Journal of Agromedicine

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/wagr20

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To cite this article: Toyin S Olowogbon, Raphael O Babatunde, Edward Asiedu & Aaron M Yoder (2021) Agrochemical Health Risks Exposure and Its Determinants: Empirical Evidence among Cassava Farmers in Nigeria, Journal of Agromedicine, 26:2, 199-210, DOI: 10.1080/1059924X.2020.1816239

To link to this article: https://doi.org/10.1080/1059924X.2020.1816239

Published online: 18 Sep 2020.

JOURNAL OF AGROMEDICINE
2021, VOL. 26, NO. 2, 199–210
https://doi.org/10.1080/1059924X.2020.1816239

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Agrochemical Health Risks Exposure and Its Determinants: Empirical Evidence among Cassava Farmers in Nigeria

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ABSTRACT

Background: Over the years there has been a change in the dimensions of agricultural health risk exposure among crop farmers in Nigeria due to innovation adoption. This study assessed agrochemical health risk exposures and its determinants among cassava farmers in Nigeria.
Method: The study engaged the baseline of a longitudinal study conducted using a standardized questionnaire. Randomly selected and interviewed for the study were 480 small-scale cassava farmers across 24 farming communities in Kogi and Kwara States, Nigeria. Descriptive statistics, binary regression model, and Likert scale were used for analysis.
Results: Most of the farmers were exposed to agrochemical health risks in cassava operations. The frequently used chemicals belong to WHO class II and III. There was poor knowledge of safe farm practices among cassava farmers. About 77% of farmers reported not using complete protective equipment while handling farm chemicals. Several risk factors were associated with farm chemical health risks exposure, including inappropriate time of spray (Odd ratio [OR] = 1.21), frequency of spray (OR = 1.06), long hours of daily chemical spray (OR = 1.10), and non-usage of chemical labels (OR = 2.31).
Conclusion:The study concluded cassava farmers in some selected communities in Kogi and Kwara States, North-Central Nigeria engage in unsafe farm practices via the use of farm chemicals that expose them to health risks. There is, therefore, a need for efficiently delivered agricultural health education as an intervention tool to alleviate Nigerian crop farmers from being exposed to such health risks.

KEYWORDS
Agriculture; health Risks; risk Factors; chemical; crop farmers; Nigeria

Introduction

Globally, occupational related accidents, diseases, and fatalities constitute a major burden to human productive capacity, as there are about 340 million occupational accidents and 160 million victims of work-related illnesses annually.[1] The International Labour Organization (ILO) further estimates that about 2.3 million women and men around the world die of work-related accidents or diseases every year, corresponding to over 6000 deaths every single day.[1] These figures are likely under-reported, since records of occupational injuries, illnesses, and deaths are not kept in most developing countries.[2,3] It has been previously demonstrated that the rate of occupational injury and death in farming is greater than those observed in other occupations.[4–6] This issue has attracted the attention of researchers globally; for example, two recent studies from Pakistan estimated the target values of agrochemical use and its impact on crop productivity and human health on rice farmers from selected districts in Pakistan. The authors found an indiscriminate use of agrochemicals in the study area. They found that indiscriminate use of pesticides not only compromises rice quality but also impedes the health of workers in Pakistan.[7,8] A Study from Turkey discovered high depression rate, physical health problems and high social isolation among farmers.[9] In the United States, a significant relationship was demonstrated between the incidence of lung and lymphohematopoietic cancers among farmers raising poultry and cattle.[10] It has also been reported that, compared to individuals in other occupations, those working in agriculture are more predisposed to developing occupational diseases such as asthma and respiratory ailments caused by chemicals,

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dust, and allergens.[11] Because of the high rates of occupational-related diseases, accidents, and injuries, farming is considered to be the second most hazardous occupation worldwide, after mining.[12] Common health problems experienced by farmers include dermatoses, adverse effects associated with exposure to excessively hot and cold conditions, zoonoses, hearing loss, and certain cancers.[13,14] Garcia and McCarthy stated that "positive health" has three linked dimensions (social, psychological, and physical) that should all be included when measuring health.[15]

