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Effect of occupational exposure on hematological and biochemical parameters in workers at oil and gas companies

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Abstract: Petroleum refineries are the largest chemical industries that are responsible for the emission of several pollutants into the atmosphere. Benzene and its metabolites are regarded as the most hazardous compounds emitted by petroleum refineries. These contribute to toxic oxidants, which cause many serious health risks to petroleum refinery workers. This study aimed to analyze the effects of chemical exposure on hematological and biochemical parameters among workers at Zawia oil refinery and Mellituh oil and gas refinery companies. A total of 200 workers participated in this study which consisted of two equal groups (each group: n=100). The first group consists of petroleum refineries workers and the second group consists of non-oil work civil servants who were recruited as exposed and control subjects, respectively. The results of blood pictures, liver enzymes and kidney functions were compared between the groups. Mean white blood cell counts, platelet counts, and hematocrit counts were significantly higher, while the mean red blood cell count was insignificantly changed in petroleum refinery workers. The mean hemoglobin and corpuscular hemoglobin concentration levels were significantly lower, the mean corpuscular volume and mean corpuscular hemoglobin levels were insignificantly changed in petrol refinery workers. Liver enzymes and renal functions were significantly higher in petrol refineries workers. The present findings indicate that occupational exposure to benzene causes significant alterations in hematological and biochemical parameters and workers are at high risk of developing blood, hepatic or renal-related disorders. Protection and frequent medical attention should be given to petroleum refinery workers.

Introduction

Worldwide, a huge number of people are exposed to petrol vapor as a part of their occupation or environmental place [1]. Petrol can be defined as a volatile liquid containing mixtures of particles and gases. Typically, there are more than 150 particulate chemicals in petrol, including minor quantities of organic compounds like

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aromatic and aliphatic hydrocarbons, metals such as lead and minute quantities of other compounds [2]. As the size of most particulate chemicals is less than ten microns, and the size of numerous particulate chemicals is less than one micron, approximately all those particles are respirable [3, 4]. The oil and gas industry has harmful chemicals through processing and operating. Environmentally, this industry is the main source of volatile aromatic hydrocarbons (VAHs) [5]. These VAHs were considered toxic oxidants that affect human health and the environments. The environmental levels of VAHs vapor can be increased significantly by the ambient temperature and the amount of petrol used in refinery operations [6, 7]. The most abundant hydrocarbon compounds are benzene, toluene, ethylbenzene and xylene (o-, m- and p-) commonly abbreviated as BTEX [8]. In petroleum refineries, among this group, BTEX, benzene is regarded as the most dangerous as it is involved in nearly every operation of petroleum refinery processes [6, 7]. The health hazard of benzene exposure in the atmosphere of petroleum refineries has been announced by numerous organizations using guideline values [9]. Benzene is classified as a class one carcinogen and mutagen which can contact animals and humans through several routes including inhalation, and oral and dermal exposure. But, the main route of benzene exposure at workplace is via inhalation [10]. The health consequences of benzene depend on the duration of exposure, in which, acute exposure to benzene causes dizziness, drowsiness, headache, fatigue, tremors and unconsciousness. However, more serious health outcomes occur on chronic benzene exposure including myeloma, myeloid leukemia and decreased production of white and red blood cells, weakened immunity. In addition to liver and kidney failure, central nervous system damage and cancer can be induced [11, 12]. The toxicity of benzene can be described using several mechanisms. The major toxic consequence of continuous benzene exposure is leucopoiesis suppression which causes increased vulnerability to infections and injuries [13]. Many years ago, health hazards were recognized among petroleum refineries workers in different ways. These hazards are problems in different parts of the world. Therefore, a series of studies were conducted to investigate the blood parameters in addition to renal and hepatic function testes of exposed workers [14, 15]. The objective of this study was to investigate the effects of exposure to petrol vapor on hematological and biochemical parameters (blood picture, liver enzymes and kidney functions) among Libyan workers in Zawia oil refinery and Mellituh oil and gas refinery companies located in west Tripoli (the capital city of Libya). This may indicate a hepatotoxic or nephrotoxic response among exposed workers at these companies.

Materials and methods

Study design: A comparative cross-sectional study was conducted among workers in Zawia refinery and Mellituh Company in west Libya during the period from 1st of March 2019 to 30th of July, 2019. The questionnaire was used to collect the following information: sociodemographic data, the occupational profile of the workers; usage of personal protective equipment, general health status and respiratory complaints.

