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Smallholder Farmers Perception and Awareness of Public Health Effects of Pesticides usage in selected Agrarian Communities, Edo Central, Edo State, Nigeria

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ABSTRACT: Strong evidence exists for long-term negative health outcomes from pesticide exposure including birth defects, fetal death, neurodevelopmental disorder, cancer, and neurologic illness including Parkinson's disease. This paper therefore examined the smallholder farmers' perception and awareness of public health effects of pesticide use in Edo Central, Nigeria. Data from 400 farmers were collected through questionnaires. Results revealed that most farmers relied on fellow farmers for information on pesticides (65.3%) rather than trained extension services (7.3%). Moderate toxic pesticides (WHO Class II) were commonly used, with a few cases of highly toxic pesticides (WHO Ib). Affordability (53.3%) and efficacy (41.8%) were the main factors driving pesticide purchases. The majority of farmers (63.9%) did not read pesticide labels before use, especially those with no formal education (77.2%) or basic education (57.8%) and those with less than 5 years of experience (54.6%). Reasons for not reading labels included reliance on success stories of other farmers (30.3%) and lack of clarity on labels (23.5%). Pesticides were often stored inside homes (43.3%), and used cans were disposed of with household waste (37%). Overall, farmers demonstrated a moderate level of awareness regarding public health effects of pesticide use. The relationship between farmers' awareness level of public health effects of pesticides use and socio-economic variables shows that level of awareness is not dependent on age ($\rho>0.05$, d=0.35), educational background ($\rho>0.05$, d=0.27) and years of farming experience ($\rho>0.05$, d=0.41). The study highlights the importance of training farmers on safe and proper pesticide use to reduce risks to human health.

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Pesticides are both plant growth regulator and chemical compounds e.g. herbicides, insecticides, fungicides, rodenticides, nematicides, molluscicides used to prevent and control pests in order to increase crop productivity (Aktar *et al.*, 2009; Gomez *et al.*, 2020). Over one thousand pesticides are being used around the world in agriculture to eliminate pests that harm crops, and for weed control. Pesticides have been

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noted to be potentially toxic to organisms and humans and need to be used safely and disposed of properly (WHO, 2020; Tudi *et al.,* 2021). These pesticides are among the leading causes of death by self-poisoning, with low- and middle-income countries bearing a disproportionately share of the burden (WHO, 2020) due to users inadequate and inappropriate use of Personal Protective Equipment (PPE), inability to follow safety measures among others. Public health refers to organized measures used to hinder disease, foster health, and elongate life among people in the society. Pesticide residues are a public health issue as they have been related to a number of disorders and diseases (Matthews, 2008). Due to the risk associated with the use of pesticides, some pesticides such as dichlorodiphenyltrichloroethane (DDT) and lindane have been banned by some countries because they have long shelf life which make them build up in the food chain and adversely affects a significant part of the ecosystem. However, people who work directly with pesticides, e.g. agricultural workers and those in the environs while pesticides are applied are highly at risk of these adverse health effects (WHO, 2020). Additionally, Smallholder farmers who specifically handle pesticides have high exposure probability to pesticides due to contact with pesticide residues on treated crops, unsafe handling, poor maintenance of spraying equipment, storage and disposal practices, and the lack of protective equipment or improper use of it (Litchfield, 2005; Matthews, 2008). These may be due to perception and attitudes of smallholder farmers (Atreya *et al.,* 2012), ignorance on best practice on pesticides usage and illiteracy (Karunamoorthi *et al.*, 2012) as well as inadequate information on pesticide hazards (Matthews, 2008) on the one hand, while literacy on the other hand allows for better access to information and knowledge of the risk associated with pesticide use (Damalas and Hashemi, 2010). Agricultural development is an important tool to promoting nation's economy and ending extreme poverty especially in developing countries (London et al., 2002). In Africa, agriculture remains a vital economic sector, employing a substantive part of the population, and accounts for 14% of GDP in Sub-Saharan Africa (Oxford Business Group, 2021). In Nigeria, agriculture accounted for 22.35% of the total GDP between January and March in 2021 with over 70% of the populace engaging in the sector (Statistica, 2022; FAO, 2023). With 70.8 million hectares of agriculture land area, maize, yam, cassava, rice, beans, guinea corn and millet are the major crops grown in Nigeria at a subsistence level (FAO, 2023), hence farmers use pesticides to reduce pest damage. To increase productivity, smallholder farmers use pesticides to hinder damage by rodents, insects, and molds as well as help to control growth of weeds which usually leave little quantity of pesticides on or in the food known as pesticide residues (Naveen *et al.,* 2012). According to Ingenbleek *et al.* (2019), pesticide residues in food have been linked to various diseases, including allergies, cancer, self-poisoning, irritability, and some problems associated with reproduction and birth. Increasing population in many sub-Saharan African countries and growing need for export have put enormous pressure on agriculture. Thus, the use of pesticide has become imperative in order to sustain high yields and profits (De Bon *et al.,* 2014). Studies have shown developing countries to have low compliance with pesticides safety rules due to lack of stringent legislation and regulations, lack of training programs for pesticide consumers as well as lack of efficient programs for personnel to inspect and monitor the use of pesticides (Ecobichon, 2001; Sosan *et al.,* 2018; Sosan *et al.,* 2020). However, even in developed countries where there are restrictions on pesticide use and preference given to organic food crops, the risk of significant production losses caused by pests hinders farmers' willingness to minify the use of synthetic pesticides irrespective of the effects on average profit (Chèze, 2020). Hence, there is need to investigate the perception and awareness of pesticides users on pesticides effects on public health. Several reports in Africa show wide usage of pesticides, but poor knowledge in handling the substance. Oluwole and Cheke (2009) revealed that 86.7% of the pesticides used by farmers in Nigeria were categorized by the World Health Organization (WHO) as highly hazardous that have been restricted or banned in many developed countries, and almost all the farmers received no formal training in safe application of pesticides. Adesuyi *et al.* (2018) revealed that small-scale vegetable farmers in Lagos wetlands were highly exposed to toxicity and health hazards of pesticides during preparation and application of pesticides due to lack of compliance to safety measure and ignorance among others. Similarly, Oshatunberu *et al.* (2023) found that exposure to food pesticides caused twenty thousand fatalities and over three million episodes of acute food poisoning. Adherence to instructions on pesticides labels, avoidance of splashing, spray drift, leaks and contamination of clothing in addition to storing them in a locked cabinet, building or enclosed area where unauthorized persons, children, pets or livestock do not have access to it have been noted as some best practices (UCIPM, 2019). Thus, understanding farmer's perception and awareness of public health effects of pesticides is vital to providing continuous trainings for small holder farmers to educate them on the risk associated with non-adherence and compliance of safety measures recommended for pesticides application which is the main thrust of this study.

MATERIALS AND METHODS

Research Design: The study adopted an exploratory research design, which was suitable for investigating a phenomenon with little or no previous research. This design allowed the researcher to gather preliminary data, identify problems, and develop hypotheses. The study also adopted a cross-sectional design, which enabled the researcher to collect data at a single point in time.