For Nigeria, with a population of over 175 million people, the agricultural sector provides employment to about 70% of the population, making agriculture a major sector.[16,17] Agriculture has been further described to be fundamental to economic growth, poverty alleviation, improvement in rural livelihood, and environmental sustainability of developing nations.[18]

Despite agriculture's potential for poverty reduction potential, it has been described as a risky occupation, exposing farm workers in developing countries to fatal and nonfatal injuries, work-related lung diseases, noise-induced hearing loss, cardiovascular and respiratory disease, skin diseases, adverse reproductive outcomes, musculoskeletal disorders, certain cancers associated with chemicals, and chemical poisonings.[19–21]

Deaths due to unintentional poisoning from exposure to pesticides are estimated at 355,000 people yearly, two-thirds of whom are in developing countries.[18] Estimates by the World Health Organization (WHO) showed that worldwide 30 million people suffer severe pesticide poisoning annually, and 25 million of these occur among agricultural workers in developing countries, including Nigeria.[22,23]

There is inadequate access to agricultural health training and education, as many farmers have been reported to contract pesticide-related diseases.[24,25] This can be attributed to a paucity of agricultural health professionals in Nigeria and poor capacity building in this area of expertise, as agricultural health gaps exist in the Nigerian agricultural curriculum and agricultural policy.[26] Poor agricultural safety training leads to unsafe practices among farmers. This could lead to agricultural injuries and diseases affecting farmer's productivity and income. As highlighted by Asenso-Okyere et al.,[25] the effects of ill health on farm households include absenteeism from work due to morbidity (and eventual death), family time diverted to caring for the sick, and loss of savings and assets in dealing with disease and its consequences. The ultimate impact of ill health is a decline in household income and possible food insecurity leading to severe deterioration in household livelihood.[25,27]

Currently, systematic studies on agrochemical-occupational related risks are rare in Nigeria. The paucity of this data has provided no impetus for policy formulation in this regard. This study intends to fill this information gap by providing robust data on agrochemical health risks, its exposure, and its determinants.

Materials and methods

Study area and design

The study was carried out in Kogi and Kwara States, Nigeria. Both states are located in the North-Central geo-political zone of Nigeria, which accounts for about 30% of the cassava produced in Nigeria[11,28] (Figure 1). This cross-sectional study constitutes the baseline of a randomised control trial of an agricultural health intervention. The baseline data collection was carried out from February 2017 to July 2017 in the study area.

Study participants and interview

The study engaged cassava farmers. In recent times, these farmers face massive use of agricultural chemicals due to labour shortages.[29] The sample size was estimated using optimal design (OD) software developed by Steve Raudebush and was engaged for power calculation.[30] Randomly assigned to the study were a total of 480 respondents; 20 respondents in each of 24 cassava cropping communities, with a power of 80%. The sample was found sufficient based on experience from similar studies in other parts of the world.[31,32] The selection of farmers was done by random assignment into the study based on the entry criteria. Respondents were interviewed individually using a standardized semi-structured questionnaire. See Table 1 for a list of communities sampled for the study.

Figure 1. Map of Nigeria showing the location of Kogi and Kwara State.
Source: http://www.ngex.com/nigeria/images/maps/nigeriamap.gi.

Statistical methods

Descriptive statistics involving frequency tables, measure of central tendency, and measure of dispersion were used. In examining the factors predisposing crop farmers to chemical health risks, binary logistic regression was adopted. Logistic regression was developed in the late 1960s and early 1970s.[33-35] and became popular among researches in various fields, particularly among health researchers. Over the past years, logistic regression has been commonly used to investigate risk factors for health-related prevalence.[36–39]

Table 1. List of communities assigned to the project.

States	Project Communities	Total sample/ state
Kogi	Odo-Ape (T), Otu-Egunbe(T), Kakun (T), Ejiba(T), Aiyegunle-Gbede(T), Ohakiti, Iyara, Aiyetoro, Mopa, Okene, Egbe, Kabba	240
Kwara	Oke-mi, (T), Ogbondoroko (T) Ladabu (T), Oro (T), Odo-Owa,Omu-aran, Omupo, Aiyedun(T), Ganmo/Jimba-Oja, Osi, Orogan and Offa.	240

*Note: The (T) in parenthesis means treated community while others are the control communities.

