MERIT RESEARCH JOURNALS
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Merit Research Journal of Medicine and Medical Sciences (ISSN: 2354-323X) Vol. 8(8) pp. 432-447, August, 2020
Available online http://www.meritresearchjournals.org/mms/index.htm
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DOI: 10.5281/zenodo.4008682

Original Research Article

Qualitative Adverse Health Experience Associated with Pesticides Usage among Farmers from Kura, Kano State, Nigeria

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Abstract

The battle to combat pesticide use in Kano State appears uppermost in the mind of the state government. Efforts are therefore, geared towards effective protection of the human and environmental rehabilitation. Hence, understanding the health and environmental risks posed by chemicals pesticides released into the environment is an important context for decision making in which emerging data streams may play a significant role. Over the following year, a range of studies that evaluated the potential impacts of chemical pesticides on development and growth in areas of skin irritation, hypersensitivity, reproductive abnormalities, neurological and behavioral disorders, cancer, premature hair greying, miscarriages, DNA mutation and genetic damage, and effects on biological processes can be the results of pesticide contamination in water, and food commodities. In such circumstances, it is critically important to interpret information from rapid assessments into forms that place high value on health protection and err on the side of precaution. This study assesses the effect and health problems associated with exposure to pesticides application among farmers in Kano State, Nigeria. A structure questionnaire was developed focusing on sociodemographic characteristics, knowledge and experience of adverse health effects related to pesticide use, details of work practices and an inventory of pesticides used on the farm. Of the 400 copies of questionnaire administered 392 copies representing 98% of the administered questionnaire was retrieved and found useable. Majority of the respondents (76.9%) were aware of the side effect of the use of pesticides with only 23.1% of the respondents not aware of the side effect of pesticide use, it can be deduced that less than half of the farmers who use insecticides are aware of its effect on the environment. This results add to the body of literature that examined the effect and health problems associated with exposure to pesticides application among farmers in Kano state, Nigeria. A far better solution would be to conduct testing prior to commercial use or storage of a chemical to ensure that the information is complete and immediately available in the event of an environmental release. An example of this trend highlights the potential to develop health and environmental fate/exposure data to make rapid predictions of chemical effects upon release into the environment during an emergency. This will help demonstrate new methods to support decisions about chemicals in the environment. Although, there is a need to consider both the scientific validity of the new methods and the values applied to a given decision using this new information to ensure that the new approaches are used to improve public health and environmental protection. Additional research on biomarkers of exposure may be required to provide a comprehensive assessment of the risks of environmental pollution to farmers in Kano State.

Keywords: Public health and Environmental Protection, Biomarkers, Farmers, Chemical Pesticides, Potential Impacts, Genetic damage.

INTRODUCTION

Danger lurks around the corner for Kura farmers in Kano State, which are already facing challenges from all manners of pesticides exposure due to her over dependence on pesticides as the only veritable source to increase crop yield and has become an albatross due to its health effect. This, of course, should worry the State and Federal Government. It would appear that Kano is an agro-economy based state, where most population depend on agriculture, which has gradually become an important part of the Nigeria economy and agriculture is vital for development of society and economy. To this end, it is inevitable that enormous variety of pesticides will be used in agriculture to reduce the impact of pests on crops (Liu *et al.,* 2012). Besides, plant protection products, or pesticides, are not only used to protect fruits and vegetables from pests, diseases and weeds, but also to ensure a good harvest and associated cost. Their widespread use in global food production is reinforced by the demand for high cosmetic quality (colour, shape, defects) on the export markets for fresh fruit and vegetables (Okello and Swinton, 2011 cited in Isah, 2019). In general, the use of pesticides reflects the economic goal of maximum productivity at minimum costs, which translates into an intensification of agricultural production. This increase is seen as a solution to food security concerns. On the other hand, questions arise when pesticides used for securing food production jeopardize food safety. Modern agriculture is largely dependent on the use of chemicals. It is estimated that 150 million tonnes of fertilizers and 6 million tonnes of pesticides are used each year to increase agricultural production in fields and crops (Bernhardt *et al.,* 2017). While it appears that the use of herbicides can increase crop yields in many crops (Gianessi, 2013). It also seems that many fungicides and insecticides also do not appear to be successful in increasing yields (Lechenet*et al.,* 2017). On the other hand, the ecological risks of the release of these chemicals into the environment have been ignored by the general public when those who claim to increase the number of people fed at all costs (Jeschke, 2016), including health, economic and environmental costs (Pop *et al.,* 2013; Wilson and Tisdell, 2001). Pesticides considered an essential component to the continued functioning of agriculture occupy an important place in modern agriculture. Indiscriminate use and inappropriate handling of pesticides in agriculture have caused serious health problems in the Global South, including Nigeria, which represent 30% of the global pesticide consumer market (Peres *et al.,* 2006). Organophosphate (OP), Carbamate (CM), Cypermethrin, Primextra and Apron insecticides are frequently used to spray crops in Nigeria, particularly in Kano State (Raimi *et al.,* 2020). Although pesticides have good benefits for crop yield, insufficient protective measures to deal with the harmful effects of pesticide are a major health issue in the crop growing areas. Farmers who grow crop are more predisposed to adverse health effects of pesticides because spraying is required regularly on the broad and succulent leaves for pest control (McDaniel *et al.,* 2005; Damalas *et al.,* 2006). Acute pesticide poisoning is a disease or health effect resulting from suspected or confirmed exposure to a pesticide within 48h (WHO, 2008). Depending on the toxicity of the compound, dosage and time of exposure, the symptoms of pesticide exposure vary from headache, vomiting, skin rash, respiratory problems and convulsions (Cornwall *et al.,* 1995). Plasma cholinesterase (PChE) levels are more reliable indicators than symptoms attributed to exposure, for assessing risk and monitoring of pesticide intoxication in agricultural workers (Dasgupta *et al.,* 2007).

