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Insight into hematological parameters of petrol station workers

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Abstract. – OBJECTIVE: Benzene is one of the major carcinogenic factors that can affect liver, kidneys, and lungs. Chronic inhalation of benzene vapor by petrol stations workers has been shown to have an impact on hematological parameters; thus, the present study aimed to investigate the effect of benzene exposure on petrol station workers.

SUBJECTS AND METHODS: The study involved 99 participants, 50 of whom have been exposed to benzene and 49 of whom have not (control). A 5 ml blood sample in an ethylenediaminetetraacetic acid (EDTA) anticoagulant tube was collected from each subject, and a complete blood count test was used to test hematological parameters.

RESULTS: The current study showed a significant decrease in red blood cells, packed cell volume, and hemoglobin in the exposed group compared to the control group. However, the amount of white blood cells was significantly increased ($p < 0.0001$) in the exposed group compared to the control group. Notably, there was no significant difference in platelet counts between the two groups. In terms of exposure time, subjects who have been exposed to benzene for more than a year and fewer than 10 years showed a significant decrease ($p < 0.05$) in RBCs indices and a significant increase ($p < 0.0001$) in WBCs compared to those in the control group

CONCLUSIONS: Thus, the findings indicated that significant differences in hematological parameters were found in workers who were exposed to benzene compared to those who had not been exposed.

Key Words:
Benzene exposure, Hematological parameters, CBC, Petrol station workers, Benzene.

Introduction

Benzene is a natural element of crude oil and a by-product of petrol refining that is often released by oil refineries. It has been identified by the International Agency for Research on Cancer (IARC)[1,2] as one of the major occupational carcinogens among more than 165 occupational carcinogens. Gasoline, another crude oil product, has been well studied and considered as an environmental pollutant and toxicant. It has been found to be harmful to organs, such as the kidneys, lungs, and liver[3]. Because of heavy metals found in gasoline, vapor inhalation has been shown to alter hematological parameters and result in anemia through bone marrow hypoplasia[4].

Occupational illnesses afflicting those who work around and with benzene have been documented for many years and impacted workers in various ways. Moreover, such diseases continue to be a worldwide issue. In fact, the number of such work-related ailments in underdeveloped nations has significantly been higher than what has been reported. Notably, the prevalence and type of occupational sicknesses have increased in both developed and developing countries[5].

Historically, a complete blood count (CBC) has been acknowledged[6] as a simple and easily accessible screening technique for detecting benzene hematotoxicity. The typical benzene poisoning symptoms, such as headache, dizziness, and fatigue, have already been documented[7,8]. Long-term exposure to unprotected persons may further result in persistent suppression of bone marrow function and/or a decrease in the creation of new blood cells, leading to bone marrow disease, such as aplastic

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anemia (AA). These illnesses are thought to be induced by poisonous benzene metabolites in mature blood cells and bone marrow tissue[5,9,10]. In addition to that, chronic benzene exposure is thought to be linked with hematological cancers, including acute myeloid leukemia (AML), chronic myeloid leukemia (CML), acute lymphoblastic leukemia (ALL) and myelodysplastic syndrome (MDS)[11,12].

Several studies[13-15] have found that benzene and ethylene oxide were carcinogens prevalent in the workplace and among employees who were exposed to benzene. Even exposure to low amounts of benzene [< 1 part per million (ppm)] has been associated[16] with non-cancerous abnormalities, such as hematological changes and nervous system disorders. Furthermore, previous studies[17,18] have shown a link between benzene exposure and decreased white blood cells (WBCs), red blood cells (RBCs), lymphocytes, and neutrophils, even at low doses. Another study[19] has identified that an increase in temperature raised the rate of gasoline vaporization, which in turn increased the inhalation amount. This is critical because it might boost the health risk; therefore, nations with warm climates should focus on applying a limit to the amount of time that the station workers exposed to benzene spend in the workplace[20]. In addition, other studies[21,22] have investigated the effect of benzene on workers exposed to the carcinogen for long periods. However, there have been inconsistencies with the effect of benzene on hematological parameters. Therefore, this study aimed to accurately determine the change in the hematologic parameters for the petrol station workers group and find a correlation, if any, between the number of years working in these stations and the hematologic parameters of the same group.

