# MULTIVARIATE PROBIT ANALYSIS OF FACTORS PREDISPOSING COCOA FARMERS TO PESTICIDE TOXICITY IN NIGERIA

**[1]*Aminu, F. O., [2]Ayinde, I. A. and [2]Sanusi, R. A.**

*[1]Department of Agricultural Technology, School of Technology, Yaba College of Technology, Epe Campus, P. M. B. 2011, Yaba, Lagos State, Nigeria*
*[2]Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Nigeria*
**Corresponding Author:* folaafeo2@gmail.com *+2348036027236*

**Abstract**
The study investigated the factors predisposing cocoa farmers to pesticide toxicity in Nigeria. A multistage sampling procedure was used to select 390 respondents from five geo-political zones where cocoa is commercially grown in Nigeria. Data were collected with the aid of questionnaire and analysed using descriptive statistics and multivariate probit (MVP) model. Results revealed that cocoa farming was dominated by male farmers (76.6%), literate (88.3%) with a mean age of 49±9.63 years and household size of 10±4.78. The study further revealed that majority of the farmers were exposed to pesticide toxicity through their skin (84.6%), eyes (49.4%), mouth (54.3%) and lungs (58%). Results of the multivariate probit model revealed that the significant factors predisposing cocoa farmers to toxicity through skin (dermal) were period of pesticide application, use of personal protective clothing and pesticide packaging; through eyes were training, use of PPE, weather condition and pesticide packaging materials; through mouth were, age, wearing of PPE, pesticide labels and period of pesticide application; through lungs were age, training, pesticide preparation method, and weather condition. The study recommended that effective training and awareness programmes that targets hazards resulting from exposure of cocoa farmers to pesticide toxicity should be intensifies in the study area.

**Keywords:** Cocoa farmers, Multivariate probit, Pesticide toxicity, Nigeria,

## Introduction

The contribution of cocoa to the economy cannot be over-stressed. One of the major problems facing cocoa production in Nigeria is pests and diseases outbreak and these include black pod disease, capsids and swollen shoot disease. The effect of pests and diseases reduced crop yield, losses in the value of foreign exchange, reduction in farmer's income and also reduction in government revenue, etc. For example, about 10-40% loss in yield of cocoa in Nigeria has been ascribed to myriads of insect pests such as *Planococcoides njalensis* (15%), *Zonocerus variegatus* (15%), *Macrotermes bellicocus* (5%) and *Sylepta derogata* (10%) which are abundant during the dry spell, whereas *Carlibatus spp* (10%), *Bathcoelia thalassina* (15%), *Earias Biplaga* (10%), *Stictoccocus sjostedti* (10%), *Sahlbergella singularis* (25%) and *Phytophtora megakarya* (40%) caused a lot of cacao damage during the raining season (Azeez, 2016).

Pesticides are important agricultural inputs to protect crops from diseases, pests and weeds. According to Kughur, (2012), the uses of pesticides contribute not only to healthy growth of crops but also to improve farm work efficiency and regular supply of tasty agricultural produce. Cocoa farmers use a wide range of pesticides to reduce losses from pests and diseases in cocoa farming. Prominent among these, according to Tijani, (2006a) are: Copper (II) Sulfate pentahydrate (CuSO4) solution (a fungicide popular in the treatment of black pod infection; Benzene Hexachloride (BHC) (an insecticide that controls cocoa mirids); Aldrin/Dieldrin (Agrifume EDB 4,5) (to control mealy bugs); Carbamate-Unden (3% carbofuran) (an insecticide which is effective in controlling cocoa mirids in West African countries). Others are Didimac 25 (25% DDT) and Basudin (O, O-Diethyl O[4-methyl-6-(propan-2-yl) pyrimidinyl-2-yl]phosphorothioate). Pesticides is an important component of worldwide agriculture system that allows a noticeable increase in crop yields and food production in meeting the food demand of the ever growing population and control of vector-borne diseases (Alexandratos and Bruinsma, 2012). However, pesticides proved to be dangerous due to indiscriminate and excessive use, contaminating food, ground water, soil and the environment in general, resulting in pest resistance and pest outbreaks (Shankar, 2014). Overuse and misuse of pesticides can result in harmful effects on humans, the environment and toxicity to non-target organisms, thus affecting biodiversity negatively (Sande *et al.,* 2011). Components of synthetic pesticides have been attributed to chronic human ailments either due to consumption or exposure (Damalas and Koutroubas 2016).

