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# Effect of agrochemical use on rice farmers health in Niger and Ogun States, Nigeria

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**Abstract**

The use of agrochemical has led to increase in crop yield. However, its utilization has been associated with some negative health and socio- economic effects. Therefore, this study assessed the effect of agrochemical use on rice farmers' health. A structured questionnaire was used to obtain cross-section data from 304 rice farmers in Niger and Ogun States, Nigeria, through a multi-stage sampling procedure. Data were analyzed through the use of descriptive statistics and Multivariate Probit (MVP) regression. Results showed that rice farming was carried out by males (91.2%) who had at least primary education (63.8%) with an average age of 44 years. Fertilizer (32.9%) and herbicide (28.4%) were the most common agrochemical utilized while hat (47.5%), nose guard (37.0%) and boots (35.3%) were the protective kits commonly used during agrochemical application. Rice farmers in the study area used banned chemicals of paraquat, 2-4D and propanil without optimally utilizing them. Nearly 90 per cent of farmers did not follow label guidelines and 58.10 per cent of farmers suffered from cough due to agrochemical use. The MVP regression revealed that rice farmers who applied herbicides (â = 0.501, p<0.05) and those who revisited their farms within 24h of spray (â = -0.542, p<0.01) had a higher probability of experiencing skin diseases. The study recommends that assessment, monitoring and environmental implications of agrochemical should be reinforced by the relevant agency before allowing its use. The engaging of children for agrochemical application should be discouraged.

**Keywords:** Agrochemical, Health, MVP, Rice.

## Introduction

The use of agrochemical no doubt has led to a growth in crop yield and production. McActhur and McCord (2014) stated that agrochemical usage has a strong causal relationship with crop yields which further translates to economic growth. The use of pesticides for rice production helps to lessen the crop damage due to infestation by harmful pests and insects which can severely limit yields and also cause both pre- and post-harvest losses. Pest like Africa rice gall midge (AFRGM) (*Orseolia oryzavora*) and stem borers are of significance in the production of rice in Nigeria. The AFRGM is a lowland rice pest that destroys the rice crop from the point of seedling to the extent that it prevents the panicle from emerging. According to Rodenburg and Johnson (2013) and Otto (2015), practically all weeds compete with rice plants for nutrients, water and light. However, some weeds (*e.g.* witch weed, *Striga* spp) act as parasites. Similarly, in some cases, the quality of the rice output is reduced because some of the weeds (*e.g.* Saramollagrass, *Ischaemum rugosum* and Itch grass, *Rottboellia cochinchinensis*) have grains that are similar in sizes and shapes that getmixed up with the rice grains.

The estimated yield loss in rice farms due to weed infestation in Nigeria was in the range of 28-74 per cent in transplanted lowland rice, 28-89 per cent in

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direct seeded lowland rice and about 48-100 per cent in upland rice (Rodenburg and Johnson 2013). In order to control these weeds, the use of herbicides is recommended to combat the social effect (increased workload especially for children and women) associated with hand weeding (Nwilene et al., 2012). Similarly, the African rice gall midge and stem borers are of economic importance in rice production and moderate use of fertilizers (60kg/ha) and use of carbofuran (even though it is a highly toxic substance that has been banned in countries like United State and European union) have been recommended as control (Otto, 2015). Hence, the use of herbicides such as paraquat, glyphosate, and other agrochemical has become inevitable in rice farming.

Agrochemical use have been associated with increased income or security of yield for farmers, increased employment opportunity through agrochemical sales, labour during application and improved food security. However, its utilization is not devoid of some negative socio-economic effect such as health risk for the applicators/farmers, consumers of the products due to residues in the crop, crop losses due to the emergence of new and/or more resistant pests and health effects resulting from contamination of food and water stored in pesticide container (Mahmood et al., 2015). This therefore, necessitate the need to examine the use and application of agrochemical in rice production *vis-à-vis* its health effects on the rice farmers, as a way of creating more awareness to the farmers, policy makers and agrochemicals manufacturers on the deleterious effects or otherwise of agrochemical use on the farmers.

