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Adverse effect of chronic lead paint exposure among painting workers in Wadi AL-hayah, Obary, Libya

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A B S T R A C T

Lead is a toxic and harmful substance that can impact the homeostasis process of blood components and blood pressure. The objective of the study was to evaluate blood lead levels among painting workers (lead paint exposed group) and in unexposed group (control group).The second objective was to investigate its impact on hematological components and blood pressure. A total of 64 adult male subjects whose ages ranged between 20-45 years were included in this study, 34 of painting workers and 30 subjects as a control group. All the results were statistically analyzed using SPSS version 14 for applying one way ANOVA test. The mean age of painting workers was 33.02 ± 7.02 years and 34.23 ±7.12 years control group. Blood lead, RBCs, WBCs, Hb, HCT, MCV, MCH and systolic, diastolic blood pressure were measured in the study. Blood Lead level of exposed group was 6.39±3.32 µg/dL and 1.25±0.58 µg/dL for unexposed group. Significant decrease in the levels of RBCs, Hb, MCV, HCT and MCH among lead paint exposed group as compared to unexposed group. On the other hand, WBCs levels were almost the same and were not significant for both groups. Systolic and diastolic blood pressure levels were significantly increasing in exposed group as compared to unexposed group. It is concluded that lead exposure has an adverse effect on hematological components and causes anemia. Lead exposure contributes to cardiovascular diseases by elevating blood pressure even at low lead levels. Moreover, long susceptibility to lead exposure deteriorates blood components and blood pressure.

Introduction:

Lead (Pb) is a harmful environmental pollutant which has high toxic effects to many body organs [1, 2]. Lead has wide-ranging effects on health, with concomitant personal, societal and economic impacts, and thus, it was identified as one of the 10 chemicals of major public health concern globally [3]. Lead is a hazardous substance that can impact blood components like hemoglobin, erythrocytes, leukocytes, and platelets. It can imbalance the homeostasis of blood circulation and inhibits the body's ability to make hemoglobin by interfering with several enzymatic steps in the heme synthesis pathway [4]. There is no safe level of exposure to lead. Even low blood lead levels (<10 μg/dl) are believed to be associated with abnormalities in hematopoietic, nervous, and renal systems [5]. Currently, the lowest existing total lead limit in paint is 90 parts per million (ppm), which is the standard in many countries with lead-paint laws [6]. Lead can be found in all parts of our environment, including the air, soil, water, and even inside our homes [7] Much of the exposure comes from human activities such as the use of fossil fuels including leaded gasoline, some types of

industrial facilities, and lead-based paint in homes [8]. Lead and lead compounds have been used in a wide variety of products found in and around our homes, including paint, ceramics, pipes and plumbing materials, solders, gasoline, batteries, ammunition, and cosmetics [7, 8]. Lead paint is still considered the major source of lead toxicity in most countries; about 60% of all countries still allow using lead in paints [6].

Occupational lead exposure occurs mainly through the respiratory tract. Approximately 30–40% of inhaled lead is absorbed into the bloodstream. 99% of circulating lead is bound to erythrocytes for approximately 30–35 days and is distributed into the tissues, such as the liver, renal cortex, blood vessels, brain, lungs, spleen, teeth, and bones, over the following 46 weeks. In adults, approximately 80–95% of absorbed lead is stored in bones [9]. The half-life of lead in the soft tissue and blood is 20–40 days whereas in bone is 10–30 years [10]. Lead poisoning remains pervasive around the world, causing more than a million deaths a year globally [11]. Human exposure to lead and its compounds occurs mostly in lead related occupations with various sources like leaded gasoline, industrial processes such as smelting of lead and its combustion, pottery, boat building, lead based painting, lead containing pipes, battery recycling, grids, arm industry, pigments, printing of books [12].

The Centers for Disease Control and Prevention (CDC), 2016 adopted the current reference value of ≥5 µg/dL (≥50 ppb) for case management [13]. According to CDC, 2020, the current upper reference level in the United States (US) is 5 µg/dL [14]. According to WHO, 2020, about 11% of all African countries have lead paint laws and legislation to regulate lead use in paints, unfortunately Libya was not included [6]. According to a study conducted in Alshati southwest, Libya, which reported that blood lead level was 2.07±1.38 µg/dL for unexposed group and 2.216± 0.423 µg/dL among painting workers which was the second highest level among other study occupations [15]. Therefore, the objective of the study was to evaluate blood lead levels among painting workers (lead paint exposed group) and in unexposed group (control group) in Wadi ALhayah, Obary, southwest Libya. The second objective was to investigate its impact on hematological components and blood pressure.

