https://doi.org/10.26682/sjuod.2023.26.2.10
Journal of University of Duhok., Vol. 26, No.2(Pure and Engineering Sciences), Pp 106-117, 2023

OCCUPATIONAL RISK ASSESSMENTS OF HEMATOLOGICAL PARAMETERS ALTERATIONS OF KAR OIL REFINERY WORKERS IN ERBIL PROVINCE, KURDISTAN REGION, IRAQ

ARAM QASIM ABDULKAREEM and BUSHRA MOHAMMED AMIN MOHAMMED
Dept. of Biology, College of Science, University of Duhok, Kurdistan Region–Iraq

(Received: May 26, 2023; Accepted for Publication: July 16, 2023)

ABSTRACT

Workers at petroleum refineries are exposed to an extensive variety of toxic chemical compounds utilized in the production of petroleum derivatives. A total of 100 participants were participated in this study, which consisted of two groups, the first group constitute 60 refineries workers (34 non-smokers and 26 smokers), the second group constitute of 40 control participants (20 non-smokers and 20 smokers). The main objective of this work was to demonstrate the possible effects of the mixture of hydrocarbon compound gases and vapors emitted from petroleum products on different hematological parameters (complete blood picture), as well as to reveal the correlation of those biomarkers with exposure period, smoking habit, age, and body mass index of workers at Kar refinery. Data showed significant reduction in hemoglubin, hematocrite, mean corpuscular hemoglubin, mean corpuscular hemoglubin concentration and elevation in red cell distribution width value in the exposed workers when compared to controls. A negative correlation was revealed between platelets and body mass index, and between hemoglubin and service period within the refinery. This study concluded that the observed changes in blood parameters may refer to damage in the hematopoietic system due to continuous exposure to vapors of petroleum product.

***KEYWORDS*: ** Crude oil, refinery hazards, hematotoxicity, hydrocarbon exposure, blood parameters

1. INTRODUCTION

KAR oil refinery is one of the main oil refineries in the Kurdistan region of Iraq, which is located northwest of Erbil governorate. The refinery consists of three production lines for crude oil refining and the production, storage, distribution, and supply of petroleum products in accordance with applicable standards, representing the first crude oil refining plant in Kurdistan since 2005 (Hussein & Goran, 2020).

It's well known that raw oil deposits would cause various health impacts, particularly upon those occupationally exposed workers ranging from mild to lethal health influences. Oil refineries are a major source of air pollution especially the volatile chemical contaminants (VCC) like benzene, its activities have adverse health impacts by continuously emitting pollutants into the air we breathe (Churg *et al.*, 2003).

It is well known that prolonged exposure to the hydrocarbons found in petroleum is associated with large incidences of hematological disorders such as anemia, leukopenia, thrombocytopenia, and aplastic anemia as a result of damage to the hemopoietic system accompanied by depletion to the bone marrow. eventually, exposure to petroleum hydrocarbons may also result in the development of more than one type of leukemia (Snyder, 2012)

This study was made to evaluate the toxic stress induced by pollutants among petrol refinery workers, exposed to highly toxic gases emitted and other petroleum products on hematological parameters (red blood cell (RBC), hemoglobin (Hb), white blood cell (WBC), platelet (PLT), hematocrit (HCT), mean cellular volume (MCV), mean cellular hemoglobin (MCH), mean cellular hemoglobin concentration (MCHC) and red cell distribution width (RDW)), and to study the correlation of those biomarkers with other confounding factors, for example, years of working (exposure period), smoking habit, age, and BMI.

To the best of our knowledge, no study has been conducted in the Kurdistan region of Iraq on the impact of the leakage and combustion of crude oil on refinery workers health, thus, this is the first study designed to determine the likelihood of detecting any prior health symptoms **in workers at KAR refinery** that may act as early indicators **of hematopoietic system health syndromes**, assisting in the prediction and estimation of such problems well before they occur.

2. METHODOLOGY

2.1. Study Design

This study was accomplished in the KAR refinery for petrol in Erbil City and was carried out in the Department of Biology, College of Science, University of Duhok, with the collaboration of hematology unit at laboratory department of Azadi Teaching Hospital, for 7 months period between November 2021 and April 2022.

A total of 100 participants were participated in this study, which consisted of two groups, the first group consists of 60 petroleum refineries workers (34 non-smokers and 26 smokers). All participants in this group have worked at the KAR petroleum refinery for not less than five years and were working in different units within the refinery, they were laboratory staff, operators, storage unit workers, loading station, and other units. The exposed workers were within a range of 25-55 years of age.

The other group was apperantly health as control group, which consists of 40 unexposed persons (20 non-smokers and 20 smokers). The control group was faculty members, school teachers, hospital staff, librarians, and others, They were within the range of 25-62 years of age.

2.2. Hematology Profile

After obtaining a verbal approve from the participants, (2 ml) of venous blood was drawn and put in an EDTA tube (ethylene-diamine-tetra-acetic acid). The collected blood samples were taken to the hematology unit at laboratory department of Azadi teaching hospital in Duhok city on the same day for monitoring hematological biomarkers; total RBC, PLT, WBC count and differential count (lymphocytes, monocytes, and granulocyte), HGB, MCV, MCH, and MCHC by using automated 3-part differential Hematology Analyzer (BOULE Swelab Alfa).

All subjects received a letter outlining the aims of the research study, in which they were informed that the results would be published and that they would not receive any individual results.

2.3. Questionnaire

The required information of the participants was obtained by a questionnaire, which included demographic details; smoking status, years of working (exposure period), age, and body mass index.

