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Health Impact of Pesticides on Residents and Horticultural Workers in the Lake Naivasha Region, Kenya

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Abstract

The horticultural sector has undergone tremendous growth in Kenya and is now the second largest foreign income earning sector in the country. Lake Naivasha is the hub of large scale horticultural farming in Kenya. This growth coupled with increased use of pesticides, may increase the possibility of pesticide exposure and its associated risks to workers and residents of the region. The purpose of this study was to assess the symptoms commonly experienced by residents of Naivasha town and their possible association to pesticide exposure. Purposive sampling of residents from Kamere, Kwa Muia, Kioto and Karagita was performed, as these residential areas have significant numbers of flower farm workers. By random selection, a total of 801 community members were recruited to participate in the study and data was collected by completing the prepared questionnaire and from clinical examinations. Results indicate that several residents exhibited respiratory; skin, joints and bones; and nervous system symptoms. We found a higher frequency of symptoms among planters, weeders, harvesters than in sprayers working in horticultural farms. We recommend training to planters, weeders, harvesters who are mainly women (61.6%) in this study concerning pesticide use as do sprayers; and second, longer reentry times between the last spraying of pesticide and entry of these workers is warranted, particularly in greenhouses. In this regard, reentry times for greenhouses and fields established for specific pesticides in Europe, North America, Japan or Australia should be adapted by Kenya, and these guidelines enforced by

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the Government of Kenya to reduce exposure to pesticides within this vulnerable work group. These workers should also use protective clothing including gloves and masks at all times while handling chemicals or recently sprayed plants or flowers. It would also be prudent for flower farm owners to introduce an integrated pest management regime to reduce pesticide use andworker exposures. Further research is required both to identify validated biomarkers that can reliably be used to identify pesticide exposure prior to the occurrence of acute toxicity; and to follow up individual cases of known exposures for chronic health effects.

Keywords

Pesticides, Health Effects, Horticultural Workers

1. Introduction

Pesticides are among the most extensively used industrial chemicals in the world today and, as they were specifically designed to be toxic, they are also among the most hazardous compounds to human health. The US EPA estimates that the total amount of pesticides used in the world in 2006 and 2007 was approximately 5.2 billion tons in each year [1]. The WHO estimate for 2001 was in excess of 2.5 million tons of pesticides valued at over US $30 billion for annual use in cultivation alone all over the world [2]. And pesticide use in developing countries and in the USA each accounts for about 20% of annual global use [1]. Depending on the specific handling practices employed, there are risks associated with pesticide application. Such risks cause environmental and human health problems especially to those who have direct contact with the pesticides and typically have the highest exposures. Poor pesticide storage may also lead to acute and/or chronic exposures, with adverse health and environmental consequences. Although the inhalation, dermal and oral routes of direct exposure are the most common, pesticide residues in air, soil, water and food may add to indirect exposures common in the general population [3].

Several studies have shown both direct and indirect health effects of pesticide exposures in humans. The severity of symptoms depends on the type and potency of the chemicals used as well as the amount and duration of exposure. Agricultural workers have been described as the largest identifiable occupational group at risk, especially pesticide sprayers [4]. Estimates by WHO indicate that worldwide, three million severe pesticide poisoning cases occur annually [5]. In addition, 25 million symptomatic occupational pesticide poisonings are reported to occur among agricultural workers in developing countries [6]. In 2008, Subashiny and Thiruchelvam reported that acute pesticide poisoning was a major concern to farmers handling and spraying pesticides using hand sprays leading to numerous morbidities in Sri Lanka [7].

Illnesses and symptoms associated with pesticide use include headache, malaise, tearing of eyes, asthma, and dermatitis [8]-[10]. Central nervous disorders like nervousness, irritability, depression and memory deficits have also been reported [10]-[12]. Chronic effects such as Parkinsonism and cancers may occur [9] [13]-[16]. In Kenya, researchers noted in their study the negative effects of pesticide use on the environment whereas farm workers experienced several symptoms related to pesticide use in individuals who either lacked or did not use adequate protective clothing [11] [17].

The Horticultural industry in Kenya has undergone tremendous development and is now the second largest foreign income earner in Kenya [18]. It employs over 500,000 people directly and over 2 million indirectly [18]. In Kenya, recorded pesticide use in 2005 was 7047 metric tons with insecticides accounting for 40% of that volume [19]. The negative impacts on environment are due not only to active ingredients but also to associated impurities, solvents, carriers, emulsifiers and other constituents of the formulated product that are routinely present in higher concentrations than the actual pesticide.