Materials and methods:

Study population

Retrospective cohort study was conducted between the months of January 2021 to September 2021 at Albalsam clinic, Garma, Obary, southwest Libya. A total of 64 adult male subjects whose ages ranged between 20-45 years were included in this study, 34 of painting workers (lead paint exposed group) and 30 subjects (lead paint unexposed group) as a control group. Both groups were matched in ages and gender. Information was obtained by face-to-face interviews by using structured questionnaire including age, sex and general demographic details, occupational background, work-history records with the duration of lead exposure, education, using protective equipments in work, smoking status, dietary intake habits, drugs taken, prevailing diseases and symptoms. All participants were informed of the purpose of the study, were free to ask questions throughout the study and signed an informed consent form.

Inclusion criteria:

- Healthy male subjects (unexposed group) aged 20-45 years.
- Healthy male Painting workers (exposed group) aged 20-45 years.

Exclusion subjects:

- Subjects aged above 45 years.
- Smoking subjects.
- Supplemented subjects with any kind of trace elements.
- Subjects suffering from diarrhea.
- Kidney, heart, liver and respiratory diseases.
- Digestive tract and osteoporosis diseases.

Sample collection

Subjects were made to relax and comfortably seated. Venous blood sample (5ml) was collected aseptically by using heparinized disposable syringes from a peripheral vein on arm of each subject. Blood collected was delivered into tubes contain heparin as anticoagulant used for lead determination and hematological parameters. Blood lead levels and haemotological parameters including, red blood cells (RBCs), hemoglobin (Hb), hematocrit (HCT), mean corpuscle volume (MCV), mean corpuscle hemoglobin (MCH), white blood cells (WBCs) were measured. The kit for lead measurement was supplied by Biocon, a German company. All tests were conducted between 8.0 am to 11.0 am, all subjects were fasted. Measurements of blood pressure were obtained from both arms and two measurements were performed with a 1-2-minute interval between them, with the participant in a sitting position. The mean of the two blood pressure measurements was considered as the most accurate blood pressure and was used for statistical analyses.

Statistical Analysis

All the results were tabulated and analyzed using Statistical Package for Social Sciences (SPSS) version 14 to apply one way ANOVA test to compare the means and standard deviations of Blood lead, RBCs, WBCs, HB, HCT, MCV, MCH and systolic, diastolic blood pressure of lead paint exposed and unexposed groups. The results were considered statistically significant at p. value < 0.05.

Results:

The results of the present study have been presented and summarized in the form of tables. A total of 64 adult male subjects whose ages ranged between 20-45 years were included in this study. 34 of painting workers (lead exposed group) and 30 non lead exposed group (control group). All the results analyzed using Statistical Package for Social Sciences (SPSS) version 14 for applying one way ANOVA test to compare the means and standard deviations of the variables of exposed and unexposed group. The results were considered statistically significance at p. value< 0.05.

Table1 illustrates the demographic characteristics of lead paint exposed and unexposed group. The mean age of painting workers (lead exposed group) and non exposed group were 33.02 ± 7.02 years and 34.23 ±7.12 years, respectively. Both groups were matched in ages and not statistically significance (P. value= 0.46). Duration work for the exposed group was 8.44±1.63 years.

Table 2 reveals a comparison of blood lead, RBCs, WBCs, HB, HCT, MCV, MCH and systolic, diastolic blood pressure between exposed and unexposed group. blood lead, RBC's, HB, HCT, MCV, MCH and systolic, diastolic blood pressure were statistically significance between exposed and unexposed group at p. value< 0.05, whereas; WBCs were not statistically significance (P value = 0.95).

In the table 3, the results were divided into three groups in accordance to length of work in years. First group < 5 years, the second group was between 5-10 years and the third group was > 10 years. Blood lead, systolic, diastolic blood pressure and all hematological parameters were statistically significance among the three groups (p. value< 0.05).

Table 1: Demographic characteristics of lead paint exposed and unexposed groups.

Characteristics	Unexposed group Mean±SD	Exposed group Mean±SD	P. values
Age(years)	34.23 ±7.12	33.02 ± 7.02	0.46
work duration in years	.....	8.44±1.63	…..

SD, standard deviation.

Table 2: Comparison of lead paint exposed and unexposed groups.