2.4. Statistical Analyses

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0. A comparison of means between refinery attendance and control was performed using the one-way ANOVA test (Roma-Torres *et al.*, 2006). Multiple intergroup comparisons were made for statistically significant variables using the Games-Howell (G&H) post hoc test. Pearson’s correlation coefficient was used to assess the association between tested parameters with independent variables (years of exposure, age, BMI, and smoking). The statistical significance was set at $P<0.05$.

3. RESULTS

3.1. Demographics of the Study

The baseline characteristics of the participants were reported in Table 1. In this study, we analyzed a group of 60 male occupationally exposed workers (26 smokers and 34 non-smokers), the average age was (34.46 ± 8.51, 34.08 ± 6.17) respectively, concerning their working position within the refinery they were 29.7% operators, 21.45% laboratory staff, 11.55% loading station workers, 11.55% storage unit attendants, and 24.75% were maintenance and others. The range of service years within the refinery was from 5 to 13 years with a mean duration of 9 years. The mean working hours/days in a week were (10.53/4.21) compared with 40 healthy male subjects (20 smokers and 20 non-smokers) the mean age was (37.25 ± 11.11, 37.9 ± 9.64) respectively. Additionally, the mean number of cigarettes consumed per day by exposed smokers and control smokers was (21.38 ± 14.08, 24.05 ± 16.42,) respectively. The body mass index was recorded as follows (exposed smokers (27.61 ± 5.94), exposed non-smokers (26.41 ± 3.6), control smokers (26.12 ± 3.54), control non-smokers (26.11 ± 2.35)).

Table (1): Demographic features of participants in studied participants.

Variables	Control			Refinery workers		
	Number of participants (40)			Number of participants (60)		
	N (%)	Smokers 20 N (%)	Non-smokers 20 N (%)	*N (%)*	Smokers (26) N (%)	Non-smokers (34) N (%)
Age (years)						
25-35	19	11 (27.5)	8 (20.0)	40 (66.0)	17 (28.05)	23 (37.95)
36-45	(47.5)	4 (10.0)	9 (22.5)	17	8 (13.2)	9 (14.85)
46-55	13	4 (10.0)	1 (2.5)	(28.05)	-	2 (3.3)
>55	(32.5)	1 (2.5)	2 (5.0)	2 (3.3)	1 (1.65)	-
(Mean ± SD)	5 (12.5)	(37.25 ±	(37.9 ± 9.64)	1 (1.65)	(34.46 ± 8.51)	(34.08 ±
	3 (7.5)	11.11)				6.17)
Body mass index (BMI)*						
Underweight (<18.5)	-	-	-	-	-	-
Normal weight (18.5-24.9)	13	9 (22.5)	4 (10.0)	19	7 (11.66)	12 (20.0)
Overweight (25-29.9)	(32.5)	7 (17.5)	16 (40.0)	(31.66)	13 (21.66)	17 (28.33)
Obese (≥30)	23	4 (10.0)	-	30 (50.0)	4 (6.66)	7 (11.66)
(Mean ± SD)	(57.5)	(26.12 ±	(26.11 ±	11	(27.61 ±	(26.41 ± 3.6)
	4 (10.0)	3.54)	2.35)	(18.33)	5.94)	
Number of cigarettes per day						
(number)	4 (10.0)	4 (10.0)	-	6 (9.9)	6 (9.9)	-
1-10	8 (20.0)	8 (20.0)	-	13	13 (21.45)	-
11-20	8 (20.0)	8 (20.0)	-	(21.45)	7 (11.55)	-
>20		(24.05 ±		7 (11.55)	(21.38 ±	-
(Mean ± SD)		16.42)			14.08)	
Exposure period (service years)						
≤10	-	-	-	39	11 (18.15)	28 (46.2)
>10	-	-	-	(64.35)	15 (24.75)	6 (9.9)
(Mean ± SD)				21	(9.53 ± 3.03)	(8.58 ± 2.52)
				(34.65)		
Working hours (hours/day)						
4 hours				5 (8.25)	2 (3.3)	3 (4.95)
8 hours	-	-	-	12 (19.8)	5 (8.25)	7 (11.55)
12 hours	-	-	-	43	19 (31.35)	24 (39.6)
(Mean ± SD)				(70.95)	(10.61± 2.5)	(10.47 ± 2.6)
Position within refinery						
Operators	-	-	-	18 (29.7)	5 (8.25)	13 (21.45)
Laboratory	-	-	-	13	5 (8.25)	8 (13.2)
Loading station	-	-	-	(21.45)	3 (4.95)	4 (6.6)
Storage unit	-	-	-	7 (11.55)	4 (6.6)	3 (4.95)
Maintenance and others	-	-	-	7 (11.55)	9 (14.85)	6 (9.9)
				15		
				(24.75)		

*BMI=wight (kg)/hight (m^2) (Gallagher et al., 2013)

3.2. Comparison between the Exposed and Non-exposed participants according to Hematological Parameters

The following tables (Tables 2 & 3) show the comparison of the mean values of hematological parameters using one-way ANOVA along with the Games-Howell (G&H) multiple comparisons:

Table (2): Mean and standard deviations of hematological parameters in the exposed and non-exposed groups.