All pesticides must be toxic, or poisonous, to be effective against the pests they are intended to control. Since pesticides are lethal, they are possibly unsafe to humans, animals, other organisms, and the environment. The toxicity of a pesticide is its capacity or ability to cause damage or sickness to the text animals. The four routes of exposure are dermal (skin), inhalation (respiratory), oral (mouth), and eyes (visual) (Damalas and Eleftherohorinos 2011). The risk involved with using a pesticide depends on both the toxicity of the product and the amount of exposure to the product by the farmer or user (Hazard = Toxicity x Exposure). Pesticide hazard therefore, tends to be low if the exposure level is low, regardless of the product's toxicity. To reduce the possibility of exposure and to protect farmers' health, the personal protective equipment (PPE) is advised during pesticide application, as this is a strong requirement for pesticide application as indicated on the product label (Reigart and Roberts, 2012).

Several factors can expose farmers to toxicity during pesticide handling. Formulation of pesticide products may affect the extent of exposure (Ikpesu and Ariyo, 2013). Liquids are prone to splashing and sometimes spillage, resulting in direct or indirect skin contact through clothing contamination. Solids may generate dust while being loaded into the application equipment, resulting in exposure to the face and the eyes and also the respiratory tract. The type and size of pesticide packaging can also affect potential exposure. Other predisposing environmental factors include weather condition (such as air temperature and humidity) may also affect the chemical volatility of the product. (Gil *et al.,* 2008). Wind increases considerably spray drift and resultant exposure to the applicator. The amount of pesticide that is lost or drifted from the target area and the distance the pesticide moves is known to increase as wind velocity increases while low relative humidity occasioned by high temperature cause more rapid evaporation of spray droplets between the spray nozzle and the target (Damalas and Eleftherohorinos, 2011). Furthermore, Pesticide mishandling such as transferring the products from their original packages into household containers and also the lack of compliance with instructions of the label can be also sources of exposure (Surgan *et al.,* 2010). This study therefore seeks to analyse the factors predisposing cocoa farmers to pesticide toxicity in Nigeria. Specifically, the study sought to describe the socio-economic characteristics of the cocoa farmers in the study area; identify the major routes of exposure to pesticide toxicity and analyse the factors predisposing cocoa farmers to pesticide toxicity in the study area.

Economic Importance of Pesticide Use in Cocoa Production:
Pesticide use is an economical way of controlling pests. They are used worldwide to manage agricultural pests. There are positive effects of using pesticides and the environment actually benefits from the direct or indirect results of pesticide application (Cunningham, 2015). One major benefit of pesticide use is the eradication of certain species that pose threats to cocoa trees. For example, *Phytophthora spp.,* a fungus that causes pod rots destruction to beans in immature pods and finally results in die-back. Pesticides require low labour input and allow large areas to be treated quickly and effectively. Due to the use of pesticides, it is possible to combat pests and produce larger quantities of cocoa beans. By producing more crops, farmers are also able to increase profits by having more produce to sell. Pesticides also increase farm profits by helping the farmer save money on labour costs. Using pesticides reduces the amount of time required to manually remove weeds and pests from fields. In addition to saving crops, pesticides have also had direct benefits to cocoa farmers' health. It is estimated that since 1945, the use of pesticides has prevented the deaths of around seven million farmers by killing pests that carry or transmit diseases (Scribd, 2015). Malaria, which is transmitted by infected mosquitoes, is one of the most commonly known and deadly diseases that has decreased in prevalence due to the use of pesticides. Other diseases that were minimized due to the use of pesticides include the bubonic

plague, which is carried by rat fleas, and typhus, which is transmitted by both fleas and body lice (Cunningham, 2015).

