

Haematological Changes in Benzene Exposed Workers in Sudan

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Research article

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Abstract

Background: Exposure to benzene leads to toxicity and influences bone marrow leads to cancer, anaemia, lymphoma, multiple myeloma, leukaemia, aplastic anaemia, and other types of cancer. The current study aims to report haematological changes in workers exposed to benzene exposure <1 ppm compared with the participants of non-exposed to benzene.

Methods: Analytical cross-sectional study design applied at Kosti city, Sudan, during the year 2018. According to inclusion criteria, eighty-seven benzene stations workers chosen randomly to participate as a study group and another eighty-seven apparent healthy non-exposed to benzene, age matched, chosen as a comparative group. Blood samples (2.5ml) collected from all participants in EDTA anticoagulant containers for Complete Blood Cells analysis.

Results: The means of the lymphocyte, RBCs count, and MCHC significantly increased in the benzene stations workers compared with the non-exposed group. The lymphocyte mean ($44.61 \pm 8.41\%$ vs, $29.19 \pm 3.98\%$; $P < 0.001$), RBCs mean ($5.30 \pm 0.75 \times 10^{12}$ vs, $4.97 \pm 0.59 \times 10^{12}$; $P = 0.002$), and HCHC mean ($32.67 \pm 2.12\%$ vs, $31.71 \pm 1.37\%$; $P < 0.001$). The means of PCV, Hb, MCH, MCV, PLTs count, Monocyte counts, and the Neutrophil counts significantly decreased in the exposed group. The PCV mean (43.83 ± 2.47 l/l vs, 44.95 ± 1.15 l/l; $P < 0.001$), Hb mean (13.11 ± 2.28 g/dl vs, 14.33 ± 1.48 g/dl; $P < 0.001$), MCH mean (26.35 ± 2.01 pg vs, 29.88 ± 1.98 pg; $P < 0.001$), MCV mean (78.69 ± 4.66 fl vs, 85.93 ± 6.73 fl; $P < 0.001$), PLTs mean ($240.78 \pm 71.37 \times 10^3$ /l vs, $262.54 \pm 70.77 \times 10^3$ /l; $P = 0.046$), Monocyte mean ($4.44 \pm 2.39\%$ vs. $5.64 \pm 1.92\%$; $P = 0.001$), and Neutrophil mean ($36.98 \pm 14.93\%$ vs, $47.99 \pm 14.54\%$; $P < 0.001$). The Eosinophil counts and TWBCs count showed no statistically significant difference between the two groups.

Conclusion: The exposure to benzene has a significant haematological change in most of the complete blood count parameters among the benzene stations workers.

Background:

Benzene inhalation considered the most susceptible benzene toxicity among benzene station workers. ⁽¹⁾ The benzene exposure may occur through benzene fuel stations, chemical industry, oil pipelines, fuel tankers, petroleum refineries, and bus garages. ⁽²⁾ However, benzene is a highly volatile organic compound associated with many adverse health effects among both children and adults, in addition, contaminates the environment. ⁽³⁾ Exposure to benzene risk related to main components known as (BTEX), which include Toluene, Ethylene, Xylene, and Benzene. ⁽⁴⁾ Exposure to benzene leads to toxicity, which influences bone marrow, and leads to cancer, anaemia, lymphoma, multiple myeloma, leukaemia, aplastic anaemia, and other types of cancer. ⁽²⁾ Benzene exposure may cause other adverse effects include skin irritation, inflammation of the nasal airways and throat, central nervous system depression, immunotoxicity, and haematotoxicity. ⁽⁵⁾ Occupational previous studies reported some haematologic abnormalities and a decrease in blood cell count among workers exposed to benzene. ^(6,7) An earlier

