An investigation into factors predisposing workers to high levels of Pesticide exposure in Machakos District, Kenya

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Abstract: About 40.7% pesticides used to control the pests on crops worldwide are toxic. Over 60% workers in Kenya are exposed to pesticides due to lack of knowledge, negative attitude and poor practice. Ministry of Agriculture reported over 70% unspecified pesticides used on farms in Mavoko Division were toxic and farm workers who applied them complained of unspecified health complications of which 60% were pesticide related. These allegations were investigated on 160 workers who had been employed for over two years on farms in Kinanie sub-location. Data was collected through interviews and observations. Data collected was analyzed using Statistical Package for Social Sciences ver. 15.0. Descriptive statistics for frequencies and percentages, test for significance using Pearson's Chi-square at 5% significance level and cross tabulations were done to test for associations between factors. Results showed that 43.7% exposed workers had not been trained which revealed they lacked knowledge on pesticide risks and safe use. Over 68% were unable to understand and interpret label instructions revealing their low education level since about 90% had only primary level education. Workers had a negative attitude towards pesticide risks and use of protective clothing because over 37% said a mask and overalls were uncomfortable to wear. The claim by workers that they had a positive attitude was not demonstrated in their practice as observations revealed that none used full protective equipment , while 25% did not use any when spraying. Observed poor hygienic practices such exposed workers to pesticides. Observations showed that 68% pesticides used such as Alphacypermethrin were WHO Class II that are toxic. Post-exposure symptoms experienced by exposed workers could be attributed to pesticide exposure since all symptoms are known effects of pesticide poisoning. Only 2.5% unexposed workers experienced a headache which could be due to high temperatures.

Key words- Pesticide, Exposure, Farm worker, Machakos

INTRODUCTION

Pesticides are chemical substances used to control pests (insects, bacteria, fungi and nematodes). Agricultural pesticides are used to prevent and control pests as an effort to reduce crop losses estimated at 10 – 30% (World Health Organization, 1990). There are an estimated 450 million waged agricultural workers in Africa, 20 million being children aged between 5 - 14 years (Forastieri, 2007). In Kenya, the number employed on agricultural farms as permanent and casual workers is not well documented although Kibwage *et al*. (2007) reported an increase on tobacco farms by 67% from 1972 to 1991, and 36% between 1991 and 2000. In Machakos District, about 70% of the inhabitants work in the agricultural sector (KCBS, Ministry of Finance, 2001).

Although agricultural pesticides have played a major role in controlling pests, some organophosphates and carbamates are highly toxic and harmful to the farm worker over time (Food and Agricultural Organization, 1983). Kibwage *et al*. (2007) reported an unquantified increased foetal mortality and abortions in females who applied pesticides on tobacco farms in Nyanza Province, Kenya. Organophosphates and carbamates appear harmless and safe to use but pose the most serious health risks to farm workers such as community, environmental and occupational risks. Acute effects include: morbidity and mortality; burns; paralysis; and blindness. Chronic effects include: miscarriages; fetal deformities; skin and eye irritations; and neurological disorders (Arnold, 1990). According to Kimani (1995), acute poisoning from pesticides is a common occurrence and has been increasing with time. Investigations by Kimani (1995) in 20 hospitals in Kenya between 1989 and 1990 reported 455 cases of organophosphate and carbamate pesticide poisoning on farms in various parts of Kenya including Mavoko Division.

The Ministry of Agriculture (2005) reported that over 70% of pesticides used on farms in Mavoko Division were highly toxic and farm workers who frequently applied them complained of health complications related to pesticide risks. This study aimed to investigate factors contributing to pesticide exposure among farm workers of Mavoko Division in Machakos District, Kenya. There was need for this study to assess knowledge, attitude and practice on pesticide use, identify and quantify pesticides used, and investigate post-exposure symptoms. This data could be used to enhance training programs to educate farm workers in Mavoko Division and other parts of Kenya on pesticide risks and safe use that would reduce exposure. NEMA and Pest Control and Products Board could also use this data to enforce the pesticide regulation to protect human health and the environment. Specific objectives of the study were: to assess knowledge, attitude and practice on pesticide use; identify and quantify pesticides used; and investigate post-exposure symptoms of the pesticides used in Mavoko Division of Machakos District, Kenya.

METHODOLOGY

Study area

The study was conducted in Mavoko Division of Machakos District which boarders Kajiado District to the West and Thika to the North. It stretches from latitudes 0^0 45' south to 1^0 31' south and longitudes 36^0 45' east. Topography of the division varies from 700m above sea level (a.s.l) to 1700m a.s.l. It receives an erratic annual average rainfall of 500 – 1300mm within 2 seasons. Long rains start from March to May and Short rains between October and December. Mean monthly temperatures range from 12^0C to 25^0C. According to the 1999 population and housing census Lukenya, the specific location of study, covers an area of 706.2 Km^2 and has a total population of 14,383 (8,095 males and 6,288 females) in 3,615 households (Central bureau of statistics, Ministry of finance, 2001). Inhabitants of Kinanie sub-location, the specific study area in Lukenya Location irrigate crops using water from river Athi. The study targeted people who were currently working and who had been working on farms consistently for two years and above in Lukenya location of Mavoko Division in Machakos District. Eighty (80) people working on farms in Kinanie sub- location of Lukenya location were purposively and randomly selected from the population employed and working.