Population of the Study: The population of the study was smallholder farmers in Edo North Senatorial District of Edo State. The population was selected based on their occupation as smallholder farmers.

Sample Size: The sample size was determined using the formula for calculating sample size for a finite population. The formula is:

$$n = (Z^2 * P(1 - P))/D^2$$

Where: n = sample size; Z = standard normal deviation at 95% confidence level (1.96), P = proportion of population estimated to have knowledge, perception, and usage of pesticides (assumed to be 50%); D = margin of error (5%)

Using the formula, the sample size was:

$$n = (1.96^2 * 0.5(1 - 0.5))/(0.05^2)$$

Where n = 384

Though the calculated the sample size is 384 smallholder farmers, for the purpose of increasing the representativeness of the population, the sample size was increased to 400 per town. Hence 400 questionnaire was purposively distributed in the 20 farming villages (Fig. 1 &Table 1). Purposive sampling technique is a sampling technique where specific respondents were selected to collect specific information out of the data. The respondents were required to meet certain criteria for the objectives of this study involving the pesticide usage. The study area was chosen due its intensive reliance on smallholders farming operations and the fact that majority of the farmers use pesticides. Household heads, community and leaders who cultivate various cash crops that require the use of pesticides were interviewed. The study was conducted from January to May, 2023 among 20 villages in the Central part of Edo state.

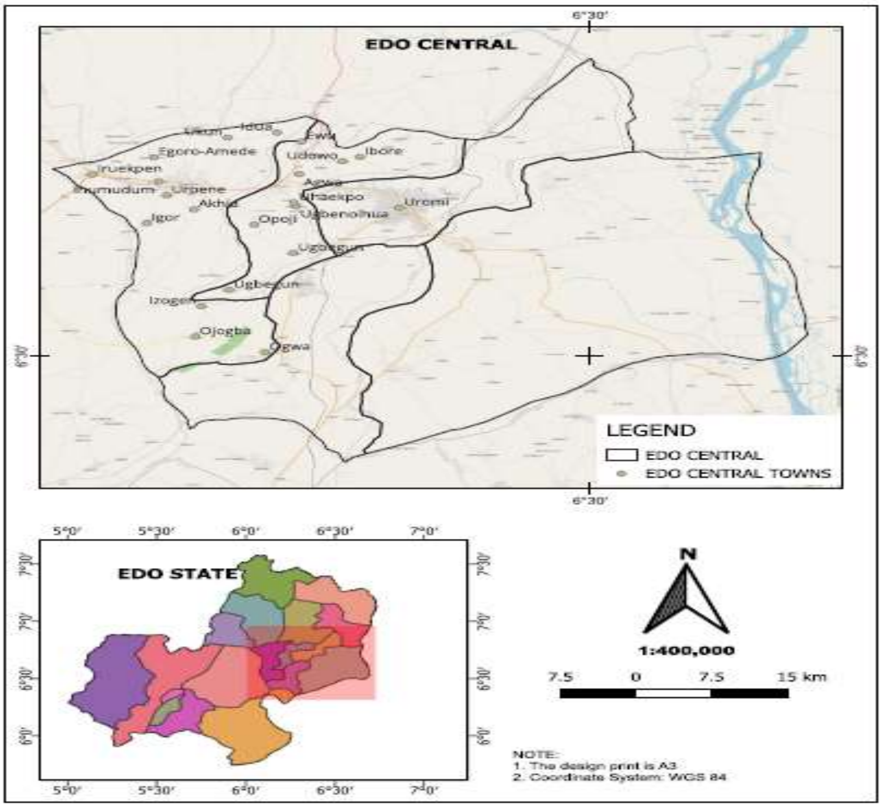

Fig. 1: Edo State, Showing study area

Table 1: Villages/Quarters Surveyed in Edo Central, Edo state, Nigeria

	Community/ Quarter	Number of questionnaire distributed	Positive responses (Pesticide Usage) %	Negative responses (Pesticide Usage) %
1	Idua	20	89	11
2	Ukun	20	77	23
3	Egoro-Amede	20	85	15
4	Iruekpen	20	87	13
5	Ihumdum	20	88	12
6	Igor	20	94	06
7	Urpene	20	89	11
8	AKhia	20	90	10
9	Ewu	20	67	33
10	Udowo	20	72	28
11	Agwa	20	86	14
12	Ibore	20	81	19
13	Ugbenolhua	20	79	21
14	Uhaekpo	20	84	16
15	Opoji	20	83	17
16	Ugbegun	20	88	12
17	Urohi	20	81	19
18	Izogen	20	77	23
19	Ojogba	20	63	37
20	Ogwa	20	87	13

*Note: % of positive and negative responses was determined from number of yes and no to pesticides usage

The questionnaire was divided into three sections, Parts A, B, and C. Part A included questions related to socio-demographic information such as farmer's gender, age, educational level, cash crop cultivation experience, types of crops cultivated. Part B is a question related to their knowledge of pesticides including common types of pesticides used by farmers, what factor informs your choice of the pesticide type, crops for which pesticides are used, sources of information on pesticides, pesticide use practices and safety management of pesticides during application, while Part C is a question about their awareness/knowledge on the public health problems associated with pesticide usage, frequency of use, protective devices, disposal of pesticide containers. Respondents were asked to select the correct and appropriate answers for the questions on knowledge and awareness of environmental impacts of pesticides usage. A total of five (5) points were given to strongly agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1). Adding all the ratings together gave us a total of 15 points. In our interpretation, any mean above 4.5 is very high, 3.5 and above high, 3.4 - 2.5 moderate or uncertain below 2.5 is poor or low.

Statistical Analysis: The results obtained from field survey were subjected to simple descriptive statistics each as mean, and standard deviation (SD). The statistical analysis are conducted using Microsoft Excel and SPSS (version 16.0) statistical package. Chi-square test was applied to evaluate the level of statistical difference between socio-economic variables. The results were presented in frequencies, and percentages for specific variables, and as mean ±SD for continuous variables. The significance levels were set at and $P \leq 0.05$.