Parameters	Non-exposed		Exposed		ANOVA		
	Smokers (Mean ± SD)	Non-smokers (Mean ± SD)	Smokers (Mean ± SD)	Non-smokers (Mean ± SD)	df between groups, within groups	F statistics	*P*-value (*P* <0.05)
RBC (10^6/µL)	5.22 ± 0.38	5.3 ± 0.41	5.39 ± 0.48	5.28 ± 0.51	3,96	0.255	> 0.05
HGB (g/dl)	15.39 ± 0.81	15.55 ± 1.31	14.46 ± 1.27	14.28 ± 1.33	3,96	6.68	< 0.01**
HCT (%)	49.93 ± 3.13	49.95 ± 3.77	47.05 ± 3.74	46.36 ± 3.78	3,96	0.493	> 0.05
MCV (fl)	87.68 ± 4.88	86.63 ± 2.98	87.66 ± 9.15	87.75 ± 9.42	3,96	0.105	> 0.05
MCH (pg)	28.99 ± 3.16	29.37 ± 1.2	27.05 ± 3.25	27.09 ± 3.3	3,96	4.08	< 0.01**
MCHC (g/L)	33.61 ± 1.07	33.89 ± 0.77	30.78 ± 0.99	30.80 ± 0.85	3,96	82.228	< 0.01**
PLT (10^3/µL)	241.51 ± 56.83	261.2 ± 80.03	257.57 ± 77.31	251.32 ± 65.14	3,96	0.324	> 0.05
WBC (10^9/L)	7.38 ± 1.79	7.57 ± 2.4	7.16 ± 1.74	6.96 ± 1.24	3,96	0.58	> 0.05
Lymphocyte (LYM) (%)	38.07 ± 7.55	33.47 ± 9.55	37.02 ± 7.7	38.07 ± 7.74	3,96	1.579	> 0.05
Monocyte (MID) (%)	12.09 ± 16.62	10.12 ± 3.3	7.75 ± 3.87	7.4 ± 3.26	3,96	1.779	> 0.05
Granulocyte (GRA) (%)	53.02 ± 9.3	56.6 ± 9.41	55.22 ± 8.07	54.52 ± 8.72	3,96	0.582	> 0.05
RDW (%)	11.16 ± 0.54	11.14 ± 0.67	13.13 ± 0.83	12.88 ± 0.72	3,96	53.816	< 0.01**
MPV (fl)	8.34 ± 0.91	8.63 ± 1.04	8.61 ± 0.74	8.85 ± 0.71	3,96	1.584	> 0.05

*P<0.05, significant; ** P<0.001, highly significant

One-Way ANOVA test was performed for statistical analysis.

Table (3): *Intergroup comparison of hematological parameters among study groups.*

parameters	Group compared	Mean difference (MD)	*P* value
HGB (g/dl	1vs 3	1.26	< 0.01**
	1vs 4	1.08	< 0.05*
	2 vs 3	1.11	< 0.01**
	2 vs 4	0.92	< 0.05*
MCH (pg)	1vs 3	2.27	< 0.01**
	1vs 4	2.32	< 0.05*
	2 vs 3	1.89	> 0.05
	2 vs 4	1.94	> 0.05
MCHC (g/L)	1vs 3	3.08	< 0.01**
	1vs 4	3.11	< 0.01**
	2 vs 3	2.80	< 0.01**
	2 vs 4	2.83	< 0.01**
RDW (%)	1vs 3	-1.74	< 0.01**
	1vs 4	-1.98	< 0.01**
	2 vs 3	-1.72	< 0.01**
	2 vs 4	-1.96	< 0.01**

1: control non-smokers; 2: control smokers; 3: exposed non-smokers; 4: exposed smokers

* P<0.05, significant; ** P<0.001, highly significant

Games-Howell (G&H) post hoc test was performed for statistical analysis

The result in (Table 2) reveals that HGB, MCH, MCHC, and RDW were significantly different among participants, ($F(3,96)$= 6.68, P<0.01, 4.08, P<0.01, 82.228, P<0.01, 53.816, P<0.01) respectively, whereas the research found no convincing evidence against the hypothesis that the impact of crude oil exposure and smoking was insignificant in RBC, HCT, MCV, PLT, WBC, Lymphocyte, Monocyte, Granulocyte, and MPV among all groups, ($F(3,96)$= 0.255, P>0.05, 0.493, P>0.05, 0.105, P>0.05, 0.324, P>0.05, 0.58, P>0.05, 1.579, P>0.05, 1.779, P>0.05, 0.582, P>0.05, 1.584, P>0.05) respectively, however the reduction in several parameters was noticed in exposed groups.

The G&H post hoc analysis (Table 3) and shows that the mean HGB in the control group is significantly higher than in exposed non-smokers (MD=1.26, P<0.01) and in exposed smokers (MD=1.08, P<0.05). Similarly, it is also revealed that mean HGB in non-exposed smokers is significantly higher than in exposed non-smokers (MD=1.11, P<.01) and in exposed smokers (MD=0.92, P<0.05). In addition, the control group and exposed non-smokers have a significant difference in MCH (MD=2.27, P<0.01), the same goes to control and exposed smokers, they are significantly different in MCH (MD=2.32, P<0.01). On the contrary, the MCH of participants who are non-exposed smokers is not significantly different from the control group, exposed non-smokers, and exposed smokers (Ps>0.05). The post hoc test has also found that mean MCHC in the control group is higher significantly than in exposed non-smokers (MD=3.08, P<0.01) and in exposed smokers (MD=3.11, P<0.01). Additionally, significantly higher MCHC is also found in non-exposed smokers when compared to exposed non-smokers (MD=2.8, P<0.01) and to exposed smokers (MD=2.83, P<0.01). On the other hand, the mean RDW in controls is significantly lower than in exposed non-smokers (MD=-1.74, P<0.01) and in exposed smokers (MD=-1.98, P<0.01), also lower and significant RDW value is found in non-exposed smokers compared to exposed non-smokers (MD=-1.72, P<0.01) and to exposed smokers (MD=-1.96, P<0.01).

Table (4): Comparison of the mean value of main hematological indices of workers with regards to their position within the refinery.

