Assessment of Occupational Safety and Health Practices for Organophosphate and Carbamate Pesticides in Flower Farms in Naivasha, Nakuru County Kenya

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Abstract: ***This study sought to explore cholinesterase monitoring practices in selected flower farms in Naivasha, Kenya, as part of occupational safety and health management. Structured questionnaires were administered to 138 personnel in charge of production and employees' medical to collect data on cholinesterase monitoring practices in place and the challenges experienced in the monitoring by the farms. Majority of the farms (82.6%) used organophosphate and carbamate pesticides for pest control. All the respondents confirmed that only male employees were involved in handling pesticides. Majority of the respondents (70%) reported that their farms conducted regular cholinesterase testing for pesticides handlers. Out of these farms all spray operators were incorporated in the testing program while 85% reported inclusion of spray supervisors and another 70% inclusion of pesticides store men in the testing program. Majority of the respondents (60%) conducted cholinesterase testing after every 3 months of handling pesticides. Cholinesterase baseline is established at a time away from pesticides handling as reported by (70%) of respondents. The most commonly done cholinesterase testing is plasma cholinesterase (PChE) as reported by three quarters of the respondents. Other medical examinations that were conducted for the pesticides handlers included clinical examination (70%) and liver function (10%) of the respondents. Three quarters of the respondents reported that neither cholinesterase nor medical results were sent to the Directorate of Safety and Health Services (DOSHS) as required by law. Most of the respondents (65%) reported that re-deployed pesticides handlers were given 3 – 4 months away from pesticides handling activities and would resume handling duties without cholinesterase re-testing. More than half of the farms (65%) were reported to have an on-site clinic, but 69% did not conduct cholinesterase testing at the farm clinic. Most of respondents (65%) reported their farms used different laboratory for cholinesterase testing. Most respondents (41.2%) reported that it took 11 – 15 days to get laboratory results after conducting the test. 70% of the respondents' stocked antidotes at the farm, mainly activated charcoal and atropine. 65% of the respondents did not know the existence of a poison information and emergency center in Kenya. Challenges encountered at the farms in the management and monitoring of employees cholinesterase program included: employees personal attributes and beliefs e.g. taking blood samples needed for cholinesterase testing not acceptable to some; cholinesterase tests being expensive especially when many employees are involved since it's done 3 monthly; few testing facilities; lack of a standardized system of conducting cholinesterase test; difference in the interpretation of cholinesterase results; delay in getting lab results and consequently delay in taking appropriate intervention; blood samples hemolysis; existing medical condition; minimal awareness on cholinesterase as subject; misdiagnosis of cholinesterase inhibition since symptoms may present as other common illnesses; few approved occupational health practitioners; poor quality personal protective equipment (PPE) and use of worn out PPE; long re-entry intervals required after spraying organophosphate and carbamate pesticides; cholinesterase depression levels due to other sources of exposure for some employees e.g. at their own farms, or domestic pesticides.***

Keywords: organophosphates; carbamates; cholinesterase; pesticides handlers; monitoring

1. Introduction

1.1 Background of the Study

According to the International Labour Organization (ILO) report released in September 2011 during the 19th World Congress on Safety and Health at Work, significant advances have been made in occupational safety and health (ILO, 2011). Many countries have realized the importance and the need to give higher priority to "preventing" accidents and ill-health at work. As a result, numbers of serious accidents appear to be declining globally although the picture for occupational ill-health is less encouraging. It is therefore no surprise that prevention dominated talks during the 20th World Congress on Safety and Health at Work 2014 in Frankfurt; emphasizing the culture of prevention on a global scale towards Vision Zero.

Pesticides are one of the known causes of occupational diseases worldwide, but exposure is potentially preventable. Pesticides can have harmful effects on the operators, other workers, the public, flora and fauna, and the environment; as they cause acute and/or chronic human health effects, contamination of the atmosphere, ground and surface water (Macharia et al., 2009).

