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Hematological alterations in Egyptian farmers occupationally exposed to pesticides

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Abstract

Background: Pesticides are agrochemicals extensively used all over the world for pest control and prevention, Egyptian farmers are occupationally exposed to many types of pesticides, making them at high risk for pesticide toxicity. Several studies have shown acute pesticide poisoning effects, but fewer have dealt with chronic pesticide toxicity, especially studies regarding pesticide's effects on hematological parameters.

Objective: We aimed to evaluate hematological parameter changes related to long-term low-level pesticide exposure. **Subjects and Methods:** The blood samples were collected from 96 Egyptian farmers chronically exposed to mixed pesticides and 54 nonexposed controls. A Complete Blood Picture (CBC) was evaluated to explore the hematological indices alterations. Statistical analysis was conducted using IBM SPSS Statistics, version 25. **Results:** A significant decrease in hemoglobin, hematocrit, mean corpuscular volume, and mean corpuscular hemoglobin in addition to platelet count in the exposed farmers compared to the control, On the other hand, white blood cell count was significantly increased.

Conclusion: Chronic occupational pesticide exposure of Egyptian farmers leads to a range of disorders in hematological indices. As an affordable and readily available test, the Complete Blood Picture can help in the chronic monitoring of farmers health status who are regularly exposed to pesticides.

Key Words: Hematological alterations, Pesticides, Egyptian farmers

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Introduction

Pesticides are a group of agrochemicals widely used for pest prevention and control. Fungicides, herbicides, and insecticides are major types of pesticides extensively used in developing countries (Sood, P. 2023). However, there are several health problems associated with chronic occupational pesticide exposure (Caldas et al., 2019). The main occupational exposure routes are skin absorption during pesticide preparation, inhalation during spraying, and ingestion through contaminated water and food. various factors affect pesticide toxicity, including pesticide type, duration, and exposure frequency as well as personal protective equipment

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(Damalas et al., 2016). Extensive pesticide use contributes to mortality and morbidity in agriculture farmers through chronic and acute toxicities. Long-term low-level pesticide exposure could lead to some health effects, like metabolism dysfunction, carcinogenesis, immunological disorders, neurotoxicity, and reproductive effects (Nicolopoulou-Stamati et al., 2016). Pesticide residues may affect hematological indices such as Hemoglobin, white blood cells, and platelet count (Ismail et al., 2010).

In the study area, the farmers cultivate several types of crops (particularly wheat, maize, and vegetables) and unsafely handle different types of pesticides including fungicides (mancozeb and Carbendazim), herbicides (Pendimethalin), nematicides (Fenamiphos and Fosthiazate) and insecticides (Chlorpyrifos, Lambda-cyhalothrin, Malathion, Dimethoate and Abamectin). Exposure to pesticides over extended periods, even in small quantities, holds the capacity to cause alterations in hematological and various other biochemical factors (Sine et al., 2021). Hematological indices have been considered good biomarkers and can be used to determine the toxic effects of pesticide exposure (Emam et al., 2021). This study was conducted to monitor hematological indices in Egyptian agricultural workers occupationally exposed to pesticides.

Subjects and method

Study population

150 adult male participants from Manshiat Radwan Village, Giza Governorate, Egypt were incorporated into this study. They were divided into a control group consisting of 54 healthy participants with no history of occupational pesticide exposure and an exposed group consisting of 96 agricultural workers occupationally exposed to mixed pesticides.

Both exposed and control groups were matched for sex, age, smoking habit, socioeconomic, marital, nutritional status, and body mass index (BMI). Individuals suffering from diabetes, hypertension, renal, hepatic, parasitic worm infestation, or any chronic diseases that affect hematological parameters were excluded from the study. Due to the low socioeconomic status of exposed workers, they mostly use their hands to handle pesticides, wearing little to no protective equipment that is ineffective at shielding them from pesticides while mixing, loading, or spraying

Ethical approval:

Study approval was obtained from the Ministry of Health. All participants provided informed consent, and the study protocol received approval from the Ethics Committee of Zagazig University's Faculty of Medicine.

Sample collection and preparation

Two ml of venous blood were collected by venipuncture and transferred into sterile EDTA vacutainer tubes for CBC analysis on the same day.

Hematological parameter determination

Fresh EDTA blood samples were utilized for conducting a comprehensive blood count (CBC) using an automated cell counter, model XN 2000 (Sysmex, Japan) Additionally, Leishman-stained peripheral blood smears were examined to determine the differential leukocyte count. Hematological parameters including HGB (hemoglobin), HCT (hematocrit), RBC (red blood cells count), WBC (white blood cells count), differential absolute cell count (neutrophils, lymphocytes, and monocytes in addition to eosinophils and basophils), PLT count (platelet), and PCT (platelet crit) were performed. Additionally, MCV (mean corpuscular volume), MCH (mean corpuscular hemoglobin), MCHC (mean corpuscular hemoglobin concentration), RDW (red blood cell distribution width), PDW (platelet distribution width), MPV (mean platelet volume) and P-LCR (platelet large cell ratio) was also performed based on the data of hematological indices

Statistical analysis

Statistical analysis of the obtained data was done using the Statistical Package for Social Science (IPM SPSS statistic version 25). Data were displayed as means along with their corresponding standard deviations (SD). The study groups were compared using an independent sample T-test, with a significance level of $p < 0.05$ indicating statistical significance.

