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(Research Article)

RELATIONSHIP BETWEEN HEAVY METAL LEVELS, LIVER FUNCTION TESTS, AND SELECTED BIOCHEMICAL PARAMETERS AMONG FUEL STATION WORKERS IN SALAH AL-DIN PROVINCE

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ABSTRACT

Background: Oil and gas stations play a crucial role in the economic advancement of Salah Al-Din Governorate. Workers in this field are often exposed to toxic substances, including hydrocarbons and heavy metals, which can adversely affect their health.

Aim of the study: The current study evaluated level of cadmium and lead in Fuel station Workers and correlated with liver enzymes test, in addition to antioxidant statue.

Materials and methods: A case control study which was conducted from December 2025 to April 2026 and involved 75 participants, including 50 Fuel station Workers, and 25 control.

Result: The current study showed increase level of Lead and Cadmium in fuel station as compared with control, at p-value <0.001. In addition, increase level of Body mass index (BMI), Cholesterol, Triglycerides, low density lipoprotein (LDL), Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Erythrocyte Sedimentation Rate (ESR), Packed Cell Volume (PCV), hemoglobin (Hb), malondialdehyde (MDA) in Fuel station workers as compared with control, at p-value <0.001. While decrease high density lipoprotein (HDL) and glutathione (GSH) in Fuel station workers as compared with control, at p-value <0.001.

Conclusion: The current study concluded increase lead and cadmium in Fuel station Workers, In addition, increase level of BMI, Cholesterol, Triglycerides, LDL, AST, ALT, ESR, PCV, Hb, MDA in Fuel station workers as compared with control. While decrease high density lipoprotein and glutathione in Fuel station workers as compared

Keywords: Fuel Station Workers, Liver Enzyme Test, Glutathione, Lead, Cadmium

1 INTRODUCTION

Benzene is a chemical compound consisting of several hydrocarbon molecules and is regarded as one of the most dangerous hydrocarbons. Benzene is a cyclic aromatic hydrocarbon consisting of six carbon atoms and six hydrogen atoms in its chemical formula. The physical characteristics suggest a low boiling point, enabling fast evaporation under ordinary conditions. It is utilised as a universal solvent in many chemical processes, pharmaceutical and industrial applications, and the manufacture of a wide range of products. As a result, it is regarded as a major contributor to environmental contamination[1]. The two main ways that benzene enters the body are through direct skin contact or breathing in polluted air. Phenol, benzene oxide, benzoquinone, muconaldehydes, hydroquinone, and catechol are among the metabolites that are eliminated in the urine after being fully absorbed by the body upon inhalation [2]. It is believed that benzene's detrimental effects stem from its metabolites, especially benzoquinone and the mucosal aldehydes. Numerous processes, including oxidative stress, DNA damage, cell cycle disruption, and apoptosis, appear to be involved in benzene-induced toxicity [3]. Additionally, as benzene can weaken innate, humoral, and cellular immunity, immunological dysfunction is thought to be a factor in benzene poisoning[4].

Lead (Pb) is a toxic environmental pollutant and a historical chemical danger. Although it is a naturally occurring compound, it can be emitted into the environment due to several industrial operations, including the manufacturing of paints, varnishes, batteries, and gasoline, where it serves as an anti-detonation agent[5].

Nutrition is a key source of exposure for nonsmoking, nonoccupationally exposed people because cadmium is a contaminant found in most human meals [6]. Free radicals or non-radical species remove a labile hydrogen atom from the bis-allylic position methylene groups of polyunsaturated fatty acids (PUFAs), causing lipid peroxidation. This produces hydroperoxides and lipid peroxyl radicals. It indicates cell oxidative stress. An imbalance in oxidant-antioxidant equilibrium increases lipid peroxidation[7]. A biomarker for lipid peroxidation and a sign of oxidative damage in the human body is malondialdehyde (MDA) [8]. Because of its toxicity, oxidative stress destroys the cell membrane. MDA should therefore be reduced if it has reached its maximal threshold [9].

