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Principal Component Analysis of Some Pesticide Handling Practices of Small Scale Vegetable Farmers in Rural and Urban Districts in Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author DTA designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Authors CAM and KAN managed the analyses and progress of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To compare the adherence to pesticide safety standards by small scale vegetable farmers from rural and urban districts in Ghana.
Place and Duration of Study: Accra Metropolitan Assembly (AMA) (Urban District) in Greater Accra Region and Kwaebibirim District (KD) (Rural District) in the Eastern Region of Ghana. The survey was conducted from August – November, 2012
Methodology: Sixty small scale vegetable farmers (30 from AMA and 30 from KD communities) responded to a questionnaire (11 questions) on pesticide handling practices. Principal component analysis with Varimax rotation was used to reduce the 11 questions for fear of redundancy. Factors

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with eigen value greater than 1 were maintained as they accounted for 77.12% of the variable in the data set. Analysis of covariance (ANCOVA) was conducted on the new factors to determine differences in scores for farmers from AMA and KD (P<.05). SPSS (version 16) was used for the analyses.

Results: After Varimax rotation, 5 new factors (F1, F2, F3, F4 and F5) were retained and they accounted for 77.12% of the variability in the data set. The new factors were renamed based on the factors that loaded in each factor. Farmers in KD had a significant higher mean score (0.70 +/- 0.46) than those from AMA (0.57 +/- 0.29) for F1 (Personal Hygiene and Sanitation). Farmers from AMA had a significant higher mean than those from KD (F = 33.99, P<0.01) for F2 (Eat and drink during or after spraying in the farm). There was no significant difference for F4 (I am the only one who sprays the field) and F5 (I have received training in pesticide application) (P>.05)

Conclusion: Farmers in rural districts (KD) take more precautions during pesticide handling than those in the urban districts (AMA). The age of the farmers may play a role in their behaviour. However, we propose that all farmers undergo training on pesticide use for better utilization with emphasis on farmers in urban districts.

Keywords: Pesticides; principal component analysis; varimax rotation; Ghana.

1. INTRODUCTION

Vegetable cultivation in Ghana is an important activity because it provides vital nutrients and jobs for some rural, peri-urban and urban farmers. The demand for vegetables is high in the expanding cities in developing countries and farmers in peri-urban and urban areas, or rural areas with good access to the cities, are in a position to find market for their produce [1].

Annual food production is below population growth, and this situation of underproduction of food poses a threat to the increasing population [2]. Consequently, vegetables and other foodstuff are increasingly grown in rural, urban and peri-urban areas to meet the demand [1]. Nevertheless, traditional vegetable farming systems (i.e. without any chemical input) are incapable of meeting this challenging demand due to pests, diseases and soil fertility related issues. Therefore, there is the need to develop strategies to manage the pests and diseases. Chemical pesticide use is a common practice for pest management in vegetable cultivation in Ghana [3,4] to increase yield [5,6]. Over 90% of Ghanaian farmers use pesticides [6] most of which are highly and moderately hazardous to man. These pesticides are used on vegetables such as tomatoes, cabbage, okra, eggplant and shallots. In spite of their beneficial effects, pesticides have potential environmental and public health impacts. For instance, they can cause direct human poisoning, accumulate as residues in food and the environment or lead to the development of resistant strains of pests if misused. Almost none or just a handful of the farmers have ever had any form of training on pesticide use [1]. [7] Observed that rural workers and farmers in Brazil are probably the group at most risk through occupational exposure and hence an increase in pesticide residue in their produce due to over reliance on pesticides. According to [8] occupational exposure to pesticides in developing countries is due to the prevailing low education among rural workers which precludes their ability to follow the hazard warnings developed by the chemical industry and regulatory agencies. We hypothesize that farmers in urban and peri-urban areas are well informed about pesticides use than those in rural areas giving their closeness to pesticide dealers and information. Consequently, we expect them to be better users of pesticides than their counterparts in rural areas. Eleven variables relating to pesticide handling practices were examined. Principal component analysis was used to reduce the variables to a reasonable number to avoid redundancy. Principal component analysis is a factor method which Pearson developed in 1901, and later modified by Hotelling in 1933 [9]. Principal component analysis is applicable when there are measures on a number of observed variables and wish to develop a smaller number of artificial variables called principal components that will account for most of the variance in the observed variables. This technique is designed to avoid redundancy in the observed variables. Principal component analysis is a very useful tool in data analysis in many fields including Agriculture, Medicine and Social Sciences.

Work has not been done in Ghana to evaluate the differences in pesticide use patterns between rural and urban small scale vegetable farmers.

We sought to find out which groups of farmers pay less attention to pesticide safety rules. Pesticide use patterns in cabbage grown in both areas were compared. The finding will give baseline information on the knowledge of farmers on handling of pesticides. Also more vulnerable farmer groups to pesticide hazards will be identified. Information like these will help maximize funds for training and proper handling of pesticides.