study done among workers chronically exposed to benzene air concentrations around or more 10 ppm, indicated haematological severe health effects with increasing benzene exposure levels. ⁽⁸⁾ Another study reported a programmed cell death, DNA damage, oxidative stress, and cell cycle disruption associated with benzene exposure. ⁽⁹⁾ Furthermore, the benzene component considered the most hazardous substance due to it is carcinogenic and mutagenic metabolites effects. ⁽³⁾ Accordingly, the benzene is metabolically activated with cytochrome P450 enzymes, resulting in Haematotoxicity. ⁽¹⁰⁾ However, exposure to benzene is usually associated with a wide range of non-cancer effects, which include haematological alterations, central nervous system, hepatic impairments, and renal functions. ⁽¹¹⁾ Moreover, benzene interferes with humoral and innate cellular immunity leading to disruption of immune function. ⁽¹²⁾ Previous studies linked exposure to benzene with the abnormality of some haematologic parameters, including the decreased Total White Blood Cells count (TWBCs), Red Blood Cells count (RBCs), lymphocyte, and neutrophil even at low exposure levels, < 1 ppm. ^(8,13) A study done in a Korean worker considered RBCs count parameter reduced by low benzene exposure level. ⁽⁶⁾ In recent years, the possible underlying mechanisms of the benzene-mediated haematotoxicity widely studied. ⁽¹⁴⁾ The metabolic toxicity of benzene act on the mature blood cells and the haematopoietic stem progenitor cells cause abnormality in the Complete Blood Counts (CBC) and suppresses hematopoietic tissue function. ^(3,15) The current study aims to investigate any susceptible CBC changes among benzene stations workers who exposed to benzene components at least three continuous years or more and compared with apparently healthy individuals at Kosti town, Sudan.

Methods:

Study Design:

Analytical cross-sectional study design applied at Kosti city benzene stations, Sudan, from July to November 2018 to report haematological changes in benzene stations workers exposed to benzene exposure (<1 ppm) for more than three years or more, 8 hours per day continually and compared with the participants of non-exposed to benzene.

Sample size and sampling:

According to inclusion criteria, eighty-seven benzene stations workers chosen randomly to participate as a study group and another Eighty-seven apparent healthy non-exposed to benzene, matched sex and age, chosen randomly as a comparative group.

Inclusion and Exclusion Criteria:

All benzene station workers who spent more than three years or more, 8 hours daily at Kosti benzene stations, and agree to participate included with participation rate 83%. The participants who refused to

participate, participants with blood diseases, participants with a hemorrhagic disease, participants under medication effects CBC, participants with Allergy and, smoking habits, ⁽⁸⁾ excluded.

Laboratory Analysis:

Blood samples (2.5ml) collected from each participant after the summer season in the morning to prevent dehydration of participants. The specimens collected in a labeled Ethylenediaminetetraacetic acid (EDTA) anticoagulant containers, mixed, checked for the absence of clots, and immediately examined for CBC using (XK-21 Sysmex, Japan) automated haematology analyzer.

Statistical Analysis:

Laboratory and demographic data analyzed using Statistical Package for the Social Sciences, IBM SPSSversion-25. Means and standard deviation, Frequency distribution, and the independent sample t-test applied to determine if there are any significant changes in CBC components among the benzene exposure group compared to the healthy individual group. An alpha error of 0.05 and *P*-value ≤ 0.05 considered as the level of significance.

Results:

Hundred percent of the study participants are male, 58.6% of the benzene stations workers spent 3-5 years continuously exposed daily to benzene concentration, 19.5% spent 6-8 years, 10.3% spent 9-11 years, 8% spent 12-14 years, and 3.4% spent 15-17 years working in the benzene stations. **Table 1** shows that the age of participants (49.4%, 47.1%) ranges between 31 and 40 years old, followed by 20-29 years old (42.6%, 44.9%). The age range indicated younger workers in the benzene stations.

Table 1
Distribution of Age among the Benzene exposure group and non-exposed group.

Category	Exposed to benzene group n=87		Non exposed to benzene group n=87		P-Value
	Frequency	percent	Frequency	percent	
20-30years old	37	42.6%	39	44.9%	
31-40 years old	43	49.4%	41	47.1%	
41-50 years old	6	6.9%	5	5.8%	
51-65 years old	1	1.1%	2	2.2%	
Mean±SD	30.98±5.04		30.67±5.88		0.709

Table 2 explains the distribution of PCV, Hb, RBCs counts, and red cell indices values (MCH, MCHC, and MCV) among the benzene exposure group and non-exposed group.