Parameter	groups					ANOVA	
	Operators (Mean ± SD)	Laboratory staff (Mean ± SD)	Loading station (Mean ± SD)	Storage unit (Mean ± SD)	Maintenance & others (Mean ± SD)	F statistics at df of (4,55)	P-value (P <0.05)
RBC (10^6/µL)	5.31 ± 0.46	5.26 ± 0.43	5.07 ± 0.60	5.26 ± 0.49	5.55 ± 0.51	1.33	> 0.05
WBC (10^9/L)	6.37 ± 1.48	7.60 ± 1.58	7.45 ±0.86	7.08 ± 1.08	7.17 ± 1.58	1.63	> 0.05
PLT (10^3/µL)	249 ± 6	266 ± 95	233 ± 46	269 ± 74	251 ± 68	0.34	> 0.05
HGB (g/dl)	13.66 ± 1.57	14.85 ± 0.76	14.81 ± 0.92	14.57 ± 1.23	14.47 ± 1.29	2.18	> 0.05

Concerning the working position within the refinery our data (Table 4) did not show any significant differences in the investigated parameters (Ps>0.05).

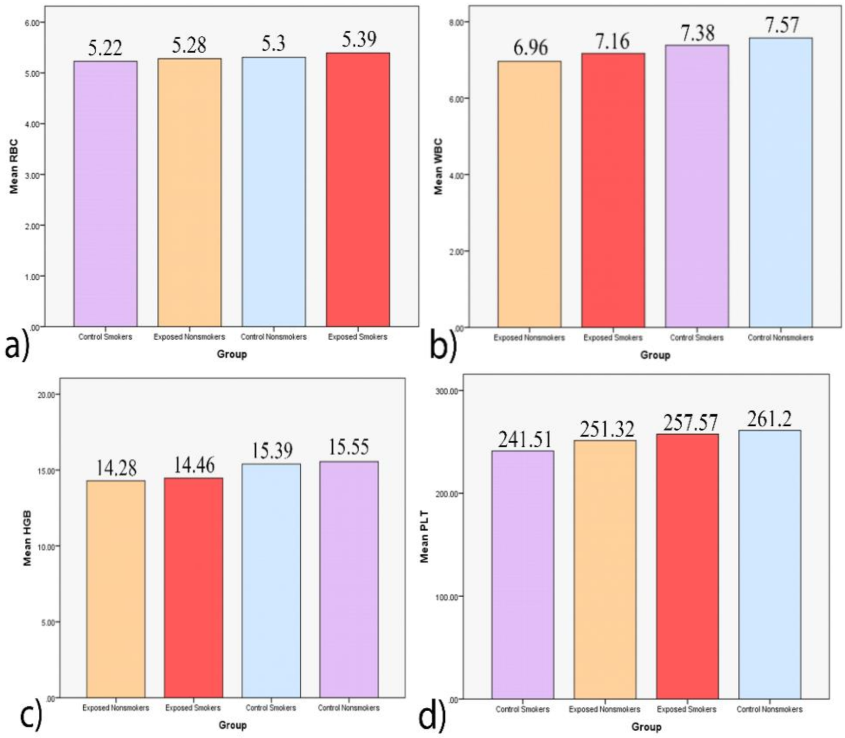
3.3. Correlation assessment between hematological parameters and some independent variables

The dependence of hematological parameters on the independent variables (age, number of cigarettes consumed in a day, body mass index (BMI), exposure period, and working hours) is examined by applying bivariate two-tailed Pearson’s correlation coefficient (Table 5)

Table (5): Pearson Correlation Coefficient between hematology indices and independent variables of interest.

Variables	Correlation *r*	*P*-value	Variables	Correlation *R*	P-value
RBC - Age	-0.182	> 0.05	WBC – Age	-0.028	> 0.05
RBC - BMI	0.174	> 0.05	WBC – BMI	0.107	> 0.05
RBC - Cigarettes/day	-0.012	> 0.05	WBC - Cigarettes/day	0.033	> 0.05
RBC - Service years	0.112	> 0.05	WBC - Service years	-0.084	> 0.05
RBC - working hours	-0.164	> 0.05	WBC - working hours	-0.140	> 0.05
PLT - Age	-0.111	> 0.05	HGB – Age	-0.064	> 0.05
PLT - BMI	-0.248	< 0.05*	HGB – BMI	0.127	> 0.05
PLT - Cigarettes/day	-0.016	> 0.05	HGB - Cigarettes/day	0.080	> 0.05
PLT - Service years	-0.007	> 0.05	HGB - Service years	-0.404	< 0.01**
PLT - working hours	0.077	> 0.05	HGB - working hours	-0.126	> 0.05
*** *P*<0.05, significant; ** P<0.001, highly significant**					

The Pearson's correlation in (Table 5) reveals a weak negative correlation between PLT and BMI (r(98)= -0.248, *P*<0.05), and a moderate negative relationship between HGB and service period (*r*(98)= -0.404, *P*<0.01). All other blood indices are insignificantly correlated with independent variables (*P*>0.05).