General information on Pesticides

Pesticides are known human and environmental toxicants that are widely used globally to assure crop protection against pests and guarantee high crop yields (Hashemi *et al.,* 2012; Salameh *et al.,* 2004). Even though several products have been banned due to their acute and chronic effects (Verger and Boobis, 2013), pesticide applicators (PAs) are unaware that even modern pesticides retain a significant toxicological profile, with a consequent global health burden (Fan *et al.,* 2015). Even though two-thirds of the 350,000 annual pesticide-related deaths occur in developing countries, figures remain of significant relevance also for high income countries (WHO, 2004; Rios-Gonzalez *et al.,* 2013). In Italy, for example, a total of around 2,500 occupational cases of acute pesticide intoxications were identified between 2005 and 2011, representing 5% of all poisonings (Settimi *et al.,* 2010). Half a century ago, Rachel Carson expressed concerns about the pervasive use of pesticides, especially insecticides in agriculture (Yang *et al.,* 2014), creating a continuing environmental movement that has lasted till today. In the United States and other developed countries, regulations about the safety of individual pesticides were enacted in the 1970s, while most emerging and underdeveloped countries stayed unmindful to their negative effects (Strong *et al.,* 2007) until their frequent abuse impacted on human health (WHO, 2004; Settimi *et al.,* 2010) and exacerbate other deleterious environmental consequences (Hashemi and Damalas, 2010; Lekei *et al.,* 2014). Potential threats to people and the environment were identified before the introduction of new agrochemical product is launched to the market. So far, the study on human health impacts have been well known**,** the environmental impact assessments are carried out using inappropriate methodologies or techniques without sound scientific basis. It is not surprising that biodiversity deficits in aquatic ecosystems are associated with the use of pesticide residues in waters and sediments (Khan and Damalas, 2015; Van Hoi *et al.,* 2009), because the foundations and function of invertebrate communities have changed (Grovermann *et al.,* 2013). At the same time, the entomofauna has decreased in developed countries (Stadlinger *et al.,* 2012; Sam *et al.,* 2008) where populations of vertebrate species that depend on them have been declining as well (Chen *et al.,* 1998; Gatto *et al.,* 2016). The available data indicate our failure to accurately evaluate the environmental threats of insecticides and other agrochemicals on the natural environment. Some authors have recommended a post-registration monitoring approach to try to determine the unknown effects of direct and indirect routes on organisms by accounting for several propagation pathways and exposures" (Zyond *et al.,* 2010). This technique assumes that pesticides already registered can have unforeseen environmental effects, when the injury has now been done. It does not prohibit the use of a new product and does not guarantee their withdrawal from the market. In the past, studies have appraised the methods and inadequacies of the current approaches used to assess the ecological risks of agrochemicals (Yassin *et al.,* 2002) and have found faults due to our poor understanding of toxicological effects at the population and ecosystem levels. This article presents a new framework for assessing the ecological risk assessments (ERA), using past and present data to clarify and validate our standpoint.

Toxicity Assessment

The main flaws in this ecological risk assessments study varied from a dearth of understanding of the toxicity of chemicals on a large populations of organisms. The whole process depends on the amount of acute toxicity of a toxic substance to a small set of non-target species that represent the most important taxa, the so-called surrogate species in ecotoxicity testing, with only the chronic toxicity to mammals only. This approach is built on our knowledge of human toxicology, which focuses only on the individual level effects and regards such effects as carcinogenicity or mutagenicity as being very high, even if these are mostly irrelevant to animal species in the wild environment; Indeed, pesticides by their precise nature, are highly poisonous chemicals specifically designed to kill either animals (e.g. insects, worms, snails, rodents) or plants and fungi. They operate on a specific biochemical or physiological mechanism to the target taxa, so the individual organisms usually die completely before they can produce any long-term effects such as cancer. The results of teratogenic malformations are rare or are not caused by pesticides. Other substances, such as dioxins and trace metals, are often associated with these aberrations (Dickman and Ryglel, 1996; White and Seginak, 1994). Of course, tests that cause carcinogenic and mutagenic effects only affect human health, not the environment. Currently, the ecotoxicity assessments of agrochemicals depends on the median lethal dose (LD50) or concentration (LC50) of a specific chemical to the non-target surrogate species that are apparently present in a particular milieu. As cited above, this type of endpoints usually refers to acute lethality, frequently within a short time frame: from 24 to 96 hours for most organisms, even if a week or two are typical with earthworms. Chronic toxicity is only tested in experimental mammals (e.g. rats, mice or rabbits) because of its significance to human health. Current guidelines have also been proposed for chronic toxicity tests with bees (Hesketh *et al.,* 2016; OECD, 2016), but this can last up *to* 10 days since forager bees generally live 30 days and winter bees up to three months. Understanding the lethal potency of pesticide is very significant, but it is not the only way to evaluate their effect on populations of organisms. Animals, plants and fungi reproduce, that is they go beyond their individual losses, triggered by either pesticides or any other factor, by producing new individuals. This is particularly evident in the case of insecticide resurgence, whereby an insect pest that has been decimated by an insecticide application reacts by mass-producing more progeny, as the insect pest struggles to cope with a threat to its own survival. Similar results are expected in a number of populations of non-target species that can be influenced by the toxic effects of the insecticide: This is called recovery, and it allows the populations affected by the toxic chemical to survive for a long-term (Van dan Brink, 1996; Wijngarden *et al.,* 2005). So no matter how lethal a pesticide may be in the short-term, the survival of a few people's lives may be enough to bring the suffering populations back to their former levels. This also means that the amount of toxicity endpoints considers only the acute effects of a substance and is not sufficient to predict long-term impacts on the populations. Our planet, however, faces the most unprecedented loss of populations of species that live in agricultural landscapes and even though they are not the only target of the pesticides applied in those areas (Chamberlain and Fuller, 2000). While pesticides are not the only cause of this declines, they are due to habitat and food losses, but they also have a significant impact on the population collapses (Mineau and Whiteside, 2013).These decrease has been observed with insect pollinators (Cameron *et al.,* 2011), especially bees (Cameron *et al.,* 2011; Kosior *et al.,* 2007) and butterflies (Forister *et al.,* 2016; Gilbum *et al.,* 2015), including insectivore vertebrates such as frogs (Fellers and Drost, 1993; Lips, 1998), fish (Scholz *et al.,* 2012), small birds (Fuller *et al.,* 1995; Hart *et al.,* 2005) and bats (Clark, 2001; Stahlschmidt and Bruhl, 2012). Sound ecological theory states that a population of organisms will deteriorate because their growth rate is associated with lower mortality (Sibly and Hone, 2002; Walthall and Stark, 1997), as growth conditions continue downward trend will eventually result to its extinction (Tanaka, 1998). The loss of a population is more significant in ecological terms than the temporary loss of a few individuals which can be rewarded by recovery. Similarly, if the decreasing populations of the above-mentioned factors is related to pesticides, the toxicity assessment should be able to explain the physiological mechanisms involved in prolonged deteriorations.