Sampling Procedure

The research design was Cross Sectional that used both quantitative and qualitative methods to collect data. Simple random sampling, but purposive, was done (to get the sample frame) basing on the principle in Mugenda and Mugenda (1999) that only those with the required information with respect to the objectives of the study to be selected. Purposive sampling was, therefore done with a specific plan of interviewing and observing farm workers who mixed and sprayed pesticides on farms in Kinanie sub-location as the exposed group and those who did not mix and spray pesticides as the unexposed group.

Selection of exposed and unexposed groups

Permission to conduct the study was obtained from the Divisional Agricultural Extension Office. A list of 80 exposed and 80 unexposed workers who had been employed and worked on farms permanently for two years and above in Kinanie sub-location of Lukenya location was made, making 160 as calculated using the formular in Mugenda and Mugenda (1999). These workers were willing to participate by signing the consent form. Exposed 80 workers who had consistently handled, mixed or sprayed pesticides for 2 years and above were purposively selected from farms along river Athi in Kinanie sub-location of Lukenya location where pesticides are intensively used. Unexposed 80 workers were purposively selected from workers who had consistently worked on farms away from the river but in other parts of Kinanie sub-location without handling pesticides for 2 years and above.

Inclusion and exclusion criteria

Farm workers who had worked on the farm for two and above years and handled pesticides by either mixing or spraying and were willing to participate by signing the consent form were recruited as the exposed group. Those who had worked on the farm for less than two years and did not mix or spray pesticides and were willing to participate by signing the consent form were recruited as the unexposed group. The exposed and unexposed workers recruited were not on any treatment. Farm workers whose age was 18 years and below, those not willing to participate by signing the consent form, those who had worked on the farm for less than 2 years, those who did not work on farms, and workers who were on treatment were excluded from the study.

Pre-test and training

After obtaining permission from my research assistant and consent from the farm workers, the questionnaire and observation checklist were pre-tested on 5 farm workers of Kinanie sub-location in Lukenya location. For the sake of uniformity of data, my research assistant was trained in the objectives of the research; familiarization of the questionnaire and observation checklist; how to record information; and sampling procedure and skills.

Data collection

Data was collected from 160 farm workers through interviews and by direct observation when mixing and spraying pesticides and while doing other farm work. Sample size was calculated using the formula in Mugenda and Mugenda (1999).

Interviews

A questionnaire was administered to exposed workers before and after spraying pesticides to get data on their knowledge, attitude and practices on pesticide use; types and quantities of pesticides mixed and sprayed and post-exposure symptoms experienced after spraying pesticides. Participants were then interviewed and followed up for 2 weeks to find out whether and when they experienced post-exposure symptoms. Unexposed workers who did not spray pesticides but did general work such as weeding and planting were interviewed before and after working and then followed up for 2 weeks to record symptoms they may have experienced after working.

Observations

Observations regarding the workers' practices leading to exposure were made using an observation check list. Exposed farm workers were observed and assessed while diluting, spraying and after spraying pesticides to obtain information on practice. This included; the condition of spray pump; protective clothing used; type, class and quantities of pesticides diluted and sprayed. Information on hygienic behavior after spraying was assessed such as; washing hands and spray pump; changing and washing clothing; and bathing. The practice of unexposed workers was also observed while working and after working.

Data analysis

Qualitative and quantitative data collected from interviews and observations was entered into MS Excel, coded and analyzed using Statistical Package for Social Sciences (SPSS) ver. 15.0. Descriptive statistics was carried out for frequencies and percentages of demographic factors; factors on knowledge, attitude and practice; type and pesticides mixed and sprayed; and post exposure symptoms experienced by farm workers. Analysis of Regressions was done using Pearson's Chi-square at 5% significance level ($p < 0.05$) to test for significance between assessed factors. Cross tabulations were done to test for association between assessed factors.

