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Research Article

Effect of Pesticide Exposure on Serum Cholinesterase Levels among Asthmatic Children in Naivasha Sub-County, Kenya

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Background: Pesticide exposure is a risk factor for asthma exacerbations in flower farm regions in the world. Data on levels of serum cholinesterase among asthmatic children exposed to pesticides in Kenya is scanty.

Objectives: To compare and identify variables which affect the concentration of serum cholinesterases in children who are exposed and unexposed to pesticides.

Methodology: The design was a comparative cross-sectional study that involved exposed and unexposed children. The study was conducted between May and July, 2014 in Naivasha, Kenya. Patients were interviewed and serum samples were analysed for cholinesterase levels. Multi-linear regression was done to identify variables that affected cholinesterase activity.

Results: Children who were exposed to pesticides had a lower median ChE activity of 5828 [IQR 4863, 6443] compared to the unexposed arm whose median was 7133 [IQR 6063, 8179]. Five predictor variables were found to be significantly associated with depression of serum cholinesterase levels. The most important predictor variable for the levels of ChE in children, was not using protective clothing by the parent [adjusted β -1457.0 (95% CI - 2594, 1319.8)]. Others were not using household pesticides [adjusted β 96.3, (95% CI 22.6, 170.0)], female sex [adjusted β -695.7 (95% CI -1296.2, - 95.3)], non school attendance [adjusted β -1676.8 (95% CI -3371.6, 18.1)] and not taking a break after spraying [adjusted β 1105.5 (95% CI (315.0, 1895.2)].

Conclusion: Children who were exposed to pesticides had low cholinesterase levels. Parents should therefore be encouraged to wear protective gear as this conferred protection of children from the effects of pesticide exposure.

Key words: asthma, exposure, children, pesticides, cholinesterase.

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1. Introduction

Pesticide exposure is associated with depressed levels of serum cholinesterase levels. The pesticides implicated are mainly organophosphates, carbamates and to some extent pyrethrins (Salameh et al, 2013). They depress serum cholinesterase levels by inhibiting it in nerve synapses. This leads to accumulation of acetylcholine at the ganglia in the autonomic nervous system which leads to toxic effects due to prolonged action of the neurotransmitter (Roberts et al, 2012). The toxic effects are divided into acute and chronic. Acute effects manifests as excessive sweating, salivation, lacrimation, nausea, vomiting, diarrhoea, abdominal cramps, general weakness, headache, poor concentration, tremors, neuropathy, respiratory failure and death. Chronic effects include: cancer, neuro-developmental and behavioral deficits, neurodegenerative diseases, cardiovascular diseases and birth defects (Jaga and Dharmani, 2003). In addition, multiple exposures are additive and can lead to respiratory diseases such as chronic obstructive pulmonary disease, asthma and pneumonia among people exposed to pesticides (Maysoon, 2007; Lu, 2009; Roberts et al, 2012). Children also tend to eat and drink more than adults in relation to their body weight and so take in relatively more residues from fruits and vegetables. They also inhale relatively more air than adults, making them more vulnerable to the effects of spray drift and household insecticides (Maysoon, 2007).

Studies done in America revealed that children of flower farm workers' had lower acetylcholinesterase activity (Hernandez et al, 2011; OCFP et al, 2012). A study in Ecuador had similar findings (Suarez-Lopez, 2012). In Zimbabwe, Kwekwe area, a study also found depressed levels of ChE among people working or living within flower farm areas. In Kenya, a study done amongst children of flower farm workers in Naivasha area found low ChE activity compared to the unexposed arm (Ohayo-Mitoko, 2000).

Naivasha Sub- County is in Nakuru County. It is located within the largest flower growing area in East Africa in Kenya. However, no study has been done amongst asthmatic children exposed to pesticides in Naivasha.