Floriculture industry in Kenya is one of the fastest growing sub-sectors having reached maturity after three decades, and maintaining an average growth of 15% per annum after its rapid expansion in the early 1990s (KFC, 2017). The industry has recorded continuous growth in production area, volume and value of cut flowers exported every year. In 2016, a total of 133,658 tons of cut-flowers were exported valued at Kshs 70.8 billion (HCD, 2017). Out of the total area of 605,000 hectares under horticulture production in Kenya in 2013, the area under flowers was 6,239 hectares according to HCD (2017). The industry employs about 100,000 people directly and more than 500,000 indirectly, while supporting about 2 million households as per the KFC estimates (KFC, 2017).

2. Literature Review

Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man. Pesticides when used for its intended purpose must not cause unreasonable adverse effects on man and the environment. This balancing process must take into account the economic, social, and environmental costs as well as the potential benefits of the use of any pesticide (Feitshans, 2016).

As outlined by ILO, the agricultural sector employs an estimated 1.3 billion workers worldwide, nearly 50% of the worldwide workforce. The sector is also one of the three most hazardous sectors of activity, along with construction and mining (ILO, 2016). While pesticides can have economic, social, public health and environmental benefits; there are significant risks associated with pesticide use (EPA, 2005).

Exposure to pesticides could be both direct and indirect, and can occur in an occupational setting, through non-occupational environmental exposure, including food and drinking water. According to Christos and Ilias (2011), agricultural workers and small scale farmers are exposed to toxic pesticides from a variety of sources including the crops they grow, harvest and store, the soil they cultivate, from spray drift, and the livestock, poultry and fish they handle. Pesticide applicators have the highest exposures mostly through pesticide contact with exposed skin especially where protective clothing is not used. They also get exposures through accidental pesticide ingestion when, for example, they eat, drink and/or smoke during the handling of pesticides. Other workers and farmers are exposed to pesticides contamination from spray drift, by working in or walking through treated areas, and handling sprayed vegetation and produce.

The main routes of pesticides entry into the body include inhalation through the respiratory tract, dermal absorption through the skin; and ingestion through the digestive tract (stomach, intestines). Indirect entry of pesticides into the body could also occur through transfer from the mother to her unborn child, since pesticides can pass through the placenta to the unborn baby.

Notwithstanding the physical and psychological suffering that is borne by the affected worker, occupational diseases place a great economic burden on enterprises, families, and the society at large (ILO, 2013).

As pointed out by ILO, majority of pesticides poisoning is from the developing countries where the more toxic materials continue to be widely used and easily available. It is estimated that developing countries consume less than 20% of the world production of agrochemicals, but are responsible for approximately 1.1 million (70%) of the aggregate cases of acute poisoning in the working population (Tiwari, 2017).

As concluded by Keifer (2000) in his study, a number of ways are effective in reducing worker exposure to pesticides including changes in application procedures, packaging, mixing, use of personal protective equipment, and biological monitoring programs. Other methods include worker education, spray rotation programs, pesticide substitutions, use of integrated pest management programs, and enacting relevant legislation, Krenz (2014).

3. Statement of the Problem

Pesticides poisoning is real and is a growing threat to human lives and to our environment, with excessive exposure having adverse health effects which may even be fatal. Majority of the pesticide handlers are however quite ignorant, or are not totally aware of the risks associated with pesticide use. Among other pesticides, agrochemical handlers in the flower industry are exposed to a broad range of agrochemicals including organophosphates (OP) and carbamates (CB), which are cholinesterase inhibiting. This is supported by the number of such pesticides approved for use in Kenya for flower production by the Pest Control Products Board (PCPB).

Over the years, the flower industry in Kenya has had its share of negative publicity on a myriad of concerns locally and internationally. Among such concerns is the exposure of workers to pesticides and environmental pollution.

In the wake of legal provisions on cholinesterase monitoring, and subscription by farms to various codes on good agricultural practices requiring such monitoring, information on the current use of cholinesterase inhibiting pesticides i.e. OP and CB pesticides; possible exposure and preventive strategies; and cholinesterase monitoring approaches in place; is of great interest to ensure no employee is exposed to these harmful pesticides beyond the set threshold limit.

Objectives of the Study

To examine the cholinesterase monitoring practices in place as part of occupational safety and health management on the use of organophosphate and carbamate pesticides in selected flower farms in Naivasha, Kenya.

4. Research Methodology

4.1 Research Design

This study adopted a descriptive cross-sectional survey design. According to Creswell (2009), a combined descriptive cross-sectional survey research design is used when seeking to gather information, summarize, present and interpret it for the purpose of clarification.