The serum contains a variety of enzymes, including catalase, superoxide dismutase, peroxidase, and glutathione peroxidase, as well as several antioxidants, including glutathione and UA[10]. The liver perform critical activities include digestion, metabolism, detoxification, and glycogen storage [11-13].High liver enzyme may indicate hepatic impairment.[13, 14]. One of the many functions of the liver is the detoxification of toxic substances. An increased risk of impaired liver function may be associated with frequent and significant exposure to gasoline constituents [11]. Benzene, toluene, and xylene are among the hydrocarbons that make up gasoline, which is a volatile and combustible liquid combination produced from petroleum along with a variety of additives[15].

2 MATERIALS AND METHODS

50 fuel station employees and 25 controls made up the 75 participants in a case-control study that take place between December 2025 and April 2026.

2.1 Blood sample collection

Venous blood samples were collected from all participants after a fasting period of at least 12 hours for biochemical examination. Blood was collected via normal antecubital venipuncture into three tubes: one designated for ESR, another containing an anticoagulant (EDTA), and 2 ml was allocated for haemoglobin and packed cell volume analysis. Three millilitres of leftover blood were put in an EDTA-free tube and allowed to coagulate in a water bath at 37°C. After centrifuging the blood samples for ten minutes at 3000 rpm, the serum was separated and split into two tubes, which were kept at -20°C until analysis was required. Before the biochemical parameters were evaluated, the samples were allowed to thaw at room temperature. Lipid profile, and liver enzyme were performed by using the BIOLABO reagents kit [16].

2.2 Measurment of Body mass index (BMI)

Anthropometric and Physiological Measurements: Body Mass Index (BMI) was computed utilising the height and weight of each participant.

2.2.1 Determination of Pb and Cd:

In order to determine the levels of lead and cadmium in the blood, a flame atomic absorption spectrophotometer was utilized [17].

2.3 Statistical analysis

GraphPad Prism (version 8.0) and SPSS software (version 26.0) were used for statistical analysis. Mean ± standard deviation (SD) was used to display the data. The Pearson correlation coefficient (r) was used to do correlation analysis between variables. Statistical significance was defined as a p-value of less than 0.05.

3 RESULT

Table (1) showed increase level of Pb and Cadmium in Fuel station workers (17.29 ± 6.28, 4.09 ± 1.65) as compared with control (10.25 ± 5.13, 1.14 ± 0.42) respectively, at p-value <0.001.

Table 1: Comparison of Blood Pb and Cadmium Levels Between Fuel station Workers and Control.

Parameter	Control Mean ± SD	Workers Mean ± SD	p-value
Pb	10.25 ± 5.13	17.29 ± 6.28	<0.001
Cadmium	1.14 ± 0.42	4.09 ± 1.65	<0.001

Table (2) showed increase level of BMI , Cholesterol , Triglycerides , and LDL in Fuel station workers (29.44 ± 9.83, 147.44 ± 26.57, 172.46 ± 40.62, 137.36 ± 26.06) as compared with control (22.93 ± 2.48, 96.88 ± 15.07, 121.44 ± 20.61, 92.71 ± 24.82) respectively, at p-value <0.001. While decrease HDL in Fuel station workers as compared with control (41.00 ± 10.81, 57.62 ± 9.54).

Table 2: Comparison of lipid profile Between Fuel station Workers and Control Subjects

Parameter	Control Mean ± SD	Workers Mean ± SD	p-value
BMI	22.93 ± 2.48	29.44 ± 9.83	<0.001
Cholesterol	96.88 ± 15.07	147.44 ± 26.57	<0.001
Triglycerides	121.44 ± 20.61	172.46 ± 40.62	<0.001
HDL	57.62 ± 9.54	41.00 ± 10.81	<0.001
LDL	92.71 ± 24.82	137.36 ± 26.06	<0.001

Table (3) showed increase level of AST , and ALT in Fuel station workers (26.34 ± 9.16, 40.06 ± 16.64) as compared with control (13.67 ± 4.65, 12.83 ± 4.48) respectively, at p-value <0.001.

