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Health Effects of Pesticide Exposure among Formulators, Repackers and Store Workers in Nairobi, Kenya

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Abstract
Though it is widely believed that adverse health effects occur among farm workers who handle pesticides, few studies have been done to quantify the extent to which pesticide formulators, re-packers and store workers are affected. The present study assessed the prevalence of signs and symptoms of illness due to pesticide exposure among factory workers in Nairobi Kenya using a descriptive cross- sectional study design on consenting factory workers. A questionnaire was administered enquiring about their biodata, work practices and occurrence of signs and symptoms associated with pesticide poisoning. Data was coded, entered into MS Access database and analyzed using SPSS version 11.5. Test for significance was done using chi-square to identify key variables associated with pesticide poisoning. Workers who had been in employment for less than one year reported a higher prevalence of signs and symptoms associated to pesticide poisoning such as burning skin (P = 0.004) and dizziness (P = 0.006). Workers who handled organochlorine pesticide had higher prevalence of burning of skin (P = 0.002), convulsions (P = 0.003), twitching (P = 0.004), painful swallowing (P = 0.004), dermatitis (P = 0.019) and headache (P = 0.028) among other pesticide exposure related symptoms. Workers who had handled pesticides for a longer period of time appeared to have less signs and symptoms of pesticide poisoning probably suggesting that long term exposure to pesticides either imparted some form of acquired immunity to pesticides or that their longer experience resulted in better risk perception and management.
Keywords: pesticide, organochlorine, organophospate, formulator, poisoning.

1. INTRODUCTION

Pesticides pose significant occupational health and environmental risks throughout the world (Forget, 1991). It is widely recognized that agricultural workers are the largest occupational group at risk of adverse health effects, although public health workers and workers in manufacturing/formulating factories, retail outlets may also be exposed. The general population, on the other hand, is at risk of pesticide poisoning through non-agricultural pesticides e.g. household pesticide use, contaminated water, food, soil and through air, dust or accidental pesticide ingestion (WHO, 1990; Wessling *et.al.*, 1997).

According to The Stockholm Convention on Persistent Organic Pollutants, 9 of the 12 most dangerous and persistent chemicals are pesticides (Gilden et al, 2010).

Health effects of pesticides may be acute or delayed in those who are exposed (USEPA, 2007). A 2007 systematic review found that "most studies on non-Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure" and thus concluded that cosmetic use of pesticides should be decreased (Bassil *et al*, 2007).

It has been estimated that globally about 1.1 million cases of acute pesticide poisoning occur each year, when accidental or unintentional factors result in some 20,000 deaths (WHO, 2002). Another estimate pertaining to developing countries suggests, however, that as many as 2.9 million cases of acute pesticide poisoning from all causes, leading to 220,000 deaths are likely to occur annually. Acute pesticide poisoning is a major public health problem in developing countries where approximately 60% of the workforce is employed in agriculture (Wessling *et al.*, 1997; He *et al.*, 1998).

Strong evidence also exists for other negative outcomes from pesticide exposure including neurological problems, birth defects, fetal death, and neurodevelopmental disorder (Stanborn *et al*, 2007; Jurewicz and Hanke, 2008).

Work-related exposure to pesticides depends to a great extent on the task being done, on how the task is done and on the physical properties of the pesticide product. Exposure in pesticide work may occur through: inhalation, absorption through the skin, or ingestion. The skin is usually the main route for the uptake of pesticides during most work operations, and this complicates the estimation of workers' exposure and uptake levels (Kangas and Tumoainen, 1993).

2. Study Area

The study was carried out in Nairobi's industrial area and its suburbs. This area was selected since most pesticide

formulations, repackaging and storage sites are located there. Nairobi is the capital city of Kenya. It is situated at an elevation of about 1660 m (5450 ft) in the highlands of the southern part of the country. The study involved a visit to the Pest Control Products Board (PCPB), at Kenya Agricultural Research Institute (KARI), which is located on Waiyaki way a few kilometers from the city centre.