RESULTS

Knowledge on pesticide use

Observations on assessment of knowledge on pesticide use showed that over 88% farm workers who were exposed to pesticides and 91.2% not exposed had only primary level education. It was observed that only 31.3% read instructions on the pesticide label before mixing as is required. However, analysis by regressions indicated that they were not significantly ($p > 0.05$) less than workers who did not read because they could neither interpret nor understand label instructions. Assessment of the worker's knowledge on risks and safe use of pesticides as shown in Table 1 indicated that 56.3% had received education or training but analysis indicated that they were not significantly ($p > 0.05$) more than 43.7% who had not received education or training. Most exposed workers (97.5%) were aware that; pesticides are toxic and harmful to their health; use of Personal Protective Equipment (PPE) reduces likelihood of poisoning (96.2%) and that maintenance of the spray pump was necessary in order to reduce poisoning (98.7%). However, 96.2% of workers interviewed knew that they should protect themselves when mixing or spraying pesticides; they would be poisoned if they did not protect themselves (95%); PPE should be used at all times while handling pesticides (97.5%); and that safety is the responsibility of both employer and worker (97.5). Only 5% did not know they would be poisoned if they did not protect themselves; PPE needed to be used at all times while handling pesticides (2.5%); and that safety was the responsibility of both employer and worker (3.7%). Most workers (88.7%) knew signs of pesticide poisoning while only 11.3% did not know. There were very high significant ($p < 0.001$) differences among factors associated with knowledge. Cross tabulations indicated that there was no association ($p > 0.05$) between knowledge and practice. Practice of those who claimed to have knowledge on risks was the same (poor) as those who were not knowledgeable.

Table. 1. Knowledge of exposed workers on pesticide use

Knowledge		Freq.	Percent	p-value
Education/ training on safe use of pesticides	Yes	45	56.3	0.462
	No	35	43.7	
What should you do when mixing or spraying pesticides	Protect self	77	96.2	< 0.001
	Don't know	3	3.8	
What will happen if you don't protect yourself	Be poisoned	76	95.0	< 0.001
	Don't know	4	5.0	
Do you know signs of pesticide poisoning	Yes	71	88.8	< 0.001
	No	9	11.2	
Pesticides are harmful to your health	Agree	78	97.5	< 0.001
	Don't know	2	2.5	
PPE should always be used while handling pesticides	Agree	78	97.5	< 0.001
	Don't know	2	2.5	
Use of PPE reduces likelihood of poisoning	Agree	77	96.2	< 0.001
	Don't know	3	3.8	
Maintenance of spray pump is necessary to reduce poisoning	Agree	79	98.7	< 0.001
	Don't know	1	1.3	
Safety is the responsibility of both employer and worker	Agree	78	97.5	< 0.001
	Don't know	2	2.5	
Attitude towards pesticide risks and protective clothing				
Pesticides are harmful		80	100	< 0.001
PPE is uncomfortable to wear		30	37.5	0.382
Protection not necessary		50	62.5	0.634

Attitude of exposed workers towards pesticide risks and protection

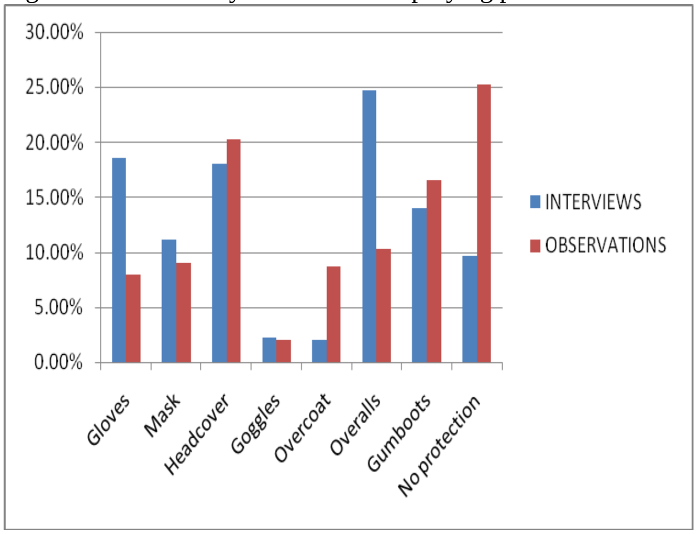
Assessment on the attitude of farm workers towards pesticides and use of protective clothing (Table 1) indicated that 37.5% of the workers had a negative attitude towards using protective clothing such as the mask because they were uncomfortable to wear due to difficulties in breathing, and overalls due to high temperatures. Over 62% saw it not necessary to protect themselves while mixing and handling pesticides. They believed they were careful enough not to be contaminated. Although all (100%) workers exposed claimed to have a positive attitude towards harmfulness of pesticides, this was not reflected in their practice. However, cross tabulations showed no association between attitude of workers and other factors ($p > 0.05$). Statistically, all workers had negative attitude towards pesticide risks and their safe use.

Practise of workers

Use of personal protective equipment (PPE)

Results (Figure 1) indicated that workers used different PPE. PPE used by farm workers when mixing and spraying pesticides varied significantly ($p < 0.001$). Most workers did not fully protect themselves and types of PPE used varied. Nevertheless, none of the workers used the complete set of PPE. About 10% responded that they do not use any protection when spraying and 8% when mixing. From observations, about 25% did not protect themselves when spraying and 35% when mixing pesticides. Workers did not protect themselves or use full PPE because the employer did not provide (43.4% when mixing, 55.7% when spraying); they could not afford (35.8% when mixing, 48.3% when spraying). Some workers did not use a mask because it was uncomfortable to wear (6.5% when mixing and 20.5% when spraying). Some (65.2% when mixing, 3.7% when spraying) responded that protection was not necessary. The majority of workers (88.7% exposed, and 91.2% unexposed) had only primary level education and had been exposed to pesticides for a period of between 2-5 years. There was no association ($p > 0.05$) between use of PPE and other variables.