RESULTS AND DISCUSSION

Smallholders demographic and land tenure characteristics: In Table 2, most farmers (61%) are male while female smallholder farmers making up the remaining 39% of all the sampled farmers in Edo Central, indicating that farm activities and pesticide spraying are primarily performed by men in the study area. More so, majority of these farmers are between the age ranges of 31years – 50years. However, farmers within the age range of 41-50years were highest (30.3%), followed by farmers within the age range of 31-40years. Farmers that are 70years and above were the least among the farmers interviewed. The above finding goes to show that main agricultural workforce in the study are young people and this population decreases with aging as expected. More than half of the smallholder farmers sampled are married (53%), followed by never married, including singles, widowers and widows (33.5%). Divorced population was least among sampled farmers (13.5%). Both married, never married and divorced all agreed that farmer is the primary source of livelihood for their families. A substantial number of the farmers (30.5%) had university education (graduates), a few had postgraduate degrees and diplomas (7.8%), while 20.5% had an elementary school education (primary education), and few (16.8%) farmers had completed secondary school, while the remaining (24.5%) had had no education (illiterate). In addition, about 53.5% of the farmers make ₦ 300,001-600,000 per farming season, followed by the group whose season income is 300,000 and below (30.8%). This also confirm that farming is an importance sources of livelihood in the study area. More than half of the farmers sampled have farming experience of over 6years with the 6years – 10years been the highest among the sampled farmers (54.5%), while farmers with more that 10years experience was 28.8%. Majority of sampled farmers have used pesticides for pest control for over 10years and above (47%), while other have also been using pesticides at different times 6years – 10y years (28.8%) and less than 5years (24.5%).

Table 2. Socio-demographic characteristics of the respondents

Variables	Frequency (n = 400)	Percentage
Gender		
Male	244	61.0
Female	156	39.0
Age group		
30 years and below	62	15.5
31 – 40 years	117	29.3
41 – 50 years	121	30.3
51 – 60 years	66	16.5
61 – 70 years	22	5.5
70 years and above	12	3.0
Marital status		
Married	212	53
Never married	134	33.5
Divorced	54	13.5
Highest educational qualification		
No formal Education	98	24.5
School Certificate (Primary Edu)	82	20.5
Secondary Education	67	16.8
B.Sc./HND	122	30.5
Postgraduate qualifications	31	7.8
Mean income level per season		
Less than N300,000	123	30.8
N300,001 – N600,000	214	53.5
N600,001 – N999,000	63	15.8
Farming experience level		
< 5years	67	16.75
6-10years	218	54.5
10>	115	28.8
Pesticides usage (Years)		
< 5years	98	24.5
6-10years	114	28.5
10>	188	47

In Fig 2,65.3% of smallholder farmers received relevant information regarding pest control and pesticide application practices via oral communication with other farmers, followed by information from retailers (27.5%). The remaining sampled farmers 7.3% stated that they had learned the information on pest control and pesticide application from Technicians including government extension services.

Common Pesticide use by farmers and frequency of usage: Predominantly used pesticides by farmers in the study area are presented in Table 3. A total of sixteen (16) (mostly insecticides) were used by farmers across the study area. On the average one farmer agrees to have used more than three pesticides types during the farming season. Samples justify that different pesticides serve different purposes, some during cultivation, others at pre-harvest and post-harvest periods.

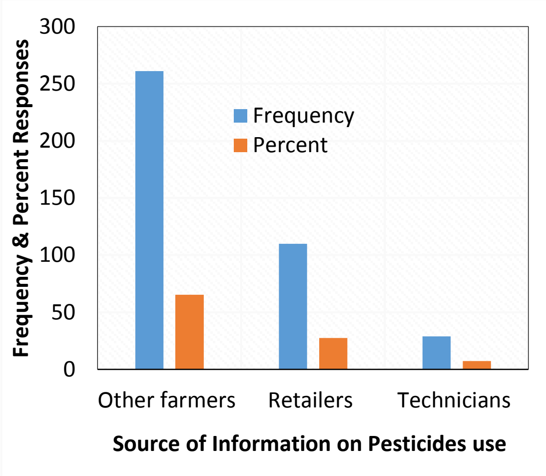

Fig. 2: Sources of information on pesticide use

From the list of predominantly used pesticides is Dichlorvos: DDVP 1000G/L EC which is considered highly toxic by the WHO classification of pesticides by hazard (WHO, 2019). Other types of pesticides used by farmers in Edo north also fall under moderately toxic according to the WHO classification (WHO, 2019). Best Cypermethrin 10% EC (14.8%) was mostly sprayed by farmers as it is considered most effective for pest control. This is followed by Attacke (13.5%), DDForce (9.8%), Sniper (8.5%), NOPEST (8.0%), while Assail Acetamiprid is believed to be least effective (1.8%). In Fig 3, frequency of pesticide spray is presented. Sampled farmers indicate that within the farming season, the spray is between once in two months (35.3%) and on monthly basis (30.5%) depending on the severity of pest attack and the general pretreatment belief. Other farmers also responded to applying pesticides fortnightly (22%). On the whole, farmers indicated that application depend on attack and farmers perception that the pesticide will preserve crops until delivery to the market. Drivers of pesticides use and predominant crops of usage: In table 4, drivers of choice of pesticide and the predominant crops cultivated in the study area are presented. Affordability was the main drivers of usage with 213 (53.3%), followed by the efficacy of the type been used 167 (41.8%), whileprior knowledge that a particular type of pesticide has minimal public health effect was least 20 (5.0%), an indication that not knowing whether a particular pesticed has any form of health effect before use is of little or no concern to the farmers. Sampled farmers indicated that they use pesticides more on maize (24.5%), followed by cassava (24.0%), yam (18.3%). Others include groundnut (11.5%), rice (10.3%), while tomatoes was least sprayed (3.8%). The major pests reported by farmers during interviews were beetles, army worms and aphids. While beetlesand aphids affect most vegetables during vegetative growth, army worms attack cropsright from vegetative growth through harvesting. Worm infestation is most damaging duringfruiting (Aniah et al., 2020). Sampled farmers reported have their own strategy to deal with new pests and unsuccessful pest control. For instance farmers interviewed revealed that when a pesticide is not effective for a given pest, the product is replaced by a 'stronger product' of high toxicity, disregarding whether the new product is appropriate for a given crop or not. Similar finding was reported by Waichman *et al.* (2007).

Table 3: Use (%) of different pesticides by farmers in Edo Central, Edo State, Nigeria

Pesticides	Active Ingredient(s)	WHO Classification	Frequency of use (n= 400)	% of use
Best	Cypermethrin 10% EC	II	59	14.8
Attacke	Lambda-Cyhalothrin	II	54	13.5
Perfect Killer	Chlorpyriphos 20% EC	II	44	11
DD Force	Dichlorvos:DDVP 1000G/L EC	1b	39	9.8
Sniper	Dichlorvos DDVP 1000 EC	Ib	34	8.5
NOPEST	Dichlorvos 1000EC	Ib	32	8.0
Marshal	Lambda-Cyhalothrin 2.5%	II	14	3.5
DB BX Force	Dichlorvos DDVP 1000 EC	Ib	16	4.0
Rocket	Chlorpyriphos 20% EC	II	10	2.5
Avesthrin	Cypermethrin 10% EC	II	15	3.8
Chlorview	Cypermethrin 20% EC	II	12	3.0
Cypeforce	Cypermethrin 10% EC	II	26	6.5
Rainbow	Chlorpyriphos 480g/L EC	II	8	2.0
Piriforce	Chlorpyriphos 480 EC	II	11	2.8
Syrux	Imidacloprid	II	19	4.8
Assail	Acetamiprid	II	7	1.8