It is proposed that decreased ChE activity may worsen symptoms of asthma by increasing endogenous levels of trigger factors like T-helper cells type 1 and 2, interleukins, tumor necrotic factors alpha and granulocyte-monocyte colony-stimulating factor. This then triggers inflammation by activation of various inflammatory cells leading to immune response to allergens but this has not been proven clinically (Ohayo-Mitoko et al, 1997). Studies are therefore required to find out the effect of low ChE levels in asthmatic children and how this affects severity of the disease. This study sought to measure ChE activity and identify predictors for variations in levels of ChE in asthmatic children in Naivasha.

2. Methodology

2.1 Study design, site and population

A comparative cross sectional design was used to compare the effect of pesticide exposure on serum cholinesterase level in asthmatic children. The study had two arms; one arm was exposed to pesticides and the other arm was unexposed. Children were considered to be exposed if they met one of the following criteria: worked in the flower farm, lived with a care giver who worked on a flower farm for more than one month, schooled or lived within a radius of 500m from the flower farm. The unexposed arm had children who did not meet all the criteria for pesticide exposure. The target population was asthmatic children aged 5-12 years who were residing in the flower growing areas located in Naivasha sub-county between May and July, 2014.

2.2 Inclusion and Exclusion Criteria

Patients were recruited into the study if they met the following criteria: either male or female, aged 5-12 years, presented to the hospital with an asthmatic attack and guardians/parents gave consent to participate in the study. In addition, they had lived in Naivasha for at least one month. Patients with the following health conditions were excluded from the study: leukaemia, liver disease, severe anaemia, respiratory tract infections like tuberculosis. Patients who were chronic steroid users were also excluded.

2.3 Sampling, sample size and patient recruitment

A list of 20 health care facilities located in flower farms was provided by the Medical Officer in charge of Health. The management of these facilities were requested to participate in the study. Only four facilities agreed to participate. Patients were sampled from 3 of these facilities.

The hypothesis was that patients in the pesticide exposure arm had lower cholinesterase activity. Because the study design was a comparative cross sectional study and the outcome was continuous, we used the formula for sample size calculation described by Campbell et al, (1997). The findings by Ohayo-Mitoko, (2000) in Naivasha was used to estimate the expected difference in the mean ChE levels across the exposed and unexposed subjects as 1510 units with a standard deviation of 840 units. The calculated minimal sample size in either arm was 8. The level of significance was set at a one sided value of 0.05 and power set at 80%. A sample size thrice this figure was used to improve the power of the study.

The exposed group was sampled from two health facilities located in two flower farms called Karagita and Finlay's Limited. The unexposed group was sampled from Naivasha sub-county hospital, which is a public health facility that serves patients who work in flower farms and those who do not work in flower farms. Convenient sampling was done over three months. Patients were sampled from the out-patient clinics and the wards.

All asthmatic patients were referred by the healthcare workers to the research assistants who were stationed at the hospitals at the time of the study. The referred patients were asthmatics and were using anti-asthma drugs. All patients who met the eligibility criteria were included in the study. The children were dichotomized into each of the study arms after a patient interview was done at recruitment to determine their exposure status.

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2.4 Data collection

The patients and caretakers were interviewed with the aid of a structured questionnaire that had been piloted. It was designed to obtain information on the exposure status, the parent/caregivers and the use of safety protective measures by the caregivers. Additional information on the location of the child's school relative to a flower farm was obtained. The patient's treatment records were used to confirm information obtained from the caregivers.

The Asthma Control Tool Test was used to confirm whether the patient had asthma and if it was well controlled (MoPS, 2011). Venous blood was collected from the brachial vein using a 5ml vacutainer containing silica clot activator (Becton Dickinson and Company). The blood was centrifuged and 1.5ml serum was obtained and stored at -21 °C for a maximum of 21 days. Frozen serum was transported to the University of Nairobi Clinical Chemistry Laboratory which is certified (ISO 9001:2008).

Cholinesterase level was determined using a colorimetric assay as described by Eli Tech Group, (2013). This assay was dependent on the catalytic hydrolysis by serum cholinesterases of butyryl-thiocholine to form thiocholine iodide. This compound was then reacted with 5, 5 dithiobis-2-nitrobenzoate to give a yellow compound (2-nitrobenzoate-5-mercaptothiocholine) whose absorbance was measured at a wavelength of 405 nm at 37 °C. ChE level was expressed as units/litre. The analysis was semi automated and was performed as per the manufacturer's instructions. The assay was validated before analysis was conducted. The equipment was calibrated and the method was validated.