Study group: The target group was the workers of Zawia oil refinery and Mellitah oil and gas refinery companies in west Tripoli. The workers in these two companies were either working in the field (exposed group) or doing office work (non-exposed group). A total of 200 blood samples were collected from the two groups. 100 blood samples from the first exposed group working in refinery services full-time. The second group comprised 100 of non-exposed workers working in services and offices at Zawia Medical Research Center, Zawia, Libya, comparable to the exposed group in most of the variables except for the risk of exposure to petrol. The workers in the two groups were interviewed and a blood sample was taken at the Department of Public Health and Community Medicine during the work day. Ethical consideration approval of the studied petrol refineries was obtained (2/2019). Consent for participation in the study was obtained for the exposed group and non-exposed volunteer office workers at the two refinery companies. The investigation was done for free.

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Laboratory analysis: Each participant gave a five ml blood sample through vein puncture for the following investigations. Complete blood picture (CBC) parameters were measured by placing two ml of blood sample in the ethylene diamine tetra-acetic acid (EDTA) test tube. While, the rest three ml of the blood sample were kept in plastic test tubes for kidney function tests (urea and creatinine) and liver function tests (alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP). The two test tubes for each participant were sent to a laboratory for analysis by 200 Mindray chemistry analyzer and 4040.

Statistical analysis: Data of petrol-exposed and unexposed subjects from the laboratory for all the investigations were reviewed and processed for statistical analysis. Descriptive statistics were used to express the data as Mean and Standard Deviation for each group. A paired t-test was used to assess the difference between benzene exposed group and the non-exposed group: $p<0.05$ was considered as statistically significant.

Results

Demographic characteristics: The subjects' demo-graphic data are shown in Table 2. A total of 200 subjects were included in this study. 100 subjects were exposed to petrol and the rest accounting for 100 were unexposed to petrol. The mean age for the exposed workers and the control group were 38.5±9.5 years and 40.0±11.5 years, respectively. The length of employment for the exposed group was 10.4±3.2 years.

Table 1: Demographic characteristic data of the subjects

Variable	Unexposed group	Exposed group
Age (years)	38.5±9.5	40.2±11.5
Experience (years)	----	10.4±03.2

Data are mean ± SD

Table 2: Hematological parameters of exposed and unexposed subjects to petrol

Parameters (units)	Exposed group (n=100)	Unexposed group (n=100)	P value
WBC (× 10^3 per µL)	08.1±02.3 ↑	07.5±02.2	0.05*
Platelets (× 10^3 per µL)	239.6±50.9 ↑	206.98±50.2	0.001***
RBCs (million cells per mcL)	4.74±0.53 ↑	04.66±0.86	0.100
Hemoglobin (g per dL)	14.01±2.19 ↓	14.9±1.18	0.001***
Hematocrit (%)	39.37±06.3 ↑	37.8±05.3	0.05*
MCV (fem to liter)	84.42±12.61 ↓	98.38± 09.9	0.07
MCH (pg/cell)	29.62±02.27 ↓	29.74± 02.9	0.37
MCHC (gm/dL)	37.07±05.6 ↓	39.24±05.78	0.01**

*Differences between benzene exposed and unexposed groups, Mean±SD. WBC White blood cells, RBC Red Blood cells, MCV mean corpuscular volume, MCH mean corpuscular hemoglobin, MCHC mean corpuscular hemoglobin concentration. Cells/mcL = cells per microliter and pg/cell = picograms per cell.

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Hematological parameters: The results of the complete blood picture are presented in **Table 2**. There are differences in hematological parameters between the unexposed and exposed subjects to petrol. The exposed workers experienced significantly increased mean WBC counts compared with the unexposed subjects (08.1±2.3 versus 07.5±2.2, $p<0.05$). Similarly, the mean platelet counts in the petrol-exposed group were significantly elevated compared with the non-exposed group (239.64±50.9 versus 206.98±50.2, $p<0.001$). The mean HB level (14.01±2.2 versus 14.9±1.2, $p< 0.001$), the percent hematocrit and MCHC level (39.37± 6.3 versus 37.8±5.3, $p<0.05$), (37.07±5.6 versus 39.24±5.78, $p< 0.01$) were significantly lower in petrol workers than the control group. All other blood parameters showed non-significant differences between the groups.