**Materials and Methods**

The study was carried out in Niger and Ogun states in the North Central and South West zones of Nigeria respectively. The states were chosen tin order to have a representative of the rice producing State from the Northern and Southern parts of Nigeria, since both states were among the 19 states producing rain-fed lowland rice. Niger State produced about 542.65 thousand MT of rice in 2010 while Ogun State on the other hand, produced about 30.68 thousand MT (NAERLS and NPAFS, 2010). Niger State is located between Latitude 8°22'N and 11°30'N and Longitude 3°30'N and 7°20'E and it covers about 86,000 Sq. km (about 8.6 million hectares), (Niger State GIS, 2007). Ogun State on the other hand, is located in the south western part of Nigeria and it lies between Latitude 6.9098°N and Longitude 3.2584°E and covers about 16,980 Sq. km$^2$. The mean annual rainfall varies from 1100mm in the north to 1600mm in the south for Niger State and 1050mm in the north to 1280mm in the south for Ogun State.The mean minimum and maximum temperature are 26°C and 36°C in Niger State and 23°C and 32°C in Ogun State. The projected population for Niger and Ogun States in 2016 was 5.214 million and 4.951 people respectively based on the 3.2 per cent growth rate (NPC, 2011) with population densities of 284 and 222 persons per square km for Niger and Ogun State respectively.

This study was based on primary data collected byusing pre-tested questionnairefrom the sampled rice farmers in Niger and Ogun States.

Multi stage sampling technique was used to select 450 respondents from 9 local government areas (LGA); 6 LGAs from Niger and 3 LGAs from Ogun as shown in Table 1. In the first stage, proportionate sampling technique (on a ratio 1:1.5) was used to select two zones (zones 1 and 3) from 3 agricultural zones in Niger State and 3 zones from 4 agricultural zones in Ogun State. In the second stage, proportionate sampling technique (on a ratio 5:1) was also used to select five local government areas; Bida, Gbako, Katcha, Lavun and Mokwa from zone 1 which was the major rice producing zone in the State, and one local government area (Wushishi) from zone 3 in Niger State. In Ogun State, three local government areas; Yewa North (under Ilaro zone), Ifo (under Abeokuta zone) and Obafemi Owode (under Ikenne zone) were selected using simple random sampling technique from a list of rice producing LGAs which served as the sampling frame.

In the third stage, four villages were randomly selected from Bida, Lavun, Katcha, Gbako and Mokwa LGAs while 5 villages were selected from Wushishi LGA through simple random sampling technique. With respect to Ogun State, 5 villages each were chosen through simple random sampling technique from each of the LGAs.

In the fourth stage, 10 respondent households were sampled through systematic sampling techniques in each village. This gives a grand total of 250 respondents for Niger State.

Further, in Ogun State, systematic sampling was used to select 10 respondents each from the 5 villages of Ifo and Yewa North LGAs (giving a total of 100 respondents) while 20 respondents were selected through systematic sampling technique (giving a total of 50 respondents) for Obafemi Owode LGA thus, giving a grand total of 200 respondents for Ogun State. However, only 302 respondents provided information and subsequently subjected to analysis.

Descriptive statistics were used to describe the socio-economic characteristics of the respondents as well as the agrochemical use.

The multivariate probit regression was used to determine the factors predisposing farmers to the health symptoms associated with agrochemical use. The multivariate probit (MVP) model is viewed as a generalized form of the bivariate probit model (Schneider and Schneider, 2009). The MVP estimates M number of equation probit models using the Simulated Maximum Likelihood (SML). The model is specified as;

$$H^*_{1i} = \beta_1 K_{1\iota} + \varepsilon_{1\iota}$$
$$H^*_{2i} = \beta_2 K_{2\iota} + \varepsilon_{2\iota}$$
$$H^*_{3i} = \beta_3 K_{3\iota} + \varepsilon_{3\iota}$$
$$H^*_{4i} = \beta_4 K_{4\iota} + \varepsilon_{4\iota}$$

For the latent dependent variable, it is assumed that;

$$Y_m = \begin{cases} 1 \; if Y_m^* \\ 0 \; otherwise \end{cases} \quad m=1.........,4$$

Where;
$H_1$= Diarrhoea
$H_2$= Cough
$H_3$= Chest pain
$H_4$= Skin Disease
K's are vectors of exogenous variables and they

*Table 1.* Sampling procedure

| Location | Number of Zones | Number of LGAs | Number of Villages | Number rice farmers/village | Total number of respondents |
|---|---|---|---|---|---|
| Niger | 2 | 6 | 25 | | 250 |
| ZONE 1 | | | | | |
| Bida | | | 4 | 10 | 40 |
| Gbako | | | 4 | 10 | 40 |
| Katcha | | | 4 | 10 | 40 |
| Lavun | | | 4 | 10 | 40 |
| Mokwa | | | 4 | 10 | 40 |
| ZONE 3 | | | | | |
| Wushishi | | | 5 | 10 | 50 |
| Ogun State | 3 | 3 | 15 | | 200 |
| Ilaro Zone | | | | | |
| Yewa North LGA | | | 5 | 10 | 50 |
| Abeokuta Zone | | | | | |
| Ifo LGA | | | 5 | 10 | 50 |
| Obafemi Owode Zone | | | | | |
| Ikenne LGA | | | 5 | 20 | 100 |