The model for stage one is stated as:

$$\ln\left(\frac{p}{1}-p\right)=a+\beta x+\varepsilon \tag{1}$$

where ln is natural log Exp and Exp = 2.71

P is the probability the event occurred p(y = 1) in this case, the probability a farmer is exposed to a chemical health risk. p/1-p is the odds ratio and ln(p/1-p) is the log odds or logit.

The implicit form is model thus:

$$D_{it}=\beta_0+\beta_1X_1+\beta_2X_2+\ldots\ldots\ldots\ldots\ldots+\beta_9X_9+U_{it} \tag{2}$$

D_{it} indicates agricultural health risks exposure (D_{it} = 1 if the respondent is exposed (if any 3 of the acute chemical poisoning symptoms is recurrently self-reported) and D_{it} = 0 otherwise)

X_1 = Age of farmer (years)

$X_{2=}$ Years of schooling

X_3 = Previous exposure to agricultural health training (yes = 1, 0 = Otherwise)

X_4 = Time of spray (1 = recommended time of spray morning/evening, 0 otherwise)

X_{5}= Average number of agrochemical application per season
X_{6}= Duration of application of agrochemicals (hours)/day
X_{7}=Re-entry time after chemical spray (hours)
X_8 = Use of personal protective equipment (1 = usage and 0 = otherwise)
X_9 = use of chemical label (1 = usage and 0 = otherwise)
U_{it} = Error term

Overview of the health-related variables and measurements

In the absence of reliable medical diagnosis, it is recommended to measure symptoms rather than diseases, since respondents are able to report symptoms with a lower degree of error.[40–43] Symptoms of chemical exposure measured in this study include dizziness, headache, skin itching, vomiting, muscle twitching, abdominal cramps in coordination, nausea, diarrhoea, blurred vision, sweating, shaking, a feeling of weakness, breathing problems, and unconsciousness. A respondent was considered as exposed to chemical-related health risks when at least three symptoms were reported to have occurred during the last spray, the past 4 weeks, and 3 months before the interview. The pesticides used were subsequently classified according to the WHO Recommended Classification of Pesticides by Hazard, a classification used to distinguish the more and less hazardous forms of pesticides from each other based on the acute risk to human health, ranging from extremely hazardous (class Ia), highly hazardous (class Ib), moderately hazardous (class II), slightly hazardous (class III), and unlikely to present acute hazards (class U).[44]

Ethical considerations

The study was approved by the Research Ethical Committee of the University of Ilorin, Ilorin, Nigeria. Participation in the study was purely voluntary, and the purpose of the study was communicated to respondents and approval obtained via the informed consent form.

Results

The average age of respondents was 38 years; the oldest being 60 years and the youngest being 24 years old. The frequency of chemical spray ranged from 3 to 30 times in 3 months. The daily duration of spray varied from 3 hours to 9 hours, and years of chemical use varied from 3 to 10 years. Average re-entry time to spray fields was found to be 16 hours; this is below the standard recommendation of at least 24 hours and 48 hours for wet-able powder. The self-reported pesticide poisoning symptoms varied from 1 to 12 (see Table 2) Table 3 shows that most farmers engaged WHO class II and III for their farming activities. About 70% of the farmers reported that they do not understand most of the information presented on the chemical labels. This suggests a need to communicate safety information on chemicals to users in a way they will appreciate and understand to enhance adherence to safe practices. Table 4 shows that about 70% of respondents re-use mixed leftover chemicals. This is a poor safety practice, as uninformed farm visitors may use the contents for unintended purposes that are hazardous to health, since it is not labelled. The study

Table 2. Respondents Demographic Characteristics (N = 480).

	Mean	Standard Deviation
Age	38.0	7.9
Household Size	4.90	2.6
Years of Schooling	13.60	2.5
Farming Experience	13.70	7.6
Farm Size	2.10	2.9
Monthly Health Expenditure	1193	1187

Source: Baseline Survey, 2017

Table 3. Chemical characteristics of farmers (N = 480).