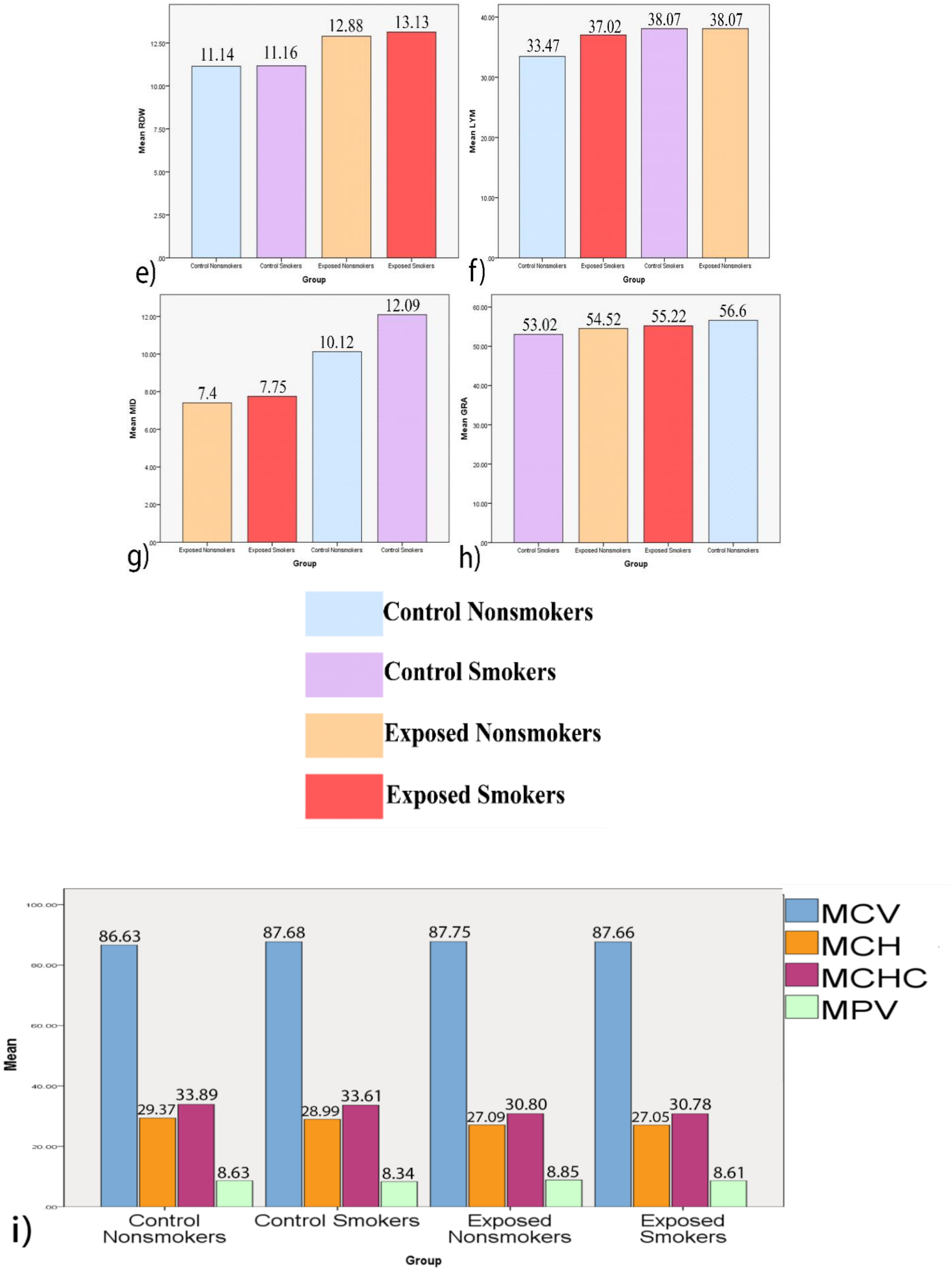


Fig. (1): Mean values of the hematological parameters of the exposed and control groups: (a); RBC (b); WBC (c); HGB (d); PLT (e); RDW (f); LYM (g); MID (h); GRA (i); MCV, MCH, MCHC, and MPV

4. DISCUSSION

Looking at the hematological parameters generally, one observed that the mean values for the individual parameters fell within their parametric reference ranges. In this study, the results showed a reduction in blood cell counts (WBCs, RBCs, and platelets), but was insignificant, however, a significant decrease was observed in HGB, MCH, and MCHC and a significant increase in RDW ($P<0.01$), values for other parameters did not show any appreciable difference in refinery workers compared with those of the non-exposed groups ($P>0.05$) (Table 2). For leukocyte differentials, the monocytes and granulocytes (neutrophils) were lower, while lymphocytes were higher in exposed groups compared to non-exposed groups, however, the differences were not significant.

Our results show partial agreement with several studies conducted previously, Sajid and Ali (2020) showed that Iraqi petrol station workers who are exposed to petrochemicals for more than 5 years experienced significant reduction in (HGB, MCH, MCHC, RBC, and HCT). Ibrahim *et al.* (2014) in Egypt found that male workers who use benzene to dissolve the drawing dyes had a significant decrease in RBC, HGB, HCT, and MCHC, in addition to an insignificant reduction in WBCs, and PLTs as compared to controls.

Another study in Libya by Salem *et al.* (2022) also found RBC, PLT, HGB, and MCHC were lower significantly in refinery workers. On the contrary, in Nigeria, Ezejiofor (2016) conducted a hematological examination on a massive number of refinery participants working for a period not less than 3 years had found no significant difference in main hematological parameters (WBC, HB, PLT, HCT). Similarly, in Bulgaria, Pesatori *et al.* (2009) found no significant differences in hematological parameters among exposed workers in petrochemical plants with an exposure period of not less than one year. Another study in Ethiopia of petrol-filling workers with more than one year of exposure showed an increment of most blood parameters including RDW, the one in line with this study (Getu *et al*., 2020).

These variations in results could be due to various factors affecting the hematopoietic system that may limit similar outcomes. These factors are represented by the differences in sample size, duration of exposure to petrol vapors, age range, smoking and alcohol consumption, nutritional status, and the proportion of the petroleum pollutants which vary according to the environment of the study and applying different safety instructions by the workers due to different work laws and systems that regulate the work at refinery and petrol stations all over the countries.

Olusi (1981) pointed out that most petroleum-related chemicals can cause deleterious effects after long exposure, and the latency period varies from ten to twenty-five years.