Source: Field Survey 2015

include;
$K_1$= Age (years)
$K_2$= Sex (male =1 and 0 otherwise)
$K_3$= Location (1= Niger state and 0 otherwise)
$K_4$= Time of Spraying (Morning =1 and 0 otherwise)
$K_5$= Duration of spray (hours)
$K_6$= Herbicide (g/a.i/ha)
$K_7$= Insecticide (gm/a.i/ha)
$K_8$= Fertilizer (kg)
$K_9$= Farm size (Ha)
$K_{10}$= Facemask (1=yes and 0 otherwise)
$K_{11}$= Hand glove (1=yes and 0 otherwise)
$K_{12}$= Boots (1=yes and 0 otherwise)
$K_{13}$= Hat (1=yes and 0 otherwise)
$K_{14}$= Goggles (1=yes and 0 otherwise)
$K_{15}$= Nose guard (1=yes and 0 otherwise)
$K_{16}$= Overall (1=yes and 0 otherwise)
$K_{17}$= Agrochemical status (1=banned and 0 unbanned)
$K_{18}$= Chewed Kolanut (1=yes and 0 otherwise)
$K_{20}$= Revisited Farm (1=yes and 0 otherwise)
$\beta$ s is a vector of parameters to be estimated
$\varepsilon$ s are error terms which are assumed to be normally distributed with constant variance $var\ \varepsilon\ mi = 1$

## Results and Discussion

The socio-economic characteristics of the respondents are presented in this section. The socio-economic characteristics of an individual have been found to influence his/her decision-making capacity in any business venture (Vukelic and Rodic, 2014). This assertion is likely true in the case of rice farmers. As shown in Table 2, about 12.4 per cent of the farmers were less or equal to 30 years of age. This is an indication that young children may not be involved in agrochemical spraying activities since most of the farmers were adults above 18 years. The mean age of the farmers in the study area was 44 years. This suggests that the rice farmers were in their active labour age group and as such have the latent energy to carry out their farming activities manually. The majority of the farmers (91.2%) were males. This indicates that rice farming in Niger and Ogun States was male dominated. This could be because rice farming involves different stages of tedious activities and Nigerian agriculture that still relies on the use of manual labour. Hence, the aged, the very young and the females are prompted to involve in other activities such as processing and marketing of the produce. This result corroborates the findings of other scholars like Ayoola and Dangbegnon (2011) and Saleh et al. (2019) who found the mean age of rice farmers in Northern Guinea savannah to be around 41 years.

Table 2 indicated that nearly 36 per cent rice farmers in the study area had no formal education. There is a high tendency that these farmers who had no formal education would have inadequate knowledge of managing and use of agrochemical in terms of inability to read and follow agrochemical label instructions.This view is also corroborated by

*Table 2.* Distribution of respondents by socio-economic characteristics

| Description | Niger State | Ogun State | All |
|---|---|---|---|
| Age | | | |
| Less or Equal to 30 | 17(9.8%) | 21(15.7%) | 38(12.4%) |
| 31-40 | 54(31.2%) | 43(32.1%) | 97(31.6%) |
| 41-50 | 57(32.9%) | 36(26.9%) | 93(30.3%) |
| 51-60 | 30(17.3%) | 18(13.4%) | 48(15.6%) |
| Above 60 | 35(8.7%) | 16(11.9%) | 31(10.1%) |
| Mean | 44 years | 45 years | 44 years |
| Sex | | | |
| Female | 10(5.8%) | 17(12.7%) | 27(8.8%) |
| Male | 163(94.2%) | 117(87.3%) | 287(91.2%) |
| Educational Status | | | |
| None formally | 78(45.1%) | 33(24.6%) | 111(36.2%) |
| Primary | 39(22.5%) | 59(44%) | 98(31.9%) |
| Secondary | 33(19.1%) | 36(26.9%) | 69(22.5%) |
| Tertiary | 23(13.3%) | 6(4.5%) | 29(9.4%) |
| Marital Status | | | |
| Single | 15(8.7%) | 14(10.4%) | 29(9.4%) |
| Married | 158(91.3%) | 112(83.6%) | 270(87.9%) |
| Widow | 0(0.0%) | 4(3.0%) | 4(1.3%) |
| Divorced | 0(0.0%) | 4(3.0%) | 7(1.3%) |
| Household Size | | | |
| 1-3 | 61(35.3%) | 43(32.1%) | 104(33.9%) |
| 4-6 | 75(43.4%) | 70(52.2%) | 145(47.2%) |
| 7-9 | 27(15.6%) | 14(10.4%) | 41(13.4%) |
| 10-12 | 10(5.8%) | 4(3.0%) | 14(4.6%) |
| Above 12 | 0(0.0%) | 3(2.2%) | 3(1.0%) |
| Mean | 5 | 5 | 5 |

