Research Article

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POINT PREVALENCE OF ACETYLCHOLINESTERASE INHIBITION, NEUROPATHY AND SAFETY AWARENESS AMONG FLOWER FARM WORKERS IN NAIVASHA, NAKURU COUNTY, KENYA.

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Abstract

Acetyl cholinesterase catalyses the hydrolysis of acetylcholine in the nerve synapses, thereby terminating nerve impulse, however, it is inhibited by organophosphates and carbamates. This study aimed to assess the level of acetyl cholinesterase inhibition and the resultant neuropathy in flower farm workers as well as the farmers' awareness of safety measures and predisposing factors while handling pesticides. A cross-sectional study was conducted involving 217 participants from different flower farms. Structured questionnaire was used to collect data to assess level of safety and predisposing awareness and to assess for neuropathy. Blood samples were collected to determine the cholinesteraselevels using spectrophotometry technique at 405 nm. The mean serum cholinesterase level in flower farm workers in Naivasha was 5873.26 U/L. There was a positive correlation (R= 0.07) between the numbers of years worked in the industry and serum cholinesterase levels as shown by Karl Pearson`s coefficient. The point prevalence of cholinesterase inhibition in Naivasha was 14% indicating a significant risk of adverse health effects. The level of safety awareness and predisposing factors among workers on pesticide exposure was 65%, suggesting that while the majority of workers had some level of safety awareness, there is still room for improvement. The point prevalence of neuropathy was 38% of the participants presenting with varying symptoms of adverse effects of pesticide exposure. Musculoskeletal impairment was leading at 19.81%, followed by skin irritation at 13.36%. These findings highlighted the need for better safety measures and awareness campaigns in the flower farm industry to reduce the risk of acetyl cholinesterase inhibition.

***Keywords**: Neurotoxicity ,acetyl cholinesterase , inhibition, safety and predisposing factor, pesticide.*

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Introduction

Pesticides play a role in agriculture through the control of pests, disease carriers and weeds, however they are toxic often towards non-target organisms. Naivasha Sub County is one of the large scale horticultural farming areas in Kenya (1), which accounts for approximately 70% of all the country`s flower exports. It's estimated that flower farms have employed about 25,000 personnel directly, thereby supporting the livelihood of about 500,000 indirectly(2). There are both large and small scale farms around Lake Naivasha and to provide for optimum growth conditions, confined green houses are in place for the regulation of crucial flower growth parameters such as temperature and humidity(3).

Pesticide aerosols get suspended in the surrounding air after spraying, and this increases the risk of pesticide exposure to flower farm workers inside the greenhouses either through skin contact or inhalation. Carbamates and Organophosphates inhibit acetyl cholinesterase and this enzyme has been used to evaluate for both acute and chronic conditions (3)(1).

Occupational exposure health conditions due to pesticide include neuropathies, respiratory failure and lung damage and due to disruption of endocrine system, male infertility has been reported(1). Other conditions which have been reported include aplastic anaemia and dermatitis for individuals who have continuously been exposed to pesticides. Carbamates and Organophosphates inhibit the acetyl cholinesterase activity in the neuron junctions and it's therefore used as a biomarker of neurotoxicity (4).organophosphates, particularly malathion and palathion affect cellular growth and cell proliferation leading to cancer development, (5),while at the same time affecting the M2 muscarinic receptors on parasympathetic neurons that innervate airway smooth muscles leading to development of asthma. In addition, it was noted that pesticides affected fertility in both men and females by affecting the functions of endocrine hormones, their time of production and them imitating the hormones(5).

There is no unit of the population completely protected against direct intended or indirect intended exposure to pesticides and the health outcomes associated with the exposure(6). Individuals can be exposed to pesticides through environmental contaminants without their knowledge, like contaminated aquatic food from the lake or taking water from pesticide containers containing pesticide residues.

Once pesticides are released into the environment, they are not readily degradable through physical, chemical and photochemical breakdown process thereby accumulating within the environment. When aquatic organisms consume food or water containing pesticides residues, bioaccumulation within their tissues occurs. Human exposure occurs via inhalation, skin contact and ingestion of food(7). The higher the animal is on the food chain, the greater the concentration of the pesticides as a result of bio magnification. Continuous exposure to pesticides can lead to adverse health effects like cancer, reproductive defects, neurophysiological disorders, endocrine and immunological toxicity(8).

Blood acetyl cholinesterase levels must be depressed to less than 20% of the normal value before systemic symptoms appear(8). Employees working in direct contact with pesticides require extensive training on pesticide and the dangers associated with exposure (9). Inadequate knowledge and (Personal protective equipment's) PPE use with increased duration of exposure elevates the risk of pesticide toxicity.