Exposure assessment

The exposure assessments are currently performed using various of models, these models are needed to identify the possible consequences of exposure to pesticide all through the registration process, as products are not exported to the environment. For already use agrochemicals, the data obtained from modelling must be corroborated by real measurements through monitoring under diverse circumstances, locations and crop conditions(Sanchez-Bayo and Tennekes, 2015). Tissues bioaccumulation, degradability in environmental matrices and persistence are the significant features to explore. Bioaccumulate agrochemicals should initially be unregistered due to their adverse effects, as evidenced by the dark history of organochlorines and chlorfluazuron insecticides. These chemicals are still present in agricultural soils (Shivaramaiah *et al.,* 2002) and are transmitted to animal tissues (Braune and Malone, 2006; Nag and Raikwar, 2011). Current study methods are applicable nowadays and are well suited to measure all residues of pesticide present in the environment. In most studies, however, the highest levels of residue were not found due to the use of inappropriate sampling methods. This gives preference to the monitoring data collected, since the root of declines in the population of certain species are not ignored in the worst-case scenarios. Passive samplers passing through water or air can have integrated residues of measurements over a time period, including peaks and troughs, which gives readily improved data than available samples (Schafer *et al.,* 2011). In all case, the monitoring residue data should be examined for highest peaks as defined as the average or residues of the median concentrations in the matrices considered, plant products under study (e.g. pollen, nectar, fruit), soil, water or air. The only requirement for this assessment is to obtain a comprehensive set of variables that may be useful for the ERA. Thus, the only hindrance is the high cost of the analyses, which often prevents or reduces the surveillance efforts necessary for risks assessment estimates. There are cheaper alternatives (e.g. ELISA kits), but they are often used for screening purposes in routine quality tasks (e.g. to eliminate harmful detections in food or matrices in the environment) and are not an alternative for instrumental analyses.

Risk assessment

Existing ERA framework seek to integrate toxicity and contact assessments to a single appraisal that is used to register a novel product or to evaluate the environmental impact of studied pesticide(s) in a specific area or region. Pesticides currently have many ERA shortcomings present, many of which have been described in our earlier publication (Sanchez-Bayo and Tennekes, 2015), and thus not enclosed here. Emphasis will now focus on using a rational and analytical framework based on the novel ecotoxicity data described above. The initial tier of an ERA emphases on the chemicals screening that pose an undesirable threat to the surrogate test species. The standard hazard quotient (HQ) ratio used for this purpose is always an evaluation of pesticide acute toxicity (e.g. LC50, LD50, NOEL) in terms of monitoring trends expected in environmental concentrations in different media (e.g. air, water, soil), accepting any chemical that produces values less than 0.1. There are three reasons for determining this threshold value: i) the critical toxicity profile estimated in the first stage denotes a representative species of a tax on, but we know that differences in sensitivity between species in any one tax on variety at minimum order of magnitude (Kooijman, 1987 cited in Isah, 2019) hence, to account for the predictability of other species HQ related patterns should be 10 times lower; ii) the A well-documented history of DDT and cyclodiene insecticides showed that populations of affected predatory birds by eggshell thinning began to decrease when these insecticide residues in their bodies were 10 times lesser than the average effective doses that formed such an effect (Walker, 2001); iii) numerous mesocosm studies on insecticides show that recovery of aquatic invertebrate populations have a habit to occur when residue concentrations in water are near 0.1 x EC50 values (Wijngaarden *et al.,* 2005).

As a result, the values of 1 for HQ proportions is unreliable for LC50 or LD50 data and are not protective and must be lowered by a factor of ten. In the present system of pesticide registration, if the resulting HQ is greater than 0.1 for a certain surrogate species, the chemical need to undertake a another tier of appraisal that reflects secondary laboratory toxicity tests (e.g. acute toxicity to more species, microcosms) and trials in semi-field (e.g. mesocosms) or field environments, as such settings could reduce the differences in exposure of the organisms and their similarity, thus, the effects may not be as clear as the predicted of the original HQ values. It should be noted that these findings are only achieved using acute, short-term toxicity records. If the data available are not conclusive to make a decision, the third step may be taken to investigate other factors that may cause additional impacts due to sublethal effects (such as endocrine disruption and others). Under no circumstances are indirect effects expected. Current pesticides of ERA are site-specific that are used in agriculture, the risk assessment may indicate differences in species sensitivity distributions (SSD) for acute toxicity values to a variety of species in the first tier as an alternative of using HQ values, although SSDs are commonly used in the second-tier assessment. In this case, SSD data was used in probabilistic risk analysis