DDVP:-Dichlorovinyl dimethyl phosphate; EC: Emulsifiable Concentrate
1a, extremely hazardous; Ib, highly toxic; II, moderately toxic; III, slightly toxic; U, unlikely to present acute hazard in normal use (WHO, 2019)

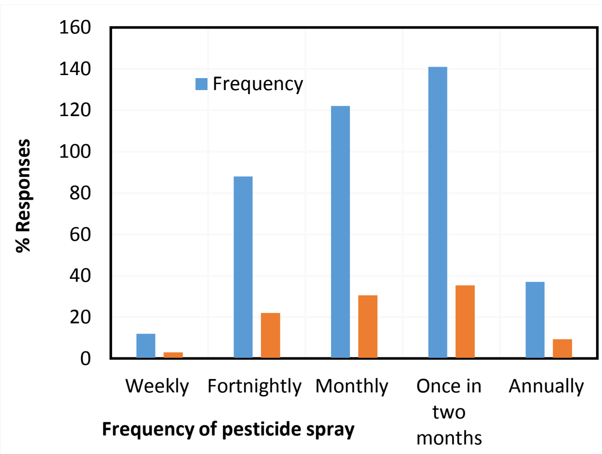

Fig. 3: Frequency of pesticide spray in Edo Central, Edo State

Table 4: Drivers of pesticides usage types and some target crops in Edo Central, Edo State

Variable	Frequency (n=400)	Percentage %
Drivers of pesticides type		
Affordability	213	53.25
Efficacy	167	41.75
Knowledge of minimal health effects	20	5.0
Some Target Crops		
Cassava	96	24
Maize	98	24.5
Yam	73	18.3
Groundnut	46	11.5
Rice	41	10.3
Vegetables	31	7.8
Tomatoes	15	3.8

Farmers' understanding of pesticides labels: Using age, educational background and years of farming experience, farmers were asked whether they read product labels or not, including dosage before application. If the answer was no, we asked why not. From those who indicated they do read labels before spray, questions were asked onwhether they understood what they read or not. In Table 5, the age of sampled farmers who don't read pesticides labels before use had mean scores of 51.4% as against the 48.6% who read labels. More importantly is the fact that the population of farmers who don't read pesticides labels are within the age bracket of 41years-70years, 41-50years (55.5%), 51-60years (61.6%), 61-70years (71.2%) and 70years and above, (58.4%). These percentages are high when compared to farmers within the same age brackets 41-50years (44.8%), 51-60years (38.4%), 61-70years (28.2%) and farmers above 70years (41.6%). The implication of the above is that there are more farmers who do not bother to read pesticides labels before use when compared to farmer that read and understand these labels, although this variation is not significant at ρ > 0.05, d = 0.42. The mean score for the educational status of sampled farmers who read pesticides labels was 54.5%, while farmers who don't read labels for the same educational background was 45.5%. Specifically, the percentage of responses of population of sampled farmers without formal education were 77.2% (don't read), 27.8% (read labels).

For farmers with primary education (elementary school), the percentage of responses were 57.8% (don't read labels) while 42.2 (read labels). For farmers with secondary school education, 52.3% don't read labels of pesticides while 47.7% indicated they read and understand labels before use. For farmers who are either graduates of universities or polytechnics, 28.6% don't read pesticide labels while a greater part of them (71.4%) read labels. Similar trend was observed for farmers with added postgraduate degrees and diplomas with 11.4% indicating they don't read labels while the remaining 88.6% agreed to reading pesticides labels before use. Although the mean score between these group differed, statistical difference was not established at ρ > 0.05, d = 0.35. On years of farming experience, farmers who read pesticides labels with different years of farming experience had a means score of 58.7 as against the 43.1. Notwithstanding this mean difference, statistical difference was not established at ρ > 0.05, d = 0.19. Farmers with 6-10years and above of farming experience were recorded to have read pesticides labels before use when compared to farmers who don't read pesticides for the same years of experience. For sampled farmers with farming experience of 6-10years who read labels, the percentage was 57.4% while farmers who don't read labels with the same years of experience was 42.6%. Farmers with more than 10years experience also indicated to have read labels more (67.8%) compared to the 32.7% who don't read labels of pesticides before use.

The above statistical trend is an indication that reading of pesticides labels and understanding the information about each type of pesticides has little or nothing to do with age, educational status and years of experience of farmers in the study area. From Fig, 4 most of the sampled farmers simply rely on the success stories on a particular pesticides (30.3%) before purchasing them, hence having no need to read the labels. This was followed by lack of clarity of the information on the labels which was 23.5%. Also from table 5, very young farmers <30years reported not to read pesticides labels (74.3%) while the remaining 25.7% of farmers of the same age read pesticides labels. In terms of educational status, farmers with postgraduate degrees responded to reading pesticides labels before application (87.8%), followed by farmers with BSc/HNDs (67.2%). Also, majority of farmers with less than 5years farming experience do not read labels before application with a mean score of 76.3% as compared to the 23.7% of farmers with similar farming experience. Most farmers considered it important to bathe after spraying (20.3%), followed by wearing of long-sleeved shirts (17.5%), wearing of gloves (11.3%), wearing of trousers and face mask 10.3% and 10% respectively. Farmers who reported applying pesticides following wind direction to protect them against the product's smell was 1.8%.

Table 5: % of farmers that read labels in Edo Central, Edo State

Category	% of farmers that read label before use		*P-value*
	Do not read	Read Label before use	
Age of farmers			
30 years and below	74.3	25.7	ρ > 0.05, d = 0.42
31 – 40 years	63.2	36.8	
41 – 50 years	55.2	44.8	
51 – 60 years	61.6	38.4	
61 – 70 years	71.2	28.8	
70 years and above	58.4	41.6	
Mean	**63.9**	**36.1**	
Educational background			
No formal Education	77.2	22.8	ρ > 0.05, d = 0.35
School Certificate	57.8	42.2	
Secondary Education	52.3	47.7	
B.Sc./HND	28.6	71.4	
Postgraduate qualifications	11.4	88.6	
Mean	**45.5**	**54.5**	
Years of farming experience			
< 5years	54.6	45.4	ρ > 0.05, d = 0.19
6-10years	42.6	57.4	
10>	32.2	67.8	
Mean	**43.1**	**58.7**	

Note: Difference is statistically significant at 0.05 level of confidence (one-tail)