Naivasha town in Kenya is the hub for large scale horticultural farming. To meet the market demands for quality flowers, fruits and vegetables in Europe, the horticultural farmers use large volumes of pesticides. Although there have been significant positive effects such as industrialization, employment and infrastructural development in the area, the industry has also brought with it several challenges that include adverse health impacts of pesticide exposures on workers and residents of Naivasha. The purpose of this study therefore is to assess the diseases and symptoms commonly experienced by residents of Naivasha town and their possible associ-

ation with pesticide use.

2. Methodology

2.1. Study Area

Naivasha has a shallow basin lake, situated 80 km northwest of the Kenyan Rift Valley. It lies at an altitude of 1890 m between the longitude 36˚20'E and latitude 0˚45'S and covers an area of approximately 100 km^2. The population in Naivasha has rapidly grown from 7000 persons in 1969 to 376,243 in 2009 [20]. Most of the people have migrated from other regions of Kenya in search of employment. This has led to a severe strain on local resources.

The most significant activity in Lake Naivasha, albeit for large scale farmers, is the extensive irrigated greenhouse floriculture and horticulture industry. Livestock ranching and private game sanctuaries and conservation areas also exist in the catchment [21].

2.2. Materials and Methods

This was a cross-sectional observational study carried out in Naivasha Municipality from July 2012 to March 2013. Purposive sampling of the residential areas where most flower farm workers live was done to ensure they were captured in the study. These included Kamere, Kwa Muia, Kioto and Karagita. Every fifth household in a row of houses was selected and only one member who was the head or eldest in the household was recruited to participate. A total of 801 residents were selected to participate in the study.

Ethical considerations were taken into account. Approval to conduct the study was obtained from the Kenya Medical Research Institute (KEMRI) and the National Council for Science and Technology (NCST). Permission to carry out the study was also requested from and approved by provincial administration and area chiefs. The participants were informed on the purpose of study and only those who signed an informed consent form participated.

A questionnaire was prepared by the researchers from Kenya and Canada, and pretested in Shabab location in Nakuru town. This was later cleaned and was administered to those who consented to participate in the study. The questionnaire consisted of personal data on age, sex, occupation including their job description, income and level of education and symptoms experienced by the participants in the last 6 months. Researchers who were trained clinicians then examined the participants for any signs of disease.

Data was entered in Statistical Package for Social Sciences (SPSS) version 17, validated and analyzed. The number of participants who indicated they suffered from specific symptoms was calculated as a percentage of total participants. Fisher's exact test was used to test if the number of those self-reporting for suffering from the symptoms were different between those working in the flower farms and those who do not. Bivariate correlation was used to evaluate the relationship between symptoms and specific farm duties. The level of significance was $P < 0.05$.

3. Results

3.1. Socio-Demographic Characteristics of the Respondents.

From the sampled group of 801, a total of 352 (43.9%) of the participants were male and 449 (56.1%) were females. A majority of the participants were between 20 to 39 years (74.9%) with an age range of 18 to 69 years. **Table 1** shows the age distribution of the participants.

Participants who indicated they were married constituted 66.3% (n = 531); 4.9% (n = 39) were divorced; 25.3% (n = 203) were single; and 3.55% (n = 28) were widowed. The education level is shown in **Table 2**. The majority of participants had either attained upper primary (42.2%) or secondary education (39.5%).

A total of 37.7% (n = 302) of participants worked within the flower farms while 56.3% (n = 499) were residents in the area who did not work directly in the flower industry. **Table 3** indicates the period of time for which the respondents had lived in Naivasha. The majority had lived there for more than 2 years.

3.2. Job Description of Flower Farm Workers

Of the flower farm workers sampled, 60.1% were male and 39.9% female. The majority of the respondents

Table 1. Age of respondents.

Age	Frequency (No)	Percent %
<20	47	5.9
20 - 24	192	24.0
25 - 29	160	20.0
30 - 34	154	19.2
35 - 39	86	10.7
40 - 44	64	8.0
45 - 49	29	3.6
50 - 59	32	4.0
>60	29	3.6
Not sure	8	1.0
Total	**801**	**100**

Table 2. Education level of respondents.

Level of education	Frequency	Percent
No formal education	47	5.9
Lower primary	38	4.7
Upper primary	338	42.2
Secondary	316	39.5
Tertiary	62	7.7
Total	**801**	**100**

Table 3. Time period of residence in Naivasha.