4.2 Target Population

The survey targeted the 23 flower producers within the KFC membership in Naivasha Sub-county of Nakuru County. Naivasha is the main flower production area in Kenya mostly owing to availability of water from Lake Naivasha, land, and labour force, and also proximity to Nairobi the main exit for flowers to the international market.

4.3 Data Collection

The study collected both primary and secondary data. Primary data was collected using survey questionnaires, although interviews and observations were also employed where necessary and possible. Secondary data sources included employee records in the farms, previous research papers, publications and journals on the study area.

The study population at the farms involved the flower production managers, spray supervisors and pesticides store men who had information on pesticides usage at the farms. The study further targeted staff who had information on cholinesterase monitoring practices at the farms including human resource managers, personnel in charge of compliance and clinicians in charge of employees' health management. The general spray operators were involved in focussed group discussions.

4.4 Data analysis

Data analysis and presentation was both qualitative and quantitative in nature. Qualitative data that was obtained from the questionnaires was edited/cleaned and classified into classes or groups with common characteristics or themes. The content within the themes was then analysed guided by the research objectives. Inferential data analysis techniques (Chi-Square) were used to analyse the quantitative data. Descriptive Statistics such as frequencies and percentages were used to show the inherent relationship between variables and research questions in the study. Findings of the study were reported in frequency tables, graphs and pie charts before being interpreted and conclusions made.

5. Results and Discussions

The study targeted a sample size of 138 respondents in which 129 filled the questionnaires making a response rate of 93.5%.

5.1. Cholinesterase monitoring practices in place at the study farms

Most of the respondents (65%) informed that human resource managers are in charge of pesticides handlers' cholinesterase monitoring and employees' health at the farms, while half of the respondents stated to have a farm clinic Nurse. Most of the respondents (65%) reported their farms engage 1-60 employees in handling pesticides i.e. spraying, pesticides storage, supervision, PPE washing, spray equipment washing, etc. All the respondents confirmed that only male employees were involved in handling pesticides. This is in agreement with Mrema's (2017) findings in Tanzania that men are more involved in pesticide application than women and the same finding by Magauzi (2011) in Zimbabwe. Focus group discussion with the spray operators confirmed that only male employees were involved in handling pesticides and female employees were strictly excluded from pesticides handling activities.

Table 4.1: Pesticides handlers, cholinesterase monitoring and employees health

Variable	Category	Frequency	Percent
Who is in charge of pesticides handlers' cholinesterase monitoring and employees' health at the farm?	Farm Clinic Nurse	30	50.0
	Human Resource Manager	39	65.0
	EHS Manager	12	20.0
How many employees are involved in handling pesticides at the farm i.e. sprays, stores, supervisors, PPE washing, spray equipment washing, e.t.c?	1 – 30	21	35
	31 – 60	18	30
	61 – 90	9	15
	121 – 150	12	20
Which gender is mostly involved in handling pesticides?	Male	60	100.0
	Female	0	0.0

Majority of the respondents (70%) reported that their farms conducted regular cholinesterase testing for pesticides handlers. From the review of the certification standards to which the most of the flowers farms prescribe to, it was noted that most of these standards require farms to conduct regular cholinesterase testing, at least once in every three months e.g. KFC Flowers and Ornamentals Sustainability Standard, Fairtrade Standard for Flowers and Plants, and MPS SQ Standard. More than half of the respondents (65%) reported to have an on-site clinic at the farm. Majority of the respondents (69%) indicated that their farms did not conduct cholinesterase testing at the farm clinic.