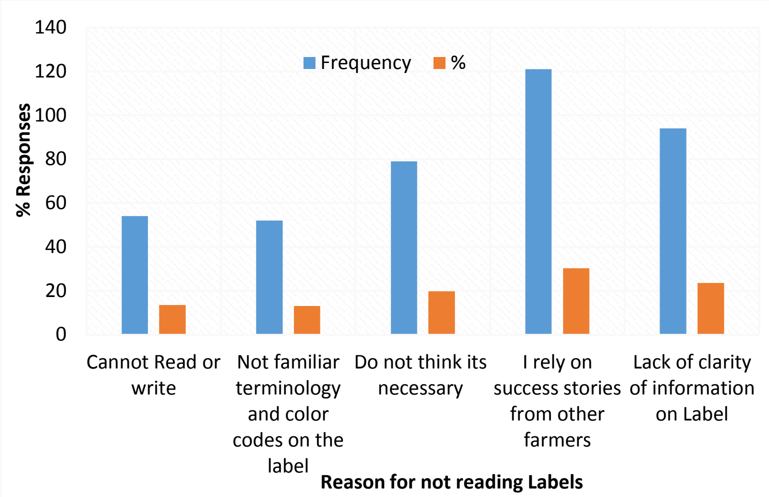

Fig. 4: Farmer's reasons for not reading pesticides labels before use in Edo Central

Pesticides handling and risk prevention Strategies: Storage of pesticides before use and methods of disposal of containers after use by farmers were also assessed as indicators of public health safety. In Table 7, majority of sampled farmers indicates that they store their pesticides inside their homes (43.3%), followed by farmers who store pesticides in stores or food bans (25.8%). Others preferred to store pesticides inside plantation fields and covered with leaves (24.5%). Buy and use up (not storing) was the least of the storage facility while cost and safety from theft was cited by farmers for the choice of keeping pesticides inside homes.

Table 6: Personal safety measures practiced by smallholder farmers in Edo Central, Edo State

Safety measures	Frequency (N = 400)	%
To spray according to wind direction	07	1.8
To wear trousers	41	10.3
To wear long-sleeved shirts	70	17.5
To wear boots	34	8.5
To wear a hat	22	5.5
To bathe after application	81	20.3
To wear gloves	45	11.3
To wear eye mask	23	5.8
To wear face mask	40	10.0
To wear a piece of cloth over mouth and nose	37	9.3

This could be hazardous when there is a leakage in pesticides containers stored inside homes or food barns. Besides, some of these homes are household with children who may be exposed to these chemicals either via dermal contact or ingestion. On methods of disposal of pesticides containers after use, majority of the farmers (37%) said their used pesticides containers are discarded alongside other household waste materials. This group falls with farmers that store pesticides chemicals in their homes. Those who reported burning used cans were 24.5%. Another group of sampled farmers dispose of their used pesticides cans in any available forest/land (19.8%), while 14% of sampled farmers reuse these used cans for other domestic purposes. These methods have implications for public health as they can cause pollution to both surface and ground water resources via diffuse pollution with the help of storm water runoff and infiltration (burying into pit).

Table 7: storage of pesticides is carried out and Disposal of empty packages

Variable	Frequency (=400)	%
Pesticides Storage		
Inside the homes	173	43.3
Store or food barn	103	25.8
Inside plantation area	98	24.5
Buy and use up	26	6.5
Disposal of empty can after use		
Burned	98	24.5
Mix up with other HHW	148	37
Discharge into forest/empty land	79	19.8
Reuse cans	56	14
Discharge into water body	19	4.8

Farmer's Level of Knowledge of Public Health effects of Pesticides usage: The level of knowledge of the risk of pesticide use to the public health was assessed on the basis of: low level (mean score <2.5), moderate level (mean score 3.4 -2.5), and high level (mean score 3.5) and very high (4.5 and above) (Table 8). On the whole, majority of farmers had a moderate level of knowledge of the risks of pesticide use on public health. On the knowledge of whether farmers are at risk of exposure to pesticide use via inhalation, ingestion (Contaminated food/water) and dermal contacts,some of the sampled farmers agreed with a mean score of 3.68 (±0.69). This followed by general knowledge that exposure to pesticides can have acute (Immediate) health effects such as irritation of the nose, throat, and skin causing burning, stinging and itching as well as rashes and blisters, nausea, dizziness and diarrhoea among others, with a mean score of 3.53 (±0.56). Farmers also reported moderate level of awareness on Chronic (Long-term) health effects such as cancer and other tumours; brain and nervous system damage; birth defects; infertility and other reproductive problems; and damage to the liver, kidneys, lungs and other body organs (2.73±0.33), endocrine effects such as decreased fertility, genital malformations, testicular and prostate cancer, diabetes and obesity, degenerative diseases in the brain, such as Parkinson's disease among others (3.03±0.45), genotoxic and carcinogenic which can interact with the genetic material (DNA) causing alterations, damage or ruptures, and those that interfere with enzymatic processes of repair, genesis or polymerization of proteins involved in chromosome segregation (2.96±0.35); and finally, Neurotoxic effects leading to disrupt blood-brain barrier receptors in the central nervous system which enhance chronic toxicity and affect the receptor-mediated transcytosis (3.29 ±0.61).

Table 8: Absolute and Relative Frequency Distribution of level of awareness of public health effects of pesticides use in Edo Central, Edo State

Knowledge of Levels of effects on Public Health	5 Strongly Agreed	4 Agreed	3 Undecided	2 Disagree	1 Strongly disagreed	Mean	Standard Deviation	Knowledge level
You can be exposed to pesticide use via Inhalation, Ingestion (Contaminated food/water) and Dermal Contacts	112 (28%)	156 (39%)	55 (13.8%)	48 (12%)	29 (7.3%)	3.68	0.69	High
Exposure to pesticides can have acute (Immediate)health effects such as irritation of the nose, throat, and skin causing burning, stinging and itching as well as rashes and blisters, nausea, dizziness and diarrhea etc.	72 (18%)	144 (36%)	119 (29.8%)	53 (13.3%)	12 (3.0%)	3.53	0.56	High
Exposure to pesticides can have Chronic (Long-term health effects) such as cancer and other tumors; brain and nervous system damage; birth defects; infertility and other reproductive problems; and damage to the liver, kidneys, lungs and other body organs	24 (6.0%)	73 (18.3%)	105 (26.3%)	164 (41%)	34 (8.5%)	2.73	0.33	Moderate
Exposure to pesticides can have endocrine effectssuch as decreased fertility, genital malformations, testicular and prostate cancer, diabetes and obesity, degenerative diseases in the brain, such as Parkinson's disease etc	42 (10.5 %)	75 (18.8%)	174 (43.5%)	69 (17.3%)	40 (10.0%)	3.03	0.45	Moderate
Exposure to pesticides can have Genotoxic and carcinogenic effects which can interact with the genetic material (DNA) causing alterations, damage or ruptures, and those that interfere with enzymatic processes of repair, genesis or polymerization of proteins involved in chromosome segregation	45 (11.3 %)	86 (21.5%)	135 (33.8%)	78 (19.5%)	56 (14%)	2.96	0.35	Moderate
Exposure to pesticides can have Neurotoxic effects leading to disrupt blood-brain barrier receptors in the central nervous system which enhance chronic toxicity and affect the receptor-mediated transcytosis	32 (8.0%)	148 (37%)	149 (37.3%)	46 (11.5%)	25 (6.3%)	3.29	0.61	Moderate

Above 4.5 is very high; 3.5 and above high; 3.4 -2.5 moderate; below 2.5 is low level of awareness