Figure 1: PPE used by farmers when spraying pesticides



Hygienic practice of workers

Exposed workers (Table 2) had a poor hygienic practice. There were very high significant differences ($p < 0.001$; $p = 0.001$) between factors associated with hygienic practice. Workers whose hygienic practice was good were much less than those whose practice was poor. When interviewed, 25% workers responded they cleaned the spray pump immediately after use with soap and with protection as recommended but observations revealed that only 3.8% cleaned it with soap while wearing protective clothing. Interviews revealed that 21.2% of the workers washed the spray pump immediately after use with soap and without protection but from observations, only 6.3% washed it immediately after use with soap without wearing protection. Only 25% responded that they washed spray pump without soap while wearing protective clothing.

However, it was observed that most workers (63.6%) washed the spray pump without soap and without protection after spraying. Although only 6.3% responded that they did not wash the spray pump immediately after use but after using twice, it was observed that 16.3% did not wash immediately after use. From interviews, 40% of the workers responded that they washed hands with soap after spraying as required but observations revealed that only 11.3% washed hands with soap after spraying. Although 47.5% workers claimed they washed hands immediately without soap when interviewed, observations revealed that only 17.5% washed hands without soap immediately after spraying. However, observations revealed that the majority of the workers (71.2%) did not wash hands immediately after spraying. Whereas 28.7% of the workers responded they changed clothes immediately after spraying pesticides when interviewed, observations revealed that only 7.5% changed clothes immediately after spraying.

Table 2. Hygienic practice of exposed workers

	Interviews			Observations		
	Freq. (30)	%	p-value	Freq. (19)	%	p-value
Cleaned spray pump immediately						
with soap & PPE	1	3.3	0.001			0.000
with soap, without PPE	3	10.0		2	10.5	
without soap, with PPE	10	33.3		1	5.3	
without soap & PPE	13	43.3		13	68.4	
NO, after using twice	3	10.0		3	15.8	
Wash hands immediately						
with soap	7	23.3	0.000	5	26.3	0.001
without soap	21	70.0		10	52.6	
after work without soap	2	6.7		4	21.1	
Change clothes immediately						
Yes	5	16.7	< 0.001	4	21.1	< 0.000
Evening/ next day	25	83.3		14	73.7	
NO need				1	5.2	
Washed clothes immediately						
Yes	2	6.7	< 0.001	2	10.5	< 0.001
Evening/ next day	25	83.3		8	42.1	
after using severally	3	10.0		9	47.4	
Bath immediately						
evening next day	30	100.0	< 0.001	19	100.0	< 0.001

However, from observations the majority of workers (76.2%) did not change clothes immediately after spraying. Interviews indicated that 12.5% of workers did not change clothes immediately after spraying because they saw no need to change, but observations revealed that 16.3% did not change clothes immediately after spraying because they saw no need to change. Washing clothes immediately after spraying pesticides as is required was not common. Although interviews indicated that 10% of the workers washed clothes immediately after spraying, observations revealed that only 5% washed clothes immediately after spraying. From interviews 65% of workers did not wash clothes immediately after spraying but washed in the evening or the following day, but observations showed that 53.7% did not wash clothes immediately after spraying. Interviews indicated that 6.3% of the workers bathed immediately after spraying pesticides but observations revealed that none bathed immediately after spraying pesticides as is recommended.

Analysis did not show significant differences (p > 0.05) between factors associated with hygienic practice of workers and knowledge. The knowledge workers claimed to have did not influence their practice.

Identified pesticides used on farms

It was observed that 10 different pesticides were mixed and sprayed by workers in Mavoko Division. Out of which, five (68%) were WHO Class II; two (10%) were WHO Class III and three (23%) were WHO Class IV. Rates and quantities sprayed varied with the pesticides but were within the recommended ranges. However results (Table 3) revealed that class 11 were more used by the workers than other classes of pesticides.