	Mean	Standard Deviation
Frequency of chemical spray/3 months	13	3.5
Daily duration of spray (hours)	6	2.4
Years of chemical usage	7	2.6
Re-entry time (hours)	16	7.4
Spray times till harvest	3	2.5
Number of symptoms/farmer	5	6.3
Length of symptoms (hours)	13	2.5
Chemical related ergonomic discomfort per week	2	3.3
Production Lost time (days)/season	6.5	3.5
Care time (days)/season	3	4.2

Source: Baseline Data, 2017

revealed that most farmers do not use the recommended protective gear during chemical handling, with the most (83%) used gear being a long-sleeved shirt and trousers, and only 23% using complete chemical protective gear when working with chemicals.

Figure 2 shows that some of the self-reported symptoms include back pain (75%), extreme tiredness (72%), muscular weakness (54%), excessive sweating (39%), Catarrh (35%), headache (29%), and nausea (21%). Table 5 reports on the severity of farmers' exposure to acute pesticide poisoning. We found that 53% of farmers studied experience these symptoms all the time after chemical handling, and 57% resorted to using over the counter drugs to self-medicate, which may be dangerous to their health. Table 6 shows the results of the model for the predisposing factors to chemical health risks exposure using binary logistic regression. For the factors predisposing cassava farmers to chemical health risks, the health effects variable, exposed (marked 1) was defined as when a respondent is considered exposed to chemical-related health risks when at least three symptoms are recurrently reported to have occurred during the last spray, the past 4 weeks, and 3 months before the interview. If otherwise, it is marked 0. We found that several risk factors were associated with chemical health risks exposure including the inappropriate time of spray (Odd ratio [OR] = 1.21), frequency of spray (OR = 1.06), long hours of daily chemical spray (OR = 1.10), and non-usage of chemical labels (OR = 2.31).

Table 4. Farmers' knowledge, attitude and practice in chemical use (N = 480).

	Item	Frequency	%
1	Mostly used WHO chemical Class		
	WHO class II only	96	20
	WHO class III only	144	30
	WHO class II and III	240	50
2	Hand washing after spraying		
	Yes	256	53
	No	224	47
3	Cloth changing after spraying		
	Yes	336	70
	No	144	30
4	Other use of agrochemicals		
	Home surrounding spray	384	80
	Pest spray	48	10
5	Hand washing before eating in the field		
	Yes	64	13
	No	416	87
6a	Sprayer washing		
	Yes	304	63
	No	176	37
6b	Sprayer washing place		
	In the field	261	86
	Near the stream	21	7
	At home	21	7
7	Container management		
	Throw in the field	312	65
	Bury in the soil	48	10
	Burn in the field	48	10
	Washed and re-used as household container	72	15
8	Chemical measurement into sprayer		
	The use of chemical lid cap	288	60
	Measured by experience	192	40
9	Reading of chemical label		
	Yes (occasionally)	336	70
	Yes (always)	29	6
	No	114	24
10	Adherence to advice on chemical label		
	Yes (Sometimes)	254	53
	No	226	47
11	Information read on chemical label		
	Expiration date	480	100
	Safety instructions e.g Protective gear use	96	20
	Re-entry time	24	5
	General Instruction of use e.g mixing volumes	400	83
12	Understanding of safety instructions on label		
	Yes	144	30
	No	336	70

Source: Baseline Survey, 2017

Discussion

Our findings were in accordance with other studies in Africa.[32] that earlier reported WHO class II and III pesticides as the top reported chemicals used by small-scale farmers in Africa.[45–48] This does not negate the fact that the chemicals most used by African farmers are still classified as hazardous, and necessary safety measures should be adopted. It should, therefore, be noted that class II and III pesticides still present a hazard and are known to have severe negative effects on human health and the environment. Other less dangerous alternatives should still be promoted to farmers, and the application of the chemicals should still be done with the appropriate safety measures.