In fact, Benzene, is one of the main constituents of crude oil, is a well-known systemic toxicant in humans and a cause of aplastic anemia (Smith, 1996). It is hematotoxic and depresses the bone marrow, leading to pancytopenia (a general depression of erythrocytes (red blood cells), leucocytes (white blood cells), and thrombocytes (platelets) (Okonkwo *et al*., 2016).

These studies demonstrate that benzene is indeed a hematotoxicant. Decreases in hemoglobin content and RBC count could be attributed to a shortened life span of RBC as well as impairment of heme synthesis by the metabolic end product of free radicals of benzene and other aliphatic hydrocarbon constituents of gasoline. These free radicals can alter the erythrocyte membrane and heme protein synthesis in bone marrow (World Health Organization, 2000; Ross, 2000).

Snyder (Snyder, 2000) reported that chronic exposure to low concentrations of benzene may produce reversible decreases in blood cell counts. However, high chronic exposures lead to the onset of irreversible bone marrow depression, which is characterized by anemia, leukocytopenia with emphasis on lymphocytopenia, and/or thrombocytopenia. A decrease in all three cell types is defined as pancytopenia, which in the case of benzene toxicity results from severely damaged bone marrow, and the disease is termed aplastic anemia.

It has been established that chronic exposure to benzene may damage the precursors, stem cells, and stromal cells resulting in bone marrow suppression due to the presence of toxic compounds that turn into oxidative compounds (Gromadzińska & Wąsowicz, 2019; Snyder, 2012). As in the present study, the reduction observed in the blood indices may be explained by the fact th**at** hydrocarbons such as benzene, a metal such as lead, and other volatile vapor may result in a pathogenic effect on the bone marrow and lymph nodes, and then on blood parameters, and the toxic effect of these materials can inhibit and destroy the hematopoietic components in the red bone marrow (Brandão *et al*., 2005).

The suppression in bone marrow function and the failure in the migration of phagocytic cells due to the continuous exposure to petroleum products could reduce the number of neutrophils and monocytes in a way that could affect the immune processes of the workers and may make them vulnerable and more susceptible to different infections (Okoro *et al*., 2010). It may also be attributed to changes in the numbers of lymphocytes, peripheral blood mononuclear cells (PBMCs), and macrophages, impaired responses to mitogens, and depression of neutrophil functions (Fenga *et al*., 2017). On the other hand, prolonged exposure may elicit the immune activation and production of lymphocytes (Getu *et al.,* 2020) which are known to play an important role in anti-tumor immunity by inducing apoptosis and by suppressing the proliferation and migration of tumor cells (Gooden *et al*., 2011; Mantovani et al., 2008; Ray-Coquard *et al*., 2009). Therefore, the elevation of lymphocytes could be an indicator of an anti-inflammatory process or associated with the inhibition of tumor progression and favorable prognosis in workers with chronic exposure.

Moreover, according to our result, the mean RDW value of refinery workers showed a significant increment compared with healthy controls. RDW is a key indicator that principally indicates impaired erythropoiesis and abnormal red blood cell destruction. However, it is also associated with inflammation and allergic reaction which might be due to benzene. RDW is a strong predictor of all-cause, cardiovascular and cancer-related mortality (Montagnana & Danese, 2016).

Thus, toxic constituents of petrol might contribute to the excess health risk upon further exposure and may put the workers under risk of developing blood hepatic or renal-related disorders or hematopoietic malignancies; hence, hematological biomarkers can be used to detect the early effects of exposure to those chemicals on various hematological complications.

The association between hematological indices and other confounding variables such as smoking, age, and exposure period is also investigated in this study by using Pearson's correlation coefficient. A negative association was noticed between most blood parameters and with smoking, age, and exposure period separately (Table 5); however, the correlations were insignificant which might be attributed to sample size or the duration of exposure was not sufficient enough to affect those parameters or may be contributed to individual susceptibility or other factors. Despite that, it is well established that with increased age and working within polluted environments such as petroleum refineries or filling stations for extended periods of time lead to oxidative stress, which induces DNA damage, and subsequently oxidative damage to hematopoietic stem cells through activation of the p53 and apoptotic pathways which finally led to cell self-destruction (Zhou *et al*., 2014).

Though the studied samples of workers in the KAR oil refinery remained clinically healthy at the time of this study, there is a need to monitor them on a long-term basis (even post-retirement from active service) specifically for lymphocytic leukemic disease, given the long latency period required for the full establishment of some of the effects of petroleum hydrocarbons, particularly benzene and other members of the BTEX (benzene, toluene, ethylbenzene, and xylene) complex.

5. CONCLUSIONS

This study demonstrates alterations in some hematological parameters when comparing exposed workers to control groups, data revealed a significant decrease in HGB, MCH, MCHC, and HCT, as well as a significant increase in RDW value, in addition to insignificant variations in other hematological parameters. Moreover, HGB and service duration in the refinery showed a negative correlation, as does PLT and BMI. Other blood indicators were found to be insignificantly linked to the selected independent factors.

laboratory investigations and periodic medical checkup for KAR refinery workers should be performed to monitor the long-term health consequences to discover early hazardous health effects. Further studies with larger sizes of sample, and longer duration of occupational exposure is warranted to evaluate the results and understand the mechanism of exposure in causing hematotoxicity response.