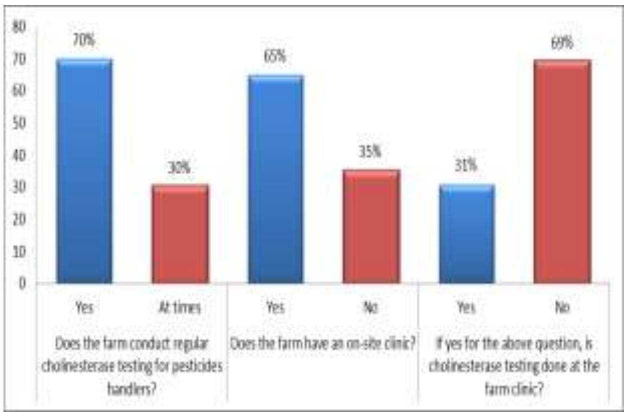

Figure 4.1: Cholinesterase testing for pesticides handlers

Respondents that reported their farms conducted cholinesterase testing were also to indicate the employee categories that undergo the test where all the respondents reported all spray operators for all pesticides, while 85% reported all supervisors for agrochemical handling tasks and another 70% for pesticides store men. As explained by employees in focus group discussion, it was not mandatory for other pesticides handlers to undergo the routine cholinesterase testing other than the spray operators i.e. supervisors, store men, laundry personnel (where applicable). Production managers do not take these regular tests. This showed that not all pesticide handlers undergo cholinesterase testing and more so the supervisors and store men.

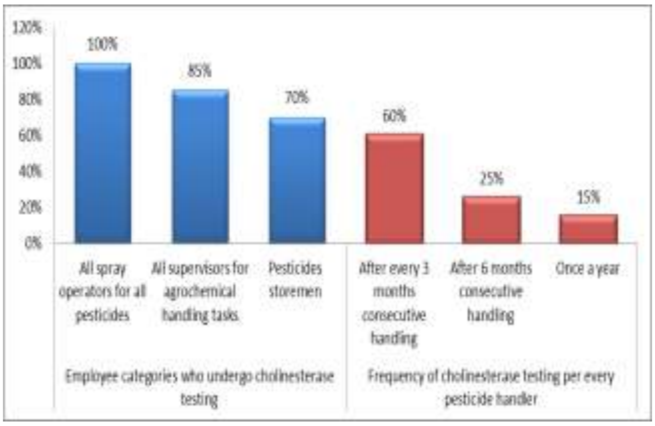

Figure 4.2: Employee categories who undergo cholinesterase testing

When asked to indicate the frequency of cholinesterase testing per every pesticide handler, majority of the respondents (60%) reported after every 3 months consecutive handling while a quarter indicated after 6 months consecutive handling and the remainder 15% once a year. The frequency was in line with what is required by most Certification Standards that farms subscribed to, while the Medical Rules of 2005 prescribe conducting red blood cell Cholinesterase (AChE) at pre-employment and repeat depending on results, while Plasma Cholinesterase (PChE) is pre-employment, periodic and a repeat depending on results.

Respondents who reported cholinesterase testing were asked to indicate if cholinesterase baseline levels had been established per employee at a time away from pesticides handling where majority (70%) reported no. This finding was further confirmed by interviewed spray operators who reported that baseline tests were not usually conducted. Those that had established employee baselines were asked to indicate the time that baseline levels were established where all of them reported once before joining pesticides handling. This is in agreement with Magauzi's (2011) findings that farm workers did not undergo pre-employment and routine annual medical checks to ensure that they were fit for the job they were employed for and to obtain baseline data. Keifer and Sheridan (2007) and Furman (2010) recommends that baseline measures be established prior to working with cholinesterase inhibiting pesticides, ensuring at least the immediate 30 days prior to testing were free of OP exposures. The longest practicable exposure-free period available is however recommended. Baselines should thereafter be established annually.

The most commonly done cholinesterase testing is PChE as reported by three quarters of the respondents followed by AChE as reported by a quarter of the respondents. This is due to the fact that most farms as reported earlier, were spraying OP as compared to CB pesticides. As described by Janice (2017), cholinesterase testing, if only working with carbamates, is not likely to be beneficial since it forms a bond that is rapidly recovered and reversal is spontaneous, and that no permanent effects generally result from carbamate poisoning. This is compared to organophosphates bonds that persists for days and may become permanent. Interviewed spray operators did not however seem to know the difference between PChE and AChE and therefore did not know the type of cholinesterase test done on them.