Subjects and Methods

Study Design

A comparative cross-sectional case-control study was conducted to assess the differences in hematological parameters between petrol station workers and non-workers. The data were collected between May 2021 and April 2022. Before participating in the study, all subjects provided written informed consent for inclusion.

Sample and Procedures

This study involved 99 male volunteers. Fifty participants were petrol station workers (PSW), and 49 subjects who had never worked at the petrol stations served as the control group (CG). Additionally, the PSWs were divided into two subgroups (1-10 years and >10 years) according to the duration of their work at the petrol stations. Normal daily working hours were 8-10 hours, and the main nature of their jobs was filling petrol into vehicles.

Demographic data were collected from the participants via face-to-face interviews and self-administrated questionnaires. The questionnaire requested sociodemographic data regarding age, presence of chest disease, acute inflammation, and atypia. A 5 ml sample of venous blood from each participant was put into an ethylenediaminetetraacetic acid (EDTA) anticoagulant tube and analyzed with a Sysmex XS-500i hematology analyzer (SYSMEX Corp., Kobe, Hyogo, Japan). A CBC and differential blood count were performed to measure the hemoglobin (Hgb) packed cell volume (PCV), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red distribution width standard deviation (RDW-SD), mean platelet volume (MPV) and platelet distribution width (PDW) of each participant's sample, as well as determining each sample's RBC, WBC, neutrophil, lymphocyte, mixed differential WBC, and platelet counts.

Inclusion Criteria

Workers who were 18 years of age or older and workers who had worked more than one year at the petrol stations were included in the study.

Exclusion Criteria

Women, individuals younger than 18, smokers, cancer patients, people having vitamin deficiency, iron deficiency, myeloproliferative diseases, or any infection were excluded.

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-Wilk normality tests were conducted. Independent *t*-tests and Mann-Whitney tests were used to determine the differences between the groups and compare their hematological parameters. The Statistical Package for the Social Sciences (SPSS) v. 25 (IBM Corp., Armonk, NY, USA) was used for data management. A *p*-value lower than 0.05 was considered significant.

Results

Demographic Characteristics

Table I shows the number of workers at petrol stations and control subjects, including the time spent at the petrol stations. As expected, the

Table I. The frequency and age of study participants.

Participants	n (%)	Median age (range)
Workers[#]	50 (50.5)	27 (18-70) years
Control	49 (49.5)	29 (25-64) years
Total	99 (100)	-
Workers[#] >1 to ≤10 years	27 (54)	22 (18-30) years
Workers[#] >10 years	23 (46)	41 (24-70) years*
Total	50 (100)	-

[#]Represents the workers at the petrol station. n: mean number of participants. *Represents significance $p < 0.01$.

median age of individuals who worked for >10 years at the petrol stations was significantly higher than the group who spent < 10 years.

Comparison of Hematological Parameters between the Control and Worker Group

The data showed that RBC count ($p = 0.035$), Hgb ($p = 0.035$), PCV ($p = 0.006$), MCH ($p < 0.001$), MCHC ($p = 0.006$), and RDW-SD ($p < 0.001$) were significantly lower in the whole cohort of PSW than the CG (Table II). However, the WBC ($p < 0.001$), neutrophil ($p < 0.001$), lymphocyte ($p = 0.001$), and mixed counts (monocytes, eosinophils, and basophil) ($p < 0.001$) were significantly higher in all the cohort of PSW compared to the CG. However, there were no significant differences between the groups (PSW and CG) in platelet counts, MCV, and MPV levels (Table II).

Table II. Comparison between PSW and control groups according to hematological parameters.