Significance of the study

The study focused on unravelling the origin of cases of neurological, peripheral neuropathy, and respiratory conditions such as asthma in personnel working in flower farms. There has been need for sensitization of workers on safety precautions to be taken into account while working in the green houses, and the predisposing factors that lead to pesticide toxicity. Additionally, flower farm management needs to be sensitized to the requirement for frequent monitoring of serum cholinesterase levels to aid in early detection of the enzyme inhibition thereby limiting the toxic health outcomes.

The information generated from this report will be shared with Ministry of Health, Ministry of Agriculture, livestock, fisheries and cooperatives, Kenya Flower Council and Pest control product board (PCPB). This is going to inform the decisions of the policy makers in these ministries and promote workers` health and protect the environment from contamination and many negative outcomes of bio magnification of toxic substances up the food chain, with man being the top most consumer.

Research Objective

1.6.1 General Objective

To determine the point prevalence of acetyl cholinesterase inhibition, neuropathy and safety awareness among flower farm workers in the Naivasha Sub County

1.6.2 Specific Objectives

1. To determine serum cholinesterase levels in flower farm workers across Naivasha Sub County, Nakuru County
2. To determine the point prevalence of serum acetyl cholinesterase inhibition in the Naivasha Sub – County, Nakuru County
3. To determine the level of awareness of safety and predisposing factors among workers on pesticide exposure in the Naivasha Sub – County, Nakuru County
4. To determine the point prevalence of flower farm workers with neuropathy in the Naivasha Sub – County, Nakuru County

2.0 Methods

2.1 Research Area and Design

A cross-sectional study design was used to study for acetyl cholinesterase inhibition, safety awareness and neuropathy among flower farm workers in Naivasha Sub County. The flower farms included are located in Kamere, Kwa Muhia, Sanctuary, Karagita and Kasarani.

2.2 Study Population

2.3 Inclusion Criteria

Flower farm workers between the ages of 18- 60 years working in different fields in Naivasha Sub County.108 females and 107 male participated in the study.

2.4 Exclusion Criteria

Employees not working in the flower farms, those with chronic condition including diabetes, hypertension, pregnant women and those who didn't consent were excluded from the study.

2.5 Sample Size Determination

Sample size was determined using Cochran formula. The population is approximately 2000 employees, with a 95% confidence level and ±5% precision. The resulting

$$n_0 = \frac{Z^2 pq}{e^2}$$

(Cochran formula, 1977)

$(1.96)^2(0.5)\ (0.5) \div (0.05)^2 = 385$ Workers

n represents sample size

Z represents standard error associated with chosen level of confidence

q Represents 1-q
P represents degree of variability
e represents margin of error
N represents Population size

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

385/ 1+ (385-1)/500 =217 farm workers

2.6 Sampling methods

Simple random sampling was used to select the participants from the different locations.

2.7 Sample testing site

After collection of samples from the field, samples were analysed at Nairobi Women Hospital Hurlingham Laboratory which is COHSASA (Council of Health service accredited of Southern Africa) A calibrated Humastar 100 equipment was used to analyse the samples for serum cholinesterase levels.

2.8 Sample Preparation and Biochemical Assay**.**

Blood sample was drawn from the median cubital vein on the anterior forearm of the 217 workers into plain tubes, BD vacutainers. Venous blood 4ml was collected in a red coded vacutainer allowed to clot for 30 minutes. Samples were placed in a cooler box then transported to the Nairobi women`s Hospital Naivasha branch for centrifugation with (Zentrifuge, D-78532, Tuttlingen, Germany) at 3000rpm for 5 minutes to separate out the serum for cholinesterase levels.

Serum was aliquoted into metro tubes which was then analysed for serum cholinesterase using spectrophotometry analytical technique. A calibrated Humastar 100 was used to determine serum cholinesterase levels. Reference ranges from 4620-11500 u/l (male) and 3930-10800u/l (female), any results below this range was treated as a reflection of acetyl cholinesterase inhibition.

2.9 Validity of Data

Unbiased study group selection was also achieved by using simple random sampling. Review of previous IQC and EQA was done by evaluating previous Levy Jenny charts, calibration data and curves if they were within the desired limit. Internal Quality control was conducted using commercially prepared Serodos IQC before analysing the samples. A sample was run 3 times to determine for accuracy and precision. EQA from Huqas was also employed to ensure validity of the data obtained.

2.10 Determination of workers` knowledge on safety

Questionnaire 1 (appendix III) was used to categorize workers on their area of work, how long they have been working in the designated departments and evaluate workers' knowledge on safety and predisposing factors. Proof reading was done to ensure that the questionnaire was clear to all participants reading it. Safety training certificates issued after they were trained provided substantial data on frequency of training.