Table 4.2: Baseline and type of Cholinesterase done

Variable	Category	Frequency	Percent
For the employees participating in cholinesterase testing, are baseline levels established per employee at a time away from pesticides handling?	Yes	18	30.0
	No	42	70.0
If Yes in question above, at what time is the baseline level established?	only once before joining pesticides handling duties	18	100.0
What type of cholinesterase testing is done?	Red Blood Cell Cholinesterase (AChE)	6	25.0
	Plasma Cholinesterase (PChE)	18	75.0
	Both AChE and PChE	0	0.0

Apart from cholinesterase testing, other medical examinations that were conducted for the pesticides handlers included Clinical examination (70%) and Liver Function (10%) of the respondents. Respondents were asked to indicate frequency of these other medical examinations where 35% reported every 6 months and another 20% when depressed cholinesterase levels are reported below 30%. Most of the interviewed employees confirmed that clinical examinations are conducted after every 6 months.

Table 4. 3: Other medical examinations conducted

Variable	Category	Frequency	Percent
Apart from cholinesterase testing, what other medical examinations are conducted for the pesticides handlers	Clinical examination	42	70.0
	Liver Function	6	10.0
	None	12	20.0
Indicate Frequency of examination	Every 6 months	21	35.0
	When depressed levels are reported below 30%	12	20.0
	Once per year	9	15.0
	No response	18	30.0

Most of respondents (65%) reported their farms use different laboratory for cholinesterase testing. A large number of the respondents (65%) indicated that cholinesterase results were only explained to the employees but result copies never given. Three quarters of the respondents reported that neither cholinesterase nor medical results were sent to DOSHS. This is against The Factories and other Places of Work Act (Medical Examination) Rules of 2005 which requires medical summary report forms as outlined in the Second

Schedule to be completed after medical examination for each hazard and submitted within 30 days to the DOSHS director.

Table 4. 4: Results of Cholinesterase test

Variable	Category	Frequency	Percent
For cholinesterase testing, does the farm use the same laboratory all the time, or different Labs?	Same Lab all the time	21	35.0
	Different labs	39	65.0
Are the cholinesterase Results given and explained to the employees?	Results only explained, but copies never given	39	65.0
	Results explained and copies also given	12	20.0
	Results are not explained and a copy not given	9	15.0
Does the farm send to Directorate of Occupational Safety and Health Services, DOSHS cholinesterase and medical results?	Both Cholinesterase and medical results	15	25.0
	Neither cholinesterase nor medical results are sent to DOSHS	45	75.0

When asked for how long cholinesterase test results are maintained at the farm before destruction, most of the respondents (85%) reported that records were never destroyed. Most of the farms (85%) were reported to redeploy or transfer employees from pesticide handling to other sections when cholinesterase results indicate depression. Half of them reported that they maintain records on when the employee was removed from spray or handling chemicals and when the employees resumed pesticides handling activities. Most of the respondents (65%) reported that re-deployed pesticides handlers were given 3 – 4 months away from pesticides handling activities and resume handling duties without cholinesterase re-testing. This was further confirmed through interviews where spray operators indicated that they were redeployed to other farm sections away from pesticides handling for 3 months when cholinesterase levels drop. Some however expressed that they were at times assigned spot spray duties but not full house application – which could still be exposing them to pesticides exposure.

Table 4.5: Cholinesterase test results and redeployment of employees

Variable	Category	Frequency	Percent
For how long are the cholinesterase test results maintained at the farm before destruction?	Records never destroyed	51	85.0
	5-6 years	9	15.0
Does the farm redeploy or transfer employees from pesticide handling to other sections when cholinesterase results indicate depression?	Yes	51	85.0
	Not always	9	15.0
Do you maintain records on when the employee was removed from spray or handling pesticides and when the employees resumed pesticides handling activities?	Yes	30	50.0
	No	21	35.0
	At times, not always	9	15.0
What duration are the re-deployed pesticides handlers assigned before they can resume pesticides handling duties?	employee resumes after ChE re-testing and levels confirmed ok	21	35.0
	3 – 4 months without ChE re-testing	39	65.0

When asked how many employees had been redeployed from pesticide handling to other sections as a result of depressed/lowered cholinesterase levels after cholinesterase testing, 85% reported 1-5 employees in the year 2014 while 70% of the respondents reported 1-5 employees in the year 2013.