Table 2
Distribution of Hb, PCV, RBCs counts, and red cell indices values (MCV, MCH, and MCHC),
among the Benzene exposure group and non-exposed group.

Variable	Exposed N (%)	Non-exposed N (%)
Haemoglobin concentration (Hb)		
<13.5 g/dl	43 (49.4%)	10(11.5%)
13.5-17.5 g/dl	41(47.1%)	75(86.2%)
>17.5 g/dl	3(3.5%)	2(2.3%)
Blood Cell Volume (PCV)		
<40 l/l	23(26.4%)	5(5.8%)
40-52 l/l	59 (67.8%)	80 (91.9%)
>52 l/l	5(5.8%)	2(2.3%)
Red Blood Cells Count (RBCs)		
<4.5 x 10 ¹²	9 (10.4%)	10(11.5%)
4.5-6.5 x 10 ¹²	51(58.6%)	73(83.9%)
>6.5 x 10 ¹²	27(31%)	4(4.6%)
Mean Cell Volume (MCV)		
<80 fl	53(60.9%)	7(8%)
80-95 fl	25(28.7%)	77(88.5%)
>95 fl	9(10.4%)	3(3.5%)
Mean Cell Haemoglobin (MCH)		
<27 pg	75(86.1%)	8(9.2)%
27-34 pg	9 (10.4%)	73(83.9%)
>34 pg	3(3.5%)	6(6.9%)
Mean Cell Haemoglobin Concentration (MCHC)		
<20%	10(11.5%)	2(2.3%)
20-35%	68(78.1%)	81 (93.1%)
>35%	9(10.4%)	4(4.6%)

Table 3 Summaries the frequencies of PLTs count, TWBCs count, Lymphocyte count, Neutrophil counts, Eosinophil counts and Monocyte count values among the Benzene exposure group and non-exposed group.

Table 3

Distribution of TWBCs count, PLTs count, Neutrophil counts, Lymphocyte count, Monocyte counts, and Eosinophil counts values among the Benzene exposure group and non-exposed group.

Variable	Exposed N (%) n=87	Non-exposed N (%) n=87
Total White Blood Cells Counts (TWBCs)		
<4×10 ³ /l	5(5.8%)	3(3.5%)
4-11×10 ³ /l	74(85.1%)	82(94.2%)
>11×10 ³ /l	8(9.1%)	2(2.3%)
Platelets count(PLTs)		
<150×10 ³ /l	14(16.1%)	2(2.3%)
150-400×10 ³ /l	71(81.6%)	80(91.9%)
>400×10 ³ /l	2(2.3%)	5(5.8%)
Neutrophil counts		
<40%	36(41.4%)	2(2.3%)
40-80%	47(54%)	83(95.4%)
>80%	4(4.6%)	2(2.3%)
Lymphocyte counts		
<20%	3(3.5%)	4(4.6%)
20-40%	15(17.2%)	78(89.6%)
>40%	69(79.3%)	5(5.8%)
Monocyte counts		
<4%	9(10.3%)	4(4.6%)
4-10%	72(82.8%)	81(93.1%)
>10%	6(6.9%)	2(2.3%)
Eosinophil counts		
1%	7(8%)	3 (3.5%)
2-4%	75(86.2%)	82(94.2%)
>4%	5(5.8)	2(2.3%)