Case definition

Patients who presented with a wheeze or chronic cough persistently at least three times a week for a period of three months were considered to be asthmatic.

2.5 Data analysis

All data was entered into an Excel spread sheet and exported to STATA version 10. All variables were subjected to descriptive data analysis. The Shapiro Wilk test was used to determine which continuous variables were normally distributed. Continuous variables that were not normally distributed were expressed as the median and the interquartile range. Normally distributed variables were expressed as the mean and the standard deviation of the mean. Categorical variables were expressed as proportions. The distribution of the variables across the two arms was compared using the non-parametric Mann Whitney, unpaired t-test and the Chi square test. Linear regression was used to identify the key determinants of ChE activity. Model building was done using a manual forward stepwise approach. P values of 0.05 and less were considered to be statistically significant.

2.6 Ethical considerations

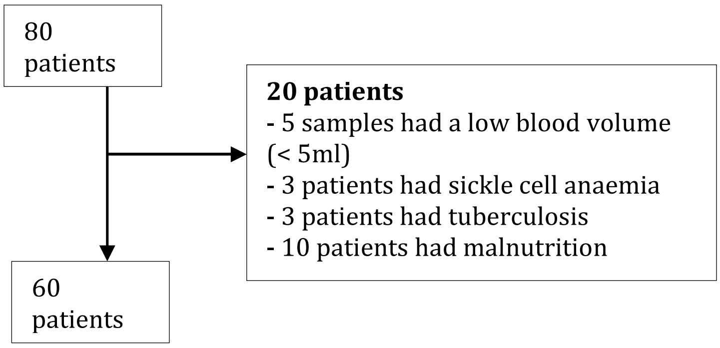
Approval to carry out the study was granted by the Kenyatta National Hospital/University of Nairobi Ethics and Research Committee (KNH/UoN ERC) as per the letter referenced KNH/ERC/A/142 dated 15th May, 2014. Confidentiality was maintained by using codes instead of patient names. All data was kept under lock and key. Proxy consent to participate in the study was provided by parents/guardians.

3. Results

3.1 Participant recruitment

Out of 20 health facilities in Naivasha, only 3 were included in the study. These included Karagita and Finlay's health centres and Naivasha sub-district hospital. From these facilities, 80 patients were screened for eligibility and 60 were included in the final study. The reasons for exclusion are presented in **Figure 1**.

Figure 1: Summary of patient selection



3.2 Baseline characteristics of study participants

When the socio-demographic traits of the patients in the two arms were compared, there were statistically significant differences in the distribution of all variables that were considered with the exception of sex, attending school and education level (**Table 1**). There was a statistically significant difference in the age between the two arms of the study (p=0.02). In the unexposed arm, most patients were aged 7 - 9 years while in the exposed arm they were aged 9 – 11 years which is the age bracket of pre-adolescents. Most of these children attended school (96.7%) in two arms except for two. This is because all children in this bracket were of school going age. There were more males than females in both arms. However, this difference was not statistically significant (p=0.79).

In the exposed arm, most children lived near a flower farm (46%) unlike the exposed arm where none lived near a flower farm (p < 0.01). None of the fathers in the exposed arm worked on the flower farm while 96% of the fathers of the children in the exposed arm worked on a flower farm (p < 0.01). Most of the guardians (61.7%) who worked on the flower farms were mothers (**Table 1**). All mothers who worked in the flower farms were married to men who also worked in the farms. Other occupations for mothers included; teaching (3.3%), farming (13.3%), business (15%) and managing homes (11.7%). Only 48.3% of fathers worked on the flower farms. The other jobs of fathers were; farmers (10%), drivers (6.7%), pastors (1.7%), teachers (8.3%) and motor cyclists (10%).

