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Research Article

Impact of Benzene Exposure on Hematological Parameters in Workers: A Comparative Cross-sectional Study with Healthy Non-Exposed Controls in Sudan

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Abstract

Benzene toxicity can lead to a range of serious health impairments, including various forms of anemia and several types of cancer, such as multiple myeloma, lymphoma, and leukemia. It is crucial to minimize exposure to benzene in industrial and environmental settings to protect public health and prevent these potentially life-threatening conditions. To investigate the potential impact of benzene exposure on the hematological profile of workers and to compare the results with those of a healthy, non-exposed population. A comparative cross-sectional study was conducted from July to November 2022 with Benzene workers at the Kosti benzene stations in Sudan were divided into two groups for a study: an exposure group consisting of eighty-seven individuals who were exposed to benzene, and an unexposed group of eighty-seven individuals who had no exposure. Blood samples were collected from all participants in Ethylene Diamine Tetra Acetic Acid (EDTA) tubes for Complete Blood Count (CBC) analysis. The results indicated that the mean values for Red Blood Cells (RBCs) count were significantly higher in the exposure group compared to the control group. Similarly, the lymphocyte count showed a significant increase in the exposure group versus the control group ($P<0.001$). Additionally, the Mean Cell Hemoglobin Concentration (MCHC) was also significantly elevated in the exposed individuals compared to the healthy participants ($P<0.001$). Conversely, the mean values for Mean Cell Volume (MCV) were significantly lower in the exposure group compared to the control group. Hemoglobin (Hb) levels were also significantly reduced in the exposed group versus the control group ($P<0.001$). The packed cell volume (PCV) was lower in the exposure group compared to the control ($P<0.001$). Other hematological significant decreases were observed in Mean Cell Hemoglobin (MCH), Neutrophil count, Monocyte count and Platelet (PLTs) count ($P < 0.001$). No significant differences were found in the mean values of Total White Blood Cells (TWBCs) count and Eosinophil count between the exposed and non-exposed groups. This analytical comparative study highlights the substantial influence of benzene exposure on

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the hematological parameters of Sudanese workers, indicating notable disparities in hematological variables, thus emphasizing the need for occupational exposure monitoring and protective strategies for benzine workers.

Keywords

Hb Concentration, Platelets Count, RBCs Counts, Benzene Exposure, TWBCs Count, Sudan

1. Introduction

Inhalation of benzene poses significant toxicity risks for workers in benzene-related environments [1]. Benzene exposure primarily originates from various industrial sources, including oil pipelines and refineries [2]. This chemical is associated with numerous adverse health effects and environmental contamination [3]. Key benzene components, such as Toluene, Ethylene, and Xylene, can lead to serious health conditions including various hematological malignancies. Additional health effects may include inflammation, hematotoxicity, and immunotoxicity [4, 5]. Research indicates that long-term benzene exposure correlates with decreased blood cell counts [6, 7]. Exposure to benzene at levels of 10 ppm or higher is linked to severe hematological changes [8]. Long-term exposure to benzene may result in DNA damage, cell cycle disruption, and oxidative stress [9]. Benzene is recognized as a carcinogen and mutagen, affecting multiple organ systems and immune function [10, 11]. Workers at benzene stations experience reduced RBC counts, with associations noted between low-level exposure and hematologic abnormalities [12].

The majority of studies highlight benzene's hematotoxicity impacting hematopoietic stem cells and altering hematological parameters [13-15]. This research aims to evaluate the hematological profile affected by benzene exposure in Kosti city, Sudan, in comparison to a healthy non-exposed cohort.

2. Material and Methods

A comparative cross-sectional study was conducted from July to November 2022 in Kosti city, Sudan. The study included 87 benzene workers as the exposure group and 87 non-exposed individuals as the control group. Venous blood samples (5 ml) were collected in EDTA anticoagulant tubes, and CBC parameters were analyzed using a hematology automated analyzer (Sysmex XK-21, Japan) from workers exposed to less than 1 ppm benzene for at least three years, alongside samples from the unexposed group.

All participants in the study group were workers exposed to benzene for eight or more hours daily for over three years. Individuals with blood diseases or those undergoing medication affecting CBC results, as well as smokers, were excluded from the study.

2.1. Ethical Approval

The study was approval by the ethics committee of University of El mam El Mahdi Faculty of medical laboratory sciences.

2.2. Statistical Analysis

Demographics and laboratory findings were entered for analysis with IBM Statistical Package for Social Science (SPSS) version 27. The Frequency distribution means and standard deviation were calculated and illustrated in the results tables. Significant changes in the hematological parameters were assessed using a t-test to determine any significant differences between the exposure and non-exposure group. The level of statistical significance is considered when the P-value <0.05.

3. Results

All participants in this study were males, 58.6% of them spent 3-5 continuous years with 8 hours daily exposed to vaporations of benzene, 19.50% of them more than 6-8 years continuously 8 hours daily, 10.3% worked 9-11 years continuously 8 hours daily, 8% spent 8 hours daily for 12-14 years, and 3.4% of them spent 8 hours daily for 15-17 years exposed to benzene.