2. MATERIALS AND METHODS

2.1 Study Area

One urban and a rural district were selected for this study. These were Accra Metropolitan Assembly (AMA) (Urban District) in Greater Accra Region and Kwaebibirim District (Rural District) in the Eastern Region of Ghana.

Accra is the capital city of Ghana and is located between latitude 5°32^{1} and 5°38^{1} N and longitude 0°06^{1} and 0°16^{1} W on the South East coast of the country. The present Metropolitan area encompasses the city itself and the outlying semi urban Ga Districts [10]. Three communities known for the intense urban vegetable cultivation namely; Dzorwulu, Korle-bu and Airport were selected.

Kwaebibirim District is in the Eastern Region of Ghana. It lies between 6° and 7° North and between longitude 1^{0}30^{1} West and 0^{0}30^{1} East. Sixty to seventy percent of the inhabitants are mainly engaged in agriculture. Crops like oil palm, cocoa, plantain, rubber and vegetables are predominantly grown in this district [11]. Three vegetable growing communities were selected from this District for the study; Topremang, Apinamang and Essienkyiem.

These research areas were proposed by the Extension Agents in the Ministry of Agriculture in the Greater Accra Region; these are hotspot of vegetable production in Ghana. A Snowballing Technique was used to sample the farmers: in which one farmer introduces us to another farmer with the help of the Extension Agents in the area.

2.2 Data Collection on Pesticide Use Patterns

A questionnaire was developed (Table 1) to obtain the needed information from the vegetable farmers. The questionnaire contained 11 closed ended questions. Additional observations were also made on the activities carried out during farm operations. The survey was conducted from August – November, 2012. Ten farmers were randomly interviewed from each community, making a total of sixty (60) farmers, 30 from AMA and 30 from Kwaebibirem district. The selected farmers were those responsible for decision making covering their respective farms. The questionnaire was designed in English but interpreted into 'Twi' and 'Ga' where necessary by the help of an Agricultural Extension Agent (AEA) from the respective district Directorates of the Ministry of Food and Agriculture (MoFA). Not more than five questionnaires were administered per day for convenience, effective time use and quality work. The questionnaires were administered on farmer's farm or in their residences individually or in small group discussion (Fig. 1).

Table 1. Variables used to collect information on pesticide handling practices

Variable	Yes	No
Do you smoke		
Do you smoke while spraying		
Do you eat during or after spraying in the farm		
Do you drink during or after spraying in the farm		
Do you apply the pesticides alone		
Have you received any training in pesticide application		
Do you change your cloth immediately after spraying		
Do you bathe immediately after spraying		
Do you wash your hands immediately after spraying		
Do you wash your face immediately after spraying		
Do you follow instructions on pesticide containers		

2.3 Data Collection and Analysis

In the analysis of the safe and unsafe variables of pesticide handling practices, a simple score of '1' – 'yes' and '0' – 'no' was used. Principal component factor analysis with varimax rotation was conducted on 11 variables (Table 1). We used Principal Component Analysis in this study because we suspected redundancy within the variables. Common factors with eigen values

above 1.0 were selected representing at least 77.12 % of all variations in the data. Factor scores for each common factor in all farmers were computed by adding the scores of variables (0 or 1) for each common factor across location (KD and AMA). Five factors were extracted from the principal component analysis and were renamed by the authors. Analysis of covariance (ANCOVA) was carried in order to determine location differences in each factor score, controlling for the effects of educational level and duration of employment. The level of significance was set at 0.05. SPSS version 16 was used for these analyses.

3. RESULTS AND DISCUSSION

3.1 Factor Extraction

Factor loading of 11 variables of safe and unsafe handling of pesticides and Eigen values of the five common factor extracted by Principal Component Analysis with Varimax Rotation obtained from 60 small scale vegetable farmers is shown in Tables 2 and 3 respectively. From the factor loading analysis five factors were derived from the 11 variables loaded. These 5 factors accounted for 77.12% of the variability in the pesticide handling practices. The eigen value criterion also known as the Kaiser criterion is one of the most widely used criterion for solving the number of components to retain. This criterion requires that any component with eigen value greater than 1.00 be retained and interpreted [12]. Thus five factors were retained and ANCOVA analysis in SPSS (version 16) was conducted on these factors for the farmers.

The resulting common factors were named based on the Factor loading of the safe and unsafe variables in Table 2.

3.2 Comparative Study of Farmer's Behaviour

Analysis of Covariance (ANCOVA) for the five common factors score of all farmers in the Rural (KD) and Urban (AMA) areas is shown in Table 4. The results reveal that of the five new factors obtained, 3 showed significant difference while 2 did not show any significant difference. Farmers in KD significantly respected (p = 0.05) Personal hygiene and Sanitation (F1) than those in AMA (Table 4). This implies that vegetable farmers from AMA expose themselves more to pesticides than those from KD. F2 (Eat and drink during or after spraying in the farms) and F3 (Smoke during or after spraying in the farms) are also new factors from the analysis. Here, farmers of AMA scored higher than those from KD. Eating and drinking during pesticide application are ways of direct entry of pesticide through the mouth and the nose. [13] Conducted a similar research with vegetable farmers in irrigation sites in Ghana. They reported that 97.5% (of 119 farmers) and 75.6% (of 93 farmers) indicated that they know that pesticide can get into their body directly through the nose and the mouth. In developing countries such as Ghana, many researchers have pointed out that farmers face immense risk of exposure owing to the use of toxic chemicals that are banned or restricted in other countries [14-16]. In the course of our visits to farmer's field, we found out that most of the farmers in AMA are young men who probably moved to the cities for greener pasture but ended up in urban vegetable production [17]. Smoking which common amongst young people could explain why there was an increase in smoking from AMA. Smoking is addictive, thus smokers will smoke just at any time even if they are spraying pesticides as was observed in this study.