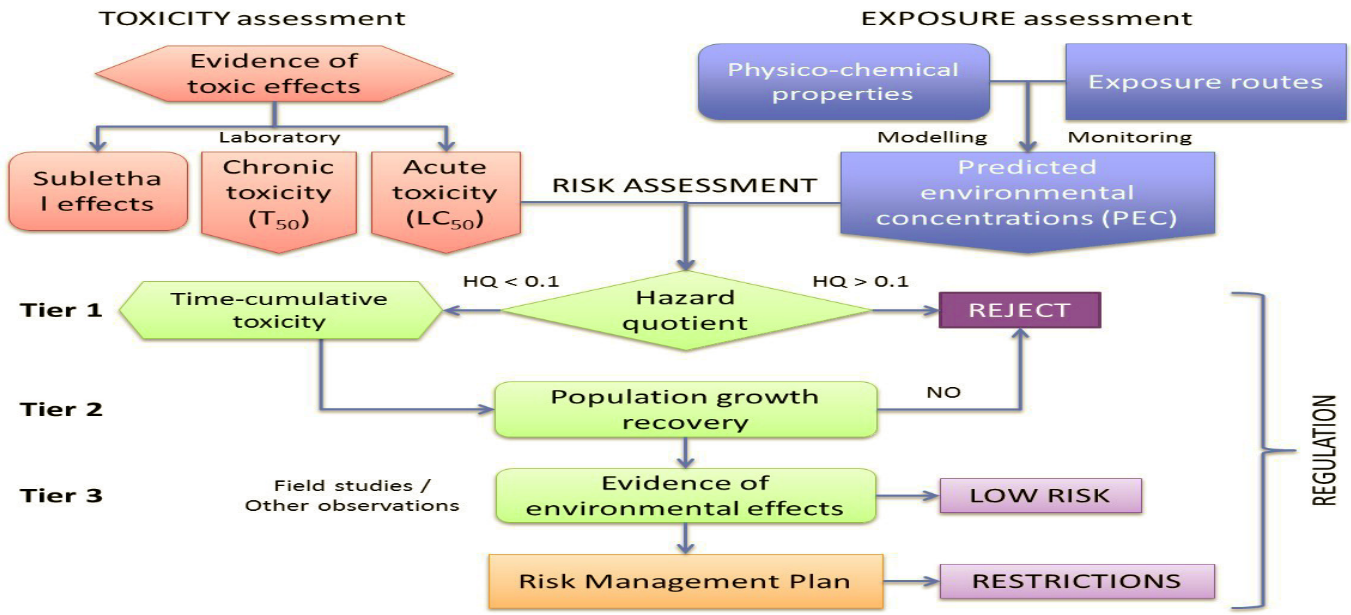

Figure 1. Proposed framework for ecological risk assessment of agrochemicals. Adapted from Sánchez-Bayo and Tennekes (2017).

(PRA) to estimate the coverage of the number of species that would be affected negatively by the highest or normal levels of residues predicted in a given milieu (Shi et al., 2014). Today, risk assessments are linked, if not significantly, based on acute toxicity data, evading certain toxicity effects that could lead to chronic exposure but are more sensitive to the long-term sustainability of a species in the natural milieu. A new starting point is projected, taking into account mortality in extreme conditions in the early stages under acute or chronic exposure, the population end growth in the second phase and sublethal effects such as endocrine disruption and other impairments in the third tier (Figure 1). The assessment of acute mortality endpoints may still be the same as before, but with an additional difference: Even if the HQ value is below 0.1, the chemical should not be given until it is assessed for its time-cumulative toxicity under sublethal chronic exposures (Figure 1).

All agrochemicals should be tested by TTE assays to ascertain if the chemical delays, time-cumulative mortality, while the chemicals produce HQ>0.1 should be removed from further assessments as they should be ignored. The reason for this is in line with our experience with a new class of neonicotinoid insecticides, which produce HQ values of below 0.1 for most brand of aquatic and terrestrial species using the acute 24 or 48-h LC50 or LD50 data, and yet produce a large proportion of mortality when exposed to the same species for a much lower concentration to a prolonged period of time (Alkassab and Kirchner, 2016). Such screening of chemicals is considered imperative – hence, its inclusion in the first group. Chemicals that act agonistically upon exact receptors, such as nicotinic or others receptors, usually cause delayed, time cumulative mortality because continuous growth of the receptor frequently leads to cell death. If the cell is unable to regenerate (i.e. neurons), this effect is unlikely, because the resulting pattern of toxicity depends not only on dose but also on the exposure time of sublethal levels (Tennekes and Sanchez-Bayo, 2013). For these chemicals, risk assessment should focus on ascertaining the average time to 50% mortality (T50) in the population at best and worst exposure situations,as described elsewhere (Sanchez-Bayo and Tennekes, 2015). In our view, chemicals that characterize this should not be trusted as a result of the long-term negative effects it has on the biological community. Once the initial level is determined, all chemicals products will be evaluated for their impact on population growth, which is an important factor in determining whether the species will recover after exposure, due to the types of techniques presented above, under normal and worst-case exposure situations. This level is important for assessing the result about the agrochemical effects being assessed so that the compounds that have no effect on the fecundity of the species and do not cause a significant rate of increase in the populations tested and should be acceptable for this assessment or else be ignored. In the same way, the history of DDT and cyclodiene insecticides suggest that although individual birds of prey that accrued these chemicals were alive and possibly healthy, their populations were still threatened with extinction simply because the hatching of their fragile, thin-shelled eggs failed; as a result, population growth rates has declined to ground levels below the natural replacement brink of the species and were unsustainable in the long-term (Sibly *et al.,* 2000). The sublethal effects that cause a serious impact on the long-term viability of populations are as significant or more than lethal effects in the short-term. Past studies such as this should be considered when designing the use of modern systemic insecticides that are implicated on colony collapses of honey bees, and other pollinators, especially because of sublethal effects (Smagghe *et al.,* 2013), and dismiss calls to the contrary (Blacquiere and Van der Steen, 2017). Further assessment should be considered as they are now, as the potential for joint community impacts can only be detected in microcosm or mesocosm studies, while the indirect effects on non-target populations can only be detected after years of using pesticides that are apparently harmless (Poulin *et al.,* 2010). Once again, we must learn from the harsh lessons of the past so as not to repeat them (Krebs *et al.,* 1999).

Objectives of the Study

The aim of this research is to examine the effect and health problems associated with exposure to pesticides application among farmers in Kano State, Nigeria.
The specific objectives are to:
i. Determine the health problems associated with exposure to pesticides among farmers in Kano state.
ii. To assess the effects of the pesticide's applications on the environment in the study area.