Table 3: Comparison of liver enzyme Levels Between Fuel station Workers and Control Subjects

Parameter	Control Mean ± SD	Workers Mean ± SD	p-value
AST	13.67 ± 4.65	26.34 ± 9.16	<0.001
ALT	12.83 ± 4.48	40.06 ± 16.64	<0.001

Table (4) showed increase level of ESR, PCV, and Hemoglobin in Fuel station workers (14.50 ± 9.74, 45.96 ± 3.94, 14.62 ± 1.28) as compared with control (8.95 ± 7.81, 43.76 ± 1.55, 14.04 ± 0.35) respectively, at p-value <0.01.

Table 4: Comparison of hematological parameter Levels Between Fuel station Workers and Control Subjects

Parameter	Control Mean ± SD	Workers Mean ± SD	p-value
ESR	8.95 ± 7.81	14.50 ± 9.74	0.0144
PCV	43.76 ± 1.55	45.96 ± 3.94	0.0014
Hemoglobin	14.04 ± 0.35	14.62 ± 1.28	0.0031

Table (5) showed decrease level of GSH in Fuel station workers (46.73 ± 8.62) as compared with control (84.10 ± 4.37) respectively, at p-value <0.001. While increase MDA in Fuel station workers as compared with control (6.78 ± 1.56, 4.46 ± 1.97).

Table 5: Comparison of GSH and MDA Levels Between Fuel station Workers and Control Subjects

Parameter	Control Mean ± SD	Workers Mean ± SD	p-value
GSH	84.10 ± 4.37	46.73 ± 8.62	<0.001
MDA	4.46 ± 1.97	6.78 ± 1.56	<0.001

The correlation analysis revealed a significant negative association between blood Pb levels and HDL cholesterol ($r = -0.38$, $P < 0.05$), suggesting that Pb exposure may adversely affect lipid metabolism and increase cardiovascular risk among fuel station workers. A significant positive correlation was observed between hemoglobin and PCV ($r = 0.65$, $P < 0.05$), reflecting the physiological relationship between these hematological parameters. Furthermore, hemoglobin showed a significant negative correlation with GSH levels ($r = -0.40$, $P < 0.05$), which may indicate an association between oxidative stress and hematological alterations. In addition, triglyceride levels were positively correlated with PCV ($r = 0.42$, $P < 0.05$), suggesting a possible interaction between lipid metabolism and hematological status.