2.11 Determination of Neuropathy in workers

Questionnaire II (Appendix IV) was used to assess for neuropathy and other symptoms associated with insecticides exposure among the workers.

Questionnaires were validated by pre-testing the questionnaires with a few of the participants. Individual medical history was put into consideration while collecting data.

2.12 Statistical Analysis

Descriptive statistics was used to calculate frequencies, percentages and means. Karl Pearson`s correlation coefficient was used to analyse the relationship between the independent and dependent variables.

Results

3.0 Serum Cholinesterase Levels in Flower Farm Workers

3.1 Demography

The sample population for this study consisted of 217 employees from various flower farms in Naivasha. The data was collected and analysed using Microsoft excel 2019.

The participants' ages ranged from 22 to 56 years old, with a mean age of 35 years. The median age was also 35 years old, indicating that the sample was evenly distributed across age groups. The age group with highest participant was 27-31 with a total of 62 while the smallest was 52-56 with 6 participants.

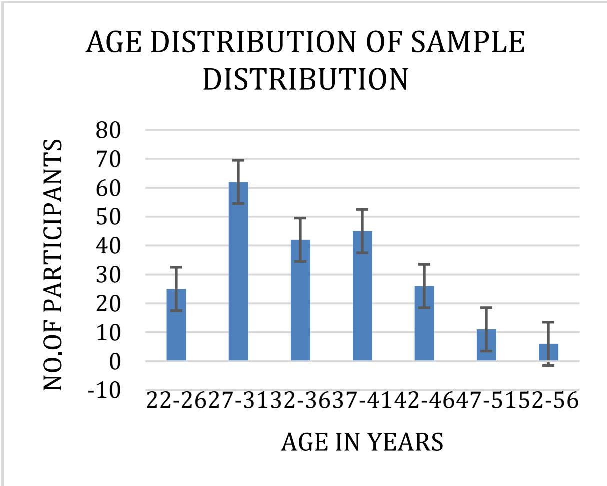

Figure 4. 1: A bar graph representing age distribution of the sample population.

There were 108 females and 109 males in the sample population. The gender distribution of the sample was females comprising 49.8% and males 50.2% of the sample population.

The average time worked in flower farms for the participants was 8 years.

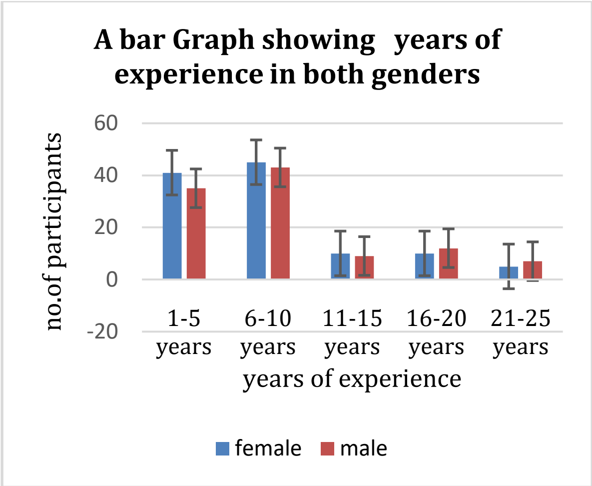

Figure 4. 2: A bar graph showing gender based versus years of experience of participants

Overall, the demographic characteristics of the sample population are evenly distributed across age and gender, and work experience in the industry.

3.2 Serum cholinesterase levels in flower farm workers across Naivasha

The mean serum cholinesterase level in flower farm workers in Naivasha was 5873.25(figure 4.3). This result provides a baseline measurement of the cholinesterase levels in this population. The highest participants had a cholinesterase range of 4459-5388u/l with a total of 54 individuals and the smallest being 9109-10039 with a total of 7 participants.

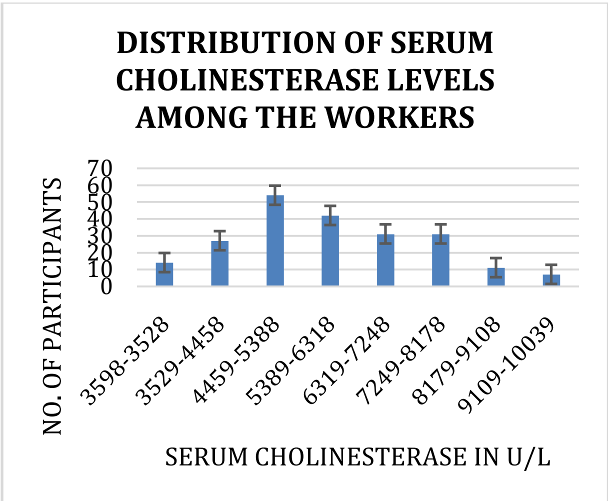

Figure 4.3. Bar graph illustrating number of participants versus serum cholinesterase levels.