6. REFERENCES

Brandão, M. M., Rêgo, M. A., Pugliese, L., Clarêncio, J., Bastos, C. M., Ferreira, J., . . . Freire, S. M. (2005). Phenotype analysis of lymphocytes of workers with chronic benzene poisoning. *Immunol Lett, 101*(1), 65-70. doi:10.1016/j.imlet.2005.04.004

Churg, A., Brauer, M., Avila-Casad, C., Fortoul, T., & Wright, J. (2003). Chronic exposure to high levels of particulate air pollution and small airway remodeling. *Environ Health Perspect, 111*(5), 714-718. doi:10.1289/ehp.6042

Ezejiofor, T. (2016). Haematological Indicators of Exposure to Petroleum Products in Petroleum Refining and Distribution Industry Workers in Nigeria. *Journal of Clinical Toxicology, 06*. doi:10.4172/2161-0495.1000276

Fenga, C., Gangemi, S., Di Salvatore, V., Falzone, L., & Libra, M. (2017). Immunological effects of occupational exposure to lead (Review). *Mol Med Rep, 15*(5), 3355-3360. doi:10.3892/mmr.2017.6381

Gallagher, D., Chung, S., & Akram, M. (2013). Body Composition. In B. Caballero (Ed.), *Encyclopedia of Human Nutrition (Third Edition)* (pp. 191-199). Waltham: Academic Press.

Getu, S., Shiferaw, E., & Melku, M. (2020). Assessment of hematological parameters of petrol filling workers at petrol stations in Gondar town, Northwest Ethiopia: a comparative cross-sectional study. *Environ Health Prev Med, 25*(1), 44. doi:10.1186/s12199-020-00886-1

Gooden, M. J., de Bock, G. H., Leffers, N., Daemen, T., & Nijman, H. W. (2011). The prognostic influence of tumour-infiltrating lymphocytes in cancer: a systematic review with meta-analysis. *Br J Cancer, 105*(1), 93-103. doi:10.1038/bjc.2011.189

Gromadzińska, J., & Wąsowicz, W. (2019). Health risk in road transport workers. Part I. Occupational exposure to chemicals, biomarkers of effect. *Int J Occup Med Environ Health*, *32*(3), 267-280. doi:10.13075/ijomeh.1896.01343

Hussein, S. F., & Goran, S. M. A. (2020). *Biological and Physical Enhancement of WWTP of KAR Refinery, Erbil, Kurdistan Region.* (master's thesis), Salahaddin University-Erbil (SUE), Erbil-Kurdistan.

Ibrahim, K. S., Amer, N. M., El-dossuky, E. A., Emara, A. M., El-Fattah Ael, S., & Shahy, E. M. (2014). Hematological effect of benzene exposure with emphasis of muconic acid as a biomarker. *Toxicol Ind Health*, *30*(5), 467-474. doi:10.1177/0748233712458141

Mantovani, A., Allavena, P., Sica, A., & Balkwill, F. (2008). Cancer-related inflammation. *Nature, 454*(7203), 436-444. doi:10.1038/nature07205

Montagnana, M., & Danese, E. (2016). Red cell distribution width and cancer. *Ann Transl Med*, *4*(20), 399. doi:10.21037/atm.2016.10.50

Okonkwo, C. O. J., Ehileboh, A. D., Nwobodo, E., & Dike, C. C. (2016). The effects of acute gasoline vapour inhalation on some haematological indices of albino Wistar rats. *Journal of Acute Disease, 5*(2), 123-125. doi:https://doi.org/10.1016/j.joad.2015.11.005

Okoro, A. M., Ani, E., Ibu, J., & Akpogomeh, B. A. (2010). Effect of petroleum products inhalation on some haematological indices of fuel attendants in CalabarMetropolis, Nigeria. *Nigerian journal of physiological sciences, 21*, 71-75. doi:10.4314/njps.v21i1-2.53954

Olusi, S. O. (1981). *Human health hazards associated with Petroleum related pollution.* Paper presented at the the 1981 seminar on Petroleum industry and the Nigerian Environment, Lagos.

World Health Organization [WHO] (2000). Benzene. In *Air Quality Guidelines for Europe* (3rd ed., pp. 62-66). Copenhagen: WHO Regional Office for Europe.

Pesatori, A., Garte, S., Popov, T., Georgieva, T., Panev, T., Bonzini, M., . . . Merlo, D. (2009). Early effects of low benzene exposure on blood cell counts in Bulgarian petrochemical workers. *La Medicina del lavoro, 100,* 83-90.

Ray-Coquard, I., Cropet, C., Van Glabbeke, M., Sebban, C., Le Cesne, A., Judson, I., . . . Blay, J. Y. (2009). Lymphopenia as a prognostic factor for overall survival in advanced carcinomas, sarcomas, and lymphomas. *Cancer Res, 69*(13), 5383-5391. doi:10.1158/0008-5472.Can-08-3845

Roma-Torres, J., Teixeira, J. P., Silva, S., Laffon, B., Cunha, L. M., Méndez, J., & Mayan, O. (2006). Evaluation of genotoxicity in a group of workers from a petroleum refinery aromatics plant. *Mutat Res, 604*(1-2), 19-27. doi:10.1016/j.mrgentox.2005.12.005

Ross, D. (2000). The role of metabolism and specific metabolites in benzene-induced toxicity: evidence and issues. *J Toxicol Environ Health A, 61*(5-6), 357-372. doi:10.1080/00984100050166361

Sajid Jabbar, A., & Ali, E. T. (2020). Impact of Petroleum Exposure on Some Hematological Indices, Interleukin-6, and Inflammatory Markers of Workers at Petroleum Stations in Basra City. *J Environ Public Health, 2020*, 7693891. doi:10.1155/2020/7693891

Salem, G. M., Shaboun, S., Algamodei, Y. M., Almalyan, M. F., Althwadi, E. M., Zaid, A. A., . . . Bahroun, S. A. (2022). Effect of occupational exposure on hematological and biochemical parameters in workers at oil and gas companies. *Mediterr J Pharm Pharm Sci, 2*(1), 100-108. doi:10.5281/zenodo.6399948