Source: Data from Field Survey 2015

Ayinde et al. (2007) and Banjo et al. (2010). These findings also conform to Oluwatayo (2014) who found that 33.3 per cent of rice farmers in the southwest had no formal education and also indicated in Table 2 thatthe majority (88.9%) of the rice farmers were married with a mean household size of 5 persons in the study area. With few members in the household, the rice farmers had todepend on hired labourers for most of their farm activities including agrochemical application.

Rice farmers used about 50kg/ha of NPK in the Niger state while those in Ogun state utilized only 117kg (Table 3 ). This can likely lead to degradation of the soil since soil nutrients are depleted when phosphorus and potassium are under utilized (Weil and Brady, 2017). Rice farmers in the study did not follow the recommended rate (100kg/ha) for urea application. They applied 141kg/ha and 112kg/ha which are quantities greater than the recommended in Niger and Ogun States respectively. This could lead to nutrient loss due to runoff and erosion. The risk of nutrient loss in runoff and erosion increases if excessive rates ofnutrients are applied (Manitoba Agriculture, Food and Rural Initiatives, 2013).

The difference in quantity of fertilizer could be as a result of the differences in price, soil structure and chemistry and method of application. Moreover, the best way to estimate which nutrient is necessary and the quantity to apply is through soil testing (ACF, 2010). The result is in line with Adeola et al. (2008) who reported that rice farmers in Oyo state applied chemical fertilizers in varying quantities as governed by the farmer's ability to purchase the input. Results in Table 4 indicate that most of the farmers made use of agrochemicals that were listed as highly hazardous pesticides in the list compiled by Pesticides Action Network International (PAN, 2015).

*Table 3.* Rate of utilization of inorganic fertilizer

| Fertilizer type | Niger | Ogun | All |
|---|---|---|---|
| NPK(Kg) | | | |
| less or equal to 50 | 1(50.0%) | 4(30.8%) | 5(25.0%) |
| 51-100 | 1(50.0%) | 6(46.2%) | 7(35.0%) |
| 101-150 | 0(0.0%) | 2(15.4%) | 2(10.0%) |
| 151-200 | 0(0.0%) | 1(7.7%) | 1(5.0%) |
| greater than 200 | 0(0.0%) | 5(21.7%) | 5(25.0%) |
| Recommended rate (kg) | 200 | 200 | 200 |
| Mean utilization | 50.5 | 117.17 | 84.19 |
| Urea (Kg) | | | |
| less or equal to 50 | 3(9.4%) | 1(16.7%) | 4(10.5%) |
| 51-100 | 2(6.3%) | 1(16.7%) | 3(7.9) |
| 101-150 | 2(6.3%) | 0(0.0%) | 2(5.3%) |
| 151-200 | 15(46.9%) | 2(33.3%) | 17(44.7%) |
| greater than 200 | 10(31.1%) | 2(33.3) | 12(31.6) |
| Recommended rate (kg) | 100 | 100 | 100 |
| Mean utilization rate | 141.24 | 112.88 | 136.96 |

Source: Data from Field Survey 2015

About 28.6 per cent of the rice farmers in Ogun state utilized more than 2500g of glyphosate (a