3.3 Correlation between years worked and serum cholinesterase levels

A positive correlation of r = 0.07 as calculated using Karl Pearson`s Coefficient was shown between the number of years worked in the flower farm industry and serum cholinesterase levels. The scatter plot (figure 4.4) illustrates a clustered distribution of data points between the years worked and serum cholinesterase levels. Individuals with 1-10 years of experience showed the greatest cluster with a total of 173 people followed by those between 11-15 years of experience with 20 participants. The lowest cluster with 2 participants had work experience of between 26-30 years. Participants with 1-10 years of experience had the highest number of individuals with cholinesterase inhibition with 25 of them showing low serum cholinesterase levels. Those with 25-30 years having the smallest number with only 1 participant. The rest of the study group showed a normal cholinesterase serum levels clustered between 4000-10000 U/L.

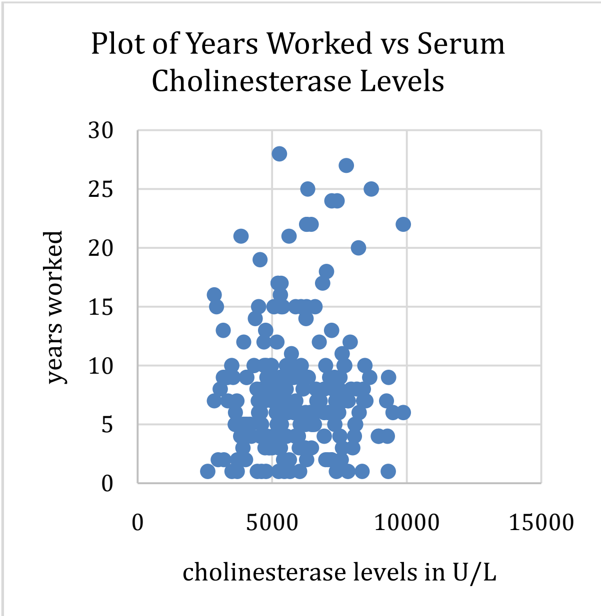

Figure 4. 4: A scatter gram showing cholinesterase levels versus years of experience of participants

3.4 Point prevalence of serum acetyl cholinesterase inhibition in Naivasha sub-county

The point prevalence of serum acetyl cholinesterase inhibition in Naivasha sub-county is 14%. Harvesting departments had the highest number of participants with inhibited serum cholinesterase levels adding up to 20 participants followed by sprayers which had a total of 4 participants (figure 4.5). This suggests that a significant proportion of the flower farm workers in Naivasha may be at risk of acetyl cholinesterase inhibition, which can lead to adverse health effects.

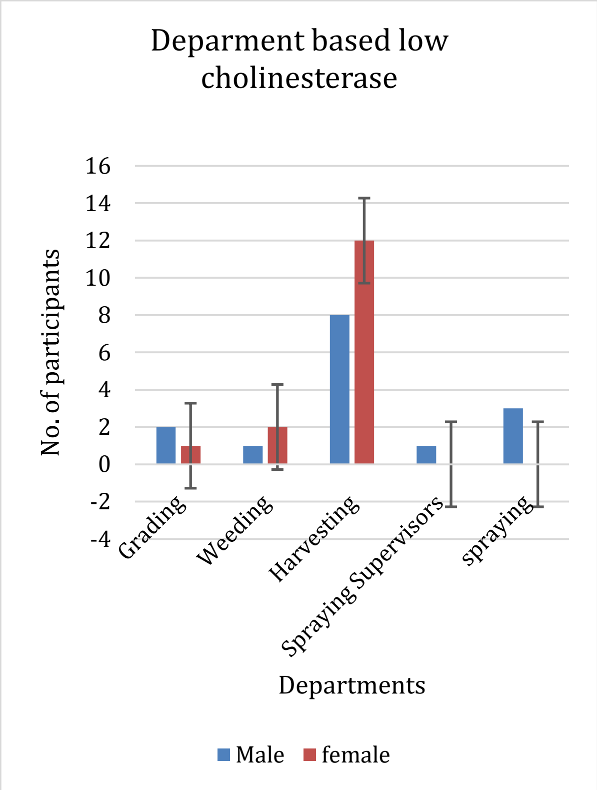

Figure 4.5: A representation of department based participants with inhibited cholinesterase levels

3.5 The level of awareness of safety and predisposing factors among workers on pesticide exposure.

The level of safety awareness and predisposing factors among workers on pesticide exposure was 65% with 35% of the participants having partial awareness on safety and predisposing factors. This was attributed to the frequency of training which was only done when they first joined the company. This result indicates that men were more informed on safety with 76 of them being fully informed while only 66 females were fully informed (figure 4.6). With 35 men and 40 females being partially informed on safety awareness, there is still room for improvement in terms of promoting safer practices and reducing exposure to pesticides.

