receive special assistance from the government, not-for-profit sectors or commercial institutions.

Consent: All the authors announced that they had received written notice from the participants.

Ethical Approval: Ethical approval for the study was sought and gotten from the Institutional Review Board of the Kwara State University. Permission to carry out the research, as well as written consent, was also obtained from the farmers after explaining the purpose of the study to them. This was done by meeting the Kano State Farmers Association. Furthermore, the purpose of the study was again explained to participants before completing the self-administered questionnaire. Participants have assured confidentiality and informed that their participation was voluntary. Respondents were advised not to indicate their names on the questionnaire to ensure the confidentiality and anonymity of the information provided.

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