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Table 1: Comparison of the socio-demographic characteristics of asthmatic patients' exposed and unexposed to pesticides

Variable		Exposed Arm N (%)	Un-Exposed Arm N (%)	Total N (%)	p-value
Child characteristics					
Age (years)	5-6.9.	9 (30)	4 (13.3)	13 (21.7)	0.02
	7-8.9	3 (10)	13 (43.3)	16 (21.7)	
	9-10.9	11 (36.7)	5 (16.7)	16 (26.7)	
	11-12.9	7 (23.3)	7 (23.3)	14 (23.3)	
	N/A	0 (0.0)	1 (3.3)	1 (1.7)	
Sex	Male	20 (66.7)	18 (60.0)	38 (63.3)	0.79
	Female	10 (33.3)	12 (40.0)	22 (36.7)	
School characteristics					
Child attending school	Yes	29 (96.7)	29 (96.8)	58 (96.7)	1.000
	No	1 (3.3)	1 (3.3)	2 (3.3)	
Location of household	Near farm	14 (46.7)	0 (0.0)	14 (23.3)	< 0.01
	Far from farm	15 (50.0)	29 (96.7)	44 (73.3)	
	Do not know	1 (3.3)	1 (3.3)	2 (3.3)	
School distance	< 500m	8 (26.7)	0 (0.0)	8 (13.3)	< 0.01
	>500m	6 (20.0)	0 (0.0)	6 (10.0)	
	Do not know	16 (53.3)	30 (100.0)	46 (76.7)	

Table 2: Patterns of Pesticide exposure amongst children and their guardians

Variable		Exposed Arm N (%)	Un-Exposed Arm N (%)	Total N (%)	P-Value
Guardians/parent worked on flower farm in the past	Yes	27 (90.0)	3 (10.0)	30 (50.0)	<0.01
	No	3 (10.0)	27 (90.0)	30 (50.0)	
Duration worked by guardian/parent (years)	0.0-0.49	0 (0.0)	1 (3.3)	1 (1.7.0)	<0.01
	0.5-0.9	6 (20.0)	0 (0.0)	6 (10.0)	
	1-1.9	6 (20.0)	0 (0.0)	6 (10.0)	
	2-4.9	5 (16.7)	0 (0.0)	5 (8.3)	
	>5	11 (36.7)	1 (3.3)	12 (20.0)	
	N/A	2 (6.7)	27 (90.0)	29 (48.0)	
Child Currently work in flower farm	Yes	1 (3.3)	0 (0.0)	1 (6.7)	1.000
	No	29 (96.7)	30 (100.0)	59 (98.3)	

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Table 3: Personal protective practices by guardians/parents

Variable	Response	Exposed arm N (%)	Unexposed arm N (%)	Total N (%)	p-value
Eat while spraying	Yes	3 (10.0)	1 (3.3)	4 (6.7)	<0.01
	No	27 (90.0)	7 (23.3)	34 (56.7)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	
Bath after work	Yes	29 (96.7)	5 (16.7)	34 (56.7)	<0.01
	No	1 (3.3)	3 (10.0)	22 (36.7)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	
Use of protective gears	Yes	29 (96.7)	8 (26.7)	37 (61.7)	<0.01
	No	1 (3.3)	0 (0.0)	1 (1.7)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	
Separation of family laundry	Yes	19 (63.3)	5 (16.7)	24 (40.0)	<0.01
	No	11 (36.7)	3 (10.0)	14 (23.3)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	
Follow label instructions	Yes	21 (70.0)	6 (20.0)	27 (45.0)	<0.01
	No	9 (30.0)	2 (6.7)	11 (18.3)	
	n/a	0 (0.0)	22 (73.3)	22 (36.0)	
Takes break from work after spraying period	Yes	29 (96.7)	1 (3.3)	30 (50.0)	<0.01
	No	1 (3.3)	7 (23.3)	8 (13.3)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	
Comply with the dilutions recommended by the pesticide label	Yes	28 (93.3)	8 (26.7)	36 (60.0)	<0.01
	No	2 (6.7)	0 (0.0)	2 (3.3)	
	N/A	0 (0.0)	22 (73.3)	22 (36.7)	

3.3 Pesticide exposure amongst the participants

There was a statistically significant difference in all variables related to pesticide exposure in the study arms ($p < 0.01$), (**Table 2**). The exposed arm had parents who had worked on farms for a longer duration of 1-2 years. Ninety percent of the unexposed parents had never worked on a flower farm. Only one child (3.3%) had worked on a flower farm. A few of the guardians (15%) knew the type of pesticides used on the flower farm. The most widely used was malathion which was cited by 90% of the respondents.