Improvement of the quality of human life is one of the benefits of pesticides and the environment can be protected at the same time. However, it cannot be denied that these chemicals also have harmful effects on humans and their environment. One major negative impact is chemical pollution; an insecticide or herbicide may be designed to have a short-lived effect. However, studies (Tijani, 2006a; Ikpesu and Ariyo, 2013) have shown that residues are found in the atmosphere, waterways, and the ground. Over time, as people keep on using synthetic chemical substances, the environment accumulates the residues that later on become pollutants. When pesticide residue piles up in the atmosphere, the quality of the air that people breath is heavily affected. Worse, it can cause humans lung related illnesses. Another effect is seen in the use of obsolete or counterfeit pesticides. According to CropLife Asia (2012), counterfeit and illegal pesticides can impact farmers and consumer health, environment, farmer's income and reputation, economic damage, crop losses and industry damage. To the farmer and consumer, counterfeit pesticides are rarely tested and may contain impurities which can be carried into harvested food, thus pose a health threat to the farmer and consumer. In the environment, toxic impurities may compromise water purity, impact wildlife and leave residues in soil that can be detrimental to future crops. Illegal products can severely damage crops, decrease yields and/or destroy land and the resulting produce may be of low quality crop while the soil may be contaminated. Counterfeit act as economy deterrents. This will lead to economic retardation and unemployment. Counterfeit products can cause loss of sales, patent and trademark infringement (Tarla *et al.,* 2014). A national priority is therefore to ensure that the country complies with the European Union Regulation 149/2008/EEC on Maximum Residue Levels (MRLs) for pesticides in cocoa beans, in order to minimise the risk of rejection of cocoa that does not meet these limits. Furthermore, Good Agricultural Practices (GAP) and Good Warehousing Practices (GWP) are seen as important for marketing of quality cocoa. Among the major constraints in the cocoa sector is farmers' illiteracy that prevents them from reading the labels attached to pesticide packages and the poor understanding by small retailers of critical information about active ingredients. This, in the past, has caused serious problems including, in some instances, human poisoning (Sonwa *et al*., 2008; ICCO, 2014).

**Methodology**

Cocoa farmers in Nigeria constituted the population for this study. The respondents were selected through a multi-stage sampling technique. The first stage involved purposive selection of five from six geo-political zones in Nigeria where cocoa is commercially grown. In the second stage, stratified sampling technique was used to group the five geopolitical zones into high, medium and low cocoa producing zones. Thus, following NBS, (2012); National Survey on Agricultural Exportable Commodities (NSAEC), (2013), the zones were classified as high (South West), medium (South South) and low (South East, North Central and North East). The third stage involved random selection of one state from each of the high, medium and low coca producing strata (zones). These are Ondo (high), Edo (medium) and Kwara (low). In the fourth stage, two agricultural zones were selected from each State through simple random sampling technique. The fifth stage involved the use of simple random sampling technique to select one Local Government Area (LGA) from each agricultural zone using the list of LGAs available in the agricultural zone as sampling frame. In the sixth stage, five villages were also randomly selected from each of the LGAs giving a total of 30 villages. Finally, in the seventh stage, a simple random sampling procedure was used in choosing 13 cocoa farmers from each of the 30 villages giving a total of 390 farmers for interview. A total of 350 questionnaires (110 for Kwara State; 118 for Edo State and 122 for Ondo State) were however, used for analysis as others were discarded due to incomplete information, outrageous data and spurious responses. Therefore, the total number of questionnaire used for analysis represented about 90 percent of the total number of sampled cocoa farming households. Data were collected on the socio-economic characteristics of cocoa farmers, routes of exposure to pesticides including data on variables that could predispose cocoa farmers to pesticide toxicity.

Analytical Framework:

Multivariate Probit Model (MVP): Various studies (Pingali *et al.,* 1994; Houndekon and De Groote, 1998; Ayinde *et al.,* 2006; Qiao *et al.,* 2012) had used univariate modelling to analyse the effects of pesticide use on health of farmers. Univariate modelling such as simple logit or probit treat the symptoms as being mutually exclusive and therefore, exclude useful economic information about interdependent and simultaneity of the health symptoms since several health symptoms and in this case, several route of exposures to pesticide toxicity were investigated. Also, the shortfall of using multinomial discrete choice model such as multinomial logit (MNL) or multinomial probit (MNP) according to Ndiritu *et al.,* (2012) is that interpretation of the influence of the explanatory variables on experience of each of the health symptoms or route of exposures is very difficult. Another disadvantage is that it is impossible to test if the health symptoms or routes of exposures are compliments or substitutes using the multinomial discrete choice model. Thus, this study used the MVP specification to overcome the shortfalls of using the separate probit equations and multinomial discrete choice estimators. MVP specification allows for systematic correlations between the routes of exposure to pesticide toxicity. The MVP approach simultaneously models the influence of the set of explanatory variables on each of the different routes of exposures, while allowing for the potential correlation between unobserved disturbances, as well as the relationship between the different routes of exposures (Belderbos *et al.,* 2004). One source of correlation may be complementarities (positive correlation) and substitutability (negative correlation) between different routes (Teklewold *et al.,* 2013). Failure to capture unobserved factors and interrelationships among exposure routes may lead to bias and inefficient estimates (Greene, 2008). The observed outcome of exposure effects can be modelled following the random utility formulation thus:

Consider the ith farm household $(i = 1 \ldots \ldots, N)$ which is facing routes of exposure due to pesticide use on their cocoa farms $j$ $(j = 1 \ldots\ldots, j)$. Let $U_0$ represent the effects on the farmer from traditional management practices, and let $U_k$ represent the effects of $k^{th}$ routes of pesticide exposure: ($k = D, I, O, E$) denoting exposure routes of dermal or skin *(D),* inhalation or respiratory *(I),* oral or through the mouth *(O))* and the eye or visual contact *(E).*

The general multivariate probit model is thus specified as follows:

$$Y^*_{ijk} = X'_{ij}\beta_k + U_{ij} \qquad (k = D, I, O, E) \ldots\ldots\ldots\ldots (1)$$

Using the indicator function, the unobserved preferences in equation (1) translate into the observed binary outcome equation for each symptom as follow:

$$Y_k = \begin{Bmatrix} 1 \ if \ Y^*_{ijk} > 0 \\ 0 \ otherwise \end{Bmatrix} \ (k = D, I, O, E) \ldots\ldots\ldots\ldots (2)$$

In the multivariate model, where the exposure to different routes are possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity (for identification of the parameters) where:

$(k = D, I, O, E) \sim MVN\ (0, \Omega)$ and the symmetric covariance matrix $\Omega$ is given by

$$= \begin{bmatrix} 1\ P_{DI}\ P_{DO}\ P_{DE} \\ P_{ID}\ 1\ P_{IO}\ P_{IE} \\ P_{OD}\ P_{OI}\ 1\ P_{OE} \\ P_{ED}\ P_{EI}\ P_{EO}\ 1 \\ \end{bmatrix} \ldots\ldots\ldots\ldots (3)$$

Of particular interest are the off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different routes of exposures. This assumption means that equation (2) gives a MVP model that jointly represents ability to experience a particular pesticide exposure route. This specification with non-zero off-diagonal elements allows for correlation across the error terms of several latent equations, which represent unobserved characteristics that affect the experience of alternative exposure routes.

The model is thus specified as:

$Y_{ij} = \beta_0 + \beta X_{ij} + \epsilon \dots\dots\dots\dots..(4)$
$Y_{ij}$ takes on values 1, 2……4, if individual i experiences alternative j

$Y_{ij} = \propto + \beta_1 X_1 + \beta_2 X_2 \dots\dots.. + \beta_9 X_9 + \varepsilon \dots\dots\dots\dots.(5)$

Where:
$Y_{ij}$ is a binary dependent variable that takes the value of 1 if the ith farmer reports jth exposure to pesticide toxicity and 0 otherwise., the jth route of exposure is as stated below;

$Y_1$ = Dermal (skin),
$Y_2$ = Eye (visual),
$Y_3$ = mouth (oral) and
$Y_4$ = Inhalation (respiratory).

$Xj\grave{\imath}$ is a vector of explanatory variables and is specified as:

$X_1$ = Age of farmer (years).
$X_2$ = Education (years of schooling).
$X_3$ = Period of pesticide application (years).
$X_4$ = Undergone training on pesticide application (1 if trained, 0 otherwise).
$X_5$ = Use of personal protective garment (1 if used, 0 otherwise).
$X_6$ = Pesticide preparation method (1 if mixed in spraying equipment, 0 otherwise).
$X_7$ = Adherence to pesticide instruction manual/label (1 if adhered, 0 otherwise).
$X_8$ = Weather condition (1 if windy, 0 otherwise).
$X_9$ = Pesticide packaging (1 if spillable, 0 otherwise).
$\varepsilon_i$ = Random error term.

**Results and Discussion**

Table 1 presents the results of the socio-economic characteristics of the sampled cocoa farmers in the study area. The results reveals that a larger proportion (38.9%) of the respondents were within the age range of 51 to 60 years of age. The mean age of 49 years implies that cocoa farmers were getting older and replacement by younger ones is needed. This result is in line with the findings of Adeniyi and Ogunsola (2014) who reported that, older farmers might find it difficult to meet the demands which the intensive care of cocoa farms required. Also older farmers tend to be slow in accepting innovations (Aminu and Hassan, 2016). Majority (76.6%) of the respondents were male while 23.4% were female. This implies that cocoa farming in Nigeria is male dominated. Sowunmi *et al.,* (2019) affirms the dominance of male in cocoa farming and that females were more involved in the processing and marketing of agricultural produce. In terms of educational distribution of the respondents, most (38.3%) of the sampled cocoa farmers had secondary education, 36.3% had primary education while 11.7% had no formal education. The modal educational level (primary education) implies that the sampled cocoa farmers in the study areas were relatively literates (who could read and write), implying a possibility of the cocoa farmers adopting new cocoa production technologies.