The findings of the current study revealed that the means of the lymphocyte counts, Red Blood Cells (RBCs) count, and Mean Cell Haemoglobin Concentration (MCHC) statistically significantly increased in the benzene workers group compared with the non-exposed group; the lymphocyte counts mean (44.61 ± 8.41 % vs, 29.19 ± 3.98 %; $P < 0.001$), Red Blood Cells Count (RBCs) mean ($5.30 \pm 0.75 \times 10^{12}$ vs, $4.97 \pm 0.59 \times 10^{12}$; $P = 0.002$), and HCHC mean (32.67 ± 2.12 % vs, 31.71 ± 1.37 %; $P < 0.001$). **Tables 4, 5** The means of Blood Cell Volume (PCV), Haemoglobin Concentration (Hb), Mean Cell Haemoglobin (MCH), Mean Cell Volume (MCV), Platelets count (PLTs), Monocyte count and the Neutrophil counts were statistically significantly decreased in the benzene stations workers group compared with the non-exposed group. The PCV mean (43.83 ± 2.47 l/l vs, 44.95 ± 1.15 l/l; $P < 0.001$), Hb mean (13.11 ± 2.28 g/dl vs, 14.33 ± 1.48 g/dl; $P < 0.001$), MCH mean (26.35 ± 2.01 pg vs, 29.88 ± 1.98 pg; $P < 0.001$), MCV mean (78.69 ± 4.66 fl vs, 85.93 ± 6.73 fl; $P < 0.001$), PLTs count mean ($240.78 \pm 71.37 \times 10^3$ /l vs, $262.54 \pm 70.77 \times 10^3$ /l; $P = 0.046$), Monocyte counts (4.44 ± 2.39 % vs. 5.64 ± 1.92 %; $P = 0.001$), and the mean of Neutrophil counts (36.98 ± 14.93 % vs, 47.99 ± 14.54 %; $P < 0.001$). The Eosinophil counts and Total White Blood Cells Counts (TWBCs) showed no statistically significant difference between the benzene station workers and the non-exposed group. Eosinophil count mean (2.70 ± 1.72 % vs. 2.50 ± 1.08 %; $P < 0.373$), and the mean TWBCs ($7.00 \pm 2.37 \times 10^3$ /l vs, $6.67 \pm 2.02 \times 10^3$ /l; $P = 0.316$). **Tables 4, 5**

Table 4

Haematological parameters Hb, PCV, RBCs counts, and red cell indices values (MCV, MCH, and MCHC) among the Benzene exposure group and non-exposed group.

Parameter		N	Mean	SD	t	P value
Haemoglobin concentration (Hb)	Exposed	87	13.11 g/dl	2.28 g/dl	-4.154	<.001*
	Non-exposed	87	14.33 g/dl	1.48 g/dl		
Blood Cell Volume (PCV)	Exposed	87	43.83 l/l	2.47 l/l	-3.838	<.001*
	Non-exposed	87	44.95 l/l	1.15 l/l		
Red Blood Cells Count (RBCs)	Exposed	87	5.30 x 10 ¹²	0.75 x 10 ¹²	3.184	0.002*
	Non-exposed	87	4.97 x 10 ¹²	0.59 x 10 ¹²		
Mean Cell Volume (MCV)	Exposed	87	78.69 fl	4.66 fl	-8.244	<.001*
	Non-exposed	87	85.93 fl	6.73 fl		
Mean Cell Haemoglobin (MCH)	Exposed	87	26.35 pg	2.01 pg	-11.672	<.001*
	Non-exposed	87	29.88 pg	1.98 pg		
Mean Cell Haemoglobin Concentration (MCHC)	Exposed	87	32.67%	2.12%	3.549	<.001*
	Non-exposed	87	31.71%	1.37%		

*Significance at the level ≤ 0.05 N-Number-SD-Standard Deviation

Table 5

Haematological parameters TWBC counts, PLTs count, Neutrophil counts, Lymphocyte count, Monocyte counts, and Eosinophil counts and t-test analysis values among the Benzene exposure group and non-exposed group.

Parameter		N	Mean	SD	t	P value
Total White Blood Cells Counts (TWBCs)	Exposed	87	7.00x10 ³ /l	2.37x10 ³ /l	1.006	0.316
	Non-exposed	87	6.67x10 ³ /l	2.02x10 ³ /l		
Platelets count(PLTs)	Exposed	87	240.87x10 ³ /l	71.37x10 ³ /l	-2.010	0.046*
	Non-exposed	87	262.54 x10 ³ /l	70.77 x10 ³ /l		
Neutrophil counts	Exposed	87	36.98%	14.93%	-4.924	<.001*
	Non-exposed	87	47.99%	14.54%		
Lymphocyte counts	Exposed	87	44.61%	8.41%	15.457	<.001*
	Non-exposed	87	29.19%	3.98%		
Monocyte counts	Exposed	87	4.44%	2.39%	-3.630	<.001*
	Non-exposed	87	5.64%	1.92%		
Eosinophil counts	Exposed	87	2.70%	1.72%	0.893	0.373
	Non-exposed	87	2.50%	1.08%		