Results

A total of 96 exposed farmers and 54 nonexposed participants as a control were recruited in this cross-sectional study. All the participants were male. They lived in the same village, with similar nutritional, marital status, and lifestyle. Their age ranged from (30 to 55 years) and their BMI was between (20.1 and 34.8 Kg/m2). No notable differences were observed in age, BMI, or smoking habits between exposed and control (P > 0.05) as shown in Table 1. The average pesticide exposure was 11.04 hours/week and the average work experience was 19.68 years (ranging from 10 to 30 years). The farmers were exposed occupationally to different types of pesticides mainly organophosphates, carbamates, and pyrethroids as demonstrated in Table 2.

Table 3. demonstrates the evaluated hematological indices in both groups. Hemoglobin, Hematocrit, Mean Corpuscular Volume, Mean Corpuscular Hemoglobin, and platelet count were markedly reduced in the exposed farmers compared to non-exposed (p= 0.002, 0.048, 0.034, 0.011, and 0.031) respectively, On the other hand, white blood cells count (WBCs) and absolute Neutrophils count showed a significant increase (p=0.004, 0.007 respectively) in the exposed farmers compared to controls. Table 4. shows the frequency of individuals with hematological abnormality, among 96 exposed farmers; about 24%, 35.4%, 37.5%, 10%, 17.7% and 4.2% showed reduced values of HGB, HCT, MCV, MCH, WBCs, and neutrophils, respectively.

Table 1: The demographic information of the study participants.

Parameter	Control (Mean±SD)	Exposed (Mean±SD)	P- value
Age (years)	42.43±7.76	44.43±7.56	0.123
BMI (Kg/m2)	27.27±3.08	26.68±2.58	0.214
Smoking (number/%)	18 (33.3)	40 (41.7%)	0.155
Exposure (hrs./week)	0	11.04±5.42	-------
Exposure (years)	0	19.68±5.66	-------

SD (standard deviation), BMI (body mass index Kg/m2), hrs. (hours)

Table 2: List of frequently used pesticides in the area of study.

Common name	Chemical class	Use
Prothiofos, profenofos, Malathion Chlorpyrifos-methyl, Fosthiazate, chlorpyriphos, Fenitrothion, Diazinon, Dimethoate, Fenamiphos	Organophosphates	Insecticide
Carbosulfan, Methomyl	Carbamates	Insecticide
Abamectin	Pyrethroid	Acaricide
Lambda-cyhalothrin	Pyrethroid	Insecticide
Acetamiprid	Neonicotinoides	Insecticide
Mancozeb	Dithiocarbamates	Fungicide
Carbendazim	Benzimidazole	Fungicide
Pendimethalin	Dinitroanaline	Herbicide
Penconazole	Triazole	Fungicide
Fenpyroximate	Pyrazole	Acaricide
Thiophanate- methyl	Thioureas	Fungicide

Table 3: Evaluated hematological indices in the study groups.

Hematological	Reference	Control	Exposed	P- value
Hemoglobin (g/dL)	13.2-17.3	14.42±0.79	13.94±0.95	0.002*
RBC (x106 /µL)	4.3-5.7	5.07±0.40	5.06±0.46	0.955
Hematocrit (%)	39-49	41.98±2.70	41.00±3.01	0.048*
MCV (fL)	80-100	82.77±4.57	80.85±5.61	0.034*
MCH (pg)	27-34	28.52±2.04	27.51±2.43	0.011*
MCHC (g/dL)	32-37	34.38±1.48	34.07±1.43	0.219
RDW (%)	11.5–14.5	13.78±1.35	13.81±0.98	0.846
Platelets (x103/µL)	150 - 450	239.3±41.4	222.23±48.38	0.031*
PCT (%)	0.10-0.50	0.21±0.05	0.21±0.06	0.848
MPV (fL)	8.0-12	9.10±0.93	9.30±1.15	0.284
PDW (fL)	8.3-25.0	38.68±1.94	38.65±2.94	0.956
P-LCR (%)	13-43	29.12±7.19	29.21±6.07	0.935
WBC (x103/µL)	4 – 10	6.65±1.89	7.65±2.01	0.004*
Neutrophils (x103/µL)	2 – 7	3.39±1.27	4.09±1.62	0.007*
Lymphocytes (x103/µL)	1 – 3.5	2.61±0.92	2.87±0.89	0.086
Monocytes (x103/µL)	0 – 1.0	0.37±0.15	039±0.16	0.585
Eosinophils (x103/µL)	0 – 0.5	0.20±0.08	0.21±0.08	0.561
Basophils (x103/µL)	0 – 0.1	0.04±0.02	0.04±0.02	0.541

Data displayed as Mean ± standard deviation, red blood cell (RBC) count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), plateletcrit (PCT), mean platelet volume (MPV), platelet distribution width (PDW), platelets large cell ratio (P-LCR), white blood cell (WBC). * Statistically significant difference between control and exposed at ($p < 0.05$).