MATERIALS AND METHODS

Research Design

The descriptive survey research design was adopted for the study. The descriptive survey design according to Gift and Obindah (2020) is a kind of research design in which the researcher collects data from a cross section of the study population in respect of the variables. This design was considered appropriate for the study since it solicits information from a target group. The design involves collection and analyzing data gathered. Abdulraheem*et al.,* (2018), Funmilayo *et al.,* (2019) and Raimi *et al.,* (2019) described descriptive survey design as a type of design to be employed when a study involves the use of questionnaire to seek the opinion of the respondents. Abdulraheem *et al.* (2018), Funmilayo *et al.* (2019), Raimi *et al.* (2019) and Gift and Obindah (2020) 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 considering the fact that this study's primary objective centers on risk assessment associated with pesticides application on selected agricultural farmland in Kano State. The choice of descriptive survey design is premised on its value and facility in addressing the research problem raised in the study.

The Study Area

Location

Kano State is located between latitude 130N and 110N and longitude 80W and 100E (Figure 2). 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, DawakinTofa, Doguwa, Gabasawa, Garko, Garun Mallam, Gaya, Gezawa, Gwale, Gwarzo, Kabo, Karaye, Kibiya, Kiru, Kumbotso, Kura, Kunchi, Madobi, Makoda, Minjibir, Kano Municipal, Nassarawa, RiminGado, 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) (Isah, 2019). 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 prolong dry spell usually from the month of 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 the month of June to early September (Isah, 2019).Average precipitation ranges from 63.3mm + 48.2mm in May and 133.4 mm + 59mm during the month of 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 its forced to increase by means of convection or over a barrier of highland's or a mass of air; and it came like rain. Peak period happens when the sun sets across West Africa amongst March through June. The dry spell begins in the month of October then lasts until April of next year. Low temperatures are usually experience around this time as the sun faces 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 (Isah, 2019).

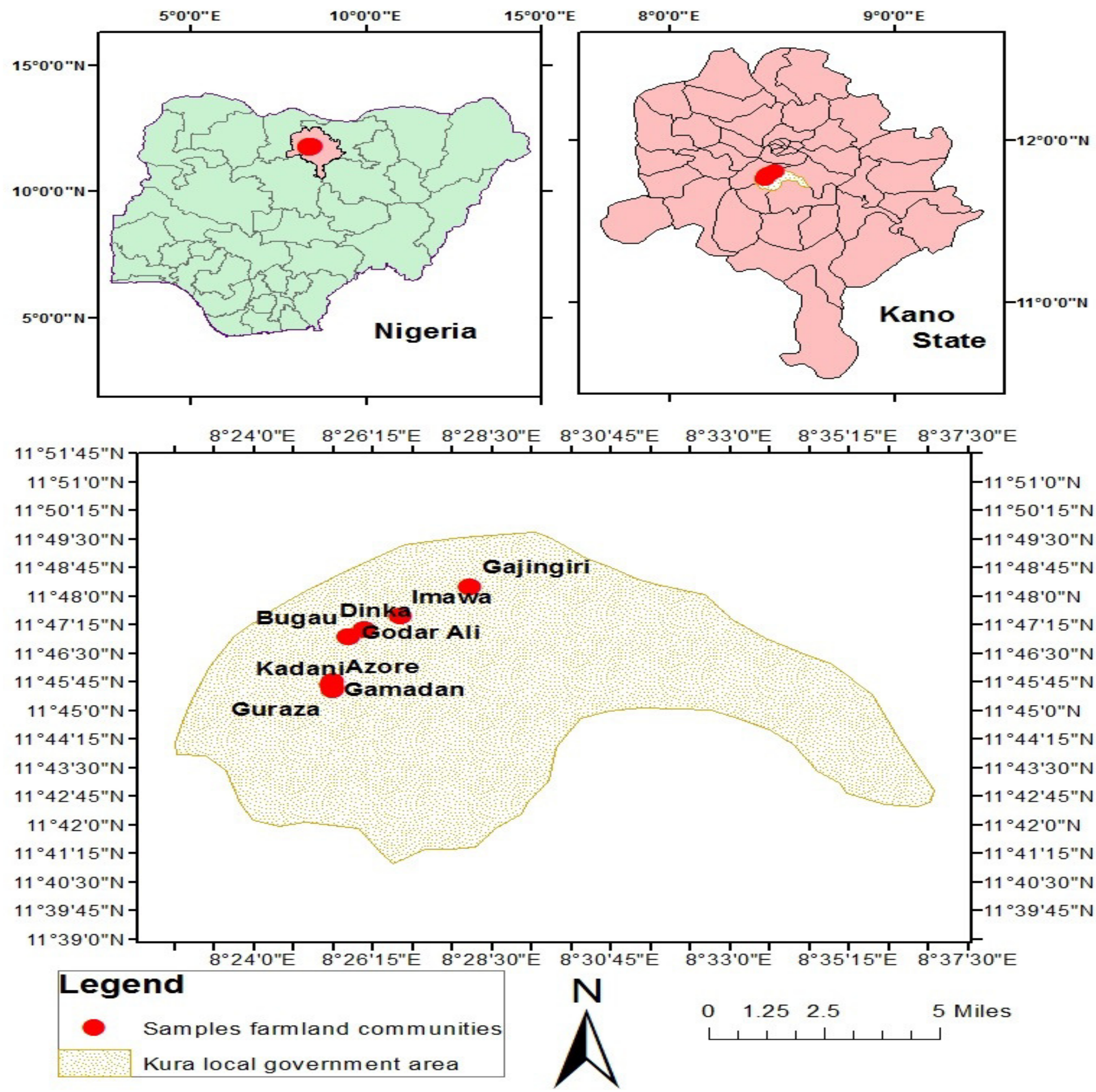

Figure 2. Map of Kano State showing the Study Area

Population and Sample Size

The population for this study comprised farmers in Kura Local Government Area of Kano State, North West, Nigeria. Based on available statistics based on 2006 Population Census showed that Kura Local Government Area has a total population of 143,094 people with 80% of them being farmers (Ayodele, 2016). Hence, the population of the farmers was estimated to be 114475. The population of the study was projected to 2018 using population growth rate of 2.47 percent as provided by the Nigeria population commission (NPC, 2006). The projected population was obtained as follows:

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

P_t = Projected population, P_o = population as at 2006, =114475, r = population growth rate (%) = 2.47% = 0.027, and t = number of years = 12.