*Significance at the level ≤ 0.05 N-Number-SD-Standard Deviation

Discussion:

According to the study results, all the benzene station workers participating in this study are male, and the majority of them (90%) are youngsters with an age range from 20 to 40 years old. These findings are consistent with the study conducted in Sudan in 2015 by Abozer Elderderly and his research team who stated that fuel stations workers are younger male and due to social issues in Sudan females didn't work in fuel stations. ⁽¹⁶⁾ The results of some previous studies reported significant changes regarding haematological indices among benzene-exposed people compared with the non-exposed. ^(16, 17) However, changes in the blood parameters and cell indices are considered a reliable toxic effects indicator of the substance, such as heavy metals, benzene, and drugs. ⁽¹⁸⁾ Our findings reported significant changes in

haematological parameters among benzene stations workers who exposed to benzene exposure < 1 ppm for more than three years or more, 8 hours per day continually, support the previous studies' potential haematotoxicity findings. ^(6-8, 16-17) The findings of the current study indicate significant increases in lymphocyte counts, RBCs count, and MCHC means in the benzene workers group when compared with the non-exposed group. Table 4, 5 These findings come in agreement with previous studies conducted by Abozer et al., ⁽¹⁶⁾ Alfadaly et al., ⁽¹⁹⁾ and Liu et al. ⁽²⁰⁾ who confirmed significantly higher lymphocyte count and lymphocytosis among long-term benzene exposure. The same results recorded in the previous studies ^(21, 22) regarding increased MCHC. However, other studies stated decreased RBCs counts in participants exposed to benzene compared with the non-exposed groups conversely the increased RBCs count findings in this study. ^(19, 21, 23, 24) Furthermore, the study results illustrated in Table 4 and Table 5 showed a significant reduction in the means of PCV, Hb, MCH, MCV, PLTs count, Monocyte counts, and the Neutrophil counts among benzene station workers compared with the healthy individuals. These findings are in agreement with many studies ^(21, 23, 25) reported a decrease in PLTs count and decreases in MCH among benzene exposure workers and with the study, ⁽²⁶⁾ who reported a reduction in Hb concentration. The findings also agree with previous studies ^(22, 24, 26) which stated the same results regarding decreases of PCV. While other studies concluded inconsistent findings, concerning the mentioned haematological parameters results in the exposed groups compared with the non-exposed groups. ^(19, 24, 27) No statistically significant difference observed in individuals who were exposed to benzene and non-exposed to benzene regarding Eosinophil counts and TWBCs count, as illustrated in Tables 4, 5. These findings support previous studies ^(24, 28) regarding increased TWBCs count and contrast with the previous studies ^(21, 25, 29) who mentioned decreases in TWBCs count in benzene exposed compared to unexposed controls, and the study ⁽¹⁹⁾ who reported increased Eosinophil counts. The difference between recent study results and those of the other studies could be due to the period of exposure to benzene, blood parameters measured, and study design.

Conclusion:

According to the study's findings, benzene exposure has apparent influence in most of the complete blood count parameters among the benzene stations workers compared with non-exposed to benzene. However, further researches needed to validate the current findings.

Declarations

Acknowledgment:

Author would like to thank all participants

Funding:

Availability of data and materials:

The datasets of the current study are available from the author on reasonable request.

Ethical approval:

Each participant completed the informed consent form before collecting the specimens. Ethical approval obtained from the ethics and research board at the Medical Laboratory Sciences Faculty at the University of El Imam El Mahdi, Sudan, according to the Helsinki declaration ethical standards.

Consent for publication:

Not applicable.

Competing interests:

The authors declare that they have no competing interests.

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