The results in table one further shows that majority (79.9%) of the sampled cocoa farmers were married, 40% had between 9 and 12 people as their household size with a mean household size of 10 people. This implies that the farmers had a large household which could probably serve as an insurance against short falls in supply of hired labour. This result corroborates the findings of Ayinde *et al.,* (2013), that a relatively large household size enhances the availability of family labour which is a cheaper alternative to hired labour. Also, 27.4% of the respondents cultivated between 4.1 and 6 hectares of land for cocoa production, 15.7% cultivated 2.1- 4hectares while 14.9% cultivated above 10 hectares of land in the study area. The mean area cultivated by all respondents was 6.82 hectares. This indicates that the cocoa farmers in the study areas were medium scale farmers according to Ogunlade *et al.,* (2009). This has implication on the output level and revenue accruable to the cocoa farmers. This finding is supported by the findings of Ogunlade *et al.,* (2009), that 75.5% of the cocoa farmers in Nigeria were either small or medium scale farmers. Majority (52.3%) of the sampled cocoa farmers in the study areas did not belong to cooperative association. This could have negative influence on their credit mobilisation which could affect cocoa farm expansion in the study areas. Also, 64% of the cocoa farmers in the study area financed their farm business through personal savings, 21.7% through *esusu*, 6.9% through friends and family while 3.7% financed through both money lenders and bank loans. This agrees with the findings of Akinnagbe and Ajayi, (2010) that access to bank loan by cocoa farmers has been a big problem due to lack of collateral and the risk associated with agricultural production.

Results in Table 2 reveals that majority (76.6%) of the sampled cocoa farmers in the study area had contacts with extension agents. Results on frequency of visits shows that, a larger percentage (36.9%) of the respondents in the study areas had contacts with extension agents fortnightly, 24.3% had monthly contacts and 7.1% had contacts on quarterly basis.

This could have positive implication on innovation dissemination and adoption in the study area. The results also showed that 61.4% of the sampled respondents were trained on pesticide application. This implies that cocoa farmers in the study areas were knowledgeable in the techniques of pesticide application. Majority (76.9%) of the sampled cocoa farmers in the study areas used pesticides frequently in their cocoa farms. Only 23.1% used pesticide occasionally. This implies that the cocoa farmers are likely to nip the incidence of pests and diseases attack in the bud which can increase their output and revenue. Furthermore, most (40.6%) of the respondents had cocoa farming experience of between 21 to 30 years of farming experience. The mean cocoa farming experience of about 20 years suggests that cocoa farmers in the study areas had considerable years of farming experience which could translate to increased productivities. This result agrees with the findings of Lawal and Sanusi (2010) that most cocoa farmers in Nigeria have more than 20 years of farming experience.

Personal Protective Equipment (PPE) Used by Cocoa Farmers in the Study Area:
Table 3 indicates that, the prominent personal protective equipment worn by majority of the sampled cocoa farmers during pesticide application in the study area were cap (71.1%), boot (67.4%), nose guard (66.3%), and face mask (55.7%) This is an indication that cocoa farmers do not wear full personal protective clothing and therefore, expose themselves to health impairments occasioned by pesticide application in the study areas. According to Oluwole and Cheke (2009) farmers cited economic reasons, inconveniences involved, lack of available protective equipment and lack of information as major reasons for not using protective equipment.

Routes of Exposures to Pesticide Toxicity in the Study Area:
Table 4 presents the description of the routes of exposure to pesticide toxicity as reported by the cocoa farmers in the study area. The results revealed that majority (84.6%) of the cocoa farmers in the study areas were exposed to pesticide toxicity through the skin, 58% through inhalation and 54.3% through mouth while 49.4% were exposed to pesticide toxicity through the eyes.