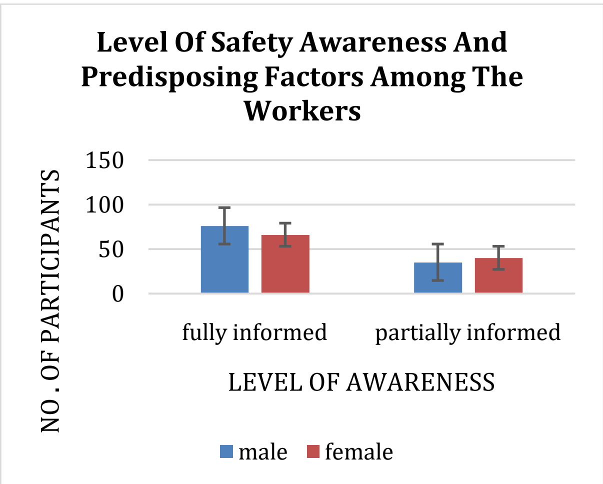

Figure 4.6 represent level of safety awareness and pre disposing factors among the participants.

As illustrated by figure 4. 7 below, participants who were fully informed on safety had worked for less than 10 years while those that worked between 21-25 years had the lowest knowledge on safety. The 35% who were partially informed (figure 4.5) it was noted

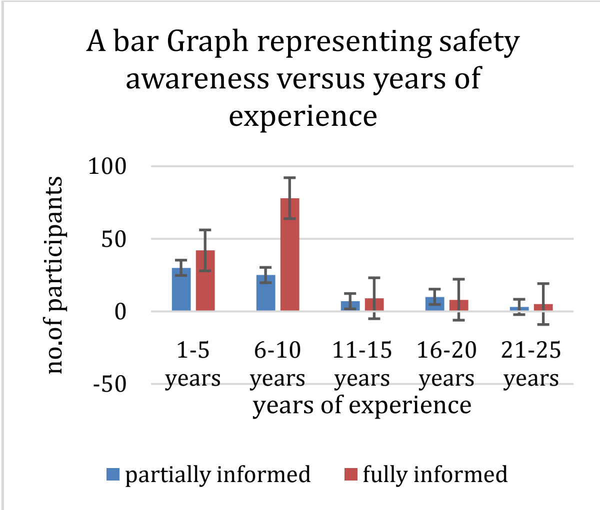

Figure 4.7: A graph showing number of participants versus who were partially and fully informed on safety based on years of experience

As illustrated by table 1. Only 23% of the participants were provided with full PPE. These were mostly the sprayers with the rest provided with gloves, overalls and boots only. It was also noted that only sprayers were required to take showers after downing the overalls. Participants preparing the chemicals were well informed on need to read the inserts.

In all the companies water taps were provided outside the green houses but still non-compliance was noted at 71% attributing to soap not being provided while some forgot to practice hand washing hygiene due to workload.

Eating sheds were provided to most of the participants accounting to 67 % compliance on non-food consumption inside the green houses. The 23 % who were non-compliant stated that they felt the need to take snacks in the fields since the sheds were too far and they didn't have time due to the workload. At the same time some companies had not provided eating area for the employees.

It was noted that 83% of participants were compliant on changing of clothes, uses of chemical containers while the small percentage that were non-compliant went home with the same clothes they were working with and mixed them with the rest of the clothing's while washing. Some individuals who used the waste containers for water storage had the containers washed at the company while some washed the at home which wasn't adequate to clear the pesticide residues.

Table 1: illustrates compliance and non – compliance on different variables

Variables	compliance	percentage	Non compliance	Percentage
Protective clothing provision	50	23%	167	77%
Hand washing and showering	64	29%	153	71%
Eating, drinking and smoking in the green houses	150	69%	67	31%
Changing of clothes after work	180	83%	37	17%

3.6 Point prevalence on neuropathy

A point prevalence of 38.2% on neuropathy was noted with participants presenting with various conditions. As illustrated by table 2 below musculoskeletal symptoms were the most prevalent with 19.8% presenting with joint stiffness, joint pains, back pain and numbness of extremities, followed by skin condition where they complained of eye irritation, tearing and blurred visions. Several of the participants were using eye drops to ease the irritation. The rest of the conditions are presented in the table below (Table 2) with memory loss being the least prevalent.

Table 2: Table representing the various medical condition, gender based frequencies and percentages representation of each condition.