3. MATERIALS AND METHODS

3.1 Study Design

The study population consisted of workers at pesticide factories who were involved in formulation, re-packaging and storage of pesticides. This Board provided information on registered companies that deal with the formulation, repacking, distribution and warehousing of pesticides in Nairobi. This information was used to locate the companies and establish those that were willing to participate in the study. Once these companies were identified, an appointment with the Human Resource Manager was made and a booking for the days to collect the data. A brief meeting with the workers was held and what was expected of them and the benefits of the present study was discussed. Prior to participation an informed consent was administered to workers and only those who consented in writing were included in the study. A standardized questionnaire consisting of structured and unstructured items was administered face to face by the investigator. The questionnaire covered demographic information (e.g. age, sex, occupation, and work experience), health information of self and family, and knowledge questions on hazard recognition, pesticide handling practices and perceptions, signs and symptoms associated to pesticide poisoning. The level of education and knowledge on pesticides was also recorded. Additional data was collected through observation by the interviewer and this was included at the bottom of the questionnaire as interviewer's remarks. Individual identity of companies was not stated in the final report.

4. RESULTS

4.1 Demographic Distribution of Study Subjects

This study involved 301 study subjects to whom the questionnaire was administered. There were 220 men (73.1%) and 81 women (26.9%). Table 4.1 shows the demographic distribution of all the study subjects. Of the companies that participated, only 45% volunteered to provide an inventory of the pesticides that they handled.

Figure 1: Distribution of types of pesticides formulated, repackaged or stored

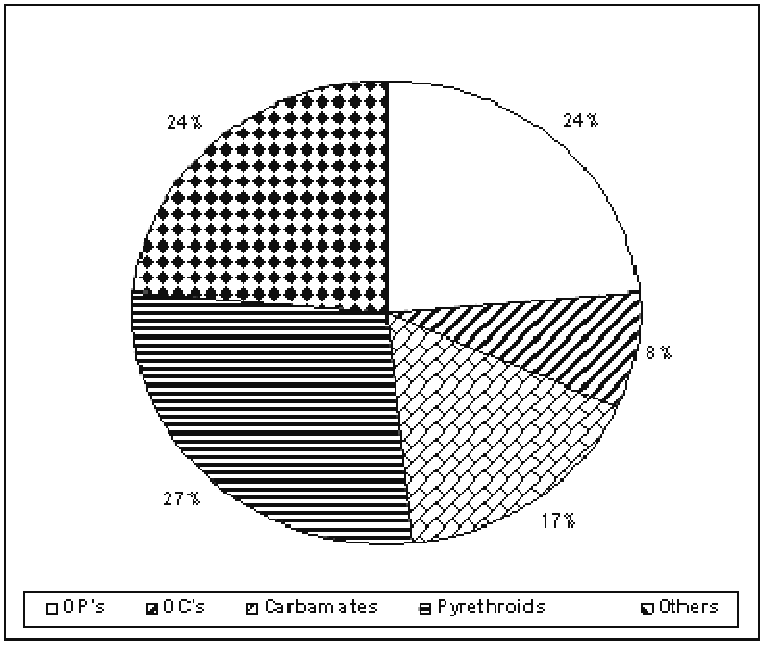

Table 4.1: Distribution of study subjects by categories of pesticides formulated, repackaged and stored

Pesticide types	(n)	%
OP, OC, Pyrethroids, Carbamates, others	48	28.6
OP, Pyrethroids, others	42	25.0
Pyrethroids	26	15.5
OP, Pyrethroids, Carbamates, others	52	31.0
Total	168	100

Comparison Tables Concerning Demographic Data

Some companies preferred to employ male workers, hence the difference in the number of female workers. Female workers were however, more affected by the pesticides (Table 4.5) compared to the male workers. Notably women had higher prevalence for headache (p = 0.013), nausea (p = 0.005), vomiting (p = 0.0001) and stinging/burning of skin (p = 0.004). Some female workers complained of irregular menstrual cycle. This they would relate to particular products, while some males complained of low libido and erectile dysfunction. There was however, no case of miscarriages or failure to conceive from the female workers or wives of the male workers.