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

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

Hence, the projected population of 153417 farmers in Kuru Local Government Area of Kano State was estimated.

Sample Size

A sample size of 399 farmers in Kura Local Government was estimated using Taro Yamane (1967). The sample size was estimated as follows:

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

n = Sample size to be determined, e = Level of significance and N = Population size.

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

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

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

$$n = 399$$

Sampling Techniques

The study adopted a multi-stage random sampling techniques in the selection of the sample. At the first stage of the sampling, the simple random sampling was used to sample of 10 villages out of the total of 26 villages in Kura Local Government Area. Randomisation was done through balooting. The selected villages are Sarkin Kura, Gamadan, Azore, Kadani, Guraza, Imawa and Godar Ali. At the stage of sampling, the simple random sampling was used to select sample of farmers from each of the selected 10 villages. To give each of the selected villages each number of farmers, the sample size was divided equally across the 10 selected villages and a sample of 40 farmers were selected from each of the village.

Instruments for Data Collection

Researcher-developed instruments entitled "Risk Assessment Associated with Pesticides Application Questionnaire" was used in data collection. The instrument comprised 25 items which focused on the different areas of research which include sex, marital status, age, educational qualification, farming experience, farm size and land ownership status, use of pesticides, common used pesticides, 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 safety practices adopted by the farmers in handling pesticides and the behaviours when using pesticides.

Validity of Instrument

The instrument was presented to experts for face-validation. Copies of the instrument 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 instrument in terms of language, clarity and content in line with the purpose of the study, research questions and the hypotheses it will measure.

Method of Data Collection

To facilitate data collection, the researchers engaged the services of four research assistants. The two research assistants helped in the administration of the data. The research assistants was properly briefed on how to administer the instrument. The instrument was administered within two weeks. Each of the research assistant covered two communities while the researcher also covered two communities. Out of the 400 copies of the questionnaire administered 392 copies representing 98% of the administered questionnaire was retrieved and found useable.

Methods of Data Analysis

Data obtained were analysed using frequencies, simple percentages, Chi- Square test and logistic regression. Frequency and simple percentages were used to analyse the demographics of the respondents and to answer the research questions. Also, result of the analysis of some vital results were also presented using pictorial representation like bar chart, cluster bar charts and other forms of pictorial representation. To enhance data analysis and computation of results, the Statistical Package for Social Sciences (SPSS version 20.0) was used.

RESULTS

Table 1 presents the demographics of the respondents. Result of the distribution of the respondents based on sex reveals that 54.6% of the farmers were male and 45.4% were female. Result also shows 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 while the remaining 15.3% of the respondents were above 55 years. In terms of their educational qualification, 20.2% of the farmers had no formal education, 31.6% had primary

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 degrees	4	1.0
Farming Experience		
1-10 years	181	46.2
11-20 years	187	47.7
Above 20 years	24	6.1
Farm size		
0.5-2	170	43.4
2.5-4	151	38.5
Above 4 hectares	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.

education, 36.2% of the farmers had secondary education, 6.4% were OND/NCE holders, 4.6% were B.Sc/HND holders while 1.0% had postgraduate degrees. Result also shows 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 hectares of land, 38.5% had 2.5-4.0 hectares of land and only 18.1% of the farmers had above 4 hectares of land. In terms of land ownership status, 52.3% of the farmers acquired their land through inheritance while 47.7% of the farmers acquired their lands through leasing.

Answering of Objective Questions

Objective 1: Determine the health problems associated with exposure to pesticides among farmers in Kano state

Table 2 shows that the majority of the respondents (76.9%) were aware of the side effect of the use of pesticides with only 23.1% of the respondents not aware of the side effect of pesticide use. Out of the 351 farmers who have used pesticides, 28.2% complained of pesticide related symptoms with 41.4% complained of headache, 39.4% complained of stomach cramps, 46.5% complained of muscle weakness, 37.4% complained of

Table 2. Health problems associated with exposure to pesticides among farmers in Kano State

Questions	No. of Respondents	Percentage (%)
Are you aware of the side effect of the use of pesticides		
Yes	270	76.9
No	81	23.1
Have you ever had any pesticide related health symptoms		
Yes	99	28.2
No	252	71.8
If yes, which of the following health related symptoms have you experienced		
Headache	41	41.4
Stomach cramps	39	39.4
Muscles weakness	46	46.5
Vomiting	37	37.4
Dizziness	36	36.4
Shortness of breadth	27	27.3
Blurred vision	11	11.1
Eye irritation	54	54.5
How often do you experience theses symptoms?		
Regularly	54	54.5
Occasionally	27	27.3
Rarely	18	18.2

Table 3. Effects of the pesticide's applications on the environment in the study area

Effects of the pesticide's applications on the environment in the study area	No. of Respondents	Percentage (%)
Do think the use of pesticides could affect the environment in the following ways		
Destruction of soil by reducing its quality	126	32.1
Harm to beneficial insects	134	34.2
Decrease in biodiversity	140	35.7
Pollute rivers and streams	160	40.8
Harm non-target organism	154	39.3

Multiple responses applied.

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. When they were asked about the regularity of these symptoms 54.5% said they experienced these symptoms regularly while 27.3% and 18.2% of the respondents experienced these symptoms occasionally and rarely.

Objective 2: To assess the effects of the pesticide's applications on the environment in the study area

Results presented in Table 3 shows that some of the effects of the pesticide's applications on the environment that respondents were aware of include destruction of soil by reducing its quality (32.1%), harm to beneficial insects (34.2%), decrease in biodiversity (35.7%), pollute rivers and streams (40.8%) and harm non- target organism (39.3%). From these results, it can be deduced that less than half of the farmers who use insecticides are aware of its effect on the environment. This is because less than half of these users of pesticides were able to identify the effect on its application on the environment.