Influence of farmers socio-demographic factors on awareness levels: The relationship between some socio-economic variables with farmer's levels of awareness of effect of pesticides usage on public health is presented in Table 9. From the table, the higher the age of farmers the more their levels of awareness of public health effects of pesticides usage. Farmers from the age of 70years and above who are aware of the health risk associated with pesticide use was 77.2% as against the 22.8% farmers within the same age group. For farmers between 61-70years, 52.5% indicated that they are aware, while 47.8% reported not been aware. However, for young farmers, between the age of 30-50years, the level of awareness ranges from poor to moderate, with the age group less than 30years being worst hit (64.4%), while the remaining 35.6% of farmers of similar age was 35.6%. This is followed by farmers of the age 31-40years among whom 61.6% are not aware of the public health problems associated with pesticides use. Another 56.2% of the farmers within the age range of 41-50years also reported not being aware of the public health problems associated with pesticides spray. Although the mean score of level of awareness differed among the different ages, statistical differences were not established at ρ > 0.05, d = 0.35. On whether the educational background of sampled farmers influenced their knowledge the public health effects of pesticides usage, farmers with no formal education have least knowledge of public health risk of pesticide usage (67.5%), while only 32.5% of farmers of the same educational background agree that they are aware. This followed by farmers with first school leaving certificate (primary/elementary education) (64.1%) and secondary school (55.0%), while at the same time, farmers with knowledge of public health impact of pesticide use for the same educational backgrounds were 35.5% and 45% for primary and secondary education respectively. Farmers with postgraduate degrees and BSc/HND reported highest levels of awareness levels (91.6%) and (87.1%) for postgraduate and BSc/HND holders respectively. On the whole, total mean score of farmers who are aware of the public health effects of pesticides use with different educational is greater (58.4%) than farmers who are not aware of the environmental effects of pesticides use (41.6%). However, this difference is not significant as differences were not established at ρ > 0.05, d = 0.27. On whether the years of farming experience of sampled farmers influenced their knowledge of the public health effects of pesticides usage, farmers with less than five years farming experience have least knowledge of health risk of pesticide usage accounting for 67.3% compared to the 32.7% who reported they were aware. Farmers with farming experience of 10years and above and between 6-10years reported the highest awareness levels with mean scores of 76.4% and 50.8% respectively. The percentages are relatively high when compared to farmers that reported they were aware with percent scores of 23.6 (10 years and above) and 49.2% (6-10years farming experience). On the whole, total mean score of farmers who are aware of the environmental effects of pesticides use with different years of farming experience is greater than farmers who are not aware of the environmental effects of pesticides use with mean scores of 53.3 and 46.7 respectively. Although the mean values differed, statistical differences were not established at ρ > 0.05, d = 0.41.

Table 9: Relationship between Socio-economic variable and Famer's Level of Awareness of Public Health Impacts of Edo Central, Edo State

Category	% awareness on Public health impacts		*P-value*
	Not Aware of Public health impact of pesticides use	Aware of Public health impact of pesticides use	
Age of farmers			
30 years and below	64.4	35.6	
31 – 40 years	61.6	38.4	
41 – 50 years	56.5	43.5	ρ > 0.05, d = 0.35
51 – 60 years	55.2	44.8	
61 – 70 years	47.8	52.2	
70 years and above	22.8	77.2	
Mean	**47.5**	**52.5**	
Educational background			
No formal Education	67.5	32.5	
School Certificate	64.1	35.9	
Secondary Education	55	45	ρ > 0.05, d = 0.27
B.Sc./HND	12.9	87.1	
Postgraduate qualifications	8.4	91.6	
Mean	**41.6**	**58.4**	
Years of farming experience			
< 5years	67.3	32.7	
6-10years	49.2	50.8	ρ > 0.05, d = 0.41
10>	23.6	76.4	
Mean	**43.0**	**57**	

Note: Difference is statistically significant at 0.05 level of confidence (one-tail)

From the study, male population performed majority of farming operations in Edo Central (61%), compared to the female population and this may be attributed to access to land resources. Similar findings were reported by Adegbite and Machethe (2020) in Nigeria, Kassie et al. (2020) among farmers in rural Kenya, Ahmed *et al.* (2016) and Ankrah *et al.* (2020) in Ghana. Danso-Abbeam *et al.* (2020) and Yokying and Lambrecht (2020) also reported that in Africa both men and women contribute significantly to agricultural production, yet their access to agricultural resources remain unequal. In another study by Tsige *et* *al.* (2020), women encounter various challenges in their land accessibility owing to cultural, social, economic and demographic barriers and portions of land they control are usually less fertile and further aggravated by insecure ownership. Doss *et al.* (2018) indicated that access to land is gendered and discriminates against women. This concurs with similar observations made by several authors showing women's differential access to farm lands (Kang *et al.*, 2020; Johnson *et al.*, 2020). Bryceson (2019) has reported that globally, women amass only 2% land entitlement and are denied the opportunity to inherit properties, and this trend is not different from situation in the study area. Over 50% of sampled farmers are within the age brackets 31-50years. This age bracket is considered most productive age where culturally, any young man or woman is expected to be both married and economically productive. This finding is in contrast with the study of *Happe et al.* (2008), where only 6% of EU farm managers are younger than 35years, while more than half are 55years and older.

Not being able to get white-collar-job was reported to be the main driver into farming operations. Global youth unemployment rate has been reported at 13% and believed to be about three times higher than that among the adult population at 4.3% (ILO Citation 2020). According to Mulema *et al.* (2021), sub-Saharan Africa (SSA) is worst hit with youth unemployment rates of 40%. Hence, some of these young adults do not consider agriculture as a lifelong career that can sustain their lifestyle but view it as a poor man’s activity or one that is reserved for school drop-out. Others authors in their studies (Daum and Birner 2017; Udemezue 2019; Yami *et al.*, 2019) have shared similar opinion. These authors conclude that most youth view the sector from the farming perspective with backbreaking work (laborious) generating low productivity and offering less in return. Majority of sampled farmers are married and living together with members of their household, the implication of which is that farming becomes a mainstay of livelihood sustenance. As other studies have reported, agriculture holds potential to provide employment opportunities, increased investments and promote sustainable livelihood. According to Mukasa *et al.* (2017), agriculture is the main source of livelihood for more than 600 million people in SSA, directly employing around 80% of the rural population and contributing an average of 25% of the Gross Domestic Product (GDP) in the region. In Nigeria, Sabo *et al.* (2017) found that agriculture, especially smallholder farm level contributes to 99% to the national product and total crops output. In south and southeast Asian countries, agriculture’s share of GDP stood at 19% in 2016, and agricultural employment accounted for around 47.4% and 38.9% of total employment in south Asian and southeast Asian countries respectively, during the period 2003–2016 (Liu *et al.*, 2020). Majority of sampled farmers are either illiterate or some of the farmers that reported to having elementary education (Primary and secondary) cannot read fluently in English language. In their study, Khan and Iqbal (2009 also reported similar trend in Pakistan, Mergia *et al.* (2021) in Ethiopia, Waichman *et al.* (2007) in Brazil, Aniah *et al.* (2020) in Ghana. Education is important to sustainable farming operations as have recognized by different authors (Wouterse, 2016; Wouterse and Badian, 2019; Ninh 2021). The fact that majority of sampled farmers could not read English language has implication for pesticide misuse and overuse without recourse to environmental and public health effects. Majority of sampled farmers mostly farmers with over 10years of experience also reported to have used more than three types of pesticides mainly for pest control, indicating farmer’s reliance of pesticide for pest control and profit maximization. Sabran and Abas (2021), reported that globally, only 25% of the total agricultural land is cultivated organically; the rest uses pesticides. According to United Nations (2015) the worldwide population is projected to increase to 9 billion by 2050. To accommodate this increase, food production will necessarily need to increase to meet the teeming global population. Sustainable application of pesticides has been considered an important component of a comprehensive strategy to increase crop yield by preventing both pre and post-harvest loss to pest (Bonner and Alavanja. 2017). This is more of concern in the developing countries as FAO date shows around 13% of the population are suffering from undernourishment (FAO, 2020).