Table 4.2: Prevalence of signs and symptoms of pesticide poisoning controlling for gender

Signs and Symptoms	Prevalence		O.R	C.I (95%)	P-Value
	n (%) (n=220) Male	n (%) (n=81) Female			
Neurobehavioral					
Headache	103(46.2)	49(62.8)	0.508	0.299-0.862	0.013
Dizziness	83(37.2)	39(50.0)	0.593	0.352-0.998	0.060
Mental Confusion	16(7.2)	7(9.0)	0.784	0.310-1.983	0.623
Restlessness	27(12.1)	6(7.7)	1.653	0.656-4.168	0.399
Nausea	62(27.8)	36(46.2)	0.449	0.264-0.766	0.005
Intestinal					
Diarrhoea	10(4.5)	3(3.8)	1.174	0.315-4.380	1.000
Vomiting	2(0.9)	9(11.5)	0.069	0.015-0.329	0.0001
Salivation	79(35.4)	35(44.9)	0.674	0.399-1.138	0.175
Painful Swallowing	40(17.9)	16(20.5)	0.847	0.443-1.618	0.615
Epithelial/mucosal surfaces					
Dermatitis	62(27.8)	28(35.9)	0.688	0.398-1.189	0.197
Stinging /Burning Skin	99(44.4)	50(64.1)	0.447	0.262-0.762	0.004
Blurred Vision	70(31.4)	29(37.2)	0.773	0.451-1.326	0.401
Twitching	50(22.4)	20(25.6)	0.838	0.461-1.524	0.641

Table 4.3 represents the prevalence of signs and symptoms with number of years worked. Those who had been in the company for duration of one or more years showed less of the signs and symptoms associated with pesticide poisoning compared to those who had been there for less than a year. The most significant being differences in the prevalence of neuro-behavioral signs and symptoms such as headache (p = 0.038), dizziness (p = 0.006), and convulsions (p = 0.006).

Table 4.3: Prevalence of signs and symptoms of pesticide poisoning with years worked

Signs and Symptoms	Prevalence		O.R	C.I (95%)	p-Value
	n (%) (n=102) <1yr	n (%) (n=199) ≥1yr			
Neurobehavioral					
Headache	60(59.4)	92(46.0)	1.718	1.058-2.790	0.038
Dizziness	52(51.5)	70(35.0)	1.971	1.212-3.206	0.006
Convulsions	14(13.9)	9(4.5)	3.415	1.424-8.192	0.006
Mental Confusion	12(11.9)	21(10.5)	1.149	0.541-2.441	0.701
Restlessness	36(35.6)	61(30.5)	1.262	0.761-2.094	0.443
Nausea	44(43.6)	54(27)	2.087	1.263-3.448	0.004
Intestinal					
Diarrhoea	4(4.0)	9(4.5)	0.875	0.263-2.914	1.000
Vomiting	7(6.9)	4(2.0)	3.649	1.242-12.772	0.047
Salivation	43(42.6)	71(35.5)	1.347	0.826-2.197	0.258
Painful Swallowing	27(26.7)	29(14.5)	2.151	1.192-3.885	0.012
Epithelial/mucosal surface					
Dermatitis	40(39.6)	50(25)	1.967	1.180-3.280	0.011
Stinging/ Burning Skin	62(61.4)	87(43.5)	2.065	1.267-3.365	0.004
Blurred Vision	31(30.7)	68(34.0)	0.860	0.514-1.438	0.605
Twitching	17(16.8)	53(26.5)	0.561	0.305-1.032	0.062

4.2 Pesticide Perceptions and Practices

Employers in all the companies visited were aware of the level of risk that their workers were exposed to. This

was evident from the number of personal protective equipment (PPE) provided to its workers. Those who had more than two PPE were working at places that had high concentrations of pesticide exposure hence the number of PPE used. Some complained of the protective equipment being uncomfortable and would often resist wearing it for long periods of time especially in hot working conditions. Some protective equipment is usually poorly designed, and offers limited protection. Poor design does not take into account the different sizes and build of people or their different facial characteristics in the case of masks or the difference between men and women.