Parameters	Lead paint unexposed group Mean±SD	Lead paint exposed group Mean±SD	P. value
Lead µg/dL	1.25±0.58	6.39±3.32	< 0.05
RBCs x 10^6 µl	4.98±0.45	3.89±0.57	< 0.05
WBCs x 10^3 µl	5.54±1.24	5.56±1.54	0.95
Hb g/ dl	15.93±1.14	12.49±1.36	< 0.05
MCV fL	91.34±4.69	81.73±9.47	< 0.05
HCT %	38.64±2.14	32.46±4.16	< 0.05
MCH pg	30.53±1.99	25.70±3.73	< 0.05
Systolic blood pressure mmHg	100.03±12.96	121.26±16.24	< 0.05
Diastolic blood pressure mmHg	69.46±6.16	84.35±9.63	< 0.05

The results were analyzed using Statistical Package for Social Sciences (SPSS) version 14 for applying one way ANOVA test to compare the means and standard deviations of parameters of exposed and unexposed group. The results were expressed as means and standard deviations (SD). The results were considered statistically significance at P. value<0.05.

There was statistical significance between the two groups regarding blood lead, RBCs, HB, MCV, HCT,MCH and systolic blood pressure, diastolic blood pressure (p. value< 0.05), whereas WBCs were not statistically significant between the two groups (p. value = 0.95).

Table 3: Distribution of lead paint exposed group in accordance to work duration.

	Work duration (years)			
Parameters	**< 5**	**5-10 years**	**> 10 years**	**P. value**
	N = 8	**N = 17**	**N = 9**	
	2.62±1.06	**7.82 ±1.77**	**14.88±2.08**	
Lead µg/dL	3.02±0.73	5.61±2.02	10.85±1.32	< 0.05
RBCs x 10^6 µl	4.30±0.41	3.97±0.43	3.38±0.95	< 0.05
WBCs x 10^3 µl	3.91±0.30	5.47±1.04	7.20 ±1.35	0.95
Hbg/ dl	13.73±1.12	12.68±0.97	11.01±0.72	< 0.05
MCV fL	94.75±3.84	81.82±3.48	70±2.95	< 0.05
HCT %	36.23±1.52	33.61±2.04	26.93±3.09	< 0.05
MCH pg	30.12±2.29	25.64±2.34	21.88±2.47	< 0.05
Systolic blood pressure mmHg	103.87±13.39	120.47±9.18	138.22±11.64	< 0.05
Diastolic blood pressure mmHg	76.62±3.15	82.23±5.10	95.22±10.95	< 0.05

The results were analyzed using Statistical Package for Social Sciences (SPSS) version 14 for applying one way ANOVA test to compare the means and standard deviations of parameters of lead paint exposed group in relation to work duration. The results were expressed as means and standard deviations (SD). The results were considered statistically significance at P. value<0.05.

All parameters were statistically significant among the three groups at p value < 0.05.

Discussion:

Exposure to lead, even at very low levels can cause multiple adverse health effects causing morbidity and mortality which remains high in many countries [16]. According to WHO, 2009 98% of adults and 99% of children living in low and middle-income countries are affected by lead exposure [17]. Lead poisoning refers to excessive human exposure to lead. Exposure may occur over a short space of time (acute poisoning) or over a prolonged period of time (chronic poisoning). No safe level of exposure to lead has so far been identified. As a consequence some health authorities define excessive exposure as having a blood lead concentration above the reference value for the population as a whole [18]. The study showed significant increase lead levels in lead paint exposed group 6.39±3.32 µg/dL as compared to unexposed group 1.25±0.58 µg/dL. The prevalence of elevated lead levels among painting workers was above the CDC, 2020 reference level of ≥5 µg/dL. The result was higher than of a study's result conducted in Alshati, Libya which reported that blood lead level was 2.216± 0.423 µg/dL for lead paint exposed group and 2.07±1.38 µg/dL for unexposed group. Adverse effects occur at blood lead level ≤5 µg/dL including (neurological, renal, cardiovascular, hematological, immunological, reproductive) [19].

Observed elevations of blood lead levels were due to inadequate awareness of workers to work in safety procedures. Workers were in conditions of exposure to lead for 6-7 hours during painting work. All workers did not use the personal protective equipment, such as protective clothes, masks, and goggles, as they were unaware of possible adverse health effects of lead poisoning, however, 60% of workers were educated (Bachelor level).