There was a greater awareness of the impact of pesticide knowledge amongst parents of children in the exposed arm compared to the unexposed arm. However, this difference was not statistically significant ($p=0.07$).

3.4 Personal protective practices by guardians/parents

The most commonly used personal protective practice was use of protective gear 37 (61.7%). Only 40% of the guardians washed their clothes separately from that of the children (**Table 3**). Four (6.7%) respondents ate while spraying. Parents in the unexposed arm were least likely to report use of any personal protective measures ($p < 0.01$).

3.5 Cholinesterase level of asthmatic children

The serum ChE level ranged from 618 to 10575 U/L but the normal ranges were between 5320-12000 U/L. Using a cut off of 5320 U/L, the children were dichotomized as having low and high ChE levels. The histogram in **Figure 1** presents the ChE activity in all patients.

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From the histogram, there are significant outliers. Some children had extremely low values (618 U/L) and others had very high values (10575 U/L). The median ChE activity of the exposed arm was 5828 [IQR 4863, 6543] while that of the unexposed arm was 7133 [IQR 6063, 8179].

Forty eight (80%) of the asthmatic children had levels that were within the normal value while 12 (20%) children had levels below the normal reference range. In the unexposed arm, only one child had a level that was below the reference range while the rest were in the exposed arm.

The exposed arm had a lower median ChE levels than the unexposed pesticide arm. This was reflected in bivariable analysis, which showed the difference in serum levels between the unexposed and exposed arm was 1698.58 U/L. Kruskal - Wallis test showed that there was a statistically significant difference between the medians of exposed and unexposed arms (p=0.001).