Most of the protective equipment was unsuitable for the task at hand especially the masks and gloves. Dust masks were used in all departments, regardless of the pesticide state. Disposable dust masks were the choice masks for most companies. These were replaced after a week hence the level of protection was compromised. Proper respirators or disposable masks with charcoal filters were not available in most of the companies. The type of gloves used was not suitable for the task since most companies opted for disposable gloves. These could not withstand most of the work since they are smooth and slippery when wet. Workers in the liquid section especially, had a difficult time trying to handle wet bottles with these gloves. The overalls worn by workers in some companies were worn out, while some wore the wrong sizes. The safety boots came in one size and would be distributed on a first come first served basis. Some companies preferred gum boots to safety boots putting the workers at risk of falling objects. PVC aprons were also found in some companies that had liquid products.

The formulators and re-packers worked on shifts and they would be alternated between the two sections of formulation or re-packaging. The workers were provided with shared lockers for storage of their clothing and personal effects. However, a separate locker was not provided for storage of their personal protective equipment; hence, everything was put in the same locker leading to contamination. Restrooms were found in most companies but workers complained that there was no time allocated for them to take a shower after work.

Most of the companies visited provided a tap with clean water that was accessible to the workers. Some companies provided proper lunch to the workers; other companies provided tea and bread. This raises great concern on the health of these workers who are exposed to the pesticides for over five hours before the lunch break and another four to five hours after the break if indeed this is a proper meal to people working with these pesticides.

A health and safety committee had been established in most of the companies but the workers were not aware of its role. The companies had also trained a team of workers on first aid techniques. They give first aid incase of accidents before a victim is rushed to the nearby clinic or hospital. Most companies did not have medical histories of its employees and no medical check and/or follow up was done after workers had been employed

All companies visited provided their workers with some form of personal protective equipment (PPE). However, some of the workers found them to be uncomfortable and cumbersome. Workers who used dust masks plus other protective equipment (77.4%); showed more signs and symptoms associated with pesticide poisoning (Table 4.7) than those who did not use the dust masks (22.6%). Significant differences were notable with stinging/burning of the skin (p = 0.0001), headache (p = 0.013), dizziness (p = 0.036), salivation (p = 0.033), painful swallowing (p = 0.021) and blurred vision (p = 0.002).

Table 4.4: Prevalence of signs and symptoms of pesticide effects with use of dust masks

Signs and Symptoms	Prevalence		O.R	C.I (95%)	P-Value
	n (%) (n=229) Used masks	n (%) (n=72) Not used			
Neurobehavioral					
Headache	127(54.5)	25(36.8)	2.061	1.181-3.594	0.013
Dizziness	102(43.8)	20(29.4)	1.869	1.044-3.359	0.036
Convulsions	19(8.2)	4(5.9)	1.421	0.466-4.327	0.795
Mental Confusion	24(10.3)	9(13.2)	0.753	0.332-1.707	0.510
Restlessness	69(29.6)	28(41.2)	0.601	0.344-1.051	0.078
Nausea	79(33.9)	19(27.9)	1.323	0.730-2.399	0.381
Intestinal					
Diarrhoea	10(4.3)	3(4.4)	0.972	0.262-3.635	1.000
Vomiting	11(4.7)	0(0.0)	1.306	1.226-1.392	0.076
Salivation	96(41.2)	18(26.5)	1.946	1.070-3.542	0.033
Painful Swallowing	50(21.5)	6(8.8)	2.823	1.154-6.906	0.021
Epithelial/ mucosal surfaces					
Dermatitis	75(32.2)	15(22.1)	1.677	0.888-3.167	0.132
Stinging /Burning Skin	130(55.8)	19(27.9)	3.255	1.805-5.869	0.000
Blurred Vision	87(37.3)	12(17.6)	2.781	1.412-5.479	0.002
Twitching	56(24.0)	14(20.6)	1.220	0.631-2.362	0.627

Study subjects whose inventory included organochlorine pesticides presented with high prevalence of signs and symptoms associated with pesticide poisoning, (Table 4.10). The prevalence of stinging/burning of skin (62.5%), restlessness (62.5%) and twitching (54.2%) were notably much higher among workers in companies where organochlorine pesticides were handled.