Variables	Freq. in male	Freq. in female	Total	Percentage
Skin condition	10	19	29	13.30%
Abdominal pain	1	1	2	0.92%
Musculoskeletal signs	24	19	43	19.8%
Respiratory symptoms	6	5	11	5.06%
Eye condition	12	7	19	8.8%
Headache/seizures	6	4	10	4.6%
Tingling/numbness	15	9	24	11.06%
Memory loss	1	0	1	0.46%
Cardiovascular symptoms	8	7	14	6.45%

Figure 4.8 is a graphical representation of participants both male and female versus the medical conditions they presented with. Skin condition and musculoskeletal symptoms were most prevalent in female with each having a total of 19 participants. Musculoskeletal symptoms were most prevalent in male with 24 of them showing symptoms followed by numbness and tingling of their extremities with 15 of the male participants having similar complaints.

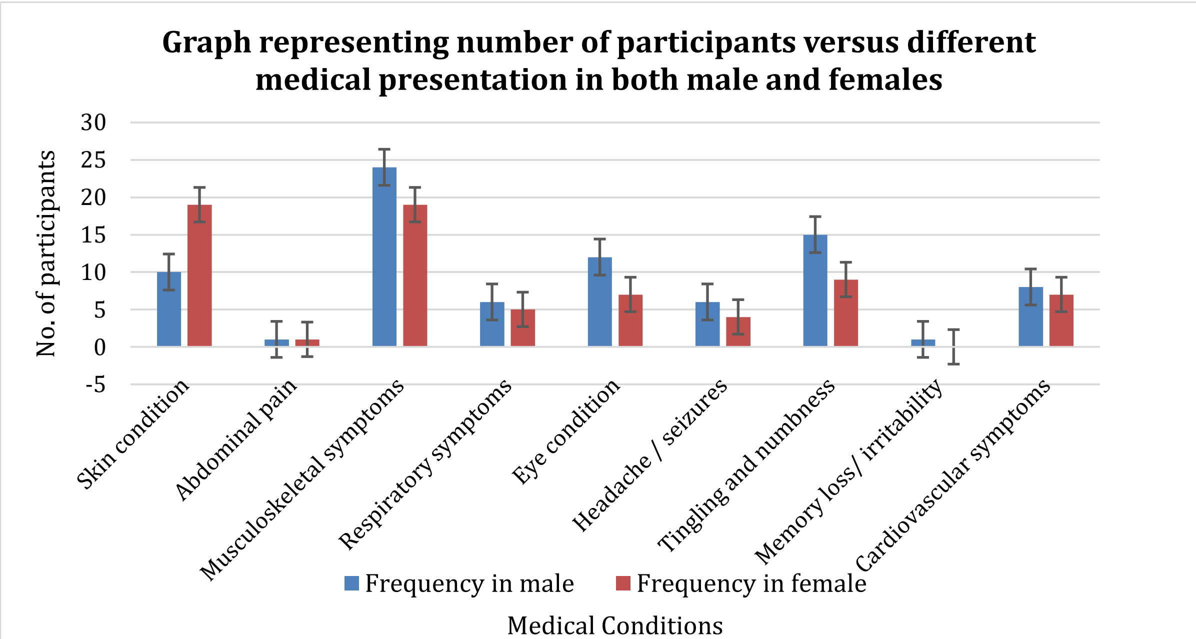

Figure 4.8. Represent number of participants versus gender based medical presentation.

4.0 Discussion

4.1 Serum cholinesterase levels among flower farm workers

Serum cholinesterase (ChE) is an enzyme produced primarily in the liver, but also in other tissues, including the brain, that is involved in the regulation of the neurotransmitter acetylcholine. Serum cholinesterase inhibition can occur with exposure to certain pesticides and is a potential biomarker for pesticide exposure and toxicity.

In the context of flower farm workers, exposure to pesticides is a significant occupational hazard. The positive correlation (r=0.07) observed between the number of years worked in flower farms and serum ChE inhibition, as reported in the study, suggests that long-term exposure to pesticides in flower farms may have an inhibitory effect on ChE activity.

Several studies have investigated the association between pesticide exposure and serum ChE levels in agricultural workers. For instance, it was shown that a significant reduction in ChE activity among Egyptian farmers exposed to pesticides(10). Similarly, a study reported that occupational exposure to pesticides was associated with a decrease in serum ChE levels in Iranian greenhouse workers(11).

In addition, some studies have reported that ChE inhibition may be reversible following cessation of exposure to pesticides. For example, a study reported that ChE activity returned to normal levels six months after cessation of pesticide exposure in Greek greenhouse workers(12).

Overall, the weak positive correlation observed between the number of years worked in flower farms and serum ChE inhibition, as reported in the study, is consistent with previous research suggesting that pesticide exposure can lead to ChE inhibition in agricultural workers. In my study conducted in Naivasha, Kenya. I established that the mean serum ChE level among flower farm workers was 5873.26. This value provides a baseline for comparison with ChE levels measured in flower farm workers who have been exposed to OPs. A significant decrease in ChE activity in these workers would suggest OP exposure and potential toxicity.