Period of residence	Frequency	Percent
0 - 4 months	34	4.2
4 - 8 months	36	4.5
8 - 12 months	63	7.9
1 to 2 years	68	8.5
> 2 years	600	74.9
Total	**801**	**100**

(42.5%) worked within the greenhouses or fields where activities included planting, weeding, harvesting and/or pruning. The majority of the females worked within the fields (61.6 %) as compared to males; in the packing areas, 35.7% of the flower farm respondents were females. Although men had larger proportions in the remaining activities, they were most predominant in spraying (88.5%) and irrigation (100%). The results of the analysis of flower farm work activities are shown in **Table 4**.

3.3. Symptoms Reported to Be Experienced

General malaise and headache were the most common symptoms reported by the respondents (47.2%) followed

by respiratory system symptoms which included cough, difficulty in breathing and asthmatic attacks that were experienced by 34.3% of the respondents. The results are presented in **Table 5**.

3.4. Comparison of Symptoms between Flower Farm Workers and Other Residents

Table 6 below gives the comparison of the incidence of symptoms between the flower farm workers and the rest of the residents who did not work on flower farms. The occurrence of each of the symptoms, except for central nervous symptoms (anxiety, depression, fits, loss of consciousness) and gastrointestinal symptoms (heart burn, water brush and abdominal pain, vomiting, diarrhea, bloody vomitus or jaundice) was significantly higher in the flower farm workers than in those who did not work on a flower farm.

3.5. Relationship between Symptoms and Specific Farm Duties

Those weeding, planting and harvesting reported the highest proportion of symptoms potentially related to pesticide exposure. Results of bivariate correlation of all symptoms and specific duties on the flower farm are presented in **Table 7**. There was a significant positive correlation for each of the following symptoms: itchy painful

Table 4. Flower farm workers duties.

Flower farm duties	Sex		Total
	Male	Female	
	No (%)	No (%)	No (% of total population)
Irrigation	12 (100.0)	0 (.0)	12 (4.0%)
Spraying	23 (88.5)	3 (11.5)	26 (8.7%)
Weeding, planting, harvesting	49 (38.4)	78 (61.6)	127 (42.5%)
Packing	27 (64.3)	15 (35.7)	42 (13.0%)
Supervisor	8 (66.7)	4 (33.3)	12 (4.0%)
Messengers, clerks, secretary	5 (38.5)	8 (61.5)	13 (4.3%)
Security, gardening	20 (90.9)	2 (9.1)	22 (7.4%)
Maintenance	37 (82.2)	8 (17.8)	45 (15.1%)
Total	**181 (60.1)**	**120 (39.9)**	**301 (100.0)**

Table 5. Symptoms experienced by participants.

System category	Symptoms	Count (%) with symptoms	
		Yes	No
General	Malaise, headache	380 (47.4%)	421 (52.6%)
Nervous system	Anxiety, depression, fits and loss of consciousness	39 (4.9%)	762 (95.1%)
Cardiovascular	Palpitations, chest pain and leg swelling	247 (30.8%)	554 (69.2%)
Respiratory	Cough, sneezing, dyspnea and wheezing	276 (34.5%)	525 (65.5%)
Gastric	Heat burn and water brush	193 (24.1%)	608 (75.9%)
Gastrointestinal	Abdominal pain, vomiting, diarrhea, bloody vomitus or jaundice	237 (29.6.3%)	564 (70.4%)
Nose and throat	Itchy painful ear, nose and throat	62 (7.7%)	739 (92.3%)
Skin	Skin rash, itching or other skin conditions	93 (29.6%)	708 (88.4%)
Eyes	Itchy painful or tearing eyes	178 (22.2%)	623 (77.8%)
Joints	Painful swelling of bones, joints or spine	190 (23.7%)	611 (76.3%)
Head or neck abnormality	Swelling on head or neck	34 (4.2%)	767 (95.8%)

Table 6. Comparison of symptoms between flower farm workers and non-flower farm workers.