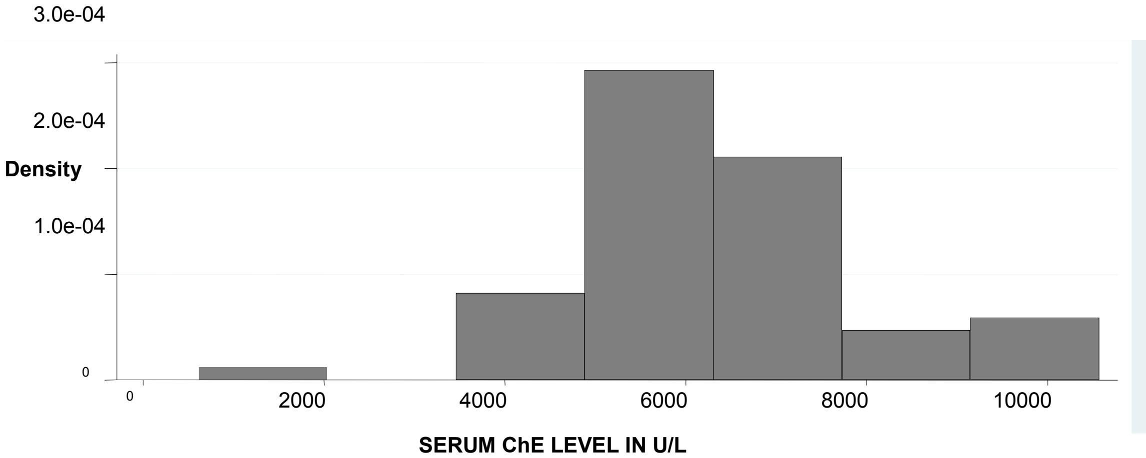

Figure 1: Histogram for distribution of serum cholinesterase activity

Table 4: Predictor variables of serum cholinesterase activity among children

	Adjusted Crude ß-coefficient (95% CI)	p-value	Adjusted ß-coefficient (95% CI)
Variables affecting parental exposure of pesticides to children			
Failure to wear Protective gears	-5,240.3 (-7,223.0, -3,257.6)	**<0.001**	-1,456.9 (-2,594.1, -319.8)
Not using household pesticides	158.3 (61.6, 255.0)	**0.002**	96.3 (22.6, 170.0)
Failure to break after spraying	885.4 (-114.7, 1885.5)	**0.081**	1105.5 (315.0, 1895.2)
Variables affecting children exposure to pesticides			
Female sex	-902.6 (-1764.7, - 40.6)	**0.04**	-695.7 (-1,296.2, - 95.3)
Not attending school	-3,662.8 (-5,861.7, -1,464.1)	**0.001**	-1,676.8 (-3,371.6, 18.1)

3.6 Regression Analysis for Predictors of serum cholinesterase levels

Linear regression analysis was done to identify variables predictive of serum cholinesterase levels. Bivariable and multivariable analyses were conducted and results are presented in **Table 4.** They are classified as follows: exposure status of the child, child's characteristics, guardian's characteristics, household pest management and the location of the child's school near the flower farm. The parsimonious model accounted for 58.8% of the variation in serum ChE activity.

From the model, five predictor variables were found to be significantly associated with depression of serum cholinesterase levels. The most important predictor variable was not using protective clothing by the parent [adjusted β -1456.96, 95% CI (-2594, 1319.82; p=0.01)]. Others were; not using household pesticides [adjusted β 96.3, 95% CI (22.6, 170.0; P=0.01)], female sex [adjusted β -695.7, 95% CI (-1296.2, -95.3; p=0.02)], non school attendance [adjusted β -1676.8, 95% CI (-

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3371.6, 18.1; p= 0.05] and not taking a break after spraying [adjusted β 1105.5, 95% CI (315.0, 1895.2; p=0.01)].

Influence of proximity of the school to the flower farms

On bivariable analysis, proximity of the school to the flower farm was the most important determinant of ChE levels. It was responsible for 29% of the variation in serum ChE activity. However, on multivariable analysis, it was not a significant predictor of ChE activity. Children who did not attend school had depressed ChE levels by -3662.8U/L. Children whose schools were located 500m away from the flower farms, also had higher ChE levels which was expected, however this was not statistically significant (p=0.06) but is clinically significant.

Effects of exposure of the guardian/parent to pesticides

Children whose parents worked away from flower farms such as pastors, teachers had higher levels of cholinesterases. This was statistically significant on bivariable analysis (p=0.05). The mother's occupation had a greater effect on ChE levels compared to the father's occupation. In addition, the longer the parent worked on the flower farm, the lower the child's ChE levels. Children who were working on the flower farms had lower ChE levels but this was not statistically significant (p=0.69).

The guardians' education level had a beneficial effect on the serum ChE levels. Children of parents who were aware of the health impact of pesticides had higher ChE levels on bivariable analysis but this was not statistically significant on adjusting for confounders. However, for parents who were able to site the specific health impact of pesticides, there was a statistically beneficial effect on serum ChE activity [adjusted β 205.9, 95% CI (2.31, 409.5; p=0.05)]. On multivariable analysis, parents' education and their awareness about the health impact of pesticides was not statistically significant.

Influence of use of personal protective measures

The analysis of the effect of protective practices was restricted to parents who worked on flower farm. Amongst children whose parents worked on flower farms, use of protective gear by the parent accounted for 44.4% of the variation in serum ChE level. Parents who washed their clothes separately from their children's conferred a protective effect although the results were statistically insignificant (p=0.23). Children whose parents failed to follow pesticide label instructions had a depressed serum ChE levels and this was not statistically significant (p= 0.66). Surprisingly, failure to take holidays from work on the farm had a protective effect against pesticide exposure and this was statistically significant (p=0.007). Parents' use of protective gear was the most important predictive variable. Decreasing use of household insecticides increased the children's cholinesterase levels (p=0.01). The only personal protective practices that remained significant on multivariable analysis was failure to use protective gear and failure to take a break after spraying (p=0.01).