The study revealed significant decrease in the levels of RBCs 3.89±0.57 x 10^6µl, Hb 12.49±1.36 g/ dl, MCV 81.73±9.47 fl, HCT 32.46±4.16% and MCH 25.70±3.73 pg among lead paint exposed group as compared to unexposed group 4.98±0.45x 10^6 µl, 15.93±1.14 g/ dl, 91.34±4.69 fl, 38.64±2.14% and 30.53±1.99 pg. On the other hand, WBCs levels were almost the same and were not significant for both groups (5.56±1.54 and 5.54±1.24 x 10^3 µl for exposed and unexposed groups respectively).

In the present study, the results of lead paint exposed group were classified into three groups according to work duration in years, first group < 5 years, the second group was between 5-10 years and the third group was > 10 years. Blood lead levels were significantly increasing with the increase of work duration (3.02±0.73, 5.61±2.02 and 10.85±1.32 µg/dL) and conversely, there was a significant decrease in RBCs, Hb, MCV, HCT and MCH with the increase of work duration. Furthermore, WBCs levels were significantly increasing with the increase of work duration. The study was consistent with previous studies conducted for adults who revealed significant decrease in blood hemoglobin concentration in lead exposed workers at the level of 5.4–7.0 µg/dL compared to control 1.5–3.0 µg/dL [20, 21].

Lead compounds can adversely affect the metabolism of blood cells in the bone marrow or mature erythrocytes. Lead impairs the integrity of the permeability of red blood cell membrane. Heme synthesis is also disturbed by lead exposure [22]. Lead binds to the red blood cells and impairs the formation of heme by interfering with enzymatic steps in the heme synthesis pathway, which decreases red blood cells, resulting in the increased risk of anemia. Moreover, increased lead level interferes with the absorption of iron in the intestine causing iron deficiency in the body, and subsequently increases the risk of anemia [23, 24].

There are three enzymes involved in heme synthesis which are δ-aminolevulinic dehydrase (δALAD), ferrochelatase, and δ-ALA synthetase (ALAS) [25]. Lead can interfere with the function of these enzymes and results in disrupting heme synthesis. Yet, it decreases the circulating erythrocytes life span via raising the cell membranes fragility [26]. Delta aminolevulinic acid dehydratase (δALAD) is extremely sensitive to lead exposure. Inhibition of this enzyme results in increased circulating aminolevulinic acid (ALA) which leads to restriction of ALAD at level of <10 µg/dl of lead in blood. Biosynthesis of heme does not reduce till the action of ALAD is restricted by 80-90% that takes place at a higher concentration of lead 55 µg/dl in blood [27, 28].

The study showed a significant increase in systolic and diastolic blood pressure among lead exposed group. Systolic blood pressure was 121.26±16.24 mmHg and 100.03±12.96 mmHg in exposed and unexposed group respectively, whereas diastolic blood pressure was 84.35±9.63 mmHg and 69.46±6.16 mmHg in exposed and unexposed group respectively. Moreover, systolic and diastolic blood pressure was significantly increasing with the increase in work duration in years (> 5 years, 5-10 years and > 10 years). Systolic blood pressure' results (103.87±13.39, 120.47±9.18 and138.22±11.64 mmHg respectively), on the other hand, diastolic blood pressure (76.62±3.15, 82.23±5.10 and 95.22±10.95 mmHg respectively). The results of the study were in agreement with other studies which showed increased blood pressure and increased risk of hypertension with high blood lead level [29,30, 31, 32 and 33], Further, the study was consistent with the largest meta-analysis involving 58,518 subjects documented increase in systolic and diastolic blood pressure in lead exposed subjects [34]. The cardiovascular manifestations in the form of elevated blood pressure due to chronic lead exposure is reported at blood lead levels as low as 1.41–1.75 µg/dL [35]. The lowest mean blood lead associated with increased systolic and diastolic was 1.33 µg/dL [36]. However, the association of hypertension at low blood lead levels is uncertain [37, 38].

Conclusion: It is concluded that lead exposure has an adverse effect on hematological components and causes anemia. Lead exposure contributes to cardiovascular diseases by elevating blood pressure even at low lead levels. Moreover, long susceptibility to lead exposure deteriorates blood components and blood pressure.

Limitations: The study has some limitations including small sample size; trace elements such as calcium, iron, magnesium which can influence the absorption of lead in the intestine were not measured in the study.

Recommendations: Establishing law or legislation by the authority to regulate and restrict the amount of lead in paint, raising the awareness among painting workers of lead toxicity to take safety

procedures and using protective equipments during painting work. Further researches should be conducted for lead toxicity among children aged 1-6 years. Moreover, more researches should be conducted for other lead exposed occupations.

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