System involved	Flower farm worker		Total	P-value
	Yes	No		
Malaise, headache	161 (53.3%)	219 (43.9%)	380 (7.4%)	0.006
Anxiety, depression, fits, loss of consciousness	20 (6.6%)	19 (3.8%)	39 (4.9%)	0.054
Palpitations, chest pain, leg swelling	112 (37.1%)	135 (27.1%)	247 (30.8%)	0.002
Heart burn water brush	80 (26.5%)	113 (22.6%)	193 (24.1%)	0.198
Painful leg swelling, bones joints or spine	93 (30.8%)	97 (19.4%)	190 (23.7%)	0.000
Itchy or painful, ear, nose or throat	39 (12.9%)	23 (4.6%)	62 (7.7%)	0.000
Itchy or painful or tearing eyes	89 (29.5%)	89 (17.8%)	178 (22.2%)	0.000
Head, neck or mouth	21 97.0%)	13 (2.6%)	34 (4.2%)	0.003
Skin rash or itching or other skin conditions	53 (17.5%)	40 (8.0%)	93 (11.6%)	0.000
Abdominal pain, vomiting, diarrhea, bloody vomitus or jaundice	99 (32.8%)	138 (27.7%)	237 (29.6%)	0.072
Cough, sneezing, dyspnea or wheezing	122 (40.4%)	154 (30.9%)	276 (34.5%)	0.004

Table 7. Relationship between specific duties on a flower farm and symptoms.

	Flower farm duties								Total	P-value
	Irriga-tion	Spraying	Weeding, planting, harvest-ing	Packing	Supervi-sor	Messen-gers, clerks, secretary	Securicor, gardening	Maintan-ance		
	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	
Itchy painful or tearing eyes	3 (25.0)	11 (42.3)	37 (29.1)	22 (52.4)	2 (16.7)	2 (15.4)	4 (No (%)18.2)	8 (17.8)	89 (29.8)	0.008
Anxiety, fit, depression	0 (0)	3 (11.5)	12 (9.4)	2 (4.8)	2 (16.7)	0 (0)	0 (0)	1 (2.2)	20 (6.7)	0.219
Palpitations, chest pain, leg swelling	3 (25.0)	13 (50.0)	52 (40.9)	22 (52.4)	4 (33.3)	2 (15.4)	6 (27.3)	8 (17.8)	110 (36.8)	0.010
Cough, sneezing, dyspnea, wheezing	6 (50.0)	15 (57.7)	51 (40.2)	22 (52.4)	3 (25.0)	2 (15.4)	8 (36.4)	12 (26.7)	119 (39.8)	0.044
Heart burn, water brush	6 (50.0)	5 (19.2)	32 (25.2)	13 (31.0)	1 (8.3)	4 (30.8)	6 (27.3)	13 (28.9)	80 (26.8)	0.878
Malaise, headache	5 (41.7)	20 (76.9)	75 (59.1)	25 (59.5)	7 (58.3)	5 (38.5)	7 (31.8)	16 (35.6)	160 (53.5)	0.006
Painful bones, joints or spine	4 (33.3)	8 (30.8)	42 (33.1)	13 (31.0)	3 (25.0)	3 (23.1)	7 (31.8)	14 (31.1)	94 (31.4)	0.997
Head, neck or mouth	2 (16.7)	3 (14.5)	10 (7.9)	3 (7.1)	0 (.0)	0 (.0)	1 (4.5)	2 (4.4)	21 (7.0)	0.634
Itchy painful ear nose and throat	0 (0)	7 (26.9)	12 (19.4)	11 (26.2)	0 (0)	1 (7.7)	2 (8.9)	6 (13.3)	39 (13.0)	0.021
Abdominal pain, vomiting diarrhea	3 (25.0)	14 (53.8)	42 (33.1)	21 (50.0)	3 (25.0)	2 (15.4)	5 (22.7)	8 (17.8)	98 (32.8)	0.008

or tearing eyes; palpitations, chest pain, leg swelling; cough, sneezing, dyspnea, wheezing; malaise, headache and itchy painful ear, nose and throat, in those who were employed on the flower farms as weeders, planters or harvesters.

3.6. Symptoms Recorded during Clinical Examination of the Participants

Results from the clinical examination of respondents are shown in **Figure 1** below. There is an indication that a higher proportion of flower farm workers exhibited symptoms related to lungs and chest; cardiovascular; bones, joint or spine; eyes and skin and lymph nodes.

Symptoms related to bone and joint presented mainly as swollen joints and tenderness over the bones. Those related to the cardiovascular system included lower leg swelling (edema), pallor, and tachycardia. A few respondents had elevated blood pressure (above 140 mm Hg systolic and above 90mm Hg diastolic). Symptoms related to the respiratory system included rhonchi lung sounds, chest congestion and tachypnea. Abdominal observations included signs of epigastric tenderness, splenomegaly and enlarged abdomen. Skin lesions observed included skin rash, hyper- and hypo-pigmented lesions and varicose veins. In regard to the eye, ear nose and throat symptoms observed included hoarseness of voice, rhinitis and nasal congestion. The respondents with eye symptoms mainly showed tearing redness but a few had eyelid swelling. Symptoms related to the nervous system included fine tremors, anxiety and mental disturbance.