Influence of the child's demographic traits on ChE levels

The child's age had no influence on cholinesterase level. However, sex was significantly associated with the serum ChE levels both on bivariable and multivariable analysis. On adjusting for confounders, females had a lower serum levels by about 695.7 U/L compared to the males (**Table 4**).

4. Discussion

This study found that patients who were exposed to pesticides had lower ChE levels which concurs with other studies done in Naivasha and Lebanon (Ohayo-Mitoko et al, 2000; Salameh et al, 2013). The parsimonious model accounted for 58.8% of the variation in serum ChE activity. Other factors such as genotype and nutrition factors could have explained the remaining variation.

A second key finding in this study was failure to use protective gears by parents which had a significant effect on ChE levels of their children. These findings concurs with a study done in Zimbabwe which reported depressed ChE levels among children whose guardians did not use personal protective equipment (Regis et al, 2011). The practice probably led to body spills which could easily be transferred to children through contact and inhalation in cases where parents did not take a bath after spraying or working on a flower farm. Consequently, the total cumulative effects of pesticides had a long term health impact on the exposed children leading to low ChE activity (Lu, 2009).

The children who were not going to school had significantly depressed cholinesterase activity by 1676.8 U/L. It was expected that children who went to school had greater environmental exposure to pesticides and therefore, they would have lower ChE levels compared to those who stayed at home (Salameh et al, 2006). This is because children who stayed at home were from poorer households and probably did not receive adequate nutrition. This could have explained why staying at home had a negative effect on ChE level. Inadequate nutrition is a known risk factor for reduced serum ChE levels (Steven et al, 2009).

In our study, females had lower ChE levels by 695U/L compared to males because of the hormonal status, genetic status and use of contraception (Abdulkareem, 2010). Similar to other studies, sex was a very strong predictor variable to the levels of depression of serum cholinesterase.

It was noted that nearness to a flower farm did not have a statistical significant effect on serum ChE level as expected on multivariable analysis. However, this observation had a clinical significance. From our study, children whose schools were located further away from the flower farms (>500m) had higher ChE levels which were protective. Other studies have found depressed ChE among people living near flower farms (Ohayo-Mitoko et al, 2000; Salameh et al, 2006; Regis et al, 2011).

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It is known that taking time off after spraying helps reduce pesticide exposure by allowing time for the pesticides to break down. However, some pesticides take long to break down after the re-entry time pausing prolonged exposure to the farm workers (UNEP, 2004). This then results to further depression of serum ChE activity. In this study, not taking break after spraying led to increased serum ChE activity by 1105.5 U/L contrary to the expectations. More studies should therefore be done to confirm or dispute this result.

Another notable finding was use of household insecticide. It is interesting to note that this practice led to a slight increase of ChE activity by 96.3U/L contrary to the expectations on multivariable analysis (Regis et al, 2011). This is because as one tends to the miscellaneous combined pesticides the depression of serum ChE reduces as this involved use of rodenticides, miticides, bush clearing among others. These methods of pests control have no activity against serum ChE. However, the most commonly used insecticides in this study were pyrethrins; which are known to depress serum ChE levels by exerting oxidative stress on the liver (Jokanovic,1997; Suarez-Lopez et al, 2012; Regis et al, 2013).

The key limitation of this study was that assessment of hepatic function; nutritional status and genotype were not carried out despite that these factors are known to influence ChE activity. Therefore, it was not possible to relate the interactions between pesticides exposure and these risk factors.

It is necessary to determine how ChE activity may affect severity of asthma and the degree of control in asthmatic children. Therefore, a study should be conducted to determine if indeed depressed ChE levels worsen asthma control. From the findings of this study, there is need to promote the use of personal safety measures actively as a means of reducing pesticide exposure to children.

5. Conclusion

Pesticide exposure to children led to depressed cholinesterase levels. The most important predictor variables for the levels of ChE in children were: parents not taking a break after spraying and failure to use protective clothing; child related risk factors were female sex, non exposure to household pesticides and non-school attendance.

Conflict of Interest declaration

The authors declare no conflict of interest.

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