Several studies have reported a significant correlation between OP exposure and decreased serum ChE levels in flower farm workers. For instance, in a study conducted in Ecuador,found that flower farm workers exposed to OPs had significantly lower ChE levels compared to non-exposed workers(13). Similarly, in a study conducted in India, reported that ChE activity was significantly decreased in flower farm workers exposed to OPs compared to non-exposed workers(14).

The correlation between OP exposure and decreased ChE levels has also been reported in other occupational settings, such as in pesticide sprayers (15)and agricultural workers (16). These findings suggest that measuring serum ChE levels can be a useful biomarker for monitoring occupational exposure to OPs and identifying individuals at risk of toxicity.

4.2 Safety and predisposing factors Awareness among flower farm workers

The correlation between safety awareness and serum cholinesterase levels in flower farm workers is a critical aspect of evaluating the health impact of pesticide exposure in the workplace. In this regard, the study's finding that the level of safety awareness and predisposing factors among workers on pesticide exposure is 65% indicates a positive correlation r= 0.07 between safety awareness and serum cholinesterase levels.

A study investigated the correlation between serum cholinesterase levels and pesticide exposure among small holder farmers in Tanzania. This study found that workers with low levels of safety awareness had a higher risk of developing acute pesticide poisoning, which is associated with reduced serum cholinesterase levels. These findings are relatable to the findings from this study. Improving safety awareness among workers may reduce the incidence of pesticide poisoning and improve serum cholinesterase levels(17).

Similarly, a studyevaluated the relationship between pesticide exposure and serum cholinesterase levels among agricultural workers in India. The study found that workers with low levels of safety awareness were at higher risk of developing pesticide poisoning, which was associated with reduced serum cholinesterase levels(18). The authors suggested that improving safety awareness among workers is essential to prevent pesticide poisoning and reduce the risk of long-term health effects associated with exposure.

Another studyinvestigated the relationship between safety training and pesticide exposure among agricultural workers in China(19). The study found that workers who received safety training had higher levels of safety awareness and were less likely to experience pesticide poisoning. Additionally, the study found that workers who received safety training had higher serum cholinesterase levels, indicating better health outcomes.

Moreover, a study investigated the impact of safety training on the knowledge, attitude, and practice of pesticide use among Iranian farmers(20). The study found that safety training significantly improved farmers' knowledge and attitudes towards pesticide use and increased their use of personal protective equipment (PPE). The authors suggested that safety training can be an effective intervention to improve safety awareness and reduce the risk of pesticide exposure among farmers.

Furthermore, a study evaluated the effect of safety training on pesticide handling practices and health outcomes among agricultural workers in Bangladesh(21). The study found that workers who received safety training had better pesticide handling practices and were less likely to experience pesticide poisoning. Additionally, workers who received safety training had higher serum cholinesterase levels, indicating better health outcomes.

It is worth noting that serum cholinesterase levels are a reliable biomarker for assessing the effects of pesticide exposure on human health. Pesticides inhibit the activity of cholinesterase enzymes, leading to decreased serum cholinesterase levels, which is a sign of acute or chronic pesticide poisoning (20). Therefore, maintaining normal serum cholinesterase levels is essential to prevent the adverse health effects associated with pesticide exposure.

The literature supports a positive correlation (r=0.07) between safety awareness and serum cholinesterase levels in flower farm workers. Improving safety awareness among workers is crucial to prevent pesticide poisoning and improve health outcomes. The findings of this study suggest that interventions to improve safety awareness among workers can contribute to reducing the incidence of pesticide poisoning and improving serum cholinesterase levels. Companies should therefore ensure that all staff are adequately trained on safety and precaution measures while working in the farms. Full Personal Protective equipment's should be provided to all staffs as noted in this study only the sprayers and the those mixing chemicals were fully geared up while the rest of the employees were only provided with overalls, boots and gloves. Provision of eating sheds away from the farms should also be put in place. In addition, hand washing sink should be provided with enough hand washing soap. As noted in the study, several of the company only provide for water without soap. Training on proper hand washing technique should be availed to all employees.

Continuous education and training program should be put in place in all flower farms on safety, predisposing factors and potential health risk arising from pesticide exposure, with an emphasis on proper use of PPE and basic safety precautions, implementation of safety practices and measures while working in the green houses or when handling pesticides.