The difference between the incidences of the symptoms observed in those working on flower farms vs those working elsewhere was also evaluated for significance by Fisher's exact test (**Table 8**).

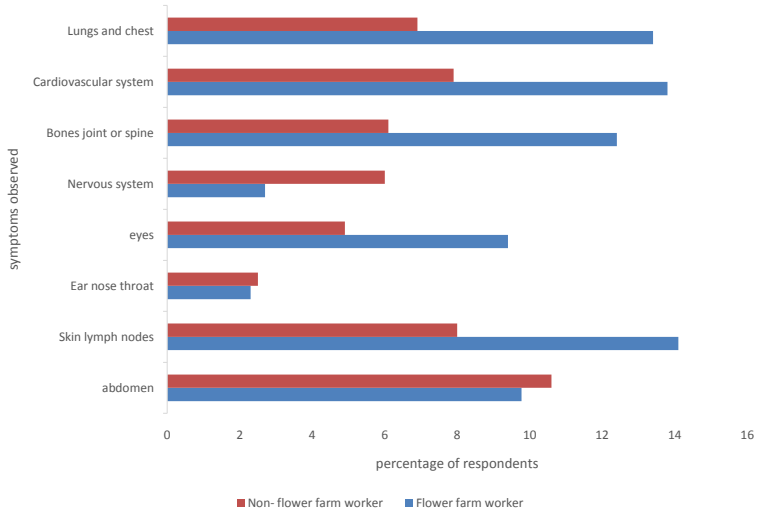

Figure 1. Proportion of respondents exhibiting symptoms.

Table 8. Comparison of incidence of symptoms observed in flower farm workers vs incidence of those observed in non-flower farm workers.

	Flower farm worker	Non-flower farm worker	Total (No/%)	P-value
Abdomen	29 (9.77)	52 (10.6%)	81 (10.3%)	0.409 (NS)
Skin lymph nodes	42 (14.1%)	39 (8.0%)	81 (10.3%)	0.010
Ear nose throat	7 (2.3%)	12 (2.5%)	19 (2.4%)	0.438 (NS)
Eyes	28 (9.4%)	24 (4.9)	52 (6.6%)	0.021
Nervous system	8 (2.7%)	3 (.6%)	11 (1.4%)	0.024
Bones joint or spine	37 (12.4%)	30 (6.1)	67 (8.5)	0.004
Cardiovascular system	41 (13.8%)	39 (7.9%)	80 (10.1%)	0.006
Lungs and chest	40 (13.4%)	34 (6.9%)	74 (9.4%)	0.004

There are significant differences in the frequency of symptoms between flower workers and non-workers for the following: skin and lymph nodes; eyes; nervous system; bones joint or spine; and lungs and chest.

4. Discussion

This study shows that the most common symptoms experienced by the population sampled in Naivasha were general malaise and headache followed by respiratory system symptoms (**Table 5**). The incidence of almost all symptoms was higher in the flower farm workers than in those who did not work on flower farms (**Table 6**). This study confirms what has been reported elsewhere from similar studies conducted in Costa Rica [7] [22] India [23], and Kenya [11], where it was found that workers exposed to pesticide exposure are more at risk of adverse health effects than workers who are not exposed to pesticides in their occupation. As with other studies we found that workers who directly handle pesticides like sprayers or those directly working in horticultural farms where pesticides are used are more at risk than flower farm workers engaged in office or support duties [16] [24] [25]. Calvert *et al.* 2008 [4] in their review of agricultural workers presenting with acute pesticide poisoning between 1998 to 2005 was highest among the farm workers who comprised 71% of the cases, those in processing or packing 12 % while farmers 3%. Although others have found eye problems and skin irritation to be common symptoms associated with pesticide exposure, only a small proportion of our respondents were so affected.

Occupational exposure of humans to agrichemicals, especially pesticides is common and results in both acute and chronic health effects, including acute and chronic neurotoxicity, lung damage and respiratory failure and male infertility [26] [27]. A variety of cancers also have been linked to exposure to various pesticides [28]. In addition, there have been reports of aplastic anaemia and related blood dyscrasias being associated with occupational exposure to pesticides. Endocrine disruption and skin effects such as contact dermatitis and allergic sensitization have been frequently observed in pesticide workers after exposure to several pesticides. Furthermore, immunologic abnormalities and adverse reproductive and developmental effects due to pesticides have also been reported [29].