Table 3. Identified pesticides used on farm in Mavoko Division

Pesticide Name	Active ingredient	WHO class	Quant-ity	Freq.	%
Interviews					
Agrinate	Methomyl	I	50g	2	1.5
Alphacyper-methrin	Alphacyper-methrin	II	25-100ml	15	11.0
Copper oxychloride	Cobox 5 WP	IV	100-400gm	4	2.9
Cyclone	Cypermethrin + Chlorpyrifos	II	100-200ml	6	4.4
Ogor-Dimethoate	Ogor 40 EC + Dimethoate	II	200-500gm	39	28.6
Dithane M-45 (Mancozeb)	Mancozeb	III	250-500gm	11	11.5
Duduthrin	Lambda-cyhalothrin	II	250-500ml	8	3.5
Karate WG	Lambda-cyhalothrin	II	100-500gm	6	4.4
Ortiva SC	Azoxystrobri n	IV	35ml	3	2.2
Oshothane 80 WP	Mancozeb	III	100-500mg	17	12.5
Ridomil	Metalaxyl	IV	100-500gm	26	19.1
Total				136	100
Observations					
Alphacyper-methrin	Alphacyper-methrin	II	50ml	12	16.9
Cyclone	Cypermethrin + Chlorpyrifos	II	200ml	3	4.2
Duduthrin	Lambda-cyhalothrin	II	250ml	3	4.2
Karate WG	Cyhalothrin	II	100-400gm	9	12.7
Malathion	Malathion	III	400ml	2	2.8
Orgor-Dimethoate	Orgor + Dimethoate	II	80-400ml	21	29.6
Ortiva SC	Azoxystro-brin	IV	80ml	5	7.1
Ridomil Gold	Metalaxyl M + Mancozeb	IV	100-500gm	9	12.7
Thiorit jet	Sulphur (elemental)	IV	500ml	2	2.8
Total				71	100

Source of active ingredients: Pest Control Products Board (2011)

Results showed very high significant differences (p < 0.001) between the classes of pesticides used. Workers were exposed to a variety of class 11pesticides that are toxic.

Post-exposure symptoms experienced by workers

Workers on farms in Mavoko Division experienced 9 different symptoms (Figure. 2 and 3). There were very high significant differences (p < 0.001) between post-exposure symptoms experienced by exposed workers that were interviewed.

Figure. 2. Post- exposure symptoms for exposed workers

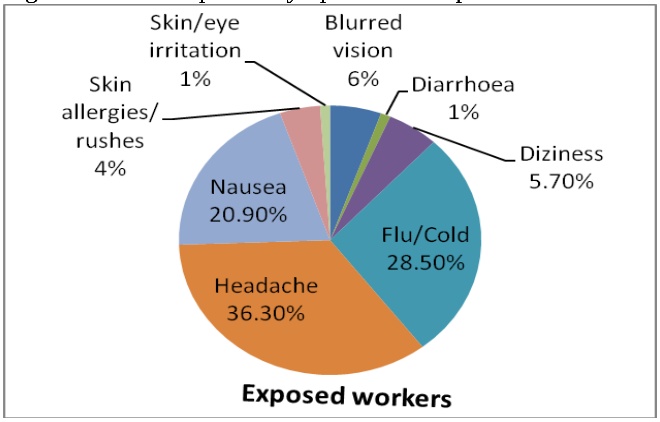
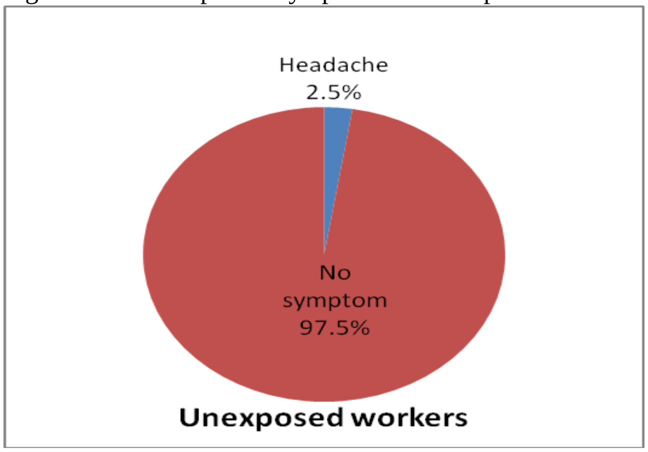


Figure. 3. Post- exposure symptoms for unexposed workers



About 21% interviewed workers reported that symptoms occurred during pesticide application while 79.2% had symptoms during and immediately after application. Only two (2.5%) unexposed workers experienced only a headache, which could have been caused by high temperatures in the area. Symptoms mostly experienced by exposed workers were; flu/cold (28.5%), headache (36.3%) and nausea (20.9%). Only 3.3% exposed workers reported to have sought medication since symptoms cleared after resting or drinking water. There was no association between post exposure symptoms reported and a particular pesticide since workers sprayed a mixture of pesticides. However, there were very high significant differences ($p < 0.001$) between exposure to pesticides and post exposure symptoms.