Groups	Parameter	Mean ± SD/median	*p*-value
PSW CG	RBC (x10^6 cell/µl)	3.82 ± 0.941* 4.17 ± 0.640*	$p = 0.035$
PSW CG	Hb (g/dl)	12.63 ± 3.106* 13.77 ± 2.11*	$p = 0.035$
PSW CG	PCV (%)	35.62 ± 6.59* 39.01 ± 5.27*	$p = 0.006$
PSW CG	MCV (fl)	87.00[#] 86.70[#]	$p = 0.785$
PSW CG	MCH (pg)	33.50[#] 30.90[#]	$p < 0.0001$
PSW CG	MCHC (%)	36.50[#] 35.50[#]	$p < 0.0001$
PSW CG	RDW-SD	32.85[#] 38.10[#]	$p < 0.0001$
PSW CG	WBC (x10^3 cell/µl)	11.45[#] 5.40[#]	$p < 0.0001$
PSW CG	Neutrophil (x10^3 cell/µl)	4.87[#] 2.77[#]	$p < 0.0001$
PSW CG	Lymphocyte (x10^3 cell/µl)	3.39[#] 2.05[#]	$p = 0.001$
PSW CG	Mixed (x10^3 cell/µl)	0.99[#] 0.52[#]	$p < 0.0001$
PSW CG	Platelets (x10^3 cell/µl)	272.00[#] 269.00[#]	$p = 0.777$
PSW CG	MPV	7.85[#] 8.20[#]	$p = 0.154$
PSW CG	PDW	15.80[#] 17.70[#]	$p < 0.0001$

* and [#] represent mean ± SD and median, respectively. *p* represents significance. Petrol station workers (PSW), control group (CG), complete blood count (CBC), hemoglobin (Hgb), packed cell volume (PCV), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red distribution width standard deviation (RDW-SD), mean platelet volume (MPV), platelet distribution width (PDW), red blood cells (RBC), and white blood cells (WBC). Microliter (µl), deciliter (dl), picogram (pg), and femtoliter (fl).

Comparisons between Hematological Parameters and Working Period in the Subgroups of Petrol Station Workers

The PSW who worked 1-10 years at the petrol stations had a significantly lower RBC count ($p = 0.02$), Hgb concentration ($p = 0.02$), PCV ($p < 0.001$), MCH ($p < 0.0001$), MPV ($p = 0.035$), RDW-SD ($p < 0.0001$), and PDW ($p < 0.0001$) compared to the control group. However, these subgroup individuals (PSW for 1-10 years) exhibited significantly higher WBC ($p < 0.0001$), neutrophil ($p < 0.0001$), lymphocyte ($p = 0.002$), MCHC ($p = 0.005$) and mixed counts (monocytes, eosinophils, and basophil) ($p < 0.0001$) as compared to the control group (Table III). No significant changes were observed in MCV ($p = 0.182$) and platelet counts ($p = 0.724$).

As given above, a similar analysis was done for PSWs, who had worked for more than 10 years at the petrol station. Leukocyte counts [WBC, neutrophils, lymphocytes, mixed counts (monocytes, eosinophils, and basophil)] were found to be significantly higher compared to the CG individuals (Table IV). However, two hematological parameters, RDW-SD ($p = 0.047$) and PDW ($p = 0.001$), exhibited significantly lower values compared to the CG. The rest of the parameters from the PSW group (> 10 years) did not show any significant changes when compared to CG.

Table III. Comparison of hematological parameters between PSW worked for 1-10 years and CG individuals.