Another index of sustainable application of pesticides is income level. Over 50% of sampled farmers reported an average income of 300,001 – 600,000 Naira per planning season, while only 28.8% earn close to one million. This income level is low with regards the size of their families (4-7 person per household). Across the developing world, the use of personal protective equipment (PPE) is highly problematic and this is closely related to household income level. Research suggests that farmers who had a higher income used significantly higher pesticide safety practices (Moradhaseli et al., 2017, Khan, 2009). They also have greater access to information that explains the need for PPE and how best to use it (Sapbamrer *et al.*, 2020). Main source of information on pesticides comes from co-farmers, followed by retailers, while information from extension works (technicians) was the least. Waichman et al. (2007) reported similar trend in Brazilian Amazon with information from other farmers constituting 54.7% while retailers accounts for 40% in Uganda (Nalwanga and Ssempebwa, 2011). The influence of sellers on smallholder farmers' pesticide use was previously reported in Ethiopia (Negatu *et al.*, 2016) and other low-income countries such as Ngowi *et al.* (2001) in Tanzania and Adjrah *et al.* (2013) in Togo. Such information include availability of pesticides, efficacy and cost. Except where such information is from extension works, it is usually not targeted at training farmers on the public health risk of pesticide as well as effective usage. This is more so as most of the retailers and other farmers are not also trained technicians on pesticides uses. In a similar study, Mergia *et al.* (2021) also reported that few retailers had a formal education about pesticides. As a result, those pesticide retailers are unable to recommend farmers on appropriate use, supervision, and disposal of pesticide which may lead to improper use and handling of pesticides resulting in increased occupational and ecological hazards.

Our result revealed that class II pesticides mostly Cypermethrin 10% EC, Lambda-Cyhalothrin, Chlorpyriphos 20% EC, Chlorpyriphos 480g/L EC, Cypermethrin 10% EC, Imidacloprid and Acetamiprid (not likely to present acute hazard in normal use), are the most commonly used pesticides by smallholder farmers in the study area. Only a few farmers still use Dichlorvos: DDVP 1000G/L EC which is considered highly toxic (class 1b). None of the sampled farmers reported class 1a (extremely hazardous) in the study area. Similar findings were reported by Anna et al. (2014) in Uganda and Waichman et al (2007) in Brazil. According to Benjamin *et al.* (2019), though case, class II pesticides are still classified as moderately hazardous and they are known to have an extremely negative impact on human well-being and the environment essentially due to misuse by farmers. Contrary to this finding are other studies in Africa and other parts of Europe, where class 1b pesticides has been reported. These include studies by Mengistie *et al.* (2017) in Ethiopia, by Matthewsa *et al.* (2003) in Cameroon.

Major driver of pesticides types used in the study was affordability and efficacy of a particular pesticide. Similar finding was reported in northwest Ghana by Aniah et al. (2020). Their study found that low income status of farmers is the reason most farmers purchase low quality inappropriate pesticides from unlicensed dealers mostly at the open local market. Their study further showed that low-income status of farmers also explains why all farmers in the study area use knapsack instead of motorized sprayers in spite of the high risk of leaking and spilling of chemicals and associated health risk.

The pesticide label is one of the most important sources of pesticide information, providing all relevant information for safe use of the pesticide and therefore for environmental and health risk reduction (Waichman *et al.* 2007). Unfortunately, majority of young/adult youth farmers sampled do not read pesticides information before use as they claimed not being able to understand the formation on the labels (English Language) or there is no need for such information as long as the pesticide is effective against pest. Additionally, majority of sampled farmers who are better classified as illiterates or having elementary education do not also read pesticides labels before use. This observation corroborates with the finding of Waichman *et al.* (2007), which revealed that product label information is often designed to address technicians, authorized and certified users with a certain level of acquired knowledge, hence the technicality of such information discourages farmers from reading them and leads to misunderstanding of products' message and inappropriate use. In similar studies Jallow *et al.* (2017) in Kuwait, Mergia *et al.* (2021) in Ethiopia, Gaber *et al.* (2012) in Egypt, and Yirdaw (2021) in Quara District of West Gondar, Ethiopia has also reported high rate of illiteracy among farmers as well as not been able to read labels before use. Damalas and Khan (2016) noted that the majority of farmers (73%) were not reading the instructions printed on bottles/containers of pesticides. According to Jallow *et al.* (2017), higher levels of education gives pesticide users better access to information and more knowledge of the risks associated with pesticides, and how to avoid exposure. While less educated farmers may be hampered in their ability to understand the hazard warnings on pesticide labels, how to avoid exposure, and how to follow recommended safety and application guidelines (Al-Zadjali *et al.*, 2015). Educated farmers are more knowledgeable about pesticide safety, have better ability to read, understand and follow hazard warnings on labels, and conceptualized the consequences of poor pesticide usage practices (Karunamoorthi *et al.*, 2012).

This finding on the percentage of farmers who read pesticide labels before use also reflects in the general knowledge of public health effects of pesticide usage as the general knowledge of whether farmers are aware that they can be exposed to pesticide use via inhalation, ingestion (contaminated food/water) and dermal contacts in the course of spray. More so, if they are aware that their exposure to pesticides can have acute (immediate) health effects such as irritation of the nose, throat, and skin causing burning, stinging and itching as well as rashes and blisters, nausea, dizziness and diarrhoea among others. Besides these levels of public health knowledge and awareness which were rated high, the levels of awareness among farmers of other indices of public health risk such as Long-term health effects, endocrine effects, genotoxic and carcinogenic effects and Neurotoxic effects were generally moderate. This finding also confirms other observations of other authors on the importance of education on the ability of farmers to read and understand the information on pesticide labels to ensure proper use and handling of pesticides as well as minimizing occupational and ecological hazards (Wouterse, 2016; Wouterse and Badian, 2019, Ninh 2021, Mergia *et al.*, 2021).