DISCUSSION

Results showed very high significant differences ($p < 0.001$) between factors associated with knowledge on pesticide risks and safe handling practices of exposed workers. Safety labels warn of the potential negative effects of pesticides on health and advice users on protective measures. It is, therefore, important and a safety requirement for workers to read, understand and follow these instructions before mixing and spraying pesticides (Oluyede and Akinnifesi, 2007; Ware, 1978). In this study, 68.7% did not read the instructions on pesticide labels because they lacked the ability to interpret and understand. This could be attributed to their low level of knowledge and education since about 90% exposed workers had only primary level education. These findings are in agreement with Oluromininiyi (2006), Kimani (1997) and Hayes *et al*. (1991) who reported that most workers had little knowledge relating to hazards, safety rules and proper personal preventive practices. There is, therefore, need to train and educate all workers who handle pesticides on agricultural farms in Kenya. Increase in knowledge and understanding of pesticide risks would increase the worker's sense of control and willingness to practice safety behaviour which would reduce exposure (Lankerster, 2002; Quandt *et al.*, 2006). Njer (1994) reported that a training of 280,000 Kenyans resulted in an increased understanding of the toxicity of pesticides. Lack of knowledge by 5% workers on whether pesticides would poison them if they didn't use protective clothing; protective clothing should be used all the time (2.5%); and that it was the responsibility of both the employer and worker concerning safety (2.5%), can be attributed to lack of or inadequate provision of information through education and training. Similar observations were reported by Olurominiyi (2006) that low level of knowledge on pesticides and their safe use was due to lack of participation by workers in education and training programmes. If good education has to increase knowledge and lead to understanding and recognition of danger, then need for appropriate care becomes an obvious matter. Although 95% of the wokers knew that they needed to protect themselves when using pesticides because they would be poisoned, this was not demonstrated in their practice. It was observed that 35% mixed and 25% sprayed without using any protective clothing and even those who protected themselves were somehow exposed because they did not use full protective clothing. It is important to know symptoms of pesticide poisoning so as to seek medication (Kimani, 1997). Although 88.7% workers who knew this were significantly more than the 11.3% who did not know this was not of any benefit because only 5.2% sought medication as is required. Workers in this study stand a risk of chronic health effects due to continuous exposure to toxic pesticides (Quandt *et al.*, 2006). It is important for workers to benefit from the knowledge received by adapting it but adoption seems to be slow (Olurominiyi, 2006). These findings are in agreement with Njer (1994) who reported that less than 30% of trained workers were adapting safe guidelines as per their training.

Generally, workers had a negative/poor attitude towards protecting themselves since observations revealed that 37.5% did not use PPE such as the mask because it was uncomfortable to wear due to difficulties in breathing, and overalls due to high temperatures. These findings are similar to those of Hanshi (2003) and Kimani (1997) who reported that workers did not use protective clothing because of discomfort caused by high temperatures. Over 62% workers saw it not necessary to use protective clothing while mixing and spraying pesticides because they believed they were careful enough not to be contaminated. Some believed that pesticides were not harmful to their health. Such beliefs which were also reported by Quandt *et al.* (2006) and Ngowi *et al.* (2007) greatly influenced the practice of workers in this study, which promoted exposure. Although all exposed workers responded that they had a positive attitude towards the harmfulness of pesticides to their health, this was not demonstrated and reflected in their practice since from observations none used full protective clothing. A worker's attitude towards safety measures affects how long and how well he/she is to live. Attitude also plays a role in risk assessment, as it is applied to issues such as whether and to what extent a person will be exposed to danger (Zimolong and Trimpop, 1998). There is need to change beliefs of farm workers in this study area in order to increase the value of and need to use PPE. This can be achieved through enhancing training and health education programs. Failure by the workers to use PPE when spraying and mixing pesticides as is required because they could not afford to buy portrays a high level of unsafe use of pesticides in Mavoko. This is in agreement with Hanshi (2003) who reported that most farm workers did not use protective clothing because of lack of purchasing power. Although some workers improvised by using a cloth as a mask, this could only be effective when combined with other protective gears to offer full protection. Failure to use or incomplete protection exposed workers to pesticides through the skin and by inhalation (Ohayo *et al.*, 2000; Ngowi *et al.*, 2007), which could be attributed to very high significant ($p < 0.001$) post exposure symptoms experienced by exposed workers. Exposure can often be prevented or minimized by wearing full PPE. Arbuckle *et al.* (2002) reported that use of full PPE by applicators significantly reduced exposure in his study. Assessment by observations during spraying operations showed that PPE used was made of cotton fabric, which was soaked with pesticides from leaking spray pumps. This brought pesticides closer to the skin leading to dermal exposure. However, this situation could have been worse had some workers not used any protection since most pesticides used were WHO Class II that are toxic. Whereas it is a safety requirement to use full PPE when handling pesticides, this was not practiced in this study. Very high significant differences ($p < 0.001$) between factors associated with hygienic practice was an indication that hygienic practice of workers was very poor. Practices of workers have been suggested as ways to reduce pesticide exposure and are included as recommended practices in the U.S. Environmental Protection Agency Worker Protection Standard training. A pesticide applicator is, therefore, required to adopt them in order to prevent or minimize exposure. Cleaning the spray pump after using several times or cleaning without soap as the majority of the workers did promoted dermal exposure. Furthermore, washing hands without soap and or after work exposed the worker to pesticides the whole day. These findings agree with Quandt *et al*. (2006) who reported that levels of pesticides on the hands of a worker could be reduced to 96% by hand washing.