Parameter		Mean ± SD/median	*p*-value
RBC (x10^6 cell/µl)	Exposed >1 to ≤10 Control	3.68 ± 0.99* 4.17 ± 0.64*	$p < 0.02$
Hb (g/dl)	Exposed >1 to ≤10 Control	12.15 ± 3.29* 13.77 ± 2.11*	$p < 0.02$
PCV (%)	Exposed >1 to ≤10 Control	34.44 ± 5.35* 39.01 ± 5.27*	$p = 0.001$
MCV (fl)	Exposed >1 to ≤10 Control	87.60# 86.70#	$p = 0.182$
MCH (Pg)	Exposed >1 to ≤10 Control	34.00# 30.90#	$p < 0.0001$
MCHC (%)	Exposed >1 to ≤10 Control	37.10# 35.50#	$p = 0.005$
RDW-SD	Exposed >1 to ≤10 Control	20.50# 38.10#	$p < 0.0001$
WBC (x10^3 cell/µl)	Exposed >1 to ≤10 Control	12.40# 5.40#	$p < 0.0001$
Neutrophil (x10^3 cell/µl)	Exposed >1 to ≤10 Control	5.26# 2.77#	$p < 0.0001$
Lymphocyte (x10^3 cell/µl)	Exposed >1 to ≤10 Control	5.45# 2.05#	$p = 0.002$
Mixed (x10^3 cell/µl)	Exposed >1 to ≤10 Control	1.05# 0.52#	$p < 0.0001$
Platelets (x10^3 cell/µl)	Exposed >1 to ≤10 Control	268.00# 269.00#	$p = 0.724$
MPV	Exposed >1 to ≤10 Control	7.50# 8.20#	$p = 0.035$
PDW	Exposed >1 to ≤10 Control	5.30# 17.70#	$p < 0.0001$

* and # represent mean ± SD and median, respectively. *p* represents significance. Petrol station workers (PSW), control group (CG), hemoglobin (Hgb), packed cell volume (PCV), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red distribution width standard deviation (RDW-SD), mean platelet volume (MPV), platelet distribution width (PDW), red blood cells (RBC), and white blood cells (WBC). Microliter (µl), deciliter (dl), picogram (pg), and femtoliter (fl).

Table IV. Comparison between PSW (exposed > 10) and control group according to hematological parameters.

Parameter		Mean ± SD/median	*p*-value
RBC (x10^6 cell/µl)	Exposed >10 Control	3.99 ± 0.86* 4.17 ± 0.64*	$p = 0.334$
Hb (g/dl)	Exposed >10 Control	13.19 ± 2.84* 13.77 ± 2.11*	$p = 0.334$
PCV (%)	Exposed >10 Control	37.00 ± 7.70* 39.01 ± 5.27*	$p = 0.264$
MCV (fl)	Exposed >10 Control	84.50# 86.70#	$p = 0.310$
MCH (Pg)	Exposed >10 Control	32.70# 30.90#	$p = 0.133$
MCHC (%)	Exposed >10 Control	36.20# 35.50#	$p = 0.118$
RDW-SD	Exposed >10 Control	34.60# 38.10#	$p = 0.047$
WBC (x10^3 cell/µl)	Exposed >10 Control	8.70# 5.40#	$p = 0.003$
Neutrophil (x10^3 cell/µl)	Exposed >10 Control	4.14# 2.77#	$p = 0.016$
Lymphocyte (x10^3 cell/µl)	Exposed >10 Control	2.83# 2.05#	$p = 0.024$
Mixed (x10^3 cell/µl)	Exposed >10 Control	0.85# 0.52#	$p = 0.022$
Platelets (x10^3 cell/µl)	Exposed >10 Control	275.00# 269.00#	$p = 0.923$
MPV	Exposed >10 Control	8.40# 8.20#	$p = 0.913$
PDW	Exposed >10 Control	16.00# 17.70#	$p = 0.001$

* and # represent mean ± SD and median, respectively. *p* represents significance. Petrol station workers (PSW), control group (CG), hemoglobin (Hgb), packed cell volume (PCV), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red distribution width standard deviation (RDW-SD), mean platelet volume (MPV), platelet distribution width (PDW), red blood cells (RBC), and white blood cells (WBC). Microliter (µl), deciliter (dl), picogram (pg), and femtoliter (fl).