This study also found that about 47% of the farmers do not wash their hands after handling chemicals when either mixing/spraying. This could lead to unintentional chemical ingestion. About 21% wash their hands near water streams. Washing near streams could pose the danger of unintentional chemical poisoning to farming households. Findings showed that after chemical use, most farmers (about 65%) throw the empty

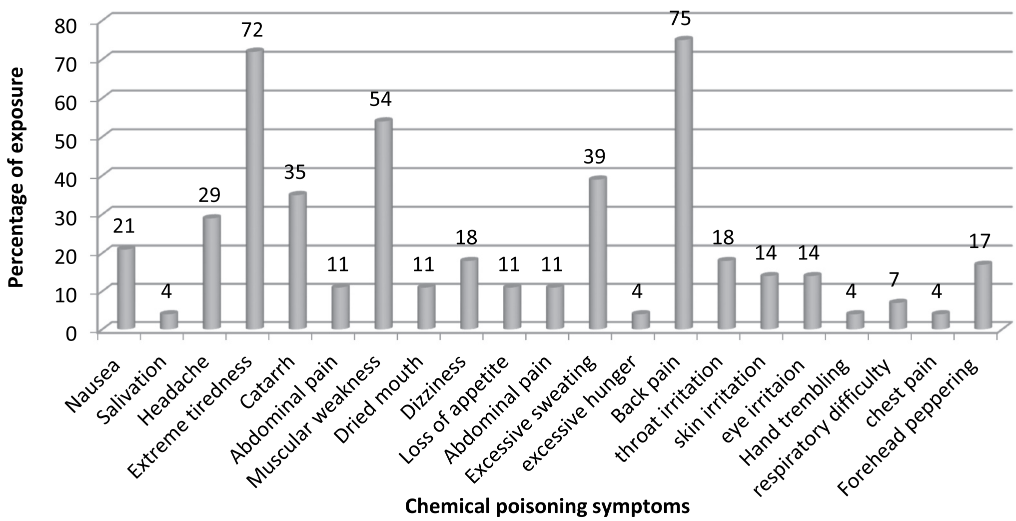

Figure 2. Baseline self-reported chemical symptoms experienced by farmers during chemical handling (N = 480).
Source: Data Analysis 2018

Table 5. Chemical Related Characteristics Cont'd (N = 480).

	Item	Frequency	%
1	Reuse of mixed leftover chemicals		
	Store in the field till next spray	256	53
	Pour on the ground	144	30
	Use for other purposes e.g spray road side/home	80	17
2	Weather consideration before spraying		
	Yes	302	63
	No	178	37
3	Knowledge of Chemical Route entry to the body		
	Eyes	178	37
	Mouth	327	67
	Nose	336	70
	Skin	327	67
	Don't know	34	7
3	Chemical incidents of during handling		
A	Incidental mild chemical swallow/ingestion		
	Yes	192	40
	No	288	60
B	Incidental chemical inhalation during mixing		
	Yes	384	80
	No	96	20
C	Incidental skin splash		
	Yes	470	98
	No	10	2
4	Personal Protective Gear Used		
	Ordinary short clothing	82	17
	Gloves	250	52
	Overall	17	4
	Boots	264	55
	Mask	197	41
	Long-sleeved shirt and trouser	398	83
	Hat	17	4

Source: Baseline Survey, 2017

containers on the field, posing potential danger to farm children who may pick the container and re-use it. About 15% reported that they re-use containers after washing for drinking and other domestic purposes. These are poor safety habits,

Table 6. Frequency of chemical poisoning and action taken by farmers.

1	Frequency of symptoms experienced after handling	Frequency	%
	All the time	256	53
	Occasionally	224	47
2	Action taken on symptoms		
	Nothing	17	4
	Rested	256	53
	Used over-the counter drug	272	57
	Visit health facility	64	13
	Used local herb	160	33

Source: Baseline Survey, 2017

as these may aid in chemical ingestion. Ogunjimi and Farinde reported some other unhealthy and unprofessional habits associated with the use of pesticides by some sampled rural farmers in Nigeria, including non-use of protective clothing, drinking during the application of chemicals, not washing their contaminated cloths after using chemicals, and smoking during application.[49] These poor safety practices were in agreement with findings in this present study.