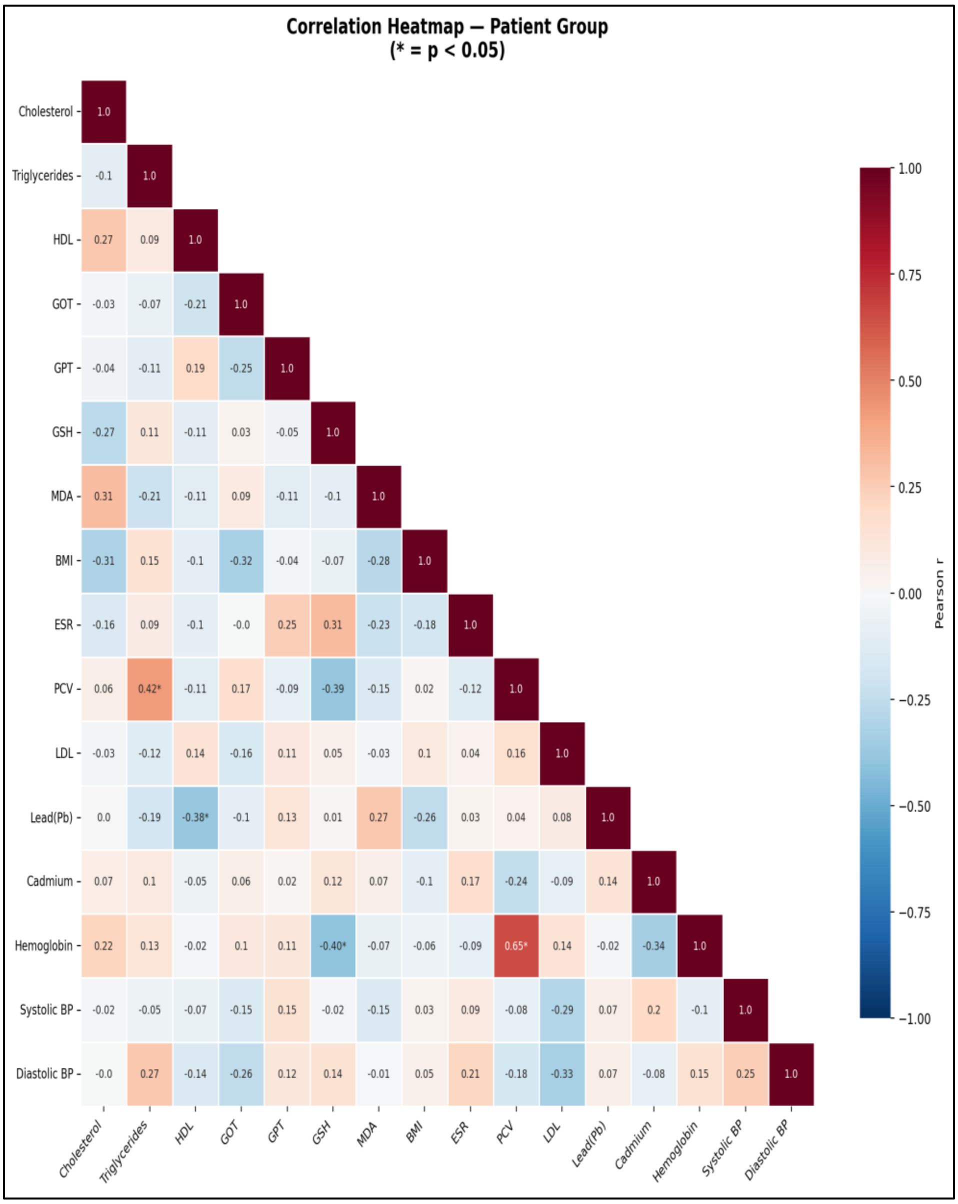

Figure 1: Correlation Heatmap of Biochemical, Hematological, and Oxidative Stress Parameters in Fuel station Workers

4 DISCUSSION

One of the main dangerous air pollutants in the environment is benzene, a significant organic component of crude oil and gasoline. Benzene exposure in the environment has long been recognised as a carcinogen that affects the components of human blood. Additionally, it may have non-cancerous consequences such renal, hepatic, and hematologic dysfunctions[18].

The current study supports [19, 20], which showed that fuel station employees had higher levels of Pb and cadmium. By changing the composition of fatty acids and membrane integrity, lead increases the susceptibility of cells to oxidative damage, which is correlated with increased levels of malondialdehyde in the liver [21, 22]. DNA damage or increased production of reactive oxygen species can result from Pb's direct interactions with DNA and DNA replication [23]. Pb can build up in liver tissues and cause peroxidative damage to liver cell membranes, which raises serum ALT and AST levels. Long-term occupational exposure to lead has been shown to raise serum transaminase enzyme levels [5, 24]. Previous studies suggest that after hepatocyte death, mitochondrial breakdown may lead to elevated serum AST and ALK levels [25, 26].

The predictive correlation between blood lipids and cardiovascular illnesses, especially coronary artery disease, has rendered the measurement of blood lipids in clinical laboratories increasingly pertinent. The current study concurs with [27], which demonstrated elevated cholesterol, triglycerides, and LDL levels in fuel station workers. While reducing HDL disagree with [5], which demonstrated no significant changes in cholesterol levels between gasoline station personnel and the control group.