The implication of this result is that the cocoa farmers are prone to experiencing health symptoms such as skin irritation, respiratory disorder and redness of eyes among others due to their exposures to pesticide. This result confirms the findings of Damalas and Eleftherohorinos (2011) that, the four routes of exposure to pesticide toxicity are dermal (skin), inhalation (lungs), oral (mouth) and eyes (vision)

Factors Predisposing Cocoa Farmers to Pesticide Toxicity in the Study Area:
Table 5 presents the multivariate Probit analysis of the significance of pesticide exposure routes on the cocoa farmers. First, we did the Wald test that farmers' exposure to pesticide toxicity through one route

is correlated with the other routes of exposure The p-value of the Wald test statistic for the overall significance of the model is 0.000, indicating that the MVP model was a better specification than univariate probit model for the observed data. The likelihood ratio test of rho (ρ) is highly significant (p-value=0.000), further indicating that a multivariate probit specification fits the data well (Table 5). Rho refers to the correlation coefficient among the error terms of the exposure routes. Rho21, for instance, is the correlation coefficient among the error terms of routes (1) and (2). Another important result is that the correlation coefficients among the error terms are significant indicating that the exposure routes are interdependent. The simultaneous modelling was also justified with the highly significant off-diagonal values of the error covariance matrix (/atrhoij). Similar result was reported by Tsegaye *et al.,* (2017).

The estimates of the factors predisposing farmers to pesticide toxicity are thereafter, presented in Table 6. Results of the four routes of exposure are presented in the following order, skin, eye, oral and inhalation.

<u>Skin exposure</u>: Table 6 revealed that the significant factors predisposing cocoa farmers to toxicity through skin (dermal) were pesticide application period ($p<0.10$), use of personal protective clothing ($p<0.05$) and leaking pesticide packaging ($p<0.05$). The coefficient of years of experience in pesticide application ($p<0.10$) and use of protective clothing (PPE) ($p<0.05$) such as overall, eye goggle, gloves, nose and face masks, and so on, had an inverse relationship with exposures to pesticide toxicity through skin. These imply that the probability of farmers' exposure to pesticide toxicity through skin is reduced by years of experience of pesticide application and use of personal protective clothing in the study area. This result corroborates the findings of Reigart and Roberts (2012) that personal protective equipment (PPE) should always be worn as indicated on the product label to reduce the possibility of exposure and to protect farmers' health. The results however indicated that the probability of farmers' exposure to pesticide toxicity through skin increased with leaking pesticide packaging materials. Damalas and Eleftherohorinos (2011) opined that, the size of cans, bottles, or other liquid pesticide containers may affect the potential for spillage and splashing on the user of the pesticide.

<u>Eye exposure:</u> The probability of cocoa farmers' exposures to pesticide toxicity through eyes decreases with training in pesticide application ($p<0.05$) and use of PPE ($p<0.10$) while it increases with weather condition ($p<0.05$) and pesticide packaging materials ($p< 0.10$). These imply that cocoa farmers who had undergone training on pesticide application and worn protective clothing such as face mask are not prone to exposure to pesticide toxicity through eyes.

Also, farmers who mixed and sprayed pesticide when the weather is windy and had leakages in their pesticide cans or bottles are liable to be exposed to pesticide toxicity through their eyes. This result corroborates the findings of Ayinde *et al.,* (2006); Damalas and Koutroubas (2016) who advised that farmers should generally take care of their eyes when spraying to prevent toxic chemicals from the insecticide from having contact with their eyes.

<u>Mouth exposure</u>: Table 6 further indicates that probability of farmers' exposure to pesticide toxicity through mouth increases with age of the cocoa farmer ($p<0.10$), wearing of PPE ($p<0.05$) and non-adherence to instructions on pesticide labels and manual ($p<0.05$). These results imply that older cocoa farmers who used PPE and did not adhere to pesticide instructions are more exposed to pesticide toxicity orally than the younger ones. It's also possible that the cocoa farmers in the study areas may not have used the appropriate PPE recommended for pesticide application thereby exposing them to pesticide toxicity orally. In contrast, exposure to pesticide toxicity through mouth decreases with years of experience in pesticide application ($p<0.01$).