Liver function test (LFT): Data of LFT are presented in **Table 3**. The results showed statistically significant differences in all the liver function parameters between the exposed and non-exposed subjects to petrol. The exposed group had a highly significantly elevated mean concentration of alkaline phosphatase (u/L) as compared to non-exposed (178.2±84.3 versus 132.32±52.7, $p<0.001$). The mean aspartate aminotransferase (IU/L) levels were significantly higher in the exposed group compared with the unexposed group (25.6±7.4 versus 23.5±7.5, $p<0.05$). Similarly, the mean serum alanine aminotransferase (IU/L) levels were increased significantly in the benzene-exposed group compared with the unexposed group (22.3±9.47 versus 18.87±9.6, $p<0.01$).

Table 3: Liver function parameters of exposed and unexposed subjects to petrol

Laboratory parameter (units)	Exposed group (n = 100)	Unexposed group (n = 100)	P value
Alkaline phosphatase (u per L)	178.2±84.3	132.32±52.7	0.001***
Aspartate aminotransferase (units per L)	25.6±7.4	23.5±7.5	0.05*
Alanine aminotransferase (units per L)	22.3±9.47	18.87±9.6	0.01**

Data expressed as mean and SD,
*Differences between petrol-exposed and unexposed groups are significant.

Kidney function parameters (KFT): Data of KFT are presented in **Table 4**. The findings showed statistically significant differences in the tested kidney function parameters between the exposed and unexposed subjects to petrol. The mean serum creatinine levels were significantly increased in the petrol-exposed group compared with the unexposed group (0.98±0.27 versus 0.70±0.24, $p<0.001$). The mean blood urea nitrogen levels were significantly increased in petrol-exposed subjects compared with the unexposed subjects (33.9±9.3 versus 22.4±9.1, $p<0.001$).

Table 4: Kidney function test parameters between benzene-exposed and unexposed groups

Laboratory parameter	Exposed group	Unexposed group	P Value
Serum creatinine (mg per dL)	0.98±0.27	0.70±0.24	0.001***
Blood urea nitrogen (mg per dL)	33.9±9.3	22.4 ±9.1	0.001***

Data expressed as mean and standard deviation,
*Differences between benzene-exposed and unexposed groups are significant

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Discussion

Benzene, which is a major organic component of crude oil and gasoline, known as one of the predominant toxic air pollutants in the atmosphere. Environmental exposure to benzene has long been known as a carcinogen of human blood components. In addition, occupational exposure to benzene may cause non-carcinogenic effects including hematologic, hepatic, neurologic, renal and immunologic dysfunctions. However, the precise mechanism of the toxic effects of benzene is not fully understood [14, 16, 17]. Thus, a thorough knowledge of the health consequences of benzene exposure is important for determining approaches to estimate the risk that may help in early detection of pathological alterations caused by benzene exposure. Earlier, it has been approved that the other chemicals in addition to benzene in petroleum refineries affect the blood, kidney and liver functions [14, 17, 18]. Many epidemiological studies in different countries have shown an association between defined types of health problems and exposure to benzene and/or benzene-containing blends. Therefore, this search study was directed to inspect the health consequences of occupational exposure to petrol components mainly benzene on the hematological and biological parameters of the petrol refineries exposed group of workers compared to the control unexposed group of workers [13]. The findings of medical analysis demonstrated these findings. First, the funding showed that exposure to petroleum at oil refineries resulted in a significant increase in mean white blood cell counts, platelets count, hematocrit percent and a non-significant increase in red blood cells count. There were significant decreases in hemoglobin concentration, MCHC counts and non-significant decreases in MCV volume and MCH counts of petrol refinery workers than those of the comparison group. Similarly, in the hematological assessment of gasoline exposure among petrol-filling workers in Baghdad, the mean hemoglobin, white blood cells and red blood cells were significantly lower [19, 20], which is comparable to the current study for hemoglobin and different for white and red blood cells. While, in the hematological assessment of petrol station attendants in Egypt, the mean WBCs, platelets, HCT, and hemoglobin were increased in the exposed group, which is in line with the current study. However, red blood cells decreased and the other parameters have not changed among exposed, which is different to present study [14]. On the other hand, in hematological and biochemical assessment of liquefied petroleum gas the exposed group in Gaza governorates. The mean platelet, red blood cells, HCT were significantly higher, which is in line to present findings. Meanwhile, the other counts increased and white blood cells decreased in exposed group which is different to present findings [21]. Similarly, the mean hemoglobin, MCV, MCH, MCHC were decreased which agreed with current findings. However, the red and white blood cell counts were significantly decreased among petroleum exposed group at petroleum stations in Basra city which were different from the results of this study [13]. The Sudanese study done among petroleum station workers showed RBC, HCT, PLT and Hb decreased which is different from this study and comparable with the decrease in the mean WBC [22]. Although several earlier studies did not detect decreased blood cell counts on routine monitoring of workers exposed to low levels of benzene [14, 23, 24]. These results showed a significant effect of petroleum vapor exposure on the hematological parameters of petroleum refinery workers. Our results agree with the findings of previous studies of subjects exposed to petroleum vapor [14, 15, 17].