*Table 4.* Rate of utilization of pesticide in the study area

| Active Ingredient | Type | Quantity of Pesticide (g/a.i/ha) Dosage rate (g/a.i/ha) | ≤1000 | 1001-1500 | 1501-2000 | 2001-2500 | >2500 | Total | Mean |
|---|---|---|---|---|---|---|---|---|---|
| NIGER STATE | | | | | | | | | |
| 2-4D | Herbicide | 3000 | 0(0.0%) | 1(3.6%) | 0(0.0%) | 2(7.1%) | 25(89.3%) | 28(40.6%) | 2661.2 |
| Cypermethrin | Insecticide | 50 | 1(100.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 1(1.5%) | 450.80 |
| Glyphosate | Herbicide | 2000 | 0(0.0%) | 1(100.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 1(1.5%) | 1650.50 |
| Lambda Cyhalothrin | Insecticide | 200 | 16(100.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 16(23.2%) | 500.00 |
| Paraquat | Herbicide | 600 | 2(12.5%) | 3(18.8%) | 4(25.0%) | 4(25.0%) | 3(18.8%) | 16(23.2%) | 1812.94 |
| Propanil | Herbicide | 2500 | 0(0.0%) | 0(0.0%) | 0(0.0%) | 2(28.6%) | 5(71.4%) | 7(10.0%) | 2607.64 |
| OGUN STATE | | | | | | | | | |
| Cypermethrin | Insecticide | 50 | 2(100.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 2(9.5%) | 500 |
| Glyphosate | Herbicide | 2000 | 8(57.1%) | 2(14.3%) | 0(0.0%) | 0(0.0%) | 4(28.6%) | 14(66.7%) | 2857.36 |
| Paraquat | Herbicide | 600 | 1(20.0%) | 3(60.0%) | 0(0.0%) | 0(0.0%) | 1(20.0%) | 5(23.8%) | 1400.10 |

Active ingredients in red signifies that they are banned by the European Union
Source: Data from Field Survey 2015

*Table 5.* Distribution of respondents by safety devices used during agrochemical application

| Description | Niger State | | Ogun State | | All | |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No |
| Face Mask | 9(7.9%) | 105(92.1%) | 14(20.3%) | 55(79.7%) | 23(12.6%) | 160(87.4%) |
| Hand Gloves | 18(15.7%) | 97(84.3%) | 42(58.3%) | 30(41.7%) | 60(32.1%) | 127(67.9%) |
| Boots | 18(16.4%) | 92(83.6%) | 47(63.5%) | 27(36.5%) | 65(35.3%) | 119(64.7%) |
| Hat | 55(50.0%) | 55(50.0%) | 32(43.8%) | 41(56.2%) | 87(47.5%) | 96(52.5%) |
| Goggles | 0(0.0%) | 109(100.0%) | 11(15.9%) | 58(84.1%) | 11(6.2%) | 117(93.8%) |
| Overall Coat | 1(0.9%) | 108(99.1%) | 27(38.6%) | 43(61.4%) | 28(15.6%) | 151(84.4%) |
| Nose Guard | 24(22.0%) | 85(78.0%) | 43(59.7%) | 29(40.3%) | 67(37.0%) | 114(63.0%) |
| Others | 14(87.5%) | 2(12.5%) | 0(0.0%) | 1(100.0%) | 14(82.4%) | 3(17.6%) |

Source: Data from Field Survey, 2015

phosphonoglysine) which was higher than the recommended dosage (1400g) and between 1501g and 1500g of paraquat which is a highly hazardous pesticide that has been banned by the EU and they also applied quantities that were higher than the recommended rates (600g). All the agrochemicals used in Niger State were highly hazardous and three (2-4D, paraquat and propanil) out of the fourhad been banned. This agrochemical presents acute or chronic hazards environmentally and can cause severe or irreversible harm to farmers and the environment.

As indicated in Table 4, most (40.6%) of the rice farmers applied 2-4D in quantities greater than 2500g (89.3%) which is less than the recommended dosage (3000g). The mean rate of utilization of lambdacyhalothrin and cypermethrin was 450g and 500g respectively for rice farmers in Niger State. While, rice farmers in Ogun State applied about 500g of cypermethrin. This is an indication that rice farmers in the study area did not experience much of insect infestation in their rice farms. However, the rate of application of lambdacyhalothrin and Cypermethrin is about 60 and 90 per cent greater than the recommended dosage respectively.

Table 5 shows the safety measures used during agrochemical use by the rice farmers in the study area. Only 12.6 per cent used face mask during agrochemical spraying in all locations while 32.1per cent used hand gloves. Majority of farmers (63.5%) used farm boots in Ogun State while the majority (83.6%) did not make use of farm boots in Niger State. In addition, the majority of farmers (93.8%, 84.4% and 63.0%) applied agrochemical without the use of goggles, protective clothing and nose guard respectively in all locations 82.4 per cent of the rice farmers used other safety devices such as socks, personal clothing, handkerchiefs, *etc.* (Table 5). These findings are indications that rice farmers in the study area exposed themselves to agrochemical related health impairments given the non-use of protective materials which are supposed to safeguard them. Thus, they may be susceptible to agrochemical-induced impairments like eye problems (eye redness, itching of the eyes, *etc.*), skin infection (*e.g.*, rashes, other skin reactions) and respiratory problems (cough, sneezing, shortness of breath, *etc.*). This finding is in agreement with Mahantesh and Alka (2009) and Okoffoet al. (2016) who reported that small farmers mostly sprayed agrochemical without the use of protective materials, thus resulting inhealth hazards.