<u>Inhalation</u>: Training ($p<0.10$) and weather condition ($p<0.05$) were found to increase the cocoa farmers' probability of exposure to pesticide toxicity through inhalation in the study area. These results imply that cocoa farmers who had undergone training in pesticide application and sprayed pesticide against the wind are more exposed to pesticide toxicity through inhalation. This could mean a possibility that farmers ignored recommendations of the trainers due to their own personal or psychological preference,

feelings of adequacy and knowledge of pesticide application or even sheer nonchalance among others. The result also indicated that exposure to pesticide toxicity increase with mixing pesticide in other container other than the sprayer ($p<0.001$) while it decreases with age of the cocoa farmers ($p<0.10$). The result also implies that younger farmers are more liable to exposure to toxicity through inhalation than older farmers in the study areas. This could be as a result of improved experience of older farmers during pesticide application.

**Conclusion and Recommendations**

This study has successfully made use of the multivariate probit to model route of expose of cocoa farmers to pesticide toxicity. The study further identified the fact that majority of the cocoa farmers were exposed to pesticide toxicity. This is surprising despite reported findings that farmers receive regular training on pesticide application techniques in the study areas.

Hence, effective training and awareness programmes that targets hazards resulting from exposure of cocoa farmers to pesticide toxicity and maintenance of farmers' on-field safety should be intensified by both the State governments and non-government agencies (NGOs) that are involved in training the cocoa farmers. Also, appropriate personal protective equipment should be made more available and accessible to the farmers at subsidized costs. Development of less-poisonous, synthetic pesticides (or even organics) which imposes little or no serious health hazard on cocoa farmers should made a research focus by most universities and research institutes.

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Table 1: Distribution of cocoa farmers by socio-economic characteristics (*N = 350)*

| Description | Frequency | Percentage | Mean | Std. dev. |
|---|---|---|---|---|
| **Age** | | | | |
| Less or equal to 30 | 27 | 7.7 | 49.02 | 9.630 |
| 31-40 | 63 | 18.0 | | |
| 41-50 | 95 | 27.1 | | |
| 51-60 | 136 | 38.9 | | |
| Above 60 | 29 | 8.3 | | |
| **Sex** | | | | |
| Female | 87 | 23.4 | | |
| Male | 268 | 76.6 | | |
| **Educational status** | | | | |
| None formally | 41 | 11.7 | Primary | |
| Primary | 127 | 36.3 | | |
| Secondary | 134 | 38.3 | | |
| Tertiary | 48 | 13.7 | | |
| **Marital status** | | | | |
| Single | 32 | 9.1 | | |
| Married | 279 | 79.7 | | |
| Widowed | 23 | 6.6 | | |
| Divorced | 16 | 4.6 | | |
| **Household size** | | | | |
| 1-4 | 20 | 5.7 | 10 | 4.775 |
| 5-8 | 120 | 34.3 | | |
| 9-12 | 140 | 40.0 | | |
| 13-16 | 29 | 8.3 | | |
| Above 16 | 41 | 11.7 | | |
| **Farm size** | | | | |
| Less than 2ha | 0 | 0.0 | 6.82 | 5.215 |
| 2.1-4ha | 55 | 15.7 | | |
| 4.1-6ha | 96 | 27.4 | | |
| 6.1-8ha | 93 | 26.6 | | |
| 8.1-10ha | 54 | 15.4 | | |
| Above 10ha | 52 | 14.9 | | |
| **Cooperative membership** | | | | |
| No | 183 | 52.3 | | |
| Yes | 167 | 47.7 | | |
| **Source of funds** | | | | |
| Bank Loan | 13 | 3.7 | | |
| *Esusu* | 76 | 21.7 | | |
| Personal Savings | 224 | 64.0 | | |
| Friends and Family | 24 | 6.9 | | |
| Money Lender | 13 | 3.7 | | |

**Source:** Field Survey Data, 2017

Table 2: Distribution of cocoa farmers by some farming characteristics *(N = 350)*

| Description | Frequency | Percentage | Mean | Std. Dev. |
|---|---|---|---|---|
| **Extension contacts** | | | | |
| No | 82 | 23.4 | | |
| Yes | 268 | 76.6 | | |
| **Frequency of visits** | | | | |
| No Visit | 82 | 23.4 | | |
| Weekly | 23 | 6.6 | | |
| Fortnightly | 129 | 36.9 | | |
| Monthly | 85 | 24.3 | | |
| Quarterly | 25 | 7.1 | | |
| Yearly | 6 | 1.7 | | |
| **Trained on pesticide application** | | | | |
| No | 135 | 38.6 | | |
| Yes | 215 | 61.4 | | |
| **Use of pesticide** | | | | |
| Occasionally | 81 | 23.1 | | |
| Frequently | 269 | 76.9 | | |
| **Cocoa farming experience** | | | | |
| Less or Equal to 10 | 51 | 14.6 | 19.94 | 7.592 |
| 11-20 | 136 | 38.9 | | |
| 21-30 | 109 | 31.1 | | |
| 31-40 | 40 | 11.4 | | |
| Above 40 | 14 | 4.0 | | |