Our findings on chemical container management were in accordance with the study by Bassi et al., who reported that about 78% of farming respondents disposed of empty pesticide containers in the field, while 2.63% used the pesticide containers as farm tools.[50] This was also in agreement with a study carried out in Nepal that pointed out that 26.3% burnt the empty agrochemical containers, while 29.2% indicated they left the empty agrochemicals containers on their farms.[51]

Kuye et al. also found that 35% and 55% of farmers reported disposing of empty pesticide containers by burning and burying them, respectively.[23] Another study in Nigeria indicated that 10.4% of farmers disposed of pesticide containers by burying them in the soil, 2.1% disposed them by burning in refuse heaps and 25.0% sold them to buyers; however, 35.4% washed their pesticide containers for other uses such as storing palm oil.[52]

We found that about 70% of farmers reported occasionally reading chemical labels, while 20% never read labels. Further questioning showed that most farmers read expiration dates and mixing instructions on labels, but neglect safety precautions and re-entry time for chemicals. This habit of not reading labels may have contributed to the non-usage of safety gear and non-compliance with the re-entry period. About 47% (226) reported not follow the advice they read on the labels, while 53 reported they occasionally follow such advice. However, 70% reported they do not understand the information presented on the labels. This finding is corroborated by Oesterlund et al., who earlier reported that (26%) of farmers sampled said they were unable to read and understand these instructions.[32]

Table 6 shows that 63% reported they consider weather conditions, such as rain and sunshine, before spraying their field. This study is supported by Kuye et al., who reported that most farmers had a preference for spraying the fields on clear sunny days and with the wind direction. We found that 37% were aware chemicals could enter their eyes, 67% were aware of oral ingestion (mouth), 70% were aware of inhalation (nose), 67% of absorption through the skin, and 7% were not aware of any route. This study found that 17% of the farmers used normal short-sleeved clothing while spraying. However, the Kuye study found 52% used gloves, 4% used the recommended overalls, 55% used boots, 41% used masks, and 83% used long-sleeved shirts. Only 4% reported using hats.[23] The study further showed that about 23% of the respondents used a complete set of the recommended protective gear while handling chemicals. The complete set is expected to cover all the major routes of chemical entry into the body including nose, mouth, and skin. Some of the farmers attributed the non-usage of protective gear to hot climatic conditions, complaining that protective gear, including masks, caused overheating, making it unsuitable for overall use on the farm. Despite the poor habit of not using protective gear, they all believed pesticides could have negative effects on their health. This was corroborated by Oesterlund et al., who found that 92% of the farmers thought pesticides could have negative effects on their health.[32] For example, a study by Lawal et al. reported about 20% of farmers used overall protective clothing, and 28.3% used jungle boots and handkerchiefs.[53] Their study concluded that cocobre-sandoz, pererox and gammalin 20 were the only pesticides popularly used by cocoa farmers, and very a low percentage of the farmers used preventive or control measures to protect against health hazards associated with these pesticides.[53] Abate et al. reported that most farmers used their normal clothes and less than one in six used any of these four protective measures: gloves, overalls, masks, or hats. This puts the environment and the health of the farmers and their families at risk.[54] This researcher further identified that incorrect dosage, incorrect timing and targeting, poorly maintained equipment, mixing with bare hands, lack of personal protective equipment, and lack of hygienic precautions during spraying may result in acute pesticide poisoning.[54] A study conducted in Bangladesh found 87% of respondents openly admitted they do not take any protective measures during the handling of pesticides.[42] The Gambian study by Kuye et al. found that most of the applicators do not use any recommended personal protective equipment in any part of the chemical handling process; 50% performed spraying in short-sleeved shirts, 30% in short pants, 60% wore sandals, 20% wore sneakers, and 10% wore plastic slippers (flip-flops).[23] The study conducted in Nigeria by Bassi *et al.* reported that 54.4% used no form of protection, while the distribution of those who used some type protective devices include: mask (21.6%), gloves (7.2%), goggles (5.6%), cap (4.8%), coat (2.4%), and apron (1.2%).[50] These studies have, overall, identified farmers' attitudes toward the use of protective gear while handing chemicals either mixing or spraying in Nigeria and other developing countries to be very inadequate, creating a poor safety culture.