Table 6 shows respondent's attitudes during and after spray. Majority (54.3%) of the rice farmers apply agrochemical without undergoing formal training. Majority (94.1%) of the farmers use agrochemical based on their previous experience. Further, 53.8 per cent of the rice farmers employed experienced farm labourers to carry out the agrochemical spraying farm activity. In Niger State, the majority (66.7%) read users guidelines on agrochemical labels while 57.9 per cent of the rice farmers adhered to the guidelines on agrochemical labels during spraying. In the same vein, rice farmers in Ogun State read (50.0%) and followed (58.7%)

*Table 6.* Awareness and use of safety measures during and after spraying agrochemical

| Description | Niger State | | Ogun State | | All | |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No |
| Trained to Apply Chemical | 44(46.3%) | 51(53.7%) | 44(65.7%) | 23(34.3%) | 74(45.7%) | 88(54.3%) |
| Had Experience | 87(97.8%) | 2(2.2%) | 57(89.1%) | 7(10.9%) | 144(94.1%) | 9(5.9%) |
| Employed Experienced Labour | 53(56.4%) | 41(43.6%) | 32(50.0%) | 32(50.0%) | 85(53.8%) | 73(46.2%) |
| Read Label/Guideline | 64(66.7%) | 32(33.3%) | 37(58.7%) | 26(41.3%) | 101(63.5%) | 58(36.5%) |
| Employed Children | 55(57.9%) | 40(42.1%) | 37(58.7%) | 26(41.3%) | 92(58.2%) | 66(41.8%) |
| Follow Guidelines | 8(8.4%) | 87(91.6%) | 8(12.3%) | 57(87.7%) | 16(10.0%) | 144(90.0%) |
| Monitored the Wind | 64(70.3%) | 27(29.7%) | 45(71.4%) | 18(28.6%) | 109(70.8%) | 45(29.2%) |
| Washed Hands & Kits | 87(90.6%) | 9(9.4%) | 54(87.1%) | 8(12.9%) | 141(89.2%) | 17(10.8%) |
| Took Meal during spraying | 2(2.1%) | 92(97.9%) | 22(34.9%) | 41(65.1%) | 24(15.3%) | 133(84.7%) |
| Took Kola during spraying | 1(1.1%) | 93(98.9%) | 13(20.6%) | 50(79.4%) | 14(8.9%) | 143(91.1%) |
| Took a Bath after spraying | 1(1.1%) | 92(98.9%) | 26(40.0%) | 39(60.0%) | 27(17.1%) | 131(82.9%) |
| Revisited Farm within 24h of spray | 25(28.4%) | 63(71.6%) | 40(62.5%) | 24(37.5%) | 65(42.8%) | 87(57.2%) |

Source: Data from Field Survey, 2015

the agrochemical application guidelines during spraying. These could have a positive effect on handling of agrochemicals by the rice farmers and possibly improve yields.

For safety purpose, it is advised that agrochemicals should be sprayed when there is no wind in order to avoid drifts of agrochemicals or dust (Dudge et al., 2008; Damalas and Eleftherohorinos, 2011).

In spite of this, 29.2 per cent of the rice farmers did not monitor the wind before spraying agrochemical and this could portend negative effects on their health. Also, about 24.2 per cent of the rice farmers ate during spray either in the form of meals or snacks (e.g., chewing kola nuts). Similarly, the majority (62.5%) of the rice farmers re-visited the farm within 24 hours of spraying agrochemical in Ogun while 28.4 per cent came back to the farm around this time in Niger State. These attitudes according to Ayinde et al. (2007) and Damalas and Eleftherohorinos (2011) expose the farmers more to the health impairments associated with agrochemicals.

The likelihood ratio test for overall error term correlation for the MVP model was significant as shown on Table 7. The implication is that there were correlated binary responses between different health symptoms. The correlation coefficients, Rhos 21 ($p<0.05$), 32 ($p<0.01$), 42 ($p<0.01$) and 43 ($p<0.01$) were significant and positive implying that cough and diarrhoea, chest pain and cough, skin disease and cough and skin disease and chest pain complement each other. That is to say the rice farmers experienced these symptoms jointly.