**Source:** Field Survey Data, 2017

Table 3: Distribution of Respondents by Personal Protective Equipment Used by Cocoa Farmers in the Study Areas

| PPE | Frequency | Percentage |
|---|---|---|
| Cap | 249 | 71.1 |
| Hand gloves | 174 | 49.7 |
| Nose guard | 232 | 66.3 |
| Face mask | 195 | 55.7 |
| Goggles | 156 | 44.6 |
| Overall coat | 152 | 43.4 |
| Boot | 236 | 67.4 |
| Long sleeve cloth | 124 | 35.4 |
| Ordinary eye glasses | 67 | 19.1 |

**Source:** Field Survey Data, 2017

Table 4: Distribution of respondents by routes of exposures to pesticide toxicity in the study area

| Description | Frequency | Percentage |
|---|---|---|
| Splash on the body (Skin) | 296 | 84.6 |
| Through Eyes (Vision) | 173 | 49.4 |
| Through Mouth (Oral) | 190 | 54.3 |
| Inhalation (Respiratory) | 203 | 58.0 |

**Source:** Field Survey Data, 2017

Table 5: Results of the Wald test of simultaneity of the factors predisposing cocoa farmers to pesticide toxicity in the Study Areas

| | Coefficients | P-value | | Coefficients | P-value |
|---|---|---|---|---|---|
| /atrho21 | -0.185 | 0.048 | rho21 | -0.183 | 0.043 |
| /atrho31 | -0.335 | 0.000 | rho31 | -0.323 | 0.000 |
| /atrho41 | -0.374 | 0.000 | rho41 | -0.357 | 0.000 |
| /atrho32 | 0.600 | 0.000 | Rho32 | 0.537 | 0.000 |
| /atrho42 | 0.376 | 0.000 | Rho42 | 0.359 | 0.000 |
| /atrho43 | 0.679 | 0.000 | Rho43 | 0.591 | 0.000 |

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43= 0: chi2(6) = 111.057
Prob > $Chi^2$ = 0.0000

**Source:** Computed from Field Survey Data, 2017

Table 6: Factors predisposing cocoa farmers to pesticide toxicity in the study areas

| Variable | Dermal | Eye | Mouth | Inhalation |
|---|---|---|---|---|
| Age (years) | -0.006 | 0.013 | 0.015* | -0.016* |
| | (-0.62) | (1.47) | (1.71) | (-1.76) |
| Education (years) | -0.005 | -0.013 | 0.008 | 0.022 |
| | (-0.30) | (-0.81) | (0.42) | (1.24) |
| Pesticide period (years) | -0.023* | 0.006 | -0.03** | 0.015 |
| | (-1.85) | (0.52) | (-2.53) | (1.29) |
| Undergone training | 0.057 | -0.28** | 0.067 | 0.149* |
| | (0.32) | (-2.19) | (0.38) | (1.85) |
| Use of protective clothing (dummy) | -0.81**4 | -0.37*1 | 0.395** | 0.202 |
| | (-2.39) | (-1.78) | (2.15) | (0.94) |
| Pesticide preparation method | 0.081 | 0.249 | 0.094 | -0.46*** |
| | (0.50) | (1.53) | (0.58) | (-2.7) |
| Adhere to pesticide label | -0.042 | -0.102 | 0.16** | -0.051 |
| | (-0.24) | (-0.06) | (2.08) | (-0.30) |
| Weather condition (dummy) | 0.166 | 0.042** | -0.045 | 0.087** |
| | (-0.79) | (2.21) | (-0.22) | (2.42) |
| Packaging | 0.517** | 0.316* | -0.152 | 0.074 |
| | (2.19) | (1.89) | (-1.47) | (0.64) |
| Constant | 1.184 | -1.490 | -1.659 | -1.941 |
| | (2.09) | (-2.73) | (-2.93) | (-3.57) |

Notes: N= 349; Log pseudo likelihood= -708.38177; Wald chi2 (36) = 55.52;
Prob. > chi2 = 0.01 ***, ** and * indicate significance at 1%, 5% and 10% levels respectively. Figures in parentheses are z-values.

**Source:** Computed from field survey data, 2017.