Liver cells may be damaged by benzene exposure and this damage can be determined by liver transaminase. The alanine transaminase enzyme is an enzyme present in numerous tissues' mitochondria. However, it is most commonly connected with the liver. So, it is a good biomarker of hepatocellular injury [25]. While the aspartate transaminase enzyme is present in eighty percent of tissues' mitochondria named mAST that primarily appears in blood as a result of severe cell necrosis and damage. While the rest 20% is found in the cytoplasm named cAST appears in blood as a result of cell injury. Therefore, different liver function parameters should be measured to increase the sensitivity, like alkaline phosphatase [26]. More specifically, in this study, the liver function was examined by estimating the serum enzyme levels among petrol exposed

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group and compared with the unexposed subjects. The findings showed that the serum levels were significantly elevated in the petrol refinery workers. Similarly, both liver enzymes were increased among the liquefied petroleum gas exposed group significantly as mentioned previously [21, 27] which come in line with current results. Also, comparable results were obtained in Nigeria [28] that stated the levels of the liver enzymes were significantly higher in the volatile petroleum hydrocarbons exposed group. These results agree with the results obtained from liquefied petroleum products or organic solvents exposures showed that long-term exposure to benzene vapor increased the risk of liver dysfunction. The reported significant elevation of some liver enzymes in these subjects may have been related to their exposure to benzene. The elevated serum levels of these enzymes could be due to the overproduction or release of enzymes from the hepatic cells in response to stimuli of hepatocellular injury or cell death. However, the exact mechanisms for overproduction or release of these serum enzymes in benzene-exposed subjects still remain to be explained [14, 17]. Urea and creatinine are nitrogenous end products of metabolism; the determination of serum creatinine and serum urea nitrogen levels is of great value in helping to check renal function in the clinical setting. Kidney dysfunction has been investigated using blood urea nitrogen and creatinine-based measures of renal function [29, 30]. Present findings showed that serum creatinine and blood urea nitrogen levels were significantly increased in petrol workers in the Zawia refinery and Mellitah Company. However, several previous studies reported similar findings among petroleum station workers in Sulaimani City (Kurdistan) and Mosul City (Iraq), in which serum levels of urea and creatinine were shown to be significantly elevated in the exposed group [3, 33]. Also, kidney functions (urea, creatinine and uric acid) were increased among liquefied petroleum gas exposed group significantly [21]. Similarly, the urea and creatinine were higher in petrol station attendees in Egypt [14]. The mixtures of aliphatic and aromatic hydrocarbons contained in petrol affect different organs in the body including the kidney. A previous study on both animals and humans suggests that the kidney can affected by several chemicals [34]. However, in this study, the findings showed that occupational exposure to petrol vapor is accompanied by prepathological, subclinical and clinical changes in blood parameters, and liver and kidney function. In some earlier published studies, the effect of exposure to benzene was well established and raised the hazard of carcinogenesis as lung and blood cancers in the exposed group [1, 6].

Conclusion: This study demonstrates that occupational exposure to petrol at oil and gas refineries caused significant alterations in hematological and biochemical parameters indicating that petrol refinery workers exposed to chemicals may be at a high risk of developing blood, hepatic, or renal-related disorders. Clinical investigations and periodic medical checkups including hepatic, renal, pulmonary, cardiac, and neurologic should be performed to monitor the long-term health consequences for petrol-exposed subjects. Personal protective equipment should be used at work to minimize workplace petrol exposure.

Author contributions: GMS, YMA, MFA, EMA & FFA conceived and designed the study, collected and analysis data; AAM, HA & OE collected data; SAH, SAB & SS analyzed and interpreted the results; AAZ & GMS drafted the first form of the manuscript with support from SS, FFA & SAH. All authors reviewed the final form and approved its submission.
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Ethical issues: Including plagiarism, informed consent, data fabrication or falsification and double publication or submission were completely observed by the authors.
Data availability statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.
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