Discussion

Exposure to petroleum-derived chemicals such as benzene is linked to multiple hematological, immunological, hepatic, and chromosomal function abnormalities, and inhalation increases the risk of carcinogenesis[23]. Thus, studying the consequences of exposure to such chemicals on a person's health is crucial to developing approaches that can evaluate the risk to affected individuals. This study aimed to investigate the changes in hematological parameters among petrol station workers and compared these data with the control subjects. The results showed that although the hematological parameters of both groups' participants were within the normal ranges, including all the CBC categories, there were several significant differences between them, indicating that working in a petrol station can induce significant alterations in hematological function as a possible cause of exposing to chemicals such as benzene.

In the present study, RBC count, Hgb, PCV, and RDW-SD significantly decreased among the PSW group compared to the control group. Free radicals produced from benzene and other gasoline constituents can affect erythrocyte membranes and heme protein synthesis, resulting in shortened RBC lifespans as well as heme synthesis impairment and consequently lowering the Hgb content and RBC count[22]. Our results were in agreement with those of Ray et al[24] and Lan et al[25], who found that exposure to solvents like

benzene decreased RBC count and Hgb levels, causing anemia. Also, Neghab et al[26] reported a decrease in PCV in workers who were exposed to benzene. However, other studies[27,28] have reported a significant increase in Hgb and RBC in relation to benzene exposure. Discrepancies in the literature may be attributed to variations in sample sizes, sociodemographic variables, dose, and length of exposure to benzene.

Our results showed that the PSW showed significant elevations of MCH and MCHC compared with the control group, a finding supported by other studies[22,29]. We did not observe any change in MCV between the studied groups; however, this finding is inconsistent with other studies[29,30] in which a significant change in MCV was reported. The differences in these findings may be due to individual susceptibility to petroleum products, such as benzene[29].

Our study revealed that the PSW medians of the total WBC count and absolute numbers of differential WBCs, including neutrophils, lymphocytes, and mixed cells, were significantly increased compared with those of the control group, a finding similar to D'Andrea and Reddy's[28]. Our findings also agree with a study conducted in the Gaza Strip[31]. The increase in WBCs may indicate the activation of defense mechanisms in the immune systems of petrol station workers. Another study[24] conducted in India also showed a significant increase in WBC count, neutrophils, eosinophils, and monocytes in benzene-exposed workers. Elkhalifa[21] also reported a significant elevation in lymphocytes among Sudanese petrol station workers. Again, however, other studies[18,25,32] have linked benzene exposure with decreased WBC, neutrophil and lymphocyte counts.

Conflicting results have previously been reported in the literature in terms of platelet count in relation to benzene exposure. D'Andrea and Reddy[28] observed a significant elevation in the mean platelet count in the benzene-exposed group compared with the control group. In contrast, other studies[22,24] have stated that participants exposed to benzene had lower platelet counts than the non-exposed group. In the present study, although the median platelet count was slightly increased and the MPV was decreased in the PSW group, the differences were not statistically significant. However, the median PDW was significantly lower in PSW, suggesting that PDW may be an indicative blood parameter in cases of petroleum exposure. This finding is supported by a previous study conducted by Obeagu et al[33].

To assess the effect of the working period, the workers' group was divided into two subgroups according to the working length. Significant differences were observed between the subgroup with 1-10 years workers and the control group. Most of the RBC-related parameters (RBC count, Hgb, PCV, and RDW-SD) were found to be significantly lower at shorter working periods (1-10 years) compared with the control, although MCH and MCHC were elevated. Studies[34,35] have offered increasing evidence that erythrocytes are sensitive to benzene, even at low doses (< 1 ppm). In contrast, Uzma et al[32] reported that average Hgb concentrations did not change for up to 10 years of exposure; after that, the parameter significantly increased. They also observed an initial increase in eosinophil count in workers with less than 10 years of exposure[32]. Our results showed that in workers who had worked from 1 year to 10 years, every WBC type had a significantly higher value compared with the controls' values. Furthermore, the PDW also showed a significant increase.