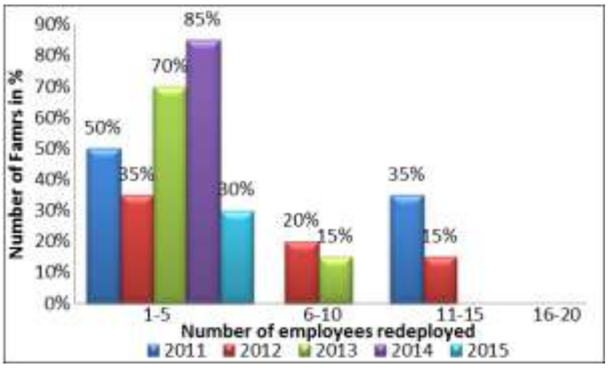

Figure 4. 3: Employees redeployed from pesticide handling in last 5 years

Respondents were asked to state the number of redeployed employees and their depressed cholinesterase levels. Most of the redeployed employees (47) in the year 2011 had depressed cholinesterase levels of 21-30%. This supports findings by Ohayo-Mitoko et al., (1997), where acetyl cholinesterase inhibition was found in all exposed individuals involved in a study, and led on average, to a decrease of baseline acetyl cholinesterase levels of 33% (± 12%), with exposed subjects in Naivasha flower growers having the largest inhibition (36%) as compared to Homabay cotton growers 35%, Wundanyi vegetable growers 33%, and Migori tobacco growers 26%. Njagi et al., (2013) further indicates that 6% of a tested population in Naivasha had significant cholinesterase enzyme depressions with no symptoms of exposure recorded.

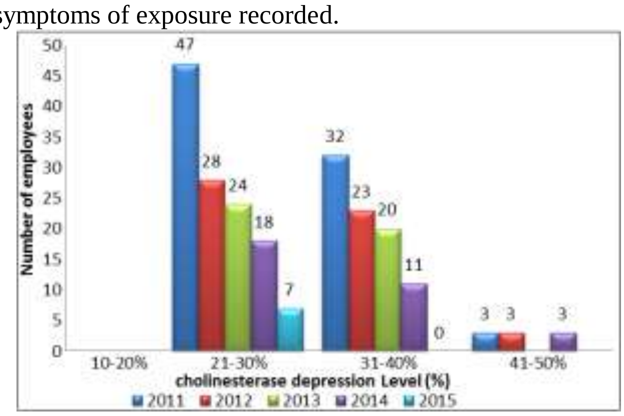

Figure 4.4: Number of redeployed employees and their cholinesterase levels

When asked if cholinesterase was re-tested before resuming pesticide handling duties for the redeployed pesticide handlers, majority of the respondents (82.4%) said yes. Most respondents (41.2%) reported that it took 11 – 15 days to get laboratory results on conducting the cholinesterase testing. This duration is quite delayed to guide emergency treatment. Janice (2017) reports that symptoms develop during or after exposure to anticholinesterase inhibitors within 5 minutes to 12 hours depending on the method of contact. Organophosphate intoxication may be diagnosed 6 hours or less after exposure, while intoxication by carbamates will develop 15 minutes to 2 hours.

On receiving lab results, most respondents (41.2%) reported it took 2-3 days to redeploy spray applicators with depressed cholinesterase levels. 82.4% reported to redeploy staff with above 30% cholinesterase depression.

Table 4.6: Cholinesterase re-testing

Variable	Category	Frequency	Percent
For the redeployed pesticide handlers, is cholinesterase re-tested before resuming pesticide handling duties	Yes	42	82.4
	Not always	9	17.6
On conducting the cholinesterase testing, how many days does it take on average to get the laboratory results?	1 – 5 days	12	23.5
	6 – 10 days	18	35.3
	11 – 15 days	21	41.2
On receiving lab results how many days does it usually take to redeploy spray applicators with depressed cholinesterase levels?	2 – 3 days	21	41.2
	4 – 6 days	9	17.6
	Within 24 hours	21	41.2
What cholinesterase depression percentage warrants an employee to be redeployed?	above 30%	42	82.4
	other	9	17.6

When asked if the farm maintained on-site antidotes for organophosphate and carbamate poisoning, majority of the respondents (70%) reported yes. The antidotes mainly mentioned included Activated charcoal and Atropine. Interviewed employees did not however seem to understand the aspect of antidotes that are maintained which may be attributed to their level of education.