Continuing to work wearing clothing used during spraying without changing; washing them in the evening or the following day; and using them several times before washing exposed the workers to pesticides. Failure to bathe immediately after spraying pesticides as is recommended and bathing in the evening or following day exposed workers to pesticides. Findings are in agreement with Quandt *et al*. (2006), Ohayo *et al*. (2000) and Hanshi (2003) who reported that such poor hygienic practice of workers had contributed to exposure on farms and thus, to the high prevalence of post-exposure symptoms. Due to the fact that parts of the skin not protected (including hands) were contaminated with large amounts or traces of pesticides, dermal exposure of the workers in this study continued the whole day by even scratching other body parts. Poor practice of workers contributed to exposure which was reflected in the high prevalence of post-exposure symptoms of exposed workers. Although practice of unexposed workers was also poor they stood no risk since they had not handled pesticides. Workers mostly sprayed WHO Class II pesticides. This is in agreement with Ohayo *et al*. (1999) who reported that workers on farms mostly sprayed Class II pesticides. WHO Class II pesticides fall under a toxic class that has small lethal oral, dermal and inhalation doses. Small quantities of exposure by inhalation, ingestion, or contact with the skin and eyes can cause severe acute effects such as skin and eye irritation. Pesticides applied are known to cause acute effects such as headaches, blurred vision, nausea and confusion (Eyer, 2003) which were experienced by workers in this study. There was a relationship between exposure to pesticides and post exposure symptoms, indicating that symptoms were caused by the pesticides applied confirming that symptoms were caused by the toxic pesticides. Full protection was, therefore, required when handling the pesticides to prevent or minimize poisoning. Safety measures should be taken inorder to reduce poisoning as is recommended since a portion of pesticides to which an individual is exposed is absorbed as the pesticide dose and can be lethal to the worker over a period of time (Quandt *et al.* 2006).

The 2.5% unexposed workers experienced a headache which could be attributed to unbearable high temperatures in Mavoko Division. This is in agreement with Ohayo *et al*. (2000) who reported that post-exposure symptoms experienced by un-exposed workers on farms in Nyanza Province were caused by high temperatures. Although nine (9) different symptoms were experienced by exposed farm workers, those mostly experienced were; flu/cold (28.5%), headache (36.3%) and nausea (20.9%), which are known acute effects of pesticides (Eyer, 2003; Ngowi *et al*., 2007). Furthermore, 40.1% workers experienced them during pesticide application and 59.9% during and after application. Exposure can often be prevented or minimized by wearing full PPE and by adhering to safe hygienic practices (Quandt *et al*., 2006), which was not followed by workers in this study. These results are in agreement with Ohayo *et al*. (2000) and Ngowi *et al.* (2007) who reported that farm workers in Nyanza province and Tanzania, respectively, experienced post-exposure symptoms after spraying WHO Class I and Class II pesticides without protecting themselves and by adopting good hygienic practice. Although quantities of pesticides mixed and sprayed were within recommended rates, protection was required. Out of 80 workers who were exposed to pesticides, the majority: were males (81.2%); fell under an active reproductive age bracket of 19-40 years (96.3%); were married (55%) and had been employed (and thus, receiving poisoning) for a period of between 2-5 years (86.2%). These results are in agreement with Zimolong and Trimpop (1998) who reported that the young and poorly educated males take the highest risks at work places and that men take high risks compared to women. Continuous exposure for months and years as a result of frequent number of spray operations might expose workers to lethal doses whose health effects would manifest in the future (Oluyede and Akinnifesi, 2007). Furthermore, being in an active reproductive age bracket, teratogenicity and reproductive toxicity could manifest in the families of the exposed workers in the near future (Kolb, 1993). This agrees with Redigor *et al.* (2004) who reported unquantified increased risk of foetal deaths from congenital anomalies in families of married workers who sprayed pesticides on agricultural farms.

CONCLUSIONS

The level of knowledge on pesticide use of workers on agricultural farms in Mavoko Division was low/poor. Most workers had neither been trained nor educated and thus not received information relating to risks and safe use of pesticides. Inability by workers to understand and interpret label instructions on pesticides attributed to their low level of education and knowledge. Generally, workers had a negative attitude towards pesticide risks and use of personal protective equipment (PPE). Workers did not use PPE when handling pesticides because they were uncomfortable to wear and some saw it not necessary to protect themselves since they believed they were careful enough not to be contaminated. Such beliefs greatly influenced practice which promoted exposure. Workers claimed to have a positive attitude towards pesticide risks but this was not demonstrated in their practice while spraying. The main symptoms experienced by exposed workers were; flu/cold, headache and nausea which are known acute effects and could be attributed to exposure to toxic pesticides. Poor hygienic practice after spraying pesticides, low knowledge, poor attitude and high level of unsafe use of toxic pesticides were major factors that influenced exposure.

ACKNOWLEDGEMENT

I wish to acknowledge my employer KALRO, formally KARI for having given me study leave. I also acknowledge Maseno University and my family for funding this research. My supervisors are highly appreciated. I acknowledge Beth Mugo (former DAEO) for permitting me to carry out this research in Mavoko Division**,** and John Wambugu (extension officer of Lukenya location) who helped in collecting data.