With the increased working period (i.e., more than 10 years), the WBC count and differential cells showed significant differences compared to the control. Although the medians of the WBC parameters in those who worked > 10 years were significantly higher than those in the control groups, they were lower than the other subgroup's (1-10 years), indicating a reversing effect on WBC parameters as time increases. It has been previously reported in the literature that benzene exposure decreases the colony formation of myeloid progenitor cells, which are more sensitive to benzene toxicity than mature WBCs. The differentiation and proliferation processes in myelopoiesis of this group of workers may decrease, which provides such a pattern in hematological parameters in this study. Surprisingly, none of the other measured parameters (RBC count, Hgb, PCV, RBC indices, RDW-SD, platelet count, PDW, and MPV) showed significant variations between the group that worked for more than 10 years and the control group. These are unexpected results, as it is known that long-term exposure to toxic chemicals like benzene has been associated with deleterious effects on many biological systems, including the blood and blood-forming organs[24,36].

These unexpected findings could be attributed to many factors. For example, they could be due

to the cells' adaptation to petroleum products such as benzene in the bone marrow, with little response from leukocytes. Swedish researchers[37] have provided evidence of human adaptation to toxic chemicals, reporting that an Andean population has the ability to tolerate an environmental stressor: arsenic. Another possible explanation could be the exposure to other types of pollutants that could influence susceptibility to hematotoxicity. Other unmeasured factors affecting blood cells include nutritional status and exposure to other pollutants that may be distributed differently. These confounding factors may be attributed to the unexpected results shown by petrol station workers who worked for more than 10 years in this study, which show no significant differences in RBC indices compared to the control.

Other factors should be considered in terms of genetic polymorphism and an individual's natural ability to detoxify chemicals like benzene. Many genetic polymorphisms have been documented38 to influence susceptibility to benzene toxicity. For example, Nourozi et al[39] concluded that individuals with null GSTT1 and null GSTM1 genotypes were more susceptible to benzene-induced hematological disorders. Other studies[40,41] have indicated that individuals with high levels of metabolic enzymes that oxidize benzene into more toxic metabolites (such as CYP2E1) and low levels of metabolic enzymes that detoxify pathways (such as GSTT1 and GSTM1) are less resistant to benzene toxicity. Additionally, Kim et al[42] provided evidence that polymorphisms of the NQO1*2, CYP2E1, and EPHX1 genes, rs1051740 and rs2234922, affect the metabolism of benzene in humans. To determine exactly how this happens, further studies are required.

Limitations

The limitation of this research is the study's cross-sectional design, as it did not consider other factors, such as gender, that may have affected the changes. Furthermore, our sample size was small, which means that the results may not be representative of the entire population.

Conclusions

Hematological parameters are significantly altered in petrol station workers, which could be a possible cause of exposure to petroleum chemicals such as benzene. These changes may be used as indicators to protect workers from chronic diseases. Further studies should be conducted with larger sample sizes to raise awareness of benzene's effect on these government laborers.

Conflict of Interest

The authors declare that they have no conflict of interest to disclose.

Ethics Approval

All subjects provided written informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki of 1975 (as revised in 2013), and the protocol was reviewed and approved by the Research Ethics Committee (REC) of the University of Ha'il (reference number 42/5/47016, approved on 03/05/2021).

Informed Consent

All subjects provided written informed consent for inclusion before they participated in the study.

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Authors' Contributions

R.E. and N.K.B. conceived the study.; R.E., H.Q., designed the study protocol.; E.M.B., H.M.E.I., and M.M.A., carried out the clinical assessment.; E.M.B., H.M.E.I., and M.M.A. carried out the laboratory work.; E.M.B., H.M.E.I., and M.M.A. performed analysis.; E.M.B., H.M.E.I., M.W.A.K., and M.M.A. performed interpretation of the data.; R.E., N.K.B., and M.W.A.K.; drafted the manuscript. All authors critically revised the manuscript for intellectual content.

Data Availability

Data will be available upon request from the corresponding author.

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