Further findings from our study as shown in Figure 2, revealed some acute pesticide poisoning symptoms self-reported by farmers. Our analysis relied solely on self-reported health effects/symptoms, where farmers were questioned if they had experienced any health impairment after mixing and spraying pesticides in a 1, 3, and 6 -month period. This study revealed that most pronounced among the acute pesticide poisoning symptoms self-reported by farmers were back pain 75%, extreme tiredness 72%, muscular weakness 54%, and excessive sweating 39%. Farmers experienced multiple symptoms, with an average of four symptoms each.

Similar findings on acute pesticide poisoning were made by Dasgupta and Meisner, who reported that over 49% of farmers experienced at least one symptom, with the most commonly reported as neurological (headaches: 27%, dizziness: 8%), eye (irritation: 26%), dermal (skin: 13%), and gastrointestinal (vomiting: 9%). The interviews further revealed that 26% of the respondents experienced multiple health effects, with an average of three and a maximum of five.[42]

It has been pointed out that the main pesticide poisoning symptoms reported by farmers include skin irritation, headache, extreme tiredness, excessive sweating, blurred vision, and dizziness, all of which are consistent with other studies.[32,47,55-58] Results from studies conducted on human health and occupational exposure to pesticides among smallholder farmers in cotton zones of Cote d'Ivoire and Lesotho showed that exposure to pesticides and occurrence of ill health symptoms was evident in agricultural households in cotton-growing areas of Cote d'Ivoire, and that a greater health risk was present when there was a lack of training and education on the use of pesticides.[58] Ogunjimi and Farinde, in a study conducted in Nigeria, reported tearing, redness of the eyes, cough, difficulty breathing, excessive sweating, and headache as symptoms of chemical poisoning.[49] Table 6 shows that about 53% experience these symptoms regularly after handling chemicals, and most of the farmers (about 57%) resorted to over the counter-drugs, while only 13% visited a health facility. This finding was corroborated by Bassi et al.'s study on farming communities, which showed that about 31.6% use some form of self-medication (mostly analgesics and local antihistamines), pointing to the risk of self-medication among respondents.[50]

Findings from Table 7 show the factors predisposing farmers to chemical health risks exposure. The probability of Chi-squared was found to be significant at 1% which implies the overall model was statistically significant with Chi-squared statistic of 221.44. The study shows that the age of farmers in years, education, frequency of spray per season, and use of chemical labels were significant at 1%. Previous safety training exposure, time of spray, and re-entry time were significant at 5%. We found that as farmers advance in age the likelihood of chemical exposure risk decreases by 0.046. This could be attributed to the fact that as farmers age, the ability to do such tedious tasks as chemical spraying decreases, thereby reducing their exposure.

Further findings showed that a higher education level lowered the probability of chemical health risks exposure by 0.796. We found that previous safety training exposure reduced chemical health risks exposure by 0.619. The time of spray shows that for every additional time in the spray, the odds of chemical health risks exposure increases by 0.193. This implies that farmers who spray in the morning have 0.193 times the odds of experiencing exposure to chemical health risks. Spraying in the morning is safer; as the day gets sunny, the higher the exposure, because skin pores are exposed to a higher absorption rate. Every chemical spray exposes a farmer to chemical health risks

Table 7. Factors predisposing cassava farmers to chemical health risks.

Binary Logistic regression estimates Y exposure to chemical health risks	Odds ratio	Z
Age (years)	0.955*	−2.41
Education (years)	0.451*	−8.17
Previous safety training exposure (yes = 1)	0.538**	−2.38
Time of spray(1 = recommended time(morning/ evening,)	1.213**	2.02
Average number of spray/season	1.065*	2.78
Duration of spray (hours/day)	1.111	1.30
Re-entry time (hours)	0.929**	−2.15
Use of protective gear (1 = usage,)	0.732	−1.21
Use of chemical labels(1 = usage)	2.308*	2.82
Constant	597,210.9	6.96
LR Chi-Squared Statistic	221.44*	
Log likelihood	−206.831	

Note:* and ** represent significance at 1% and 5% respectively by a value of 0.063. This implies the more time a farmer sprays in a season, the higher the exposure rate.