Smith, M. T. (1996). Overview of benzene-induced aplastic anaemia. *Eur J Haematol Suppl, 60,* 107-110. doi:10.1111/j.1600-0609.1996.tb01655.x

Snyder, R. (2000). Overview of the toxicology of benzene. *Journal of Toxicology and Environmental Health, Part A, 61*(5-6), 339-346. doi:10.1080/00984100050166334

Snyder, R. (2012). Leukemia and benzene. *Int J Environ Res Public Health, 9*(8), 2875-2893. doi:10.3390/ijerph9082875

Zhou, D., Shao, L., & Spitz, D. R. (2014). Reactive oxygen species in normal and tumor stem cells. *Adv Cancer Res, 122,* 1-67. doi:10.1016/b978-0-12-420117-0.00001-3

هەڵسەنگاندنا مەترسیێن پیشەیی لسەر گۆڕانکارییێن خوینێ یا کرێکارێن پاڵاوگەها کار یا نەفتێ ل پارێزگەها هەولێرێ، هەرێما کوردستانێ، عیراق

پوختە

کرێکارێن پاڵاودگاهێن نەفتێ بەرکەفتەی جۆرەها پێکهاتێت ژەهراوی کیمیاوی دبن کو د بەرهەمهێنانا وەرگیراوەێت نەفتێدا بکاردهینن. دڤێ توێژینەوەیێدا ١٠٠ کرێکاران بەشداری کریە کو دابەشکریبون لسەر دوو گرۆپان ; گروپێ بەرکەتیا پێکهاتبو ژ ٥٠ کرێکارێن کار دکر ل پاڵاودگەها نەفتێ (٣٤ نە جگارکێش و ٢٦ جگارکێش)، وگروپێ کۆنترۆڵا کو پێکهاتبو ژ ٤٠ کەسێن بەرنەکەفتی (٢٠ نە جگارکێش و ٢٠ جگارکێش). ئامانجا سەرەکی یا ڤی کاری نیشاندانا کارتێکرنا ئەگەریی یا وان غاز و هەڵما دەرچوی ژبەرهەمێت نەفتێ لەسەر پارامێتەرێن جیاوازێن خوێنێ (WBC و RBC و HGB و MCV و MCH و HCT و PLT و MCHC و RDW)، هەروەسا بۆ ئاشکراکرنا پەیوەندیا ئەوان بایۆمارکەرا دگەل سالێن بەرکفتنێ و جگارەکێشان و تەمەن و پیڤیرێن بارستا لەشی (BMI) یا کرێکارێن پاڵاوگەها کار. داتایێن مە کەمبوونەکا بەرچاڤ دئەنجامێن HGB و HCT و MCH و MCHC نیشان دا دگەل بەرزبوونەکا بەرچاڤ د بەهایێ RDW د گروپێ کرێکارێن بەرکەفتیدا دەما هاتینە بەراورد کرن دگەڵ گروپێ کۆنترۆڵکریدا. زێدەباری پەیوەندییەکا نەرێنی دناڤبەرا HGB و سالێن بەرکفتنێدا ودناڤبەرا PLT و BMI ئاشکرا بو. هەروەسا هەمی پێوەرێن دی تر یێن خوینێ پەیوەندییەکا بەرچاڤ نەبو دگەڵ گۆڕاوێت سەربەخۆدا. دڤێ توێژینەوەیێدا ئەم دگەهینە ئەوی ئەنجامی کو گۆڕانکاری دوان پارامێتەرێن خوینێدا ئاماژەیە بۆ تێکچوونا سیستەمێ خویندرووستکرنێ ژبەروێ بەرکەفتنا بەردەوام بو هەڵم و غازا بەرهەمێن پەترۆلێ.

تقييم المخاطر المهنية للتغيرات الدموية لعمال مصفى بترول كار في محافظة اربيل ،اقليم كوردستان ،العراق

الخلاصة

يتعرض العاملون في مصافي البترول لمجموعة متنوعة من المركبات الكيمياوية السامة المستخدمة في إنتاج المشتقات البترولية. في هذه الدراسة شارك ١٠٠ عامل وقسموا الى مجموعتين ; مجموعة المتعرضين وتكونت من ٥٠ عاملا اللذين عملوا في المصفى (٣٤ غير مدخن و ٢٦ مدخنا) ومجموعة السيطرة وتكونت من ٤٠ شخصا من غير المعرضين (٢٠ غير المدخنين و ٢٠ مدخنًا). كان الهدف الرئيسي من هذا العمل هو توضيح التأثيرات المحتملة لخليط الغازات والأبخرة المنبعثة من المنتجات البترولية على معايير دموية مختلفة (WBC و RBC و HGB و MCV و MCH و HCT و PLT و MCHC و RDW) وكذلك للكشف عن علاقة هذه المعاييرمع سنوات التعرض و التدخين والعمر ومؤشر كتلة الجسم للعاملين في مصفى كار. أظهرت النتائج انخفاضًا معنويا في HGB و HCT و MCH و MCHC مع ارتفاع في قيمة RDW في العمال المتعرضين مقارنة بمجموعة الضبط. كما تم الكشف عن ارتباط معنوي عكسي بين PLT و BMI وبين HGB و فترة الخدمة في المصفى. ووجد ان جميع مؤشرات الدم الأخرى لم يكن لها علاقة معنوية ملحوظة على بقية المتغيرات المستخدمة. من هذه الدراسة نستنتج أن التغييرات في مؤشرات الدم التي تم ملاحظتها تشير إلى حدوث ضرر في نظام تكوين الخلايا الدمويه وذالك بسبب التعرض المستمر لأبخرة المنتجات البترولية.