Table 4.7: On-site antidotes for organophosphate and carbamate poisoning

Variable	Category	Frequency	Percent
Does the farm maintain on-site antidotes for organophosphate and carbamate poisoning?	Yes	42	70.0
	No	18	30.0
If Yes, kindly name the antidotes maintained	Activated charcoal	9	15.0
	Atropine	21	35.0
	Activated charcoal and Atropine	12	20.0

Respondents were asked if they were aware of existence of a chemical Poison Centre in Kenya where majority (65%) did not know. Those who were aware of a chemical Poison Centre in Kenya indicated that the centre was situated at Kenyatta Hospital but none had the contact details.

Table 4.8: Awareness of Chemical Poison Centre in Kenya

Variable	Category	Frequency	Percent
Is there a chemical Poison Centre in Kenya?	Yes	12	20.0
	No	9	15.0
	I do not know	39	65.0
If yes, kindly indicate where the centre is situated?	Kenyatta Hospital	12	20.0
Do you have contact details for the chemical Poison Centre?	No	12	20.0

The respondents' choices on the Industry Certification Scheme were subjected to Chi Statistics against the cholinesterase testing.

The results showed that 82.4% of the farms that were certified under any of the Industry Certification Scheme conducted regular cholinesterase testing for pesticides handlers while majority of those not certified (88.6%) did not. This association of Industry Certification and conducting regular cholinesterase testing for pesticides handlers was statistically significant at 95% confidence level with χ^2 (df=1) =4.754 since p=.034 which is less than the conventional 5%.

Results further showed that majority of the farms (58.8%) that were certified under any of the Industry Certification Scheme conducted cholinesterase testing for pesticides handlers after every 3 months consecutive handling while majority of those not certified (90.2%) had other frequency of testing. This association of Industry Certification and frequency of conducting cholinesterase testing for pesticides handlers was statistically significant at 95% confidence level with χ^2 (df=1) =8.235 since p=.004 which is less than the conventional 5%.

Table 4.9: Association of Industry Certification and cholinesterase testing

Variable	Category	Is the farm certified to any Industry Certification Scheme?		
		Yes	No	Chi-Square
Does the Farm conduct regular cholinesterase testing for pesticides handlers?	Yes	82.4%	11.4%	χ^2=4.754, df=1, p=.034
	No	17.6%	88.6%	
Frequency of ChE testing per pesticide hander	After every 3 months consecutive handling	58.8%	9.8%	χ^2=8.235, df=1, p=.004
	Others	41.2%	90.2%	

The respondents' choices on the redeployment of employees were subjected to Chi Statistics against the cholinesterase re-testing.

Results showed no association between redeployment of employees and days it took on average to get the laboratory results.

Table 4. 10: Association of redeployment of employees and retesting

Variable	Category	Does the farm redeploy or transfer employees from pesticide handling to other sections when cholinesterase results indicate depression?		
		Yes	Not always	Chi-Square
On conducting the cholinesterase testing, how many days does it take on average to get the laboratory results?	1 – 5 days	28.6%	5.4%	χ^2=5.204, df=2, p=.074
	6 – 10 days	42.9%	16.4%	
	11 – 15 days	28.6%	78.2%	

6. Conclusion

The key findings of the study indicate that majority of the farms conduct regular cholinesterase testing for pesticides handlers. There was a significant positive relationship between industry certification and frequency of conducting cholinesterase testing for pesticides handlers.

7. Recommendations

In view of the findings of the study, the researcher recommended that;

1) Establishment of well coordinated ChE monitoring program with the involvement of all relevant stakeholders including the government, through DOSHS, industry associations, customers, and NGOs.
2) Ensure the existing exposure preventive measures are comprehensive for the protection of worker health.
3) Government involvement to increase the number of cholinesterase testing facilities across the flower growing counties to minimise on the number of days taken to obtain results.

8. Recommendations for Further Study

1) Whereas this research has relied on quantitative approaches, an in-depth analysis and testing of pesticide handlers individual cholinesterase levels over a period of time can generate useful information on the actual extent and impact of exposure to ChE inhibiting pesticides.
2) An in depth analysis of the effectiveness of the various protective equipment currently being used by the spray operators in exposure prevention.

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