Every hour increase in the daily duration of chemical spray exposes a farmer to chemical health risks by the probability of 0.105. Findings on re-entry time or interval show that for every hour increase in re-entry time, the chemical health risks exposure reduces by 0.74. However, efficient use of protective gear has the potential of reducing chemical health risk exposure by 0.321. The findings from the use of chemical label, though counter-intuitive, show that the use of chemical label increases chemical health risks exposure by a factor of 0.836. Although this is against our *a priori* expectation, this relationship may be due to the fact that farmers only concentrate on expiration dates on labels and not on the safety information that could help prevent chemical exposure. It could also be linked to the fact that a good percentage of farmers (30%) reported they do not understand the contents of the information on the label.

Engaging the odds ratios, it should be noted that statistically significant variables with positive relationships are called risk factors, and they have odds ratio >1, while negative associated variables are referred to as protective factors, and they have odds ratio <1. In the reduced model for this study, it shows that several risks factors were associated with chemical health risks exposure: wrong time of spray, frequency of spray, and non-usage of chemical labels. Different protective factors were associated with a reduction in chemical health risks exposure including age, education, and safety training. These findings implied that education and chemical safety training could help protect farmers against chemical health risks. The researcher expected that the use of protective gear should significantly reduce (be a protective factor) chemical health risks exposure. This finding may be due to the incomplete use of recommended protective gear by farmers. Most farmers do not use complete protective gear to prevent the chemical route of entry; about 23% of the respondents used complete protective gear including boots, nose masks, overalls, hats, and gloves. The researcher also expected re-entry time to be a risk factor; though nearly 1, it could be not be categorised as a risk factor. This could be explained as that the toxicity class of most of the chemicals used by farmers in the study area fall in the WHO II and WHO III classes.

Empirical evidence supports the finding of this present study, as problems associated with the use of pesticides in developing countries are largely attributable to factors such as lack of education and training, inadequate hazard information, difficulty conducting research, lack of expertise, communication problems, lack of proper personal protective equipment (PPE), unsuitability of PPE to climate, absence of pest-free periods, inadequate regulations and enforcement, farmers' unwillingness to accept risks of crop loss, application with inefficient sprayers that may directly expose applicators, early re-entry periods, and the use of pesticides more toxic than needed and handled in a hazardous manner.[59–61] Dongmei found that the education and training provided by agricultural technology personnel affect farmers' awareness of pesticide residues reducing exposure to chemical health risks.[62]

Furthermore, Isla reported that the extent of worker exposure to pesticides depends on many factors including choice of pesticide, the dose applied, methods of application, extent of worker training, and provision and use of PPE.[63] The high temperatures experienced in tropical and desert environments reduce the likelihood of compliance with effective use of PPE, as these can add to the discomfort experienced by users. Tropical environments also have high humidity in addition to high environmental temperatures. Skin absorption of pesticides is increased in hot environments, and skin that is wet with perspiration is also more conducive to systemic absorption of some pesticides.

Conclusion and recommendations

The study concluded cassava farmers in some selected communities in Kogi and Kwara States, North-Central Nigeria engage in unsafe farm practices via the use of farm chemicals, exposing them to health risks that negatively affect their well-being. The following is therefore recommended:

- A dual dissemination model for farm chemicals. Technologies should go hand in hand with safety and health education, e.g., organizing field day for farmers on safe use of chemical products by agrochemical producers.

- Government should make a mandatory policy of chemical producers providing chemical labels in the three Nigerian languages apart from English and providing key safety information such as re-entry time, toxicity class/ WHO class of chemicals, and basic farm first aids measures.
- Government and development partners should provide quality protective gear to farmers at subsidised rates adapted to meeting the personal characteristics of farmers and being climate-friendly.
- Government and development partners should encourage farmers to report symptoms at health facilities to aid the development of farm health surveillance data for policy stimulation.

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