4.3 Organophosphate exposure and Neuropathy

Organophosphate pesticides are widely used in agriculture, and flower farms are no exception. Organophosphate pesticides inhibit acetyl cholinesterase (AChE) activity, leading to acetylcholine accumulation at synapses, and thereby over stimulating the cholinergic receptors (22). This can result in a range of symptoms, such as nausea, vomiting, diarrhoea, dizziness, headache, and in severe cases, convulsions, respiratory failure, and death (23). Exposure to OPs is a significant occupational hazard for flower farm workers, who are often in direct contact with these pesticides.

One way to assess the effects of OP exposure is by measuring serum cholinesterase (ChE) levels. ChE is an enzyme that hydrolyses acetylcholine and is found in many tissues, including the blood. OPs can inhibit ChE activity, leading to a decrease in serum ChE levels. A study done at Gaza strip showed that eye and face irritation was the leading symptom with 64.3% of participants presenting with it followed by dizziness at 32.4% and difficulty in breathing and chest pain presenting in 28.1% of the study population(24).Similarly a study conducted among Thai farmers illustrated that fatigue was the leading symptom with 48.5% ,dry throat followed with 44.9% of the population, dry throat presented in 44.9% of the cases, headache at 40.4% , dizziness at 36.8 % and numbness was the last symptom present in 29.4% of the study population(25).

In addition, a study done among Philippine farmers who had been exposed to pesticide for a longer period presented with 67% of the study population having 67% of eye irritation, skin conditions (45%) and respiratory tract symptoms presenting in 45 % of the study population(26).

In contrast, this study showed 38.2 % of the study population presented with different symptoms of pesticide exposure. In addition, 19.8 % of the participants were presenting with musculoskeletal symptoms, skin irritation (13.3%), eye irritation (8.8%), tingling and peripheral numbness (11.06) most in employees who have over 15 years of experience, respiratory symptoms (5.06%), cardiovascular symptoms (6.45%), headache (4.6%), abdominal irritation (0.92%) and only 0.46 % presented with memory loss. It was noted that only sprayers were provided with full PPE while the rest of workers were only provided with gloves, boots and overalls which could increase pesticide exposure through inhalation, contact dermatitis in exposed skin was also evident in several of the workers. Hand washing was on partial with workers provided with only water without soap in some companies which could result in oral ingestion of pesticides with some eating snacks inside the green houses. To ensure that spraying is properly done, spraying supervisors are required to be present even though they aren't provided with proper PPE. It's possible that the rest of the study population were exposed to low levels of pesticides but not enough to produce physiological symptoms.

Measuring ChE activity is a useful tool for monitoring occupational exposure to OPs and identifying individuals at risk of OP poisoning.

Conclusion

This study established a point prevalence of 14% on cholinesterase inhibition. It therefore illustrates a significant impact of pesticide among the employees. Employees working in harvesting and spraying departments were mostly affected with them showing higher number of acetyl cholinesterase inhibition. These findings emphasize the need for periodic testing of employees who are in direct contact with pesticides.

The data obtained illustrated that 35% of employees had partial knowledge on safety awareness and predisposing factors. In conclusion, all companies should engage their employees on continuous safety training as they emphasize on the need for each individual to take responsibility towards promoting safer practices.

The study illustrated that the 38.2 % of the employees were presenting with signs of neuropathy with those with over 15 years of experience presenting with peripheral numbness (11.06). This could be attributed to continuous exposure to pesticides over longer duration. There is therefore need to put in place measures to mitigate the exposure of employees to pesticides.

In conclusion, proper PPE should be provided to all workers replacing them adequately once torn. Provision of hand washing areas and shower should also be put into place with adequate soap. Continuous training on safety, predisposing factors and physiological symptoms to look out for should be put in place. In addition, periodic medical check-up should be conducted by the companies' health facilities to all the employees to ensure early intervention following exposure.

Limitation

Some participants showing symptoms of pesticides exposure had normal cholinesterase levels which could have had an effect on prevalence of cholinesterase inhibition.

For the participants who had periodic cholinesterase testing especially sprayers, once their cholinesterase were notably low treatment and department rotation was immediately effected. This impaired the capture acetyl cholinesterase inhibition in this group since by the time of testing their cholinesterase levels will have already resolved.

5.4 Recommendations

All employees should be periodically tested for serum cholinesterase level not only the sprayers and full PPE provided with adequate replacement once torn. Departmental rotation of employees to ensure that those working directly with the pesticides aren`t over exposed for longer duration. Provision of hand washing area with adequate soap and water, provision of eating sheds outside the green houses should be put in place. Periodic medical check-up should be put in place to ensure early treatment of emerging symptoms and continuous safety training be done to all employees.

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Conflict of Interest

The author declares that they have no conflicting interests to disclose.

Informed Consent

Only individuals that consented to be part of the research were included in the study.

Ethical Statement

Ethical approval was sort and issued by Kenyatta University Ethical Committee while research permit was issued by NACOSTI.

Author Contribution

Authors contributed equally to this research

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