Table 4.5: Prevalence of signs and symptoms of pesticide poisoning controlling for categories of pesticides formulated, repackaged and stored

Signs and Symptoms	Prevalence of pesticide types			
	Organochlorines, Organophosphates, Pyrethroids, Carbamates (n = 48) n (%)	Organophosphates, Pyrethroids, Carbamates (n = 52) n (%)	Organophosphates, Pyrethroids (n = 42) n (%)	Pyrethroids (n = 26) n (%)
Neurobehavioral				
Headache	21(43.8)	13(25.0)	10(23.8)	8(30.8)
Dizziness	19(39.6)	12(23.1)	10(23.8)	10(38.5)
Convulsion	13(27.1)	2(3.8)	7(16.7)	1(3.8)
Mental confusion	9(18.8)	12(23.1)	1(2.4)	7(26.9)
Restlessness	30(62.5)	12(23.1)	28(66.7)	10(38.5)
Nausea	23(47.9)	16(30.8)	10(23.8)	9(34.6)
Intestinal				
Diarrhea	4(8.3)	1(1.9)	6(14.3)	0(0.0)
Vomiting	2(4.2)	0(0.0)	1(0.0)	1(0.0)
Salivation	17(35.4)	14(26.9)	13(31.0)	6(23.1)
Painful swallowing	14(29.2)	5(9.6)	5(11.9)	2(7.7)
Epithelial/ mucosal surfaces				
Dermatitis	23(47.9)	20(38.5)	11(26.2)	3(11.5)
Stinging/burning of skin	30(62.5)	3(44.2)	13(31.0)	7(26.9)
Blurred vision	24(50.0)	19(36.5)	11(26.2)	7(26.9)
Twitching	26(54.2)	15(28.8)	11(26.2)	9(34.6)

4.3 Discussions

The motivation for this study was the growing concern about the risk of pesticides to human health. Kenya is an agricultural country and different types of pesticides are used for the control of pests in crops and in animals. While previous pesticide related studies have focused on agricultural farm workers, yet workers involved in formulating, re-packaging and warehousing of these pesticides are exposed to an even greater risk as they handle more concentrated pesticide products. Results of this study demonstrated that health effects associated with pesticide poisoning were evident among workers in some of the companies visited. The workers handled pesticides for a longer duration of time than the agricultural farm workers.

Workers aged less than 30 years showed more signs and symptoms of pesticide poisoning compared to those that were older. Notable signs and symptoms were dizziness, convulsions, restlessness and stinging/burning skin. These can be explained by the fact that, younger workers were often employed as casuals who had just come from school and were not trained adequately on safe pesticide handling practices and the associated adverse health effects of pesticides. This was supported by the duration worked. Those who worked for a shorter period of time (< 1 yr) were at a higher risk of pesticide poisoning than those who worked for longer. Thus, proper training prior to employment was vital as this could reduce the level of risk of exposure to pesticides noted in this study.

Female workers were more vulnerable to signs and symptoms associated with pesticide poisoning with high prevalence of nausea, headache, vomiting and stinging/burning of skin (Table 4.5). These women also complained of irregular menstrual cycle and fatigue. This was not withstanding that; women of child bearing age should not be allowed to work with pesticide products (Pimentel and Greiner 1996). Lack of sex drive and complaints of fatigue may also be attributed to improper handling of pesticides. Notably, synthetic pesticides are capable of disrupting the endocrine system in humans and animals, resulting in a mixture of acute and chronic health effects. The endocrine system and the hormones it generates and controls play a key role in growth and development, and especially sexual differentiation in human beings and animals. Exposure to endocrine-disrupting pesticides/chemicals can result in; birth defects, immune system damage, sexual change, reduced sperm count, reduced intelligence and behavioral changes. The damaging health effects of pesticides may only be observed or reported in the next generation (ILO 2005). Body Mass Index (BMI) of most of the workers was

between the recommended ranges of 18-25 suggesting that these workers were of good nutritional health.