DISCUSSION

A review of the samples in question

Before the results of the statistical analyses are observed, the samples in question needs to be reviewed so as to ascertain from what specific population the results were generated.

The socio-demographic characteristic, including sex, marital status, age, farm size, land ownership, educational levels and farming experience of the farmers regarding pesticide handling is shown in Table 1 above. There was a significant difference observed in the distribution of gender participants in their classification. The number of male respondents was 54.6% greater than the number of female respondents. This view is also supported by Abubakar *et al.* (2015) who found that majority, 93% of the farmers are male, while 7% are female and Govinda *et al* (2018) who reported that about 90% of the farmers interviewed were males. But is contrary to the study conducted by Prince *et al.* (2016) who found that male (21.7%) and female (78.3%) and Pornpimo *et al.,* (2018) who state that most Thai agricultural workers in their study were women (60%) and that the characteristics of the agricultural workers in this study varied by farm type This study were different from the report of World Bank with similar number of female and male agricultural workers in Southeast Asia in 2007 (World Bank, 2007). It was postulate that it found a higher percentage of women agricultural workers due to more recent economic drivers that push more men to move to urban areas where they are hired in manufacturing or other cash economy jobs; however, it could also be that more women than men were willing to be subjects in their study. However, as demographic shift occurred and become more industrialized, young people discover that the hard work and high cost of farming produces an uncertain income due to the dependence on weather patterns and crop prices. Interestingly, there has been a transition in the population engaged in agriculture in Kano State. Increasingly young people are leaving the rural areas and migrating to the cities to get industrial or service sector jobs. They return to help with the agricultural work on the family farm when needed. The 36-45year age groups were the largest groups in the study. However, these findings are consistent with the study done by Govinda *et al.* (2018) who found that 47% were 30 to 49years old and the remaining 23% were above 50 years old. This was as a result of the stratified sampling procedure. This was done in order to minimise the effect that small cell sizes have on skewing the frequency distributions. Similarly, this view is contrary to the study conducted by Prince *et al.* (2016) who found that the 46-55 years (34.8%) were the largest groups in the study who engage in farming activities. The largest levels of education were SSCE or its equivalent (36.2%)as against a minority of post graduate (1.0%) who had advanced level of education. Farmers education level ranged from no formal education to a doctorate with most (36.2%) farmers having completed SSEC or its equivalent. This shows that the literacy level of participating farmers was fairly high with the majority having completed at least a secondary (36.2%) education. Meanwhile, these finding is consistent with Govinda *et al.* (2018) who found that about 30% of the farmers were illiterate and the rest had different levels of education such as primary (23%), lower secondary (20%), secondary (19%) and college (8.7%). Studies have shown that educated farmers are in a better position to receive and understand information about the health effects of pesticides, compared with those with little education (Gomes *et al.,* 1999). However, this view is contrary to the study conducted by Prince *et al.* (2016) who found that the 48.9% of the farmer had no formal education. A significantly higher proportion of participants are married (60.7%) compared to participants who are single (33.9%).This view is supported by Prince *et al.,* (2016), who found that 23 (25.0%) were single while 64 (69.6%) were married and 5 (5.4%) were divorced. Meaning that respondent with marital status of married are more involved than respondents from other categories, thus, the sample was a representative sample of the community composition. On farmer's experience, it shows that (46.2%) had between 1and 10 years' experience while (47.7%) had between 11and 20years' experience and (6.1%) had more than 20 years' experience. This view is contrary to the study conducted by Prince *et al.* (2016) who found that 67 (72.8%) had between 1and 10years' experience while 25 (27.2%) had between 11and 20years' experience.

Health problems associated with exposure to pesticides among farmers in Kano State.

Nigerians population is projected to hit 410.6 million humans by 2050. This has necessitated the need to priorities raising agricultural productivity to achieve food self-sufficiency. One of the key factors identified as having the capacity to raise agricultural productivity and achieve food security is access to and efficient use of input, especially pesticides. The toxicity of a particular pesticides is not a direct measure of its human health hazards. It is an important clue to a potential hazard. However, until the mode of action of action of pesticides is better understand, estimates of toxicity to man must await experience based upon human exposure, either accidental or planned. The general toxicity by the common exposure routes viz: respiratory, oral and dermal (injection is seldom a route of human exposure to pesticides) is the most important guide to potential human hazards and thus to the type of protection that is needed. Acute effects are easily detected in man by observation of accidental exposures when they occur. Chronic effects may not be found either in animals or in man because the dosage was too low or the exposure too short, or for any one of a number of other reasons. Thus, it is never possible to prove that there is no chronic toxicity from a given material. Understanding of the health hazards involved with specific pesticides is simplified if they are grouped according to chemical structure.

Majority of the respondents (76.9%) were aware of the side effect of the use of pesticides with only 23.1% of the respondents not aware of the side effect of pesticide use. However, this is contrary to the work of Prince *et al.,* (2016) who found that majority, 53(57.6%) indicated that the use of pesticide was always good while 34(37.0%)

indicated that it was sometimes harmful and 5 (5.4%) said they don't know. Meanwhile, in the same study, it was found that majority 46 (50.0%) indicated that the use of pesticides damages human health, 23(25.0%) indicated that it damages water bodies while 13(14.1%) indicated that it damages animal health and 10(10.9%) indicated that it damages wildlife.The overall prevalence of self-reported health problems among these Kano (Karu) agricultural farmers, out of the 351 farmers was found to have used pesticide: 28.2% complained of pesticide related symptoms with 41.4% complained of headache, 39.4% complained of 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. This was contrary to the study conducted by Pornpimo *et al.* (2018) who found that asthma 3%; allergy 4%; diabetes 7%; high blood pressure 24%; heart disease 3%; cancer 1%; thalassemia 0.5%; hypercholesterolemia 7%; thyroid disease 3%; and arthritis 5%. Reported symptom by farmers in the past 3 months after they used pesticides included dizziness 26%, nausea/vomiting 13.4%, blurry vision 23%, cramps 17%, and sweating 34%. Different indicators symptoms were considerably different depending on the farm type; dizziness, nausea/vomiting, and sweating were reported most often by rice farmers and least repeatedly by flower farmers.