Table 1 explains most of the study group is younger. 49.40% and 47.1% were aged from 31 to 40 years old, and 42.6% and 44.9% were aged 20-29 years old with the non-significant differences between the exposed and non-exposed group P=0.709. Tables 2 & 3 indicated significant decrease among exposed group mean values of Hb concentration (13.09±2.27g/dl vs, 14.80±1.47 g/dl), PCV (41.80 ± 3.45 l/l vs, 45.05±1.12 l/l), MCV (78.69 ± 4.66fl vs, 85.93 ± 6.73fl), MCH (25.80 ± 2.00 pg vs, 29.00±1.78pg), PLTs count (236.68 ± 61.37×103/l vs, 268.54±71.73×103/l), Neutrophil counts (39.87± 13.88% vs, 48.09±12.5%), and the Monocyte counts (3.60±2.32% vs. 5.66±1.72%), (P<0.001). On the other hand, the RBCs count (5.30±0.75×1012 vs 4.97±0.59×1012), lymphocyte count (44.61± 8.41% vs, 29.19± 3.98%), and MCHC (32.67 ±2.12% vs, 31.71±1.37%) showed significantly increased concerning exposure group versus comparative apparent healthy participants (P<0.001). A non-statistical difference was found between the mean values of TWBCs

(7.00±1.38×103/l vs, 6.66±2.12×103/l and the Eosinophil counts (2.69±1.70% vs. 2.49 ±1.09% among the exposed and non-exposed (P=0.35 and 0.21), respectively.

Table 1. *Distribution of Age among the benzene exposure and the non-exposure groups.*

Age range (Years)	Exposure (87) N (%)	Non-exposure (87) N (%)	*P*-Value
20-30	37 (42.6%)	39 (44.9%)	0.709
31-40	43 (49.4%)	41(47.1%)	
41-50	6 (6.9%)	5 (5.8%)	
51-65	1 (1.1%)	2 (2.2%)	

4. Discussion

All laborers in this investigation are males, and 90% are younger, within the age range of 20 to 40 years. These outcomes may be ascribed to societal issues; the predominant workforce in Sudanese fuel stations typically comprises males, and females generally do not engage in employment at fuel stations [16]. These observations correspond with a study conducted by Abozer Elderdery and his associates in 2015 among Sudanese fuel station employees, who indicated that the majority of laborers are younger males [16]. These insights underscore the need for further exploration of the socio-cultural factors influencing employment patterns in this industry, as well as potential strategies to promote gender inclusivity in the labor market.

Hematological modifications were documented among the benzene-exposed workers who have been subjected to less than one ppm of benzene vapor for 8 hours per day continuously for three consecutive years or more, consistent with the assertions of previous studies [6-8, 16, 17]. These alterations are regarded as reliable indicators of toxic effects resulting from benzene compounds [18]. Significant elevations were identified in the mean values of MCHC, RBC counts, and lymphocyte counts among the benzene-exposed participants relative to non-exposed individuals. These modifications serve as crucial biomarkers for assessing the toxicological impact of benzene and highlight the need for ongoing monitoring and protective measures for workers in environments where benzene exposure is a risk.

Current findings align with prior research that corroborated an increase in lymphocyte count and lymphocytosis in prolonged benzene inhalation scenarios. [16, 19, 20]. Furthermore, antecedent research noted an elevation in MCHC mean values in concordance with the present findings [21, 22]. Published investigations also reported a significant decline in RBC counts among those exposed to benzene, in contrast to the current findings [19, 21, 23, 24]. Results depicted in Tables 2 and 3 demonstrated a decrement in mean values of Hb concentration, monocyte counts, MCH, neutrophil counts, PLT counts, PCV, and MCV among the study cohort. Analogous to prior investigations, these results documented reductions in MCH and PLT counts along with a decrease in Hb concentration [21, 23, 25, 26]. The findings are also consistent with studies addressing a reduction in PCV mean values [22, 24, 26]. Conversely, earlier research indicated divergent results regarding the current hematological parameter outcomes [19, 24, 27]. A non-significant difference was observed concerning the mean values of the TWBC count, and the eosinophil counts among the exposed and non-exposed groups, which contradicts the conclusions of previous studies [24, 28]. This is consistent with other earlier findings that indicated a decrease in the TWBC count and noted a significant increase in eosinophil counts among those exposed to benzene [19, 21, 25, 29]. Overall, these findings contribute to the growing body of evidence on the hematological implications of benzene exposure, underscoring the necessity for continued research to clarify these inconsistencies and enhance our understanding of the compound's toxicological impact. Such research efforts should focus on elucidating the underlying mechanisms of benzene's effects on blood parameters, potentially incorporating genetic, environmental, and lifestyle factors that may modulate individual responses to exposure.