Table 4: Abnormal cases (Number, %) in the study groups

Hematological	Range	Control	Exposed	P-value
Hemoglobin (g/dL)	<13.2	3 (5.6%)	23 (24%)	0.000*
Hematocrit (%)	<39	4 (7.41%)	34 (35.42%)	0.000*
MCV (fL)	<80	10 (18.52%)	36 (37.5%)	0.008*
MCH (pg)	<27	9 (16.67%)	10 (10.42%)	0.271
Platelets (x103/µL)	<150	0 (0%)	0 (0%)	-------
WBC (x103/µL)	>10	2 (3.7%)	17 (17.7%)	0.007*
Neutrophils (x103/µL)	>7	0 (0%)	4 (4.2%)	-------

mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and white blood cell (WBC) count *Statistically significant difference between control and exposed at ($p < 0.05$).

Discussion:

Since pesticides are "poisons by design," improper use of them exposes agricultural workers, especially in developed countries to the most common and dangerous occupational risks. Organophosphates, Carbamates, and Pyrethroids are major classes of used pesticides globally (Agnandji et al., 2018). While the majority of previous studies have focused on analyzing hematological parameters in cases of acute pesticide poisoning, only a limited number of research studies have explored the effects of long-term occupational exposure (Nejatifar et al. 2022). There is a belief that continuous exposure to low levels of pesticides can accumulate in biological systems, exerting cytotoxic effects at the cellular level before evident clinical signs and symptoms manifest. The impact of prolonged pesticide exposure on hematological indices has not received much attention, and there are conflicting findings regarding this matter. (Varol et al. 2014).

The results revealed that White Blood Cells Count (WBC) was significantly higher in the exposed group compared to the control (P=0.004), these data were consistent with other previous studies (Al-Sarar et al., 2009, Singh et al., 2014, García et al., 2016, Cortés-Iza et al., 2017and Jamil et al., 2021) and might result from chronic inflammation and immunological reaction to pesticide exposure (Nejatifar et al., 2022). On the other hand, some researchers showed no significant difference between the exposed and control group (Rojas-García et al., 2011, Payán-Rentería et al., 2012, and Sine et al., 2021). Contrary to our results Gaikwad et al. and Srilesin et al. reported a significant decrease in WBC count in exposed farmers compared to controls (Gaikwad et al. 2015 and Srilesin et al., 2022). A significant decrease in Platelet count (PLT) was observed in pesticides exposed group compared to the control (P=0.018), this result is consistent with other results (Varol et al., 2014, Agnandji et al., 2018 Jamil et al., 2021, and Srilesin et al., 2022). In addition to oxidative stress, Pesticides can potentially exert a direct toxic effect on the bone marrow, leading to a subsequent decrease in platelet indices. This effect is believed to occur through the interaction of cholinergic receptors present on platelets (Varol et al., 2014). which was in disagreement with the results of previous studies (Singh et al., 2014, García et al., 2016, Cort´es-Iza et al., 2017 Tang et al., 2018 and Nejatifar et al., 2022). Leili observed a significant elevation in platelet counts among Iranian farmers exposed to pesticides compared to the unexposed group (Leili et al., 2022).

The results revealed a significant reduction ($p>0.05$) in HGB, HCT, MCV, and MCH in the exposed group compared with the control, these results are consistent with those (Rastogi, Patil et al., 2009, Agnandji et al., 2018 and Jamil et al., 2021). Pesticides act as toxicants that can impede the biosynthesis of heme and shorten the lifespan of red blood cells. (Patil et al., 2003, Agnandji et al., 2018, Sine et al., 2021 and Nuryati et al., 2022). Leili reported a significant decrease in Hemoglobin, MCH, and MCHC in farmers exposed to pesticides and concluded that farmers exposed to pesticides had notably experienced significant hemotoxic effects throughout their pesticide exposure period (Leili et al., 2020). Contrary to our results other researchers found no significant differences in these parameters (Nejatifar et al., 2022 and Srilesin et al., 2022). Some studies agree in part with our results (Hassanin et al., 2018, and Sine et al., 2021) Hassanin et al., (2018) showed a significant decrease in MCV while no significant change in HGB, HCT, and MCH. Sine et al., (2018) also reported a significant decrease in MCH and MCHC among the exposed group meanwhile no difference in HGB, HCT, and MCV. While García et al., (2016) reported that the exposed group showed a significant increase in hemoglobin levels compared to the control group.

Conclusion

The study findings demonstrate that chronic pesticide exposure causes a wide range of hematological changes. Hence, hematological parameters should be assessed at more frequent intervals to determine the frequency of deleterious effects of chronic mixed pesticide application particularly during the early stages of pesticide exposure, before the onset of adverse clinical health effects. Farmers' health hazards from pesticide exposure must be regularly and carefully observed, and programs must be developed and implemented to raise awareness of safe pesticide usage.

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