Fig. 1. Researcher with some farmers during interviews (photos @ D. T. Achiri, 2012)

Table 2. Factor loading of 11 variables of safe and unsafe practice of pesticide handling for five common factors (F1-5)

Variables	Factors				
	F1	F2	F3	F4	F5
Do you wash your hands immediately after spraying	**0.693**	-0.066	0.264	-0.073	-0.101
Do you change your cloth immediately after spraying	**0.758**	-0.148	-0.333	0.009	0.111
Do you wash your face immediately after spraying	**0.842**	-0.076	0.054	-0.093	-0.047
Do you eat during or after spraying in the farm	-0.223	**0.850**	0.093	-0.158	0.025
Do you drink during or after spraying in the farm	-0.063	**0.926**	0.026	-0.072	-0.140
Do you smoke while spraying	-0.025	0.123	**0.890**	-0.069	-0.053
Do you smoke	0.051	-0.034	**0.923**	0.028	0.096
Do you bathe immediately after spraying	0.532	-0.105	-0.143	**0.649**	0.078
Have you received any training in pesticide application	-0.029	-0.058	0.039	-0.027	**0.958**
Do you apply the pesticides alone	-0.346	-0.131	0.042	**0.825**	-0.069
Do you follow instructions on pesticide containers	**0.500**	0.492	-0.041	0.095	0.313

Table 3. Eigenvalues of five common factors extracted by Principal component factor analysis with Varimax rotation

Components	Initial eigenvalues			Rotation sums of squared loadings		
	Eigenvalue	% of variance	Cumulative %	Eigenvalue	% of variance	Cumulative %
F1	2.654	24.130	24.130	2.474	22.490	22.490
F2	2.039	18.538	42.668	1.901	17.286	39.775
F3	1.699	15.444	58.111	1.862	16.928	56.703
F4	1.071	9.741	67.852	1.161	10.556	67.260
F5	1.019	9.266	77.118	1.084	9.858	77.118

Eigenvalue – Total variance explained by each principal components. % of variance – Percentage of the total variance attributed to each factor. Cumulative – Percentage of variance attributable to that principal component and those that precede it in the table

Table 4. Differences in Factor Scores of Safe and unsafe practices of pesticide handling

Component factor	KD		AMA		Differences
	Mean	SD	Mean	SD	F- value
F1: Personal hygiene and sanitation	0.70	0.460	0.57	0.298	4.644*****
F2: Eat and drink during or after spraying in the farm	0.54	0.500	0.97	0.181	33.984******
F3: Smoke during or after spraying in the farm	0.05	0.320	0.18	0.190	0.023*****
F4: I am the only one who sprays the pesticides	0.53	0.503	0.52	0.504	0.093
F5: Have received training in pesticide application	0.27	0.450	0.23	0.430	0.086

F1-5 represent the first, second, third, fourth and fifth factor respectively, SD-Standard deviation.
**P < 0.05 **P < 0.01*

In F4 (I am the only one who sprays the pesticides) and F5 (Have received training in pesticide application), there was no significant difference in the scores of the farmers from KD and AMA. In both groups of farmers, very few of them had received training on pesticide handling as their mean score were just about 0.27 (KD) and 0.23 (AMA). This implies that training of farmers will be a very veritable ingredient in improving farmer's safety. [18] had reported that many vegetable farmers in Ghana had not received proper training in pesticide handling. [16] also posits that wrong application techniques, badly maintained or totally unsuitable spraying equipment and inadequate storage practices of farmers could be attributed to lack of training on such subjects and their illiteracy precludes them from having and appraisal of the pesticide labels [19].

4. CONCLUSION

The findings from this research indicate that small scale vegetable farmers in rural areas appear to respect safety requirements than those in urban areas. Contrary to the hypothesis those farmers in urban areas who are close to information will be. The overall situation here is that all set of farmers still need training to better improve pesticide management. A limitation in this study includes the possibility of farmers giving subjective responses. Farmers may not have given appropriate information for fear of being investigated or perhaps for secondary gains. While we acknowledge that in this study, we still believe that the relevance of this study is beneficial. Our findings are important for policy making in the area of pesticide management and use. This is even more eminent considering that farmers use from mild to very hazardous pesticides.

CONSENT

Farmers consent was sought before interviewing them. They were also informed that the findings of this research were purely for academic purposes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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