Effects of the pesticide's applications on the environment in the study area

Nigeria, a geographic space of inequality where wealth and suffering both coexist in abundance with so much wealth, many Nigerian also suffer so much on a range of issues, from education to health, infrastructure, food security and human insecurities. The snag, however is that modern advancement especially urbanization was built after the introduction of new forms and the widespread use of various chemicals. All of these substances serve an intended purpose for different periods. When their utility is expended, they construct a disposal problem. The elimination of pesticides is important since their usefulness is based on biological activity. Environmental pollution problems can have particular ecologic implications and the fear that pesticides could cause serious disturbances in the ecosystem has led to much discussion of the possible consequences and need for control. The most extensive recent investigations of the current situation were that conducted by the subcommittee on reorganization and international organization of the senate committee on government operations beginning in 1964 (United State Congress, 1964). This committee, under the chairmanship of senator Ribicoff (United State Congress, 1966) reported a consensus "that mankind must continue to fight insects and other pests in the most efficient manner possible". The present use of chemical pesticides constitutes a hazard to human health or to the productivity of our environment.

Some of the effects of the pesticide's applications on the environment and respondent's awareness include destruction of soil by reducing its quality (32.1%), harm to beneficial insects (34.2%), decrease in biodiversity (35.7%), pollute rivers and streams (40.8%) and harm non-target organism (39.3%). From these results, it can be deduced that less than half of the farmers who use insecticides are aware of its effect on the environment. This is because less than half of these users of pesticides were able to identify the effect on its application on the environment. This is not in tandem with Abubakar *et al.* (2015) who found that farmers' perception of the impact of pesticides on the environment include, soil destruction (54.7%), harming beneficial insects (28.1%), decrease biodiversity (61.7%) and air pollution contribution (48.1%). About 70% of the farmers believe that pesticides contaminate streams and rivers while the majority (80.5%) understand the harmful side effects of pesticides on non-target animals, birds and earthworms. The study found that farmers cultivating vegetable in the study area were aware of numerous concerns related to pesticides misuse.

SUMMARY AND CONCLUSION

Kano being an agric-based state, where a bulk of the population is reliant on agriculture. Improving agriculture sector is therefore still considered has the prime important to improve the economy of the nation's and meeting the nutritional requirements of the growing population. However, pesticides use and fertilizers arefrequently usedand improper management results in food and water bodies contamination, that could expose population to health perturb. Likewise, consumers exposed to manifold pesticides at the same time through use of numerous pesticide contaminated products. Manifold pesticide exposure can cause alterations in toxicokinetic stage (modifications with esteem to absorption, metabolism, distribution or excretion in the presence of other pesticide) or toxicodynamic stage (changes through related to interaction with target site) (Nyman *et al.,* 2012; Meek *et al.,* 2013).Pesticides have been shown to increase the levels of ROS (Karami-Mohajeri *et al.,* 2013) which inhibits lipids, proteins, DNA and mitochondrial membrane, causing several hypothetically harmful effects on cells that can eventually cause cytotoxicity (Yaduvanshi *et al.,* 2010). Oxidative stress is caused by various diseases such as Alzheimers, Parkinsons, asthma, cataracts, atherosclerosis, diabetes, aging of skin, and cancer (Furukawa *et al.,* 2017).

In turn, it has been suggested that prolonged exposure either environmentally or by occupational exposure to pesticides can escalate generation of ROS leading to increased oxidative stress resulting in genomic damage and oxidative stress can cause DNA damage in telomeric regions, thereby increasing the rate of telomere attrition. Therefore, more efforts are needed to support and monitor affected populations due to use of pesticide and also how to implement robust measures that can help reduce the influence of potential genotoxic damage. Future studies investigating the long-term exposure to pesticides by farmers in relation to DNA damage biomarkers including telomere shortening and methylation changes need to be replicated in larger epidemiological studies.

Given the ability to readily assess the hazard, exposure, and risk associated with chemicals pesticide is a pressing need for decision-makers across a wide range of decision contexts. The usefulness of the information provided by the new tools for different decision-making situations and levels of health partnerships is an important consideration in the development of these approaches. Although the emergence of a paradigm shift may be slow and incremental, increased understanding of the ways in which the application of new tools could increase or potentially reduce human health and environmental protections, allowing decision-makers to adjust the pace of incorporating new methodologies and data streams. Taking into account the prospects of Kano State food situation in the coming century and its ambition to contribute to food security policy, the improvement of intensive cropping system with increasing use of modern input will likely continue to be the dominant farming practice in Kano. Pesticides use is expected to increase and is expected to continue if no practical alternative pest management technologies, regulations, and policies are developed to effectively reduce the overuse of pesticides in the production of crop. However, chemical pesticide is a double-edged sword. In this study, it was demonstrated that both visible acute and invisible chronic health impairments and health costs were closely linked with the extent of their exposure to pesticides. This work therefore, aim to encourage the scientific community to study the chemical pesticides identified here, in particular to improve our understanding of the potential health consequences from exposures to chemical pesticides found in environmental media. In addition, research effort should be focused on a fit-for-purpose level of evaluation (i.e., the information provided by the method should fits the requirements of the particular decision context and value structure under to be used). Similarly, this study calls for a ban of pesticides from our food notwithstanding Federal Governments efforts to promote the use of pesticides in Nigeria, the continuous use of the commodity to the extent of dominating the local market, is making non-sense of an existing ban with attendant capital flight.

Data Availability Statement

The data availability used to support the findings of this study are included within the article.

Competing Interests

We declare that we have no conflict of interest that could be perceived as prejudicing the impartiality of the research reported. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONSENT

All authors declare that 'written informed consent was obtained 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 were assured of confidentiality and informed that their participation was voluntary. Participants were advised not to write their names on the questionnaire in order to ensure the confidentiality and anonymity of the information provided.

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