The use of Personal Protective Equipment (PPE) during pesticides application is necessary and required to provide some adequate protection for farmers from harm. The findings revealed that majority of sampled farmers only bath after pesticide spraying (20.3%), while another 17.5% reported wearing long-sleeved shirts during application. Another 11.3% reported to be wearing gloves while spraying, 10.3% wear trousers as PPE. The least PPE practised in the study area is spraying following the direction of the wind (1.8%). The fact that most of the sampled farmers do not use protective equipment confirms the findings of Sekiyama *et al.* (2007) in Indonesia where most of the farmers did not wear safety gear, especially respirators/masks, and smoked during pesticide application, and Kachaiyaphum *et al.* (2010) in Thailand where over three quarters of farmers (76%) did not wear protective clothes. Similar findings were also reported by Damalas *et al.* (2006); Isin and Yildirim (2007) and Yassin *et al.* (2002) in Greece, Turkey and Gaza respectively. Similarly, only about 40% of farmers in Iran use protective equipment when spraying (Hashemi *et al*., 2012). .

Cost was cited as determinant of PPE measure used by farmers as it cost nothing to bath after spray, and this is in tandem with the findings of Khan (2009); Moradhaseli *et al.* (2017) and Sapbamrer *et al.* (2020). These authors reported in their studies that farmers who had a higher income used significantly higher pesticide safety practices. Other authors have also attributed the low use of PPE among farmers to their general lack of knowledge on the dangers of pesticides on their health and the ecosystem (Jansen and Harmsen, 2011; Teklu *et al.*, 2015; Mengistie *et al.*, 2017). These authors argued that the environmental impacts of pesticides are not well understood by farmers coupled with the inadequate laboratory equipment to assess residues of pesticides on the environment. In another study in the Al-Batinah region of northern Oman, Al Zadjali *et al.* (2015) reported that farmers with better education histories and training in the use of PPE exhibited changed behaviours toward the adoptability of PPE. Another study has also cited cultural reason for non-compliance to PPE. A study by FAO (2020), showed that farmers most often do not follow manufacturers' safety recommendations for handling and applying pesticides and cannot afford or do not use adequate protective clothes or equipment. They might refuse the use of PPE due to cultural reasons, because they find it uncomfortable or because they lack the means to thoroughly wash it for reuse. The fact that sampled farmers do not generally use PPE has implications for public health (Mengistie *et al.*, 2017, Monneret, 2017; Gundogan *et al.*, 2018; Jokanovi 2018; Dereumeaux *et al.*, 2020; Rad *et al.*, 2022; Parks *et al.*, 2022). Tsimbiri *et al.* (2015) who sampled 800 residents in the Lake Naivasha region, the centre of large-scale horticulture in Kenya, showed evidence of respiratory, skin, bone and nervous system problems among pesticide users. Storage of pesticides before use or leftover after use is an important indicator of public health. Pesticides storage measures as seen in the study area was generally inadequate and has potential for both environment and public health risk. A significant number of sampled farmers reported to store leftover pesticides inside their rooms, at the kitchen, veranda behind the kitchen and inside the toilet. In a similar study, Mergia et al. (2021) reported that 94.5% of farmers along the lake Ziway watershed, Ethiopia, stored pesticides in residential rooms under the bed, on the roof, in the kitchen, in the toilet, and in animal shelters with other items. Mohanty *et al.* (2013) also reported similar trend in Puducherry, south India. Matthews (2008) reported that 27% of 8500 smallholder farmers in 26 countries stored pesticides in the home or in open areas, and nearly half indicated that they rarely or never locked pesticides away. These risky behaviours has been attributed to farmers' lack of technical knowledge and training on safe pesticide use (Jallow *et al.*, 2017). Educated farmers and farmers who have access to training on pesticide use are more likely to store pesticides in locked stores designated for pesticides (Mekonnen, and Agonafir, 2002). Likewise, they are more likely to be aware of pesticide-related adverse health and environmental effects (Hashemi *et al.*, 2012). Only 6.5% did not store pesticides, as they reported that they purchased the required amount and used it immediately. This is also in tandem with another study by Sa'ed *et al.* (2010) who found out that few farmers (7.3%) bought and used pesticides directly (did not store) and Mergia *et al.* (2021) who reported that only 5.7% of sampled farmers in Ethiopia did not store pesticides. Most farmers either disposed of empty containers alongside other household waste (37%), or burn them (24.5%) as well as dispose them on empty farmlands. Another 14% reported to re-use these empty cans for other domestic purposes (such as storing of vegetable oil, kerosene and food ingredients etc) and increases their chances of exposure to pesticides. Similar findings was reported by Jallow *et al.* (2017) in Kuwait, and Dalvie (2006) in Stellenbosch, South Africa. The least disposal method is disposal into water bodies (water source), and this is mostly practised by farmers whose farmlands are located near rivers.These disposal methods have implications for surface and groundwater pollution. According to Mergia *et al.* (2021) empty pesticide containers may retain significant amounts of pesticide solution or powder if not rinsed well, hence inappropriate disposal of used pesticide containers into the environment can threaten human health and pollute the environment (Damalas *et al.,* 2008; Osborne *et al.,* 2015; Kim *et al.,* 2017; Parks *et al.,* 2022). The present study also shows that majority of the adult youth farmers between the ages of 30years to 50years are not aware of the public health risk associated with pesticides use, compared to similar farmers of similar age bracket. On the other hand, most of the sampled farmers who are either illiterate or have elementary education and who cannot read, are also not aware of the public health risk of pesticides usage. This findings confirms the close relationship between education, ability to read pesticides labels, appropriate storage and disposal of used pesticides containers. This also been confirm in other studies (Karunamoorthi *et al.,* 2012; Mohanty *et al.,* 2013), where a significant association was reported between a good level of knowledge about pesticide disposal and education level. Studies have shown that farmers with high levels of education were well-informed about pesticide safety, and could read, recognize, and obey hazard signs on container labels, and understanding the effects of poor pesticide usage practices (Fan *et al.,* 2015; Khan *et al.,* 2015; Mengistie *et al.,* 2015; Jallow *et al.,* 2017). Blanco-Muñoz and Lacasaña (2011) for example, reported that illiteracy and lack of knowledge on the extent to which pesticides represent a hazard have been considered the most important barriers for the adoption of self-protective behaviours by farmers, in particular the use of Personal Protective Equipment (PPE).

Conclusion: The quest to increase crop yield induced smallholder farmers in Edo Central to use pesticides regardless of their little or no knowledge of the public health effects of pesticides usage. This is evident in their non-willingness to read pesticides labels and inadequate use of Personal Protective Equipment (PPE) before and during application of these chemicals respectively. This suggests a need to adequately and intensively train farmers on safety measures concerning the use of pesticides, in order to mitigate the environmental and health risk associated with their usage.

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