Table 7 shows the factors predisposing rice farmers to the observed health symptoms as a result of agrochemical use. As shown, age had a significant and negative effect on diarrhoea. This implies that younger farmers are more susceptible to experiencing diarrhoea. This could be because the younger farmers may have been directly involved in the application since some of the older farmers employ them.

On the other hand, the older farmers may have more experience in the handling of agrochemicals. This is in line with Salam et al. (2004) and Mahmood et al. (2015) who reported that infants and toddlers who are exposed to herbicides and insecticides are about 5 and 3 times more prone to infections. Also, the probability of experiencing diarrhoea is higher for the male than their female counterparts since the coefficient for sex was significant ($p<0.10$). The coefficient for location was significant ($p<0.01$) and positive for all the health symptoms. This is an indication that rice farmers in Niger state are more prone to diarrhoea, cough, chest pain and skin diseases respectively. This could be because the rice farmers in Niger State applied more

*Table 7.* Factors predisposing rice farmers to observed health symptoms

| Variables | Diarrhoea | | Cough | | Chest pain | | Skin Disease | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | z-value | Coefficient | z-value | Coefficient | z-value | Coefficient | z-value |
| Age | -0.041*** | -2.88 | -0.005 | -0.65 | 0.004 | 0.47 | 0.001 | 0.10 |
| Sex | 0.259 | 0.49 | 0.284 | 0.85 | 0.804* | 1.76 | 0.078 | 0.23 |
| Location | 2.220*** | 4.60 | 1.105*** | 4.78 | 1.105*** | 4.55 | 1.745*** | 6.86 |
| Spray time | -0.550* | -1.50 | 0.007 | 0.04 | 0.464** | 2.18 | 0.632*** | 2.69 |
| Hours spent | 0.107 | 1.68 | 0.095*** | 2.66 | 0.075** | 1.99 | -0.013 | -0.26 |
| Herbicide | -1.204*** | -2.65 | 0.752*** | 3.10 | 1.339*** | 5.09 | 0.501** | 1.85 |
| Insecticides | -1.545** | -2.51 | 0.658 | 1.58 | 1.739*** | 3.69 | 1.521*** | 2.58 |
| Fertilizer | -0.111 | -0.29 | 0.419 | 1.54 | 0.453 | 1.71 | -0.471 | -1.60 |
| Farm size | 0.214 | 1.47 | -0.096 | -1.03 | -0.223** | -2.28 | -0.090 | -0.97 |
| Facemask | 0.506 | 0.98 | 0.146 | 0.36 | 1.001*** | 2.58 | -0.046 | -0.12 |
| Hand gloves | -0.165 | -0.33 | 0.307 | 0.90 | -0.122 | -0.38 | -0.246 | -0.70 |
| Boots | 0.016 | 0.03 | -0.386 | -1.24 | -0.777** | -2.48 | 0.403 | 1.13 |
| Hat | -1.005** | -2.54 | 0.352 | 1.54 | 0.848*** | 3.33 | 0.870*** | 2.90 |
| Goggles | -5.191 | -0.04 | 0.054 | 0.12 | -0.697 | -1.19 | 0.269 | 0.55 |
| Nose guard | 1.391*** | 3.58 | 0.787*** | 3.08 | -0.127 | -0.56 | 1.065*** | 4.25 |
| Overall coat | 1.309* | 1.69 | -0.049 | -0.12 | 0.420 | 1.07 | -1.118*** | -2.65 |
| Agro status | 0.232 | 0.45 | -0.537 | -1.62 | -0.483 | -1.56 | 0.414 | 1.08 |
| Chewed kolanut | -4.282 | -0.03 | -0.902* | -1.79 | 0.845** | 2.02 | -0.105 | -0.23 |
| Revisited farm | 0.410 | 1.10 | -0.075 | -0.33 | 0.045 | -0.19 | 0.542** | 2.15 |
| Constant | -1.424 | -1.68 | -1.208 | -2.55 | -2.449 | -4.14 | -1.358 | -2.94 |
| Wald $chi^2$(51) | 278.81 | | | | | | | |
| Log-likelihood | -402.23 | | | | | | | |
| Corr. Coefficients | | | | | | | | |
| Rho 21 | 0.256** | 2.10 | | | | | | |
| Rho 32 | 0.631*** | 7.83 | | | | | | |
| Rho 42 | 0.720*** | 9.29 | | | | | | |
| Rho 43 | 0.684*** | 7.88 | | | | | | |
| $Chi^2$ (6) | 94.613 | | | | | | | |