Table 2. *Statistical analysis and distribution of the RBCs counts, PCV, Hb, and red cell indices values (MCV, MCH, and MCHC), among the benzene exposure and Non-exposure groups.*

Variables	Exposure (87) N (%)	Mean ± SD	Non-exposure (87) N (%)	Mean ± SD	*P*-Value
Hb					
<13.5 g/dl	43(49.4%)	13.09±2.27g/dl	10(11.5%)	14.80±1.47 g/dl	<.001*

Variables	Exposure (87)		Non-exposure (87)		*P*-Value
	N (%)	Mean ± SD	N (%)	Mean ± SD	
13.5-17.5 g/dl	41(47.1%)		75(86.2%)		
>17.5 g/dl	3(3.5%)		2(2.3%)		
PCV					
<40 l/l	23(26.4%)		5(5.8%)		
40-52 l/l	59(67.8%)	41.80 ± 3.45 l/l	80 (91.9%)	45.05±1.12 l/l	<.001*
>52 l/l	5(5.8%)		2(2.3%)		
RBCs Count					
< 4.5 x 10^{12}	9 (10.4%)		10(11.5%)		
4.5-6.5 x 10^{12}	51(58.6%)	5.30±0.75×10^{12}	73(83.9%)	4.97±0.59×10^{12}	0.002*
>6.5 x 10^{12}	27(31%)		4(4.6%)		
MCV					
<80 fl	53(60.9%)		7(8%)		
80-95 fl	25(28.7%)	78.69±4.66fl	77(88.5%)	85.93±6.73fl	<.001*
>95 fl	9(10.4%)		3(3.5%)		
MCH					
<27 pg	75(86.1%)		8(9.2)%		
27-34 pg	9 (10.4%)	25.80±2.00pg	73(83.9%)	29.00±1.78pg	<.001*
>34 pg	3(3.5%)		6(6.9%)		
MCHC					
<20%	10(11.5%)		2(2.3%)		
20-35%	68(78.1%)	32.67±2.12%	81 (93.1%)	31.71±1.37%	<.001*
>35%	9(10.4%)		4(4.6%)		

*Significant at P < 0.05

Table 3. *Statistical analysis and frequencies of the PLTs, TWBCs, Lymphocyte, Neutrophil, Eosinophil, and Monocyte among the benzene exposure and Non-exposure.*

Variables	Exposure		Non-exposure		*P*-Value
	N (%)	Mean±SD	N (%)	Mean±SD	
TWBCs					
<4×10^3 /l	5(5.8%)		3(3.5%)		
4-11×10^3 /l	74(85%)	7.00±1.38×10^3/l	82(94.2%)	6.66±2.12×10^3/l	0.21
>11×10^3 /l	8(9.2%)		2(2.3%)		
PLTs count					
<150×10^3 /l	14(16.1%)	236.68±61.37×10^3/l	2(2.3%)		
150-400×10^3 /l	71(81.6%)		80(92%)	268.54±71.73×10^3/l	<0.001*

Variables	Exposure		Non-exposure		*P*-Value
	N (%)	Mean±SD	N (%)	Mean±SD	
>400×10^3 /l	2(2.3%)		5(5.7%)		
Neutrophil count					
<40%	36(41.4%)		2(2.3%)		
40-80%	47(54%)	39.87±13.88%3%	83(95.4%)	48.09±12.5%	<0.001*
>80%	4(4.6%)		2(2.3%)		
Lymphocyte count					
<20%	3(3.5%)		4(4.6%)		
20-40%	15(17.2%)	44.61±8.41%	78(89.6%)	29.19±3.98%	<0.001*
>40%	69(79.3%)		5(5.8%)		
Monocyte count					
<4%	9(10.3%)		4(4.6%)		
4-10%	72(82.8%)	3.60±2.32%	81(93.1%)	5.66±1.72%	<0.001*
>10%	6(6.9%)		2(2.3%)		
Eosinophil count					
1%	7(8%)		3(3.5)%		
2-4% >4%	75(86.2%) 5(5.8)	2.69 ±1.70%	82(94.2%) 2(2.3%)	2.49 ±1.09%	0.35

*Significant at P < 0.05

5. Conclusion

This comparative analysis elucidates the significant effects of benzene exposure on the hematological parameters of Sudanese workers, emphasizing the immediate necessity for improved occupational exposure monitoring and protective measures for those engaged with benzene, thus enriching the existing literature on the health hazards of benzene and urging policymakers and health authorities to prioritize worker safety in benzene-exposed environments.

Abbreviations

EDTA	Ethylene Diamine Tetra Acetic Acid
CBC	Complete Blood Count
RBCs	Red Blood Cells
MCHC	Mean Cell Hemoglobin Concentration
MCV	Mean Cell Volume
Hb	Hemoglobin
PCV	Packed Cell Volume
MCH	Mean Cell Hemoglobin
PLTs	Platelet
TWBCs	Total White Blood Cells

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Data Availability Statement

The datasets utilized and examined in the present study can be requested from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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