According to a study by [28, 29], fuel station workers had significantly higher levels of AST and ALT, suggesting a more comprehensive hepatic involvement, possibly as a result of longer exposure times or higher exposure intensities. The results of [5], which showed no discernible variations in ALT and AST levels among Fuel station Workers, are at odds with the current study. Variations in the properties of petroleum products, the degree and length of exposure, the use of personal protective equipment, or population demographics can all be blamed for discrepancies between research.

Exposure to benzene may result in hepatic cellular damage, which can be evaluated using liver transaminase levels. The aspartate Aminotransferase enzyme is located in the mitochondria of several organs. Nevertheless, it is primarily linked to the liver. Consequently, it functions as a reliable biomarker for hepatocellular injury [30]. ALT is current in eighty percent of tissue mitochondria and predominantly appears in the bloodstream as a result of extensive cellular necrosis and injury. Concurrently, the residual 20% of AST, situated in the cytoplasm, is discharged into the bloodstream as a consequence of cellular destruction. Therefore, other liver function parameters should be evaluated to improve sensitivity, including alkaline phosphatase [31]. A meta-analysis [24] indicated that serum levels of AST, and ALT, were elevated in workers exposed to petrol and gasoline compared to the control group. Consequently, occupational exposure to fuel stations may adversely affect renal and hepatic function.

The current study concurs with [1, 32, 33], which demonstrated significant alterations in haematological parameters among individuals exposed to benzene, especially those with prolonged exposure durations (8–10 years). The research highlights the existence of a specific exposure–response link and underscores the urgent need for constant biomonitoring, improved occupational health standards, and severe regulation of environmental contaminants in work environments that are related to petroleum[34]

The current investigation demonstrated an elevated level of MDA and a diminished level of GSH, corroborating the findings of **[35]** which indicated a considerable increase in MDA and a drop in antioxidants. The decrease in GSH presumably indicates heightened utilisation of these elements due to oxidative stress from heavy metal exposure. It is possible for Pb and cadmium to act as substitutes for essential ions, which can lead to the disruption of antioxidant enzyme activity and the metabolism of cells. These disruptions make it easier for an excessive amount of reactive oxygen species (ROS) to be produced, which ultimately leads to lipid peroxidation and cells being damaged. The drop in antioxidant substances may suggest a compensation strategy, while it can also lower the body's defences, boosting vulnerability to additional oxidative injury[36]. The findings of this observation are consistent with those of a study conducted in Iraq, which found that workers working at fuel stations who were exposed to lead and cadmium had similar patterns of oxidative stress, which were marked by elevated levels of MDA and decreased antioxidant defences on their bodies[37].

The correlation study indicated a strong negative relationship between blood Pb levels and HDL, implying that heightened Pb exposure may lead to a decrease in protective high-density lipoprotein levels. This finding aligns with the work of [38], which indicated that ambient exposure to Pb and cadmium correlates with dyslipidemia and reduced HDL levels, attributable to disruptions in lipid metabolism and oxidative stress. A study by [39]indicated that occupational Pb exposure enhances reactive ROS generation and oxidative damage, leading to increased MDA levels.

5 CONCLUSION

The current study demonstrated that occupational exposure to gasoline fumes among fuel station workers is associated with significant biochemical and hematological alterations. Fuel station workers exhibited significantly elevated blood lead and cadmium levels, accompanied by increased body mass index (BMI), total cholesterol, triglycerides, LDL-cholesterol, liver enzymes (AST and ALT), erythrocyte sedimentation rate (ESR), packed cell volume (PCV), hemoglobin concentration, and malondialdehyde (MDA) levels compared with the control group. Conversely, HDL-cholesterol and glutathione (GSH) levels were significantly reduced. These findings indicate that chronic occupational exposure to petroleum products may contribute to heavy metal accumulation, dyslipidemia, hepatic dysfunction, enhanced oxidative stress, and disturbances in hematological parameters.

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