***, **, * implies significance at 1%, 5% and 10% respectively. Source: Data from Field Survey 2015

agrochemical including agrochemicals that were banned and they utilized them in quantities greater than the recommended dosage (Table 4). Although it is advisable to spray agrochemical during the early hours of the morning, the probability of experiencing chest pain and skin diseases is higher for rice farmers who sprayed agrochemical in the morning. This could be because farmers usually end their farming operations during the mid-day when the sun is out even though the farming operations started in the morning. However, spraying agrochemical in the morning reduces the probability of farmers experiencing diarrhoea. As rice farmers spend more hours spraying agrochemical, the probability of experiencing cough ($p<0.01$) and chest pain ($p<0.05$) increases. This suggests that farmers who spend more hours during the application of agrochemical are more exposed to its effect and have a higher risk of experiencing cough and chest pain. As rice farmers spend more hours spraying agrochemical, the probability of experiencing cough ($\beta=0.095$, $p<0.01$) and chest pain ($\beta=0.075$, $p<0.05$) increases. This suggests that farmers who spent more hours during the application of agrochemical are more exposed to its effect and have a higher risk of experiencing cough and chest pain. Similarly, rice farmers who applied herbicides had a higher probability of experiencing cough (â=0.752, $p<0.01$), chest pain ($\beta=1.339$, $p<0.01$) and skin diseases ($\beta=0.501$, $p<0.05$) than their counterparts who did not utilize herbicides. In the same vein, rice farmers who applied insecticides had a higher probability of experiencing chest pain (â=1.739, $p<0.01$) and skin diseases (β=1.521, $p<0.01$) than their counterparts who did not utilize insecticides. This could be because rice farmers who utilize these pesticides are more exposed to them and they could easily have contact with some of the hazardous chemicals. More so, most farmers in the study area failed to use protective devices and they also failed to follow the label instructions which are supposed to guide them and also provide them with some health information.

All safety devices are supposed to protect the farmers against agrochemical related health symptoms. However, farmers are supposed to follow the label instruction as to what protective devices to use and how to use them. Based on safety devices used, this study found that the use of overall protective clothing during application of agrochemicalin the study area reduced the probability of experiencing skin diseases (β=-1.118, $p<0.01$) while it increased the probability of having diarrhoea (β=-1.309, $p<0.10$) (Table 7). This could be due to the fact that overall clothing serves as a covering for the skin but sometimes this clothing comes in contact with farmers' food and drink and this could be a source of diarrhoea. However, the use of nose guard ($p<0.05$) increased the probability of predisposing the rice farmers to diarrhoea (β= -1.391), cough (β=0.750) and skin disease (β= -1.065). This may be due to wrong use of nose guard. Because farmers are advised to employ the use of nose guards that can filter the air and prevent them from inhaling the agrochemical and this may not be the case with rice farmers in the study area. Although, farmers are advised not to eat food during agrochemical application, the possibility of experiencing cough (â=0-902, $p<0.10$) decreased for farmers who chewed Kolanut. This could be because Kolanut acts as a cough suppressant and it also serves as a stimulant that counteracts fatigue. In addition, it helps to reduce thirst and hunger (Alajeet al., 2014). However, the act of chewing Kolanut increased the likelihood of the farmers experiencing chest pain (â=0.845, $p<0.05$). The result also showed that ricefarmers who re-visited their farms 24h after spraying agrochemical were at higher risk of the likelihood of experiencing skin diseases (β=0.542, $p<0.05$).

The study concludes that most of the pesticides used were among the PAN Africa list of highly hazardous pesticides and that rice farmers in the study area do not make use of protective devices during agrochemical application. Rice farmers who applied herbicides had a higher probability of experiencing cough, chest pain and skin diseases. In the same vein, rice farmers who applied insecticides are prone to chest pain and skin diseases. In addition, an average farmer applies agrochemical without undergoing training and they do not follow the users' instructions. Furthermore, younger farmers are more susceptible to diarrhea while farmers who applied pesticides for longer hours were more prone to skin diseases and cough. Thus, the study recommends that assessment; monitoring and environmental implications of agrochemical should be reinforced by the relevant agency before allowing its use. The information diffused to farmers through extension agents should emphasize the need for rice farmers in the study area to follow label instructions and employ the use of protective devices in line with the specification in the label during application. The use of children during agrochemical application should be discouraged so as to avoid diarrhea outbreak.

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