We found that the incidence of symptoms reported by those who worked on the flower farms varied by specific duties (**Table 7**). Whereas one might expect the sprayers to report the highest proportion of symptoms because they use more pesticides than the other workers, those who weeded, planted, and harvested flowers reported the highest proportion of symptoms in our study. This could be due to the fact that this category is more in contact with the plants that have been recently sprayed since they undertake more activities in the farms and are also likely to be proximate bystanders during application. In addition, sprayers are trained how to use pesticides and this training makes them more cautious about exposures. The weeders, sprayers and harvesters often do not know when the flowers they are attending were last sprayed, and in general are less cautious. Moreover, the sprayers have access to state-of-the-art safety equipment to decrease exposures whereas other flower farm workers do not.

Specific duties in the farms were correlated with the symptoms. Whereas one expects the sprayers to report the highest proportion of symptoms, those weeding, planting and harvesting reported the highest proportion of symptoms. This could be due to the fact that this category is more in contact with the plants that have been sprayed since they undertake more activities in the farms and are also likely to be bystanders during application. Pesticides can enter a person's body by three possible routes: by the lungs, by the mouth or through the skin. Skin contact is the most likely route of exposure to pesticides. Spray applications of pesticides increase the chance that the applicator and by-standers may inhale fine spray drops [5].

Although the respondents not working in flower farms had lower incidences of symptoms potentially associated with pesticide exposure, a significant number still either reported or exhibited these symptoms upon clinical examination. This could either be related to exposure to pesticides used in the home or to exposure to pesticides released into the environment from the flower farms and other agricultural sources. Environmental contaminants can arise through using empty contaminated pesticide containers, which still contain pesticide residues, as containers for transporting and storing water; from contaminated foods including fish and other aquatic foods caught in Lake Naivasha, and even drift of pesticide-containing air during application or volatilization of pesticides post-application [30] [31]. According to WHO [2], no segment of the population is completely protected against intended direct or unintended indirect exposure to pesticides and the potentially serious adverse acute and chronic health effects that can result, though a disproportionate burden is shouldered by those who are directly and unintentionally exposed.

5. Conclusion

Our study shows that a significant percentage of respondents from the Lake Naivasha area are suffering from symptoms that could be related to pesticide exposure. Those working on the flower farms and especially individuals in jobs that require direct contact with pesticides (weeders, planters and harvesters) but with less training than pesticide sprayers, are more at risk from accidental poisoning, based on the incidence of both self-reported (determined via questionnaire) and clinically observed symptoms (**Table 7**). Of importance, even the non-flower farm workers showed these symptoms at lower incidence (**Table 6**), most likely due to exposure in the home because domestic pesticides are widely available in Kenya. No one therefore is exempted from the adverse effects of pesticides as long as these chemicals are readily available and being used in agriculture and/or in the home within a given region.

6. Recommendations

Given that the incidence of adverse symptoms is greater in weeders, planters and harvesters than in sprayers who work on the flower farms, two actions should be taken immediately to reduce exposures to the primarily female (61.6%) weeders, planters and harvesters who frequently (almost 90% < 45 years of age) are of childbearing age. First, these workers should receive the same formal training concerning pesticides on the various flower farms as is provided to the sprayers so these individuals are as aware of their risks to pesticide exposure as are the sprayers. Second, longer times between the last spraying of pesticide and the entry of these workers into the greenhouse (reentry time) may be required, especially when reentry times in flower farms in Kenya are significantly less than those established for greenhouses for specific pesticides in Europe, North America, Japan or Australia. Appropriate pesticide-specific reentry times should be implemented and enforced by the Government of Kenya to reduce exposure to pesticides within this vulnerable work group. In addition, protective wear (gloves, single day clothing and masks provided by the flower farm owners) should be routinely available to the weeders, planters and harvesters when they are working with pesticide-related flowers or plants.

Also the flower farm owners and managers should introduce integrated pest management practices wherever possible to reduce exposures to and adverse effects arising from repeated broadcast application of pesticides, a practice that has lost favour because of safety concerns. In addition, further research is needed to follow up cases of repeated exposures to pesticides in the workplace for chronic disease, and for effective biomarkers that can be used for the early identification of those most vulnerable to chronic effects, including the pregnant.

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