Some form of personal protective equipment (PPE) was provided to the workers in all the companies visited, confirming that the employers were aware of the risk to human health that is associated with handling pesticide.

Notably workers who wore dust masks plus other protective equipment reported significantly high prevalence of signs and symptoms of pesticide poisoning, stinging/burning of skin ($p = 0.0001$) and headache ($p = 0.013$). This might be explained by the fact that, whereas companies provided the workers with disposable dust masks they often used them for durations of one week or more, exposing them to greater risks from use of contaminated PPE. Proper respirators with replaceable charcoal filters were not available in these companies yet they are the recommended types of masks in pesticide handling practices (ILO 2005).

Studies have shown that children are more vulnerable to pesticide poisoning due to the distinct physiological differences between adults and children (Pimentel and Greiner 1996). Greater attention is therefore needed to ensure contaminated clothing is not taken home. The cluster of signs and symptoms of pesticide poisoning suggested that workers predominantly handled organophosphate and pyrethroid pesticides (Table 4.5), (**Calle *et al*., 2002**, Dyro *et al.*, 2005). The greatest danger in occupational handling of organochlorine pesticides is absorption through the skin. Acute intoxication may occur in the case of a single or very few consecutive, massive exposures by ingestion or extensive skin contamination. Signs and symptoms of poisoning are headache, dizziness, nausea, vomiting, muscular weakness, ataxia and eventually epileptiform convulsions (**Calle *et al*., 2002). These symptoms were notably elevated among workers who handled organochlorines, possibly confirming that workers actually were handling these types of pesticides.**

Upon sorting workers by the actual work done, formulators and re-packers manifested greater adverse effects of pesticide poisoning compared to store men. These could be due to the fact that store men largely handled finished products that exposed them to minimum vapours and dusts. This is in agreement with observations that work related exposure to pesticides depended to a great extent on the task being done, how the task was done and on the physical properties of the pesticide product. The skin is usually the main route for the uptake of pesticides during most work operations, and this complicates the estimation of workers' exposure and uptake levels (Kangas and Tumoainen, 1993). Epithelial/mucosal surfaces were most affected, stinging and burning of the skin manifesting in all the three occupational categories of formulators, repackers and store workers.

5. CONCLUSIONS

Workers in the pesticide factories that were visited in Nairobi Kenya were found to work in a manner that exposed them to increased risks of pesticide poisoning. In particular use of contaminated personal protective equipment (PPE) was well observed. Furthermore, despite all the workers receiving some form of PPE, there was still a lot of exposure to pesticides due to the fact that these PPE were faulty, not properly used or not recommended for the job at hand. Workers in companies that handled organochlorine pesticides manifested with significantly higher prevalence of signs and symptoms associated with pesticide poisoning, confirming widely known fears about the toxicity, persistence and adverse health effects of these pesticides. Female workers were at higher risk of pesticide poisoning as compared to their male counterparts. This supported conventional knowledge and concerns that women, especially those of child bearing age should not handle pesticides. Casual workers were found to be at greater risk of health effects associated with pesticide poisoning compared to the permanent workers as they clearly manifested with higher prevalence of signs and symptoms associated with pesticide poisoning. Notably, companies that did not provide an inventory of pesticides handled manifested with significant higher prevalence of signs and symptoms associated with pesticide poisoning, possibly alluding non production of such inventories as an admission to handling dangerous and/or even banned pesticides that might be listed in the Stockholm Convention on Persistent Organic Pollutants (POPs). Overall, this study suggests lack of proper training and awareness of dangers posed by pesticides, especially among casual workers and calls for greater need to ensure their safety. Finally, this study is almost conclusive that working with pesticides in factories in Kenya presents with adverse health challenges to the workers.

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