REFERENCES

[1] Arbuckle, T. E; Burnett, R; Cole, D; Teschke, K; Docemeci, M; and Bancej, C. (2002). *Predictors of herbicide exposure in farm Applicators*. In International occupation and environmental health; vol. 75, pp.406-414.

[2] Arnold, E. (1990). *The British Medical Association guide to "Pesticides Chemicals and Health."* British Medical Association, London.

[3] Eyer, P. (2003). *Toxicology Revision. The role of oximes in the management of organophosphorus pesticide poisoning.* In Katzung, G. B. (2001). *Basic and clinical pharmacology*. McGraw-Hill, San Francisco.

[4] Food and Agricultural Organization (1983). *Crop loss Assessment methods. Plant protection and production paper*, Rome, Italy

[5] Forastieri, V. *Providing occupational safety and health services to workers in agriculture. African Newsletter on occupational and health safety*, 2007, vol. 17, pp. 4-7

[6] Hanshi, J. A. (2003). *Use of pesticides and personal protective equipment by applicators in a Kenyan District.* Human environmental and health. The journal of the association of public health officers (Kenya) 2003; issue no. 10

[7] Kenya Central Bureau of Statistics, Ministry of Finance (2001). *The 1991 population and housing census. Counting our people for development*. The Government Printer, Nairobi

[8] Kibwage K. J., Momanyi G.M., and Odondo J. A. (2007). *Occupational health and safety concerns of smallholder tobacco farmers*. In African Newsletter on occupational and health safety vol. 17, pp. 47-49

[9] Kimani, V. W. (1995). E*xposure to pesticides in Githunguri location, in Kenya. East African medical journal*; **vol.** 8, pp. 531-535.

[10] Kolb, V. M. (1993). *Teratogen: Chemicals which cause birth defects.* Elsevier, London.

[11] Lankerster, T. (2002). *Setting up community health programmes. A practical manual for use in developing countries*. Macmillan, London.

[12] Ministry of Agriculture (2005). *Eastern Province Horticulture and Traditional food crops.* Ministry of Agriculture, Nairobi.

[13] Mugenda and Mugenda (1999). *Research Methods. Qualitative and Quantitative approaches*. African Centre for Technology Studies, Nairobi.

[14] Njer, E. (1994). *Low adoption survey on safe use of pesticide practices in central and eastern provinces of Kenya*. Thesis, University of Nairobi.

[15] Ngowi, A. V. F. and Partanen, T. (2002). *Treatment of pesticide poisoning:A problem for health workers in Tanzania*. African newsletter on occupational health and safety, Vol. 12 pp. 71-74.

[16] Ngowi, A.V.F; Mbise, T.J; Millinga, L; and Ijani, A.S.M. London, L., Ajayi, O.C. (2007). *Smallholder vegetable farmers in Northern Tanzania. Pesticides use practices, perceptions, cost and health effects*. Crop protection DOI: 10.1016/J.CROPRO.2007.01.008

[17] Ohayo, G. J. A; Kromhout, H; Simwa, J. M; Boleij, J. S. M; and Heederik, D. (1999). *Identification of determinants of pesticide exposure among Kenyan agricultural workers using empirical modelling, in* Occupational and Environmental Medicine, vol. 43: pp. 519-525.

[18] Ohayo, G. J. A; Kromhout, H; Karumba, P. N; and Boleij, J. S. M. (2000). *Self reported symptoms and inhibition of acetylcholinesterase activity among Kenyan agricultural workers.* In occupational and Environmental Medicine, vol..57, pp. 195-200

[19] Olurominiyi, O. I. (2006). *Egyptian farmers' attitude and behaviours regarding agricultural pesticides: Implications for pesticide risk communication.* Correspondence to urban planning and environmental policy, school of public affairs, Texas Southern University, USA.

[20] Oluyede, C. A. and Akinnifesi, K. F. (2007). *Farmers' understanding of pesticide safety labels and field practices: a case study of cotton farmers in northern Cote d'voire*. In Scientific Research and Essay. vol. 2**,** pp.204-210.

[21] Quandt, S.A; Hernandez-Valero, M. A; Grzywacz, G. J; Hovey, D. J; Gonzales,M; and Arcury, A. T. (2006) *Workplace, household, and predictors of pesticide exposure for farmworkers. In* Environmental health perspectives vol.114 pp. 943-952.

[22] Regidor, E; Ronda, E; García, A. M; and Domínguez, V. (2004). *Occupational and Environmental Medicine* vol. 5 pp. 334-339.

[23] Restrepo, M; Munoz, N; Dayne; Parra, J. E; Romnero D; and Nyuyen, D. (1990). *Prevalence of adverse reproduction outcomes in a population occupationally exposed to pesticides in Colombia*. Scan, Colombia.

[24] World Health Organization, (1990). *Public Health Impact of pesticides used in Agriculture.* WHO/UNEP, Geneva.

[25] Zimolong, B. and Trimpop, R. (1998). *Risk perception. In ILO Encyclopaedia of Occupational health